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”JOY AT WORK”

Anna-Lisa Osvalder, Mikael Blomé and Hajnalka Bodnar (Eds.)

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WELCOME TO NES2017 – Joy at work!

Welcome to Lund and the 49th annual NES Conference – Joy at work at the Faculty of Engineering at Lund University, Sweden!

Joy at Work is a conference for a creative and sustainable working life and takes on the work environment of the future. How do we handle the challenges and opportunities of digitalization, integration and the coming generation shift? How do we create a health-promoting and competitive work environment? What can we do to encourage creativity on the job? And who is responsible for what? We are happy to host this excellent gathering of participants involved in work environment issues to meet, breaking barriers and share ideas!

Joy at Work is organised by the Ergonomics and Aerosol Technology Division at the Department of Design Sciences, Lund University's Faculty of Engineering (LTH) in association with the Ergonomics and Human Factors Society of Sweden (EHSS). The venue for Joy at Work is in a creative environment at the Ingvar Kamprad Design Center (IKDC) with direct access to the research laboratories, prototype workshops and the School of Industrial Design. IKDC is also geographically situated on the border between Lund University and IDEON Science Park.

The NES2017 conference is a truly international event. Researchers from 24 countries around the world meet in Lund for three days. The call for abstracts resulted in 95 abstracts and 36 full papers accepted for presentation and publication in the Conference Proceedings. We thank the reviewers for their precious time and commitment to give feedback to the authors; without the support of the reviewers, the NES2017 Conference would not be possible.

Finally, we want to direct special thanks to AFA Insurance, Kinnarps and Flokk for sponsoring and make it possible to arrange the conference in a traditional Lund spirit. This spirit has been developed since 1666 when Lund University was founded. Come celebrate its 350-year anniversary with us!

Enjoy the conference!

The NES2017 Organizing Committee

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LIST OF KEYNOTES SPEAKERS



Mats Bohgard
Professor in Working Environment at Design Sciences, Lund University

Subject of presentation:
Building knowledge for good work environment



Susanne Brannebo
Professional communicator and behavioral scientist in business development

Frida Tibblin
Economist and behavioral scientist

Subject of presentation:
Move slowly to change fast



Andreas Larsson
Associate Professor and Innovation Leader at Blekinge Institute of Technology

Subject of presentation:
Innovative working environment



Marie-Luise Ribbnäs MBA, Leadership development at Entira

Johan Bauer
MBA, Leadership development at Entira

Subject of presentation:
Vulnerability – the birthplace of trust, creativity and innovation



Mattias Wallergård
Researcher in interaction design, virtual reality and augmented reality at Design Sciences, Lund University

Subject of presentation:
Virtual Working Environments – Are we ready for the blue pill?



Samuel West
Clinical psychologist and PhD in organizational psychology

Subject of presentation:
More play at work

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EXHIBITORS

MONDAY, 21 AUGUST 2017 Location: Ingvar Kamprad Design Center			
8:00 - 9:00	**REGISTRATION - MINGLE**		
	ROOM: STORA HÖRSALEN		
9:00 - 9:30	**WELCOME - OPENING CEREMONY** Professor Anna -Lisa Osvalder (Chair Scientific Committeé) and Associate Professor Mikael Blomé (Head of Organising Committée) Professor Fredrik Nilsson - Head of Design Sciences Jane Ahlin (Chair EHSS Board) and Kasper Edwards (Chair NES Board)		
9:30 - 10:00	**KEYNOTE SPEAKER 1.** Mats Bohgard, Professor in Working Environment at Design Sciences, Lund University *Topic: Three aspects of comprehensive views when building knowledge for good work environments*		
10:00 - 10:30	**KEYNOTE SPEAKER 2.** Samuel West, Clinical psychologist & PhD in organizational psychology *Topic: More play at work*		
10:30 - 10:50	**COFFEE BREAK AND EXHIBITION SESSION**		
SESSION 1. 10:50 - 12:20	**ROOM : STORA HÖRSALEN**	**ROOM: 304**	**ROOM: 467**
	Topic: Joy at Work	*Topic:* Education, Learning and Training	*Topic:* Ergonomics Intervention
	Moderator: Mikael Blomé	*Moderator: Anna-Lisa Osvalder*	*Moderator: Cecilia Österman*
10:50	*Helena Tobiasson, Jan Gulliksen, Anders Lundström and Fredrik Nilbrink* *(KTH, Sweden)* Meeting to GO - we can walk IT out design of mobile system supporting work meetings while walking	*Gunnar Lagerström, Mats Bohgard, Jörgen Eklund, Lars-Åke Mikaelsson, Anna-Lisa Osvalder, Kjell Rask, David Tikka* *(Prevent, Sweden)* *Full paper:* Development of the online course “Work and Technology on Human Terms"	*Jörgen Winkel, Bernt Schiller, Lotta Dellve, Kasper Edwards, Patrick W Neumann, Therese Öhrling and Rolf H Westgaard* *(University of Gothenburg, Sweden)* *Full paper:* Scientific evidence suggests a changed approach in ergonomic intervention research
11:10	*Elma Mulaomerovic, Eric Min-Yang Wang and Milivoj Markovic* *(National Tsing Hua Univeristy, Taiwan)* *Full paper:* Is the Importance of “fun at work place” underestimated? – A cross-cultural perspective on work environment factors for creativity performance	*Calle Rosengren and Jonas Borell* *(Lund University, Sweden)* Commissioned education on work environment	*Oskar Ponnert* *(Zenit Design Group AB, Sweden)* Ergonomics and Aesthetics – conflicting challenges in a user-centered design process
11:30	*Marija Molan and Martin Molan* *(University Medical Centre Ljubljana, Slovenia)* *Full paper: Are* well-being and joy at work related to age?	*Viveka Lyberg-Åhlander, Heike von Lochow, Susanna Whitling, Jonas Christensson, Erling Nilsson and Jonas Brunskog* *(Lund University, Sweden)* Speakers’ comfort and voice use in different environments and babble-noise. Are there effects on effort and cognition?	*Cecilia Österman, Gesa Praetorius and Carl Hult* *(Linnaeus University, Sweden)* Full paper: Work environment challenges and participatory workplace interventions on passenger ships
11:50	*Liv Starheim, Peter Hasle and Birgitte Juul Diekman* *(CRECEA Work Life, Denmark)* *Full paper:* Joy in creating improvement of the psychosocial environment through workflow analysis	*Jeena Velzen, Sarah Atkinson, Alexandra Lang, Thomas Blanks, Bryn Baxendale and Steven Gill* *(Univ of Nottingham, UK)* *Full paper:* Essential non-technical skills for adult intensive care staff in managing unplanned extubations	*Jasmina Insanic, Linda Rose and Cecilia Österman* *(KTH, Sweden)* *Full paper: E* xpert user perspectives of the Ergo-Index model for analysis of work tasks
12:10	*Konstantinos S Mammas and Adamantia S Mamma-Graham* *(Prometheus I (1008239) - Aris HC-GrNET, Greece)* *Full paper:* Innovating training networks for interactive e-learning and application of ergonomics of the remote rvaluation of the grafts in organ transplantation	*Anna-Leena Kurki, Hanna Uusitalo and Anna-Maria Teperi* *(Finnish Inst of Occupational Health, Finland)* *Full paper:* Enhancing the collaborative design of safety management practices in education	*Anders Sundin* *(CREE Nordic Assessment Board)* European Ergonomist Certification
12:30 - 13:30	**LUNCH BREAK**		

MONDAY, 21 AUGUST 2017
Location: Ingvar Kamprad Design Center

SESSION 2. 13:30 - 15:10	ROOM: STORA HÖRSALEN	ROOM: 304	ROOM: 467
	Topic: Human Machine Systems	*Topic:* Risk Safety Management	*Topic:* Ergonomics Intervention
	Moderator: Lars-Ola Bligård	*Moderator: Åsa Ek*	*Moderator: Roland Örtengren*
13:30	*Eva Simonsen* *(Chalmers University of Technology, Sweden):* Full paper: A comparison of human factors evaluation approaches for nuclear power plant control room assessment and their relation to levels of design decision specificity	*Jarkko Leppälä, Peter Lundqvist, John G. McNamara, Helle Domino, Martina Jakob and Risto Rautiainen* *(Natural Resources Institute of Finland, LUKE)* The Sacurima COST action: Towards a Better Safety Culture in Agriculture	*Colleen Brents, David Gilkey and John Rosecrance* *(Colorado State University, USA)* Application of inertial measurement units to study low back kinematics of beer keg handling
13:50	*David Gillblom, Fangzhou Cao, Moa Parsland, Linnéa Söderbom and Victor Östin* *(Semcon, Sweden)* *Full paper:* Enablers for improved collaboration in a remote meeting context	*Åsa Ek and Marie Engström* *(Lund University, Sweden):* Formal and informal health and safety work in construction	*Veikko Ikone* *(VTT, Finland)* *Full paper:* Responsible Research and Innovation (RRI) – enhancing ethical design and engagement of stakeholders for the development of new technologies
14:10	*Kristin Hammarberg, Johan Fagerlönn, Stefan Lindberg, Anna Sirkka and Sofia Larsson* *(RISE Interactive, Sweden)* The design of a new type of multimodal alarm display for a paper mill control room	*Jonas Borell, Kerstin Eriksson and Åsa Ek* *(Lund University, Sweden)* Safety management at radiation research facilities with visiting users - MAX IV Laboratory and ESS	*Ida-Märta Rhén, Farhad Abtahi, Liyun Yang and Mikael Forsman (Chalmers University of Technology & Karolinska Institute, Sweden)* Feasibility of a new device to assess neck posture and movement in field studies
14:30	*Anna-Lisa Osvalder, Johan Ottosson, Fredrik Alexandersson* *(Chalmers University of Technology, Sweden)* Simulator training for improved excavator operator performance	*Cecilia Österman, Lisa Schmidt, Johan M. Sanne and Ann-Beth Antonsson* *(Linnaeus University, Sweden)* *Full paper: Preventing workplace violence and threats among professional cleaners – how not to be in the 'wrong place at the wrong time'*	*Annika Mattus Tufvesson* *(A-Ergonomi, Sweden)* *Full paper:* Could the use of unstable, shock absorbent work shoes reduce subjective musculoskeletal discomfort? A pilot study among employees in a large supermarket
14:50	*Jens Alfredson, Tim Overkamp, Jasmine Tarander, Johanna Ledin, Linda Klamer, Maria Eckerberg and Niklas Blomstrand* *(Saab Aeronautics, Sweden)* *Full paper:* Digitization of technical information for fighter aircraft maintenance	*Chuansi Gao, Lars Nybo, Hein Daanen, Jørn Toftum, Kalev Kuklane, Johanna Olsson, Stephen Fritzdorf, Koen Levels and Moniek Zuurbier* *(Lund University, Sweden)* From weather warning to personalized adaptation strategies to cope with thermal climate stress	*Konstantinos S Mammas and Adamantia S. Mammas* *(Prometheus I (1008239) - Aris HC-GrNET, Greece)* *Full paper:* Reliability of Applied Ergonomics of a New Mobile Clinical Unit for Remote, Specialized, Multidisciplinary and Personalized Service for Cancer and Diabetes Complications Integrated Prevention, in Developing Countries
15:10 - 15:30	**COFFEE BREAK AND EXHIBITION SESSION**		

MONDAY, 21 AUGUST 2017 Location: Ingvar Kamprad Design Center			
SESSION 3. 15:30- 16:50	**ROOM: STORA HÖRSALEN**	**ROOM: 467**	
	Topic: Methods in Ergonomics	*Topic: Ergonomics Intervention*	
	Moderator: Kalev Kuklane	*Moderator: Hillevi Hemphälä*	
15:30	*Linda Rose and Jörgen Eklund (KTH, Sweden)* The RAMP tool for risk management in manual handling: A seven year R&D project	*Hillevi Hemphälä, Camilla Zetterberg, Per Lindberg, Marina Heiden and Per Nylén* *(Lund University, Sweden)* VERAM, a risk assessment method for visual ergonomics	
15:50	*Erik Brolin, Dan Högberg, Lars Hanson and Staffan Björkenstam* *(University of Skövde, Sweden)* *Full paper:* Virtual test persons based on diverse anthropometric data for ergonomics simulations and analysis	*Tina Koohnavard, Lars-Ola Bligård, I.C. MariAnne Karlsson , Patrik Blomdahl, Dennis Saluäär* *(Chalmers University of Technology, Sweden)* Full paper: Driving Simulator Studies - Opportunities to Elicit Important Knowledge from Experienced Truck Drivers	
16:10	*Anna-Lisa Osvalder* *(Chalmers University of Technology, Sweden)* Using children in research regarding safety and comfort of restraint systems in cars	*Liyun Yang, Ke Lu, Farhad Abtahi, Kaj Lindecrantz, Mikael Forsman, Jörgen Eklund and Fernando Seoane* *(KTH, Sweden)* A pilot study of using smart clothes for physical workload assessment	
16:30	*Siyeon Kim, Joo-Young Lee and Kalev Kuklane (Lund University, Sweden)* Prediction of body core temperature with heart rate variability – a pilot study	*Linus Lindvall, Nina Pettersson Jalming, Stas Krupenia and Thomas Westin* *(Scania CV AB, Sweden)* *Full paper:* How not to run into a wall: A comparative experiment of Movement in Virtual Reality	
17:00 - 18:00	**ROOM: STORA HÖRSALEN**		
	GET-TOGETHER SESSION - A Network across the nordic countries with cooperation across research and practice Presentation of Liv Starheim and discussion forum about collaboration and network		
18:00 - 19:30	**Visiting the laboratories at IKDC (aerosol, light, climate, VR) Mingling and a light meal**		

TUESDAY, 22 AUGUST 2017
Location: Ingvar Kamprad Design Center

	ROOM: STORA HÖRSALEN	ROOM: 304	ROOM: 467	ROOM: 567
9:00 - 9:15	**GOOD MORNING AND REFLECTIONS FROM YESTERDAY** *Moderator: Professor Anna-Lisa Osvalder and Associate Professor Mikael Blomé*			
9:15 - 9:45	**KEYNOTE SPEAKER 3.** Andreas Larsson, Associate Professor and Innovation Leader at Blekinge Institute of Technology *Topic: Innovative working environment*			
9:45 - 10:15	**KEYNOTE SPEAKER 4.** Marie-Luise Ribbnäs, Johan Bauer *Topic: Vulnerability - the birthplace of trust, creativity and innovation*			
10:15 - 10:45	**COFFEE BREAK AND EXHIBITION SESSION**			
SESSION 4. **10:45 - 12:25**	*Topic:* Musculoskeletal Health	*Topic:* Methods in Ergonomics	*Topic:* Sustainable working life and sustainable life style	*Topic: Ergonomics Work and Organisation*
	Moderator: Göran M Hägg	*Moderator: Jörgen Frohm*	*Moderator: Martina Berglund*	*Moderator: Cecilia Österman*
10:45	*Marcus Yung, Liana Tennant, Stephan Milosavljevic and Catherine Trask (Univ of Saskatchewan, Canada)* Just shake it off: Is the human body tailored for whole body vibration?	*Roland Örtengren (Chalmers University of Technology, Sweden)* *Full paper:* Exposure and risk quantification for improved relationship assessment in occupational investigations	*Martina Berglund, Ulrika Harlin and Mattias Elg (Linköping University, Sweden)* Full paper: AFoU – a network for sustainable working life and development	*Willy Buchmann (CNAM, France)* *Full paper:* Can ergonomics help companies design sustainable workers careers paths ?
11:05	*Mikael Forsman, Ida-Märta Rhén, Xuelong Fan, Henrik Enqvist, Catarina Nordander and Camilla Dahlqvist (Karolinska Institutet, Sweden)* Physical workload in cleaning work – a comparison between hotel and hospital cleaners	*Amanda Waleh Aström, Marina Heiden, Sven Erik Mathiassen and Annik Strömberg (University of Gävle, Sweden)* Uncertainty in monetary cost estimates for assessing working postures using inclinometry, observation or self-report	*Kerstin Nilsson, Mikael Blome, Jonas Borell and Gerd Johansson (Lund University, Sweden)* Intervention for a sustainable and rewarding extension of working life	*Arja Ala-Laurinaho, Mervi Hasu, Seppo Tuomivaara and Pia Perttula (Finnish Inst for Occupational Health, Finland)* *Full paper:* Investigating digitalization of work processes in a network of organizations: a framework for analysis
11:25	*Triinu Sirge, Jaan Ereline, Tatjana Kums, Helena Gapeyeva and Mati Pääsuke (University of Tartu, Estonia)* Motor function characteristics in supermarket cashiers with and without low back pain	*Lars-Ola Bligård, Eva Simonsen and Cecilia Berlin (Chalmers University of Technology, Sweden)* Full paper: Ergonomics activities in the product development process	*Maria Sol Perez Toralla and Thibaut Heurtebize (Atitlan, France)* *Full paper:* From conflict to operational efficiency: an exploratory study on conflict management.	*Frank Power (Health and Safety Authority, Ireland)* The role of ergonomics in the development of innovative solutions
11:45	*Lars Hansson, Xuelong Fan, Ida-Märta Rhén and Mikael Forsman (Stockholm County Council, Sweden)* Aerobic workload in hospital cleaning work	*Kalev Kuklane (Lund University, Sweden)* Development of a summation method to estimate clothing insulation and thermal comfort based on clothing design – a preliminary analysis	*Martina Berglund, Mattias Elg, Henrik Kock, Malin Tillmar and Andreas Wallo (Linköping University, Sweden)* HELIX Competence Centre – Knowledge for sustainable working life	*Bas van der Doelen Eur.Erg. (SBSeating / Ergogoals, Netherlands)* Sitting and seating: Past, present and future
12:05	*Reijo Koskelo and Marie Jalkanen (Salli Systems, Finland)* Seating pressure distribution for different chair types	*Kristina Eliasson, Gunilla Dahlgren, Charlotte Lewis, Peter Palm, Jens Wahlström, Lotta Löfqvist, Ewa Gustafsson, Catarina Nordander, Magnus Svartengren and Teresia Nyman (Uppsala University, Sweden)* Hand Intensive Work: A proposed methodology for risk assessment, health examination and evaluation		*Rasmus Jørgensen and Kasper Edwards (Technical University of Denmark)* Communities of practices as means to develop creativity at work
12:30 - 13:30	**LUNCH BREAK**			

TUESDAY, 22 AUGUST 2017
Location: Ingvar Kamprad Design Center

	ROOM: STORA HÖRSALEN	ROOM: 304	ROOM: 467	ROOM: 567
SESSION 5. 13:30 - 15:10	*Topic:* Change Management and Evaluation	*Topic:* NES Student Price Presentation	*Topic:* Upcoming technologies and Competitive Digitalisation	*Topic:* Ergonomics Work and Organisation
	Moderator: Ann-Christine Falck	*Moderator: Cecilia Österman*	*Moderator: Gudbjörg Erlingsdottír*	*Moderator: Mikael Blomé*
13:30	*Ann-Christine Falck, Per-Johan Wahlborg, Mikael Rosenqvist and Rikard Söderberg* *(Chalmers University of Technology, Sweden)* *Full paper:* How do manufacturing companies acquire new knowledge? - Examples from nine Swedish companies		*Linda de Vries* *(Chalmers University of Technology, Sweden)* Here be monsters: Addressing some challenges for digitalisation in the maritime domain	*Maria Gink Lövgren and Christer Ahlström* *(Volov Bus Corporation, Sweden)* The effect of Volvo Dynamic Steering on bus drivers work environment
13:50	*Tomas Berns and Björn Nilsson* *(Ergolab, SIS, Sweden)* How to create a human centred organization and why		*Christofer Rydenfält, Johanna Persson, Gudbjörg Erlingsdottír and Gerd Johansson* *(Lund University, Sweden)* E-health as a support for staff in home health care: Where are we today and where are we heading?	*Olle Janzon* *(SSAB Europe, Sweden)* Ergonomic improvement in the handling of briquettes and pellets samples A case study at the experimental hall at SSAB Europe in Luleå
14:10	*Birgitta Wiitavaara and Marina Heiden* *(University of Gävle, Sweden)* Content and quality of questionnaires for assessment of physical functioning in neck disorders - A systematic review of the literature	*Søren Salling Weber* *(Roskilde University, Denmark)* Working life in the platform economy: a case study of the development of a platform for distribution of cleaning work	*Lena Petersson and Gudbjörg Erlingsdottir* *(Lund University, Sweden)* Factors to consider when implementing patient online access to their electronic health record	*Mikael Blomé* *(Lund University, Sweden)* Ergonomics simulation for development and evaluation of working conditions on ships
14:30		*Martin Rydell* *(Jönköping University, Sweden)* Improving the organisational and social work environment - A case study in Swedish construction industry	*Nils Holmberg, Mikael Blomé and Rikard Lundberg* *(Lund University, Sweden)* Improving the digital work environment: Designing new interfaces for product specifications using eye movement measurements	*Eric Wagner* *(Independent Consultant, Sweden)* Task analysis - An integrated model for elicitation, modelling and risk behaviour assessment
14:50		*Heidi Virkkunen* *(Saimaa University of Applied Sciences, Finland)* *Full paper* : Analysis of the physical load on the musculoskeletal system during industrial vacuuming	*David Gillblom* *(Semcon, Sweden)* Introducing MEROEX, a web-based remote meeting tool	
15:10 - 15:30	**COFFEE BREAK AND EXHIBITION SESSION**			
SESSION 6. 15:30 - 16:50	**ROOM: STORA HÖRSALEN**	**ROOM: 304**	**ROOM: 467**	
	Topic: Change Management and Evaluation	*Topic:* Psychosocial Ergonomics	*Topic:* Flexible Workplaces	
	Moderator: Jörgen Eklund	*Moderator: Christofer Rydenfält*	*Moderator: Yujing Li*	
15:30	*Isabel Piraquive-Riveros and David Puente-Lagos* *(National University of Colombia, Colombia)* *Full paper:* Industrial designers' activities and ergonomics application in SMEs - Analysis of the footwear manufacturing companies at neighborhood Restrepo in the city of Bogotá	*Randi Mork, Knut Inge Fostervold, Helle Kristine Falkenberg and Hanne-Mari S. Thorud* *(University College of Southeast Norway)* Computer work and environmental stress	*Susanne Hedin* *(Ergonomhuset AB)* *Full paper:* Introduction of an activity based workplace (ABW) – the effects on health / discomfort and stress / influence using a self-assessment tool	
15:50	*Gerolf Nauwerck* *(Uppsala University, Sweden)* *Full paper:* Assessing the digital work environment: a case study of digital transformation in higher education	*Yi-Yan Chen, Min-Chih Hsieh, Eric Min-Yang Wang, Chien-Jung Lai, Ming-I Lin and Fan-Pei Yang* *(National Tsing Hua University, Taiwan)* *Full paper: A* n investigation on intergenerational communication barriers: the difference in speech communication between elder and younger people	*Linda de Vries and Stig Franzén* *(Chalmers University of Technology, Sweden)* *Full paper:* Living Labs: a forum for enabling co-creation between multi-disciplinary actors in the workplace?	
16:10	*Ann-Christine Falck, Per-Johan Wahlborg, Mikael Rosenqvist and Rikard Söderberg* *(Chalmers University of Technology, Sweden)* Acquisition of new knowledge in Swedish manufacturing companies - How could it be improved?	*Gudbjörg Erlingsdottir, Jonas Borell and Christofer Rydenfält* *(Lund University, Sweden)* Physicians identity and loyalty: Implications for teamwork and the work environment	*Yujing Li, Aneta Wierzbicka, Emilie Stroh and Birgitta Nordquist* *(Malmö University, Sweden)* A holistic approach to healthy indoor environment	
16:30	*Jörgen Eklund* *(KTH, Sweden)* Lean retail - implementations in stores	*Maria Lindholm and Marja Keväjärvi* *(University of Oulu, Finland)* *Full paper:* Informal caregivers' perceptions of their physical load issues and safety		
16:50 - 18:00	**NES member meeting (by invitation)** **Room: 567**			
19:00	**CONFERENCE DINNER** **Location: ÅF (Sandgatan2, 223 50 Lund)**			

WEDNESDAY, 23 AUGUST 2017
Location: Ingvar Kamprad Design Center

	ROOM: STORA HÖRSALEN	ROOM: 304	ROOM: 467	ROOM: 567
9:00 - 9:15	**GOOD MORNING AND REFLECTIONS FROM YESTERDAY** *Moderator: Professor Anna-Lisa Osvalder and Associate Professor Mikael Blomé*			
9:15 - 9:45	**KEYNOTE SPEAKER 5.** Susanne Brannebo, Economist and behavioral scientist Frida Tibblin Citron, Professional communicator and behavioral scientist *Topic: Move slowly to change fast*			
9:45 - 10:15	**KEYNOTE SPEAKER 6.** Mattias Wallergård, Researcher in interaction design, virtual reality and augmented reality *Topic: Virtual Working Environments – Are We Ready for The Blue Pill?*			
10:15 - 10:45	**COFFEE BREAK AND EXHIBITION SESSION**			
SESSION 7. **10:45 - 12:25**	*Topic:* Musculoskeletal Health	*Topic:* Voice ergonomics	*Topic:* Flexible Workplaces	*Topic:* Risk Safety Management
	Moderator: Cecilia Österman	*Moderator: Göran M Hägg*	*Moderator: Calle Rosengren*	*Moderator: Jonas Borell*
10:45	*Marcus Yung, Angelica Lang, Aaron Kociolek, Stephan Milosavljevic and Catherine Trask* *(University of Saskatchewan, Canada)* *The combined multi-system effects of whole body vibration and physical and/or mental work demands*	*Susanna Whitling, Viveka Lyberg-Åhlander and Roland Rydell* *(Lund University, Sweden)* Long-time voice accumulation during work, leisure and a vocal loading task in groups with different levels of functional voice problems	*Maral Babapour and Anna-Lisa Osvalder* *(Chalmers University of Technology, Sweden)* *Full paper:* Use profiles in Activity-based Flexible Offices - A case study	*Radhlinah Aulin, Åsa Ek and Christofer Edling* *(Lund University, Sweden)* *Full paper:* Management practices as enabling factors to promote safe behaviour on construction projects
11:05	*Camilla Dahlqvist, Lothy Granqvist, Charlotta Löfqvist, Henrik Enquist, Catarina Nordander and Mikael Forsman* *(Lund University, Sweden)* Physical workload in hotel housekeeping	*Susanna Whitling, Viveka Lyberg-Åhlander and Roland Rydell* *(Lund University, Sweden)* Recovery from heavy vocal loading in women with different levels of functional voice problems	*Antonio Cobaleda Cordero and Maral Babapour Chafi* *(Chalmers University of Technology, Sweden)* *Full paper:* Discrepancies between intended and actual use in Activity-based Flexible Offices - A literature review	*Akiko Takahashi and Takashi Miura* *(National Institute of Occupational Safety and Health, Japan)* Comparison of subjective risk about occupational accident occurrence for construction workers by age
11:25	*Jihye Kim and Inseok Lee* *(Hankyong National University, South Korea)* Analysis of wrist and elbow motions of Grapes-Harvesting Tasks	**Topic: The organisation makes the difference** **Workshop (11:25 - 12:25)** **Organisers:** Ruth Carlsson, Kersti Lorén and Minke Wersäll (chair), Swedish Work Environment Authority Sweden. **Aim of the workshop:** This workshop aims to increased knowledge about implementation of a gender perspective in work environment management. discuss and explore the importance of a gender perspective in work environment management. **Format of the workshop:** The first part of the workshop will involve a brief presentation of experiences from the projects on Women's work environment. The introduction illustrates why a gender perspective is a necessity for work environment management. The second part of the workshop invites the participants to discuss how to get started and reflect on useful tools in order to go from theory to practise.	*Kari Anne Holte, Kåre Hansen, Lars Lyby and Astrid Solberg* *(Research Institute of Stavanger, Norway)* Autonomy at work, do we need a new understanding?	*Therese Öhrling, Camilla Grane and Carl Jörgen Normark* *(Luleå Univercity of Technology, Sweden)* *Full paper:* Visual communication to improve learning and affect safety culture in mining industry
11:45	*Amitava Halder, Michael Miller, Chuansi Gao and Kalev Kuklane* *(Lund University, Sweden)* Dynamic work induced muscle activity rate change (MARC) and fatigue evaluation in muscle activity interpretation squares (MAIS)			*Yung Hsin Cheng and Eric Min-Yang Wang* *(National Tsing Hua University, Taiwan)* *Full paper:* Age and gender influences on pedestrians' situation awareness
12:05	*Mamunur Rashid, Marja-Leena Kristofferzon, Marina Heiden, Annika Nilsson* *(University of Gävle, Sweden)* Predictors of work ability among women on long-term sick leave due to musculoskeletal pain			
12:30 - 13:30	**LUNCH BREAK**			
13:30 - 14:30	**ROOM: STORA HÖRSALEN**			
	CLOSING SESSION: **CONFERENCE REFLECTIONS** Professor Anna-Lisa Osvalder and Associate Professor Mikael Blomé Jane Ahlin (Chair EHSS Board) and Kasper Edwards (Chair NES Board)			
	NES2018 - ENTREPRENEURSHIP IN ERGONOMICS AND HUMAN FACTORS Oddrun Lilja Birgisdóttir (NES Board Member)			

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PART I

BOOK OF ABSTRACTS

Investigating digitalization of work processes in a network of organizations: a framework for analysis

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Digitalization and advanced information technology offer new, innovative possibilities to organize work in networks, and include previously excluded stakeholders and personnel groups to participate also in the development of work processes. In this research project we aim to analyse and evaluate the actual changes in work processes and organizational structures when taking into use new, second generation ERP (Enterprise Research Planning) systems in a network of organizations. By ERP we mean different kind of IT systems that both managers, employees and other actors (e.g. suppliers) use to plan, control and manage processes and work in the network. The changes and consequences are evaluated from the aspects of well-being at work (meaningfulness, workload), occupational safety (resilience, accident risks), innovativeness, and productivity (company-specific measures for productivity of work). The research is conducted in two different branches, forestry and accounting, during 2017-19.

The theoretical frame is based on activity theory, and takes the human being as an actor in the intentional, object oriented work activity a starting point. The ideas of employee-driven innovation further emphasize the active role of all stakeholders in the change and development processes. The changes of work and organizing are investigated using the model of activity system and the concept of service/production logic as analytical tools. These offer a systemic view on the changing work, and highlight the emerging nature and intertwined development of IT systems, work, processes and organizing (i.e. structures). The methods include interviews, observations and workshops for collective interpretation and development.

In this presentation, we discuss the operationalization of these theoretical frames and measures, and give examples of their application in the case organizations. We also present results of the expectations and fears concerning work changes when starting the implementation of the re-newed ERP-systems, and compare them across the two different branches.

Keywords. Digitalization, IT systems, ERP, activity theory, activity system, service/production logic, work process, change, employee-driven innovation

Digitization of Technical Information for Fighter Aircraft Maintenance

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The work environment for fighter aircraft maintenance was studied, with focus on the digitization of a Line Maintenance Checklist (LMC). It contains various procedures used when an aircraft is cleared for take-off and landing. In order for flight technicians to access the instructions when working with an aircraft, the PDF documents from a publication package are printed and placed in plastic sleeves in binders. Due to updates, the font in the binder decreases, consequently decreasing the readability. Also, the PDF files that make up the publication packages are interconnected by hyperlinks, but this functionality is not transferred to the printed version. Previous research suggests that digitizing the LMC would be a viable solution. This study aimed at extracting and describing requirements for a potential future digitization of the LMC. To gain an understanding of the requirements on both a future digital LMC and the current LMC, several methods were used.
Methods used included observations and interviews of users working with the LMC. The process manager was interviewed and subsequently interview questions for the flight technicians were created. Also, a persona and four scenarios were created, as well as a prototype evaluated with five participants. The prototype was evaluated at the flight test department and at the delivery and modification hangar with experienced flight technicians and technical support personnel.

It was found through observation that the daily use of LMC was limited. Since the technicians are experts in their field and work with the same type of aircraft over a long period of time, they do not always need the memory support that the LMC provides to the same extent. The results also revealed requirements on the hardware of the digital LMC, including the ability to be charged at all times, being sturdy, being able to work with it in different light conditions, not being too heavy and not being too big to fit in the leg pocket. For instance, interview reviled that the LMC should be able to handle various weather conditions like heavy rain or bright sunlight. Non-physical requirements found include the need for memory support, and that a digital LMC should be compatible with the current LMC. Also, further support on the line potentially available by new technology was found, such as aid for searching information, such as the ability to search for key terms and fault codes, but also access to pictures.

To conclude, the study was successful in extracting and describing requirements for a digital LMC. Practical implications of this include guidance for future

implementation of a digital LMC, with the potential of increased work efficiency and work satisfaction through increased usability. However, further studies have to be conducted to further understand specific hardware aspects, broader interaction aspects as well as organizational aspects that were only briefly examined in this study.

Keywords. Digitization; Maintenance; Fighter Aircraft, Observations; Interviews

Management practices as enabling factors to promote safe behaviour on construction projects

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Research is concluding that the majority of all construction accidents and injuries can be attributed to unsafe work practices rather than unsafe conditions. Underlying causes of unsafe acts have been found to be *organisational factors* (i.e. role overload, productivity before safety, socialisation influences, safety attitudes and perceived risks), *image* (i.e. macho or tough person syndrome and competence) and *avoiding negative consequences* (i.e. fear of losing a good position and teasing and harassment from co-workers). One initiative to reduce unsafe acts is to probe management commitment as a contributing factor to the underlying causes of workplace accidents. According to the Work Environment Act 1977, management has a major responsibility for systematically planning, directing and controlling work activity to ensure the success of safety behaviour on construction sites. The aim of the study reported in this abstract was to gain a better understanding of management practices that included examining both sides of the motivational continuum (constructs that encourage and constructs that discourage safety participation among workers).

A qualitative method using semi-structured interviews was adopted to capture the views of seven construction managers/safety coordinators. The interviews contained twelve questions and included subjects such as routines for safety concerning own workers, apprentices and sub-contractors, found dilemmas to prioritise safety over time and budget, reward and punishment system, and support from the main organisation for safety at work.

In general, every construction project had a good policy and regulations in place to encourage safe behaviour. All the projects received positive support from upper management which in turn created a good safety climate. However, there were a few projects that were poor in implementing the safety efforts and faced challenges from the workers. The interviewees pointed out suggestions to improve the work environment where most importantly: safety must be planned, coordination with all actors on site is vital, risk analysis must be performed before the work is to be carried out and lastly listen to all personnel and get them involved in all safety efforts and planning.

The outcome from this study will be a contribution to knowledge that will assist in understanding managements effort to engange construction workers in safe and discourage unsafe behaviour. Furthermore, an important outcome is also to influence

the safety culture of the entire construction industry and motivate workers to accept safety as a primary personal core value, creating a mentality that no level of injury is acceptable.

Keywords. Management practices, construction, unsafe behaviour, safety culture.

Use profiles in Activity-based Flexible Offices – A case study

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Activity-based flexible offices (AFOs) are non-territorial office environments in which different work zones are available for the users to choose from based on their on-going work activities or preferences. Moving to a non-territorial office requires the users to adopt new work routines in order to switch workstations depending on on-going activities and conform to a desk-sharing policy. The aim of this paper is to investigate whether the users in an Activity-based flexible office (A-FO) follow the intended desk-sharing policy, and further explore if any use profiles and patterns emerge regarding workstation choices and preferences.

A survey was developed for data collection at a case organisation in Sweden that had relocated to an AFO in 2016. The survey was sent electronically six months after relocation to all the 66 employees who had been relocated. The survey addressed several aspects regarding respondents' work conditions, nature of work activities, knowledge transfer and use profiles. This paper only concerns aspects regarding the respondents' use profiles: switching behaviour, most frequently used work zones, motivations behind the choices of work zones and compliance with clean-desk policies. A total of 46 respondents had completed the questions regarding use profiles.

The majority of the users complied with the desk-sharing policy and refrained from claiming workstations both explicitly (i.e. they did not leave their belongings on workstations), and implicitly (i.e. they avoided nesting and switched workstations on a daily basis). Two patterns were identified that describe respondents' choices of workstations: (i) those mostly using zones intended for solitary work, and (ii) those mostly using zones intended for collaborative or mixed work. Furthermore, the respondents were divided into three groups, i.e. those who did not mention quiet zones in their most frequent choices, those who mentioned it once, and those who mentioned it twice or more. Motives for switching workstations and workstation choices were categorized as: (i) temporal motives, i.e. duration of use depending in the work tasks at hand, (ii) work requirements, i.e. booked meetings and phone calls, (iii) level of concentration, (iv) physical interactions, e.g. access to height adjustable furniture, availability of screens or other tools, (v) social motives, e.g. exchanging information, working side-by-side, and (vi) ambience and likings, i.e. lively or serene atmosphere.

To conclude, several aspects were identified that can be used to distinguish different use profiles in an A-FO e.g. switching behaviours and choices of workstations, temporal aspects, work requirements, and preferences. These findings highlight that the A-FO solution matched the needs, preferences and activities of the respondents, and was used as intended and conceived during the implementation process.

Keywords. Activity-based workplaces (ABW), desk-sharing policy, non-territorial office, office design, use profiles, use patterns, survey

Working in an Activity-based Flexible Office – consequences for work conditions among employees with different activity patterns

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Allowing for increased mobility, developments in the IT industry and mobile technologies have provided organisations with opportunities to adapt new ways of working and reconfigure workspaces into Activity-based Flexible Offices (A-FOs). This office type is comprised of a variety of open, half-open and enclosed activity-related workspaces without assigned workstations. Employees in A-FOs are allowed to choose a workstation that fits their activities and preferences during a workday. Studies evaluating A-FOs present conflicting results regarding employees' satisfaction with their workspaces. Theories on office work conditions highlight that office concepts may impact job demands (e.g. cognitive workload and working hours) and job resources (e.g. communication, privacy, autonomy, and interpersonal work relations). Furthermore, task-related aspects of work are considered to moderate A-FOs' impacts on work conditions. However, little is known regarding specific task-related aspects that can moderate office environments' impact on employees' work conditions.

The aim of this paper is twofold: (i) to identify activity patterns of employees in an A-FO, and (ii) to explore if the identified activity patterns can moderate the impacts of AFOs on employees' work conditions.

A survey was developed for data collection at a case organisation in Sweden that had relocated to an AFO in 2016. The survey was sent electronically six months after relocation to all the 66 employees who had been relocated. The survey addressed several aspects regarding respondents' work conditions, nature of work activities, knowledge transfer and use patterns. This paper concerns aspects regarding work conditions and activity patterns, i.e. frequency of solitary work (both concentrative and non-concentrative) and group work (both concentrative and non-concentrative). A total of 38 respondents had completed the questions regarding activity patterns and work conditions.

The respondents were grouped based on their activity patterns, i.e. those with: (i) highly solitary work, (ii) mixed solitary and collaborative work, (iii) highly collaborative work, (v) highly concentrative work, and (vi) medium to low level of concentrative work.

A majority of the respondents (76%) were satisfied or highly satisfied with the AFO, while 24% were somewhat or neither/nor satisfied. The latter group had activity

patterns that involved (i) highly solitary and concentrative work, or (ii) mixed solitary/group and concentrative work. These respondents were dissatisfied with work conditions items such as privacy, autonomy, presence of audial and visual distractions, as well as mental workload and working hour demands.

To conclude, respondents with activity patterns that include solitary and concentrative work were more dissatisfied with the AFO solution, and their work conditions. Attention therefore should be paid for designing work zones and spaces that support these types of activities better.

Keywords. Activity patterns, Work conditions, Activity-based Flexible Office, Workspace design

AFoU – a network for sustainable working life and development

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Working life is quickly changing along with changing market and societal demands, increasing globalization as well as technical development. To stay competitive, it is important for organizations to build their operations on competent, healthy, and highly involved personnel. Although the changes in working life constitutes a risk of impaired working conditions for many employees, the need for competence also implies a possibility to create good working conditions with interesting and for the employees developing jobs. To achieve these future workplaces, there is a need to take several stakeholders' perspectives into account. The aim of this paper is to describe and reflect on the development of the Swedish network AFoU and its strive to contribute to increased competitiveness and quality through good working conditions.

AFoU stands for "Workplace related R&D for sustainable working life" (in Swedish Arbetsplatsnära FoU för hållbart arbetsliv). The overall goal with the network AFoU is to contribute to sustainable working life, research that makes significant improvements, and future organizations characterized by competitiveness, quality and renewal through good working conditions. AFoU is an open network consisting of researchers from different disciplines, practitioners and representatives for unions and employer organizations. The latter participate in a reference group appointed by the main organizations of labour parties in Sweden (LO, Svenskt Näringsliv, Sveriges Kommuner och Landsting, Saco, TCO and Arbetsgivarverket) that identifies needs and makes prioritizations. There is also a steering group that plans and develops activities based on the reference group's priorities. Both groups meet five to six times per year, and each time one organization acts as a host and presents some of its own work within the field. In addition, there are collaboration groups within the network that focus on specific topics and activities.

The AFoU network was established in 2015. The number of members increase continuously, and it now has about 120 members from more than 30 organizations. One aim is to reach a balance with representatives from different sectors, people working in private companies and public organizations, union representatives and researchers. So far, AFoU has resulted in new cross-collaboration between research fields and sectors through different activities, such as dialogue seminars and workshops with different topics, e.g. digitalization and diversity in working life, as well as collaboration between individual researchers and research projects. One initiative to create synergy effects is to collaborate in new ways between projects. This network-collaboration model is applied within the theme of "Smart improvement work", where four research projects have identified potential advantages of

collaborating with each other and organized a first joint workshop to learn from each other as well as initiate new common activities and knowledge gaps for further research.

AFoU is a network for workplace development striving to combine high-quality research with practical use. This is achieved through collaboration between different stakeholders and across disciplines, thereby co-creating new knowledge that is needed to meet current and future demands.

Keywords. Workplace-related R&D, competitiveness, quality, innovation, co-production, knowledge.

HELIX Competence Centre – Knowledge for Sustainable Working Life

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Working life is affected by challenges such as globalization, digitalization and changing demographics. There is a strong demand to increase productivity, while at the same time ensure employee health, support diversity and facilitate learning. The purpose of this paper is to describe HELIX Competence Centre at Linköping University and its work to contribute to sustainable working life. HELIX Competence Centre is a research centre financed by the Swedish Agency for Innovation Systems VINNOVA.

Research in HELIX Competence Centre is based on an interactive approach between researchers from different disciplines and partner organizations. The disciplines represented are behavioral sciences, management, business and public administration, entrepreneurship and innovation, as well as health and work sciences with researchers from Linköping University, KTH Royal Institute of Technology and Swerea IVF. The partner organizations include private firms, public organizations, labor organizations, and civil society organizations. Problems and issues to address within the interactive research are identified in dialogue between the researchers and the partner organizations.

HELIX Competence Centre was started in 2017 and is granted funds for five years. It has a background in and is a further development of the earlier HELIX VINN Excellence Centre which was active for ten years at Linköping University. The research programme that has been developed includes four research themes: 1) Sustainable development processes in industrial production systems; 2) Growth and development in small enterprises; 3) Sustainable, innovative, and coordinated health and welfare processes; and 4) Inclusive workplaces. Several interactive research projects have started and others are in their initial stages. Examples of ongoing projects are leadership for development and learning, organizing for diversity, and science parks as intermediaries for regional development. Other initial activities include seminars and partnership meetings with different topics and a yearly HELIX day.

The research and activities led by HELIX Competence Centre constitute an approach to integrate social and economic sustainability, produce scientific knowledge and add value to practice in the partner organizations.

Keywords. Interactive research, multidisciplinary, partnership approach, organizational development.

How to create a human centred organization and why

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Human well-being is now recognized by the G7 (the world's seven biggest economies) as an important economic measure to complement traditional measures of national output. Organizations are being judged not only on their return on the investment of their owners, but also on much broader issues such as how well they fulfil their responsibility to the society and the impact they have on the environment in both the short and long term. In those areas, organizations often turn to high level standards.

In the fall of 2016, ISO published the International Standard ***ISO 27500 The human-centred organization Rationale and general principles***, which explains to executive board members the values and beliefs that make an organization human-centred, the significant business and operational benefits that arise, and the policies they need to put in place to achieve this.

This standard (ISO 27500), in contrast, draws on that extensive body of ergonomics and human factors knowledge and presents the rationale and general principles of *human-centredness* in a concise form for executive board members. It explains the seven principles which characterize a human-centred organization. These principles are the following:

— capitalize on individual differences as an organizational strength;
— make usability and accessibility strategic business objectives;
— adopt a total system approach;
— ensure health, safety, and well-being are business priorities;
— value employees and create a meaningful work environment;
— be open and trustworthy;
— act in socially responsible ways.

In design processes, the term user-centred is often used to reflect that the design of the product, system, or service takes account of human characteristics both to minimize risks and to optimize well-being and performance. The term *human-centred* is used to reflect that organizations not only have an impact on their customers (the users of their products and services), but also on their employees, their families and the wider community.

The standard is intended to be useful to all types of organizations (whether large or small) in the private, public, and non-profit sectors. While not all parts of this International Standard will be of equal use to all types of organizations, the principles are relevant to every organization. It is not intended to replace, alter, or in any way, change the obligations of the state.

Keywords. Standard, human centered, human factors, usability, accessibility, meaningful work environment

Ergonomics activities in the product development process

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Ergonomics and human factors (E/HF) has an important role throughout the whole product development process, but the scope and content of E/HF work differs depending on the phase of the project. The aim of this paper is to describe ergonomics activities in the product development process, with special focus on the purpose of ergonomics activities in different parts of the process. As a base for the description the ACD³-framework is used. ACD³ divides the process into five distinct phases: Need finding, Design of use, Overall design, Detailed design and Structural design. During the course of each phase, E/HF work shifts focus from investigation to evaluation via designing.

The first phase, Needfinding, focuses on understanding the problem, describing the needs and designing the desired effects. The main task for E/HF is here to identify requirements from the users and the use situation, study how the environment affects the future product and how the product should affect its environment. Furthermore, ergonomics supports the development project by evaluating existing products.

The second phase, the Design of use, concerns how the product will be used to achieve the effects. The main task for E/HF here is to design the tasks that the user performs when using the product and to define requirements based on the intended use.

The third phase, the Overall design, deals with the product's technical architecture, which enables the intended use. The main task for E/HF here is to support in the design of concepts for the physical shape and user interface for the product, as well as supporting the formulation of detailed design requirements.

The fourth phase, Detailed design, focuses on finalising the design of the product's interface and physical shape. The main task for E/HF here is to support the finalization of the design and to support the design of manuals and instructions.

The fifth phase, Structural design, deals with the design of the product's internal structure and function. The main task for E/HF here is to support the project in testing prototypes appropriately to ensure correct design and functionality.

Even though the process is described in distinct phases, the work is often performed iteratively and in parallel. This means that the activities in several phases can be done in parallel and are iterated both within and between the phases. In these iterations, E/HF has a crucial role, in evaluating the design based on the user and the use.

As the purpose of E/HF activities varies throughout the development process, so do the demands of E/HF knowledge and competence to meet these demands. The E/HF knowledge and methods needed in the beginning of a product development process

are not the same as what is required at the end. Furthermore, in order to be useful and have a real impact on the outcome of the development project, E/HF work needs to be integrated with the technical development process. Thus, E/HF professionals must foster a strong collaboration with other roles and professionals involved in the product development process.

Keywords. Ergonomics, Human Factors, Product Development Process

Ergonomics simulation for development and evaluation of working conditions on ships

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In the maritime industry, international research on simulation tools and digital modelling are on the march. This collaborative project, Financed by AFA Insurance, was given a unique opportunity to take advantage of technological advances in the automotive industry and, based on the complicated conditions in the maritime industry to develop a long-term cross-industry tool for ergonomic simulation. A research team was established with broad expertise in ergonomic conditions in the workplace. The project has followed the principles of participatory ergonomics and user-centred design thus included the identification and modelling of critical working conditions on board vessels, adaptation and evaluation with the support of the ergonomic simulation tool IMMA, usability evaluation specialists in ship design and ergonomics as well as professionals and students of seafaring. The project was carried out in three structural parts: *1. An ergonomics simulation tool* (IMMA Marine) adapted for the maritime industry. Field studies were conducted with the help of supervised students. The students documented the working conditions on board ships through observations and interviews with representative parts of the staff. The results of the field studies were analysed with the support of the research team and summarized in the students' thesis and a conference paper. *2. Course Package* in ergonomics simulation for aspiring marine engineers and naval architects. The course package consisted of a first version of an e-book, based on a previous project and now further developed. *3. Method and dissemination strategy* of simulation tools for the design of good ergonomics in the maritime industry and new industries.

The project has resulted in a further development of the ergonomic simulation tool IMMA with customizations to the working environment on ships, IMMA Marine. In the current version, the tool works well in certain selected situations, and acceptably in some situations with manual adjustments.

In order to establish IMMA marine in the maritime industry, a more flexible manikin is needed for more efficient use. It is also necessary with a responsive proactive organization with access to information and the ability to influence the production process of ships e.g. blueprints of workstations for making ergonomic assessments before the actual ship is built. The possibilities with ergonomics simulation have been highlighted by the project in teaching, research and industry linked to shipping. The research team believes that the project approach also can be used to disseminate knowledge about ergonomics simulation to new sectors for the benefit of well-designed workstations.

Keywords. e-book, maritime industry, simulation, workstations

Safety management at radiation research facilities with visiting users - MAX IV Laboratory and ESS

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Two major material science research facilities are being established in Lund, Sweden – the MAX IV Facility and the European Spallation Source (ESS). Using radiation as means to analyse very small-scale structures, both facilities will host a large number of guest users every year, i.e. international research scientists will visit and perform experiments. The work environment the guest users will meet is mainly the so-called experimental hutches in connection with the beamlines/instruments. In order to yield high safety for guest users and facility personnel the physical environment, working conditions and safety routines at the facilities and the experimental hutches need to be well designed. Having many temporary international users visiting a safety critical activity can challenge safety performance and safety culture. Currently, a knowledge gap exist concerning the design of health and safety management in organisations operating under such conditions. Therefore, the aim of the pilot study presented in this abstract was to identify challenges concerning the physical design and the safety management organisation in order for the two facilities to be better suited and minimizing the risks for personnel and guest users.

Data was collected at the two facilities through exploratory interviews and on-site visits (ESS: head office), supplemented by written documentation. As a reference object, on-site visits and interviews were also conducted at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. A total of 11 interviews were conducted and included questions on safety management, design processes, physical design, safety culture, safety organisation, qualifications and training. Data were sorted and interpreted by using established theories and models from safety science, human factors, and human-machine interaction.

Pilot study results showed that during facility construction, processes for coordination were vital for the design of beamlines/instruments and for the development of a common safety vocabulary and tools, as well as the strive for standardized safety solutions. Often a technical view on safety was applied, highlighting the need for taking a wider socio-technical view on safety. Radiation safety was highly prioritized in the construction design. However, by taking also other risk hazards related to user groups into account, risk and safety management could be improved. During operation, having a beamline manager at every beamline was considered vital for beamline/experimental hutch safety, and operational and safety aspects would benefit from a 24/7 presence of local operators. As the research

experiments can be time consuming and lead to long working days and fatigue, guest users need to bring an adequate number of members of their research group to the facility in order to prevent individual fatigue as this can constitute a risk factor. Involving all staff in safety work is necessary for creating and maintaining a good safety culture at the facilities.

In conclusion, the studied research facilities have unique safety conditions due to the combination of physical hazards present and short-term visiting users. The safety challenges identified in the study must be reflected in the safety management system as well as in safety practice and safety-measures need to have both a technical and organisational focus.

Keywords. Radiation, MAX IV, ESS, Research labs, Work environment

Application of inertial measurement units to study low back kinematics of beer keg handling

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Small breweries in the U.S surged from 1,500 to 5,000 businesses between 2006 and 2016. Many of the breweries are small and lack resources for materials handling equipment. These limitations cause much work to be done manually. Keg lifting is a common task in breweries. One risk factor associated with low back pain is occupational lifting. The World Health Organization estimates that 37% of all back pain is occupationally related. Indirect costs associated with occupational low back pain are estimated to exceed 100 billion U.S dollars. Measuring worker motions may help with job design to reduce risk factors associated with lifting. Kinematics (displacement, velocity, and acceleration) are variables used to measure worker motion. Low back kinematics have been historically evaluated using observation techniques and bulky devices which are oftentimes most practical in a lab. The technological development of wireless inertial measurement units (IMUs) for human motion provides detailed information related to whole body kinematics, including the low back. These small, wireless, self-contained instruments make studying work environment kinematics more convenient and accessible. Kinematic data can be used to determine baseline movements and aid in job redesign.

The researchers assessed low back kinematics of workers at a Colorado brewery. Workers were suited with 17 IMUs. Data was recorded while workers lifted empty kegs from a pallet onto a conveyor belt for cleaning and filling. Kinematic variables related to the trunk in the frontal, sagittal, and transverse planes were of interest for the present study. A real-time model of each worker was developed from anthropometric measurements, data generated during recordings, and sensor fusion algorithms. Kinematic variables were compared between different lift origin heights.

Analysis of kinematic data revealed that maximum trunk displacement in the sagittal and frontal planes was greatest during lifts with lowest height origin. Axial rotation showed no significant differences between lift origin heights. During one hour of keg lifting, the worker's trunk sagittal posture exceeded 45 degrees 20% of the time.

Information on kinematics during keg lifting may assist in improved design of keg handling. Work surface adjustments can reduce the maximum worker movements in the frontal sagittal, and transverse planes. Kinematic data can be used to determine levels of occupational risk associated with low back injury and quantify effectiveness of job design interventions.

Multiple IMUs and a biomechanical model allowed researchers to collect kinematic data in a small brewery. We can use IMUs to measure worker low back motion during manual materials handling of kegs. In the present study, postures and movements required to lift kegs were characterized. Data collected from experienced workers provided researchers with information directly applicable to keg handling in small breweries. Low back kinematic data established a baseline assessment and can be used to assess workplace design intervention effectiveness.

To the authors' knowledge, this is the first study to assess low back kinematic demands during manual materials handling of kegs in a brewery.

Keywords. Inertial measurement units, occupational low back pain, brewery

Virtual test persons based on diverse anthropometric data for ergonomics simulations and analysis

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In a design process, good ergonomics is achieved when the capabilities of humans match the demands made by the product, workplace or system. Digital human modelling (DHM) tools enable simulations and analyses of ergonomics in virtual environments, particularly at early design stages when the product and workstations often only exist in a virtual format. Restrictions in the physical interaction between humans and systems can often be connected to body dimensions of the users. Several methods have been developed for the consideration of body size related anthropometric diversity in design. The most frequent referenced and used method is the boundary case method in where cases are defined as points located towards the edges of a population distribution.

However, the human-machine interaction is not only affected by the size and proportions of a user but also other physical user characteristics, e.g. muscle strength and joint range of motion (ROM). Due to the low correlation between and in-between different groups of variables, especially for ROM variables, the boundary case method has shown to have limited use when applied on data of body size, strength and ROM. Instead, cluster analysis have shown to be an appropriate alternative as it enables the generation of distributed test cases with different body size, strength and ROM, and indeed also other capability measures when data is available. This paper describes a study where diversity in body size, strength and ROM, is included in the process of generating data for a group of test cases for the digital human modelling tool IPS IMMA.

First, data on ROM, age, gender, stature and weight were extracted for adult individuals from a U.S. database. Based on this individual data, strength data where predicted and synthesized for each individual using previously published regression equations with gender, age and weight as predictive variables. Swedish anthropometric data was then used to predict and synthesize additional body size data necessary for generating digital manikins in IPS IMMA. The synthesised data was then used in cluster analysis that was set to give six unique distributed cases. The resulting virtual test persons were visualised and two were used as digital manikins in a dynamic simulation in IPS IMMA.

The results show that the cluster technique is able to produce distributed cases of different age, gender, body size, ROM and strength. The generated data is not

representative for any real population but is useful in this study to show the applicability of the methodology. When used in simulations the digital manikins shows difference in movements and joint torque actuations where a shorter and not so strong manikin is forced to use more of its strength. These, more detailed, digital manikins can be seen as a foundation for virtual personas with enhanced ability to represent the variability of the targeted population and in turn produce more realistic and accurate simulations and evaluations when using DHM tools for the design of products and workplaces.

Keywords: Virtual, test persons, diversity, Digital Human Modelling, strength, range of motion, cluster analysis.

Can ergonomics help companies design sustainable workers careers paths ?

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The management of a company specialized in the production of composite parts for the aeronautics industry encountered increasing difficulties to durably reclassify the workers most affected by Work Related Musculoskeletal Disorders (WRMSD). This observation resulted in two research questions :
- To what extent were the career paths of workers with WRMSD unsustainable?
- To what extent ergonomics could help to build sustainable career paths, especially for workers with WRMSD?

Approach and methodology

To take account of the WRMSD prevention complexity, some researches encourage medium and long-term temporal approaches to integrate the fluctuating nature of MSDs.

In this perspective, we looked for all the operators of the factory reclassified between 2004 and 2012 because of WRMSD (n=9). In collaboration with the factory occupational physician, we extracted from the medical records of these operators some data concerning joint pains and job changes. These data have been synthesized in time charts.

Results

We particularly pay attention here to several results from the data analysis :

- *Multiple pain alerts* (4<n<10) indicated by operators or physician before the initiations of a reclassification
- *Reclassifications affect elders, but also young people* : four operators aged 49 to 52 years, with considerable length of service (15 to 33 years); but also four younger (24 to 35 years) with significant seniority (5 to 13 years).
- *A reclassification is rarely final* : for each operator, we recorded between 3 and 6 assignment changes over the period considered.
- *Assignment changes are not all linked to joint pains*, and do not always integrate their existence : among the assignment changes, some aim at allowing operator to shelter from constraints that he can no longer stand, but others respond to production needs that may not permit to treat the WRMSD.

Discussion : designing sustainable professional careers, a complex compromise

A sustainable reclassification path integrate, at minimum :

- An operator with old, persistent and long-lasting WRMSD,
- The availability of a job compatible with the physical limitations and the skills of the operator,
- Production requirements at the job envisaged,
- The recruitment and training of an operator replacing the operator touched by WRMSD and leaving the job

Conclusion

The presentation of these results in the company initiated a reflection about the construction of career paths, in order to anticipate the WRMSD. Thus, we believe that ergonomics can accompany company executives in the construction of a sustainable working life :

- by showing the links between work, activity, health and skills,
- by reconstituting and mobilizing the "memory" of the company, with the aim of drawing on its experience to prepare its future.

Keywords. Sustainable career path, Time charts, Company memory, Musculoskeletal disorders

The organisation makes the difference

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Background and purpose: The Swedish Work Environment Authority has been commissioned by the Swedish government to work with women´s work environment 2011-2016. A workshop will be provided to take lessons learnt into practise. The objective is to share knowledge of and experiences from working conditions and health of women from different perspectives of relevance to inequality, such as organisational structures, physical workload and social factors. Results and conclusions will be resumed; management and implementation of new knowledge will be described.
Method: Five areas have been covered by the project:

- State of knowledge - reviews were published focusing on the following questions: what does gender mean for the work environment? Why have women more ill-health, caused by physical as well as organisational and social factors, than men?
- Communication - seminars and conferences were organised, information material produced.
- Education - inspectors increased their knowledge about the impact of organisational and social factors, ergonomics and gender issues.
- Inspection - support to perform planned inspections with a gender perspective.
- Evaluation - of internal and external results of the program 2011- 2014

Results: Factors explaining why more women than men suffer from occupational diseases:

- gender patterns in working life are the same as in society: women´s work is valued less
- the systematic work environment management needs a gender perspective
- the labour market is gender segregated and differences in work tasks contribute to women being at greater risk to suffer from musculoskeletal disorders as well as ill-health due to mental strain.

Discussion: The importance of the organisation taking into account what gender means for management of health and safety is stressed as well as the need to focus on social factors. Scientific support needs to be developed by building bridges between gender and work life science as well as occuaptional health services.
Conclusions: A learning organisation has to visualise, compare and reflect in order to take effective preventive measures for a sustainable work environment. A gender perspective is a necessity in work environment management.

Keywords. Gender perspective, work environment management, sustainability

An Investigation on Intergenerational Communication Barriers: the Difference in Speech Communication between Elder and Younger People

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Communication is an interactive process of transmitting messages among people through verbal or nonverbal ways. It plays an important role in both daily life and workplace. Moreover, population aging has been a global trend, and Taiwan has also been an aging society since 1993. Therefore, issues related to elderly are becoming important. However, previous studies related to elderly communication mainly focused on issues discussing healthcare and doctor-patient communication, fewer studies investigate intergenerational communication regarding the elderly. This study expects to put focus on the daily speech communication between elder and younger people to investigate the communication barriers and the causes between different generations.

The study integrated both qualitative and quantitative methods to collect data through questionnaires and interviews, and then analyzed and generalized the communication barriers and the causes between elder and younger people. The results showed that communicators' generation had significant influence on their perceptions of communication appropriateness and satisfaction between self and others. Young generation tended to thought others performed better then self no matter which generation the target communicators were. This might due to some characteristics in Chinese culture, like humbleness, respects, and lack of self-confidence. Besides, there were eleven factors that might result in communication barriers being extracted from interviews. Different generation perceived different situation as causes of barriers. Barriers from young perspectives were: paying respect to elders so that forcing themselves to enjoy the communication, and elders always being too talkative and holding on their own views. While the elders thought the main barriers between two generations were their difference in knowledge and opinions, and the young also holding on their own views. Other interesting finding was that young people thought

being a listener show their respects to elders, while elders regarded that youngers being too silent as one of barriers between them.

This study found some barriers and different perspectives between young and elder generations but had yet to provide solutions. Future research can further investigate the strategies to minimize the intergenerational communication barriers, and enhance conversational quality and satisfaction.

Keywords. Communication, Communication Competence, Communication Perception, Intergenerational Communication, Communication barriers

Age and Gender Influences on Pedestrians' Situation Awareness

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Nearly seventy percent of pedestrians who were killed in traffic accidents in Taiwan in 2013 are elder people according to the statistics by National Police Agency. It is suspected that poor situation awareness (SA) might be one of the causes that lead to the tragedy. The main purpose of this research is to investigate the age and gender influences on levels of SA between elder and younger pedestrian groups. Thirty elder and thirty younger participants with identical gender ratio attended the experiment. Situational Awareness Global Assessment Technique (SAGAT) was used to measure their objective SA while Situation Awareness Rating Technique (SART) is applied to evaluate subjective SA. According to the results of ANOVA, we detect neither gender nor age influence on SART, whereas both gender and age effects are significant on SAGAT task. In terms of age influence, male subjects have better performance than the other on SAGAT task, but their SART scores are similar with females. It seems that different SAGAT performance might related to driving/riding experience. With regard to age influence, elder participants have similar scores with younger ones on SART questionnaire, while they perform worse than younger group on SAGAT task. We speculate elderly might not be fully aware of their declined abilities, or they think these deteriorations would not threaten their safety. So they get similar scores with younger people on SART questionnaire. Nonetheless, their worse performance of SAGAT task indicates the influences of these declined abilities. We conclude that the discrepancy between subjective and objective SA is the reason of elder pedestrians' vulnerability, and driving/riding experience could somehow enhance SA. Based on the conclusion, we could improve elder pedestrians' safety by reducing the differences between their subjective and objective SA. Additionally, drivers play crucial roles in traffic accidents as well as pedestrians. The future study could further compare the SA between drivers and pedestrians. With this, we could address the problem of elder pedestrians' vulnerability much well.

Keywords. Pedestrian safety, Situation Awareness, Situational Awareness Global Assessment Technique (SAGAT), Situation Awareness Rating Technique (SART)

Discrepancies between intended and actual use in Activity-based Flexible Offices - A literature review

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Background and purpose. Activity-based Flexible Offices (A-FOs) became a popular trend along the last two decades. However, little is still known about their genuine effectiveness in supporting office users work life. The purpose of this paper is to provide an overview of the literature addressing A-FO case studies, focusing on employees' use patterns of the workspaces and their work conditions, in order to make visible the gap between the A-FO concept and its implementation.

Design/methodology/approach. Two databases -Scopus and Web of Science- were used for searching and selecting relevant material. A list of 38 keywords combinations for searching was used in the first stage. A total of 30 papers were finally identified after screening and filtering a list of 81.

Results. Among the reviewed studies in the literature, two main areas were identified: office use patterns and work conditions while using the office. Regarding use patterns, a majority of A-FO users did not switch workstation frequently or not at all, while a minority did so. The main arguments of people who did not use the A-FOs as intended were proximity to specific colleagues and units, the need to move stuff, the time waste to switch workstation and personal preferences. A significant proportion of users also denoted territorial behaviour through the personalization of a workspace, permanent marking with artefacts or recurrent use of the same workstation/s. Regarding work conditions in AFOs, the results were quite variable but, in general, communication possibilities, layout and architecture are the aspects that office users find more supportive. Conversely, the lack of concentration, storage and privacy are the main pending cases. Reported case-specific circumstances seem to have stronger influence on the variability of results, than the office concept itself.

Conclusions. The findings suggest that understanding the nature and variety of working patterns is essential for optimal configuration of A-FOs; e.g. the type, attributes and number of workspaces provided. However, users´ needs and backgrounds, spatial factors and implementation processes require more attention in order to reduce the disparities found between cases. Thus, additional research is needed to explore how to provide the users the appropriate means and conditions, so that they feel supported and motivated in A-FW environments.

Keywords. A-FO, Activity-Based Flexible Offices, use patterns, work conditions, literature review, office design, office layout, flexible workspace.

Physical workload in hotel housekeeping

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Background and purpose Physical load such as strenuous, awkward and constrained postures and movements during work are common in hotel housekeeping. Work in twisted and bent postures in confined spaces, for example when cleaning toilets and bathtubs are particularly demanding. Also for example vacuuming under beds and embedding contain strenuous recurring postures that are risk factors for developing injuries in the neck/shoulder region, in the back and in the arms/hands. Furthermore, postures and movements that are not directly demanding, may cause problems in the long run if they are repeated many times during a working day. Furthermore, work that is carried out during a long time and without rest is also demanding, since the muscles are not able to recover. Ergonomists give advices about different cleaning techniques, but the pace at the workplaces is often high, so even if you are working with a correct technique, the load may be too high. But what is a reasonable physical workload? Our research group has performed technical measurements in many different occupational groups, to assess the physical workload, and together with information about their musculoskeletal disorders, we have obtained knowledge about which loads (postures and movements during full workdays) we consider are too high. We have released so called action levels for a number of full-day workload measures, "OEM's action levels for ergonomic workload", and above these, the risks for developing musculoskeletal disorders are high. The purpose of the study was to measure hotel housekeepers' workload and to compare it with our action levels.
Methodology Postures and movements of the upper body in fourteen female hotel housekeepers were recorded with objective measurements during a work day. Inclinometry was used for the head, upper back and both upper arms and goniometry was used for the wrists. Half of the participants were employed by cleaning companies and half of them were employed by hotels. After each recording three different workload measures for each body part was calculated; the median workload, the top workload and the time for recovery.
Results The group mean of the median workload for the angular velocity in the upper arm was 92 °/s (action level 60 °/s), for the wrist it was 36 °/s (action level 15 °/s) and for the forward bending of the head it was 30° (action level 25°). The group mean of the top workload for the arm elevation was 61° (action level 60°).
Discussion The measurements showed that hotel housekeepers have a very high physical workload in the upper part of the body, both in terms of postures and

velocities. Hotel housekeeping exceeds nine of our eleven action levels for ergonomic workload.
Conclusions Hotel housekeepers have a very high risk for developing musculoskeletal disorders. The amount of work (the number of rooms) that is included in a hotel housekeeper's workday must be reduced to decrease the risks for developing musculoskeletal disorders. Reduced number of rooms shall not be replaced with other physically strenuous work.

Keywords hotel housekeepers, musculoskeletal disorders, action levels for ergonomic workload

Here be monsters: Addressing some challenges for digitalisation in the maritime domain

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Background and purpose: In ancient times, monsters on sea charts would warn of dangers to navigation. Today, maritime pilots and Vessel Traffic Services (VTS) operators improve safety by providing navigational assistance to vessels. As in many safety-critical domains, the integration and dissemination of information between humans and technology, across disciplines and locations, is an increasingly important part of their work. Ongoing digitalisation enables new possibilities for monitoring and control from shore and assistance on board vessels, but, to facilitate the design of future work systems, we must first understand how work is performed and how it contributes to maritime safety.

Design/methodology/approach: This paper views navigational assistance as a case of sociotechnical work in a safety-critical domain and employs a Resilience Engineering focus on 'work as done' in everyday operations. Interviews, focus groups and field observations of normal work, plus specific scenarios and events, were conducted and analysed using an iterative grounded theory-style approach together with the Functional Resonance Analysis Method (FRAM). Both data collection and analysis were informed by the traditions of Workplace Studies, Science and Technology Studies and Activity Theory, with their strong grounding in empirical observations and themes of 'making work visible', symmetry between human/non-human, and work as activity.

Results: Successful assistance was found to be dependent on: (i) the use of local knowledge, preparation and foresight to integrate information from a wide range of sources, and; (ii) communication and trust between the pilot, VTS operator, and the master and crew of the vessel, to provide timely assistance to vessels. The generic FRAM model which was developed described the practice of everyday work and how the conditions which affect its performance may vary. Instantiations of the model illustrated a scenario and case study, showing how safety may manifest itself in typical and actual events.

Discussion and Conclusions: This paper shows how safety is an emergent property of sociotechnical work. It is dependent on the interaction between many different human, technological, organisational, natural and other factors. Work is inherently uncertain, variable and must adapt to circumstances. In order to inform the design of new systems or evaluate the impact of digitalisation, one should therefore take account of the factors which affect both how work is normally performed, and also how it is actually, or may be, performed in specific circumstances. While FRAM was found to be a valuable tool in this respect, it was enriched by borrowing from the work studies traditions, indicating that bringing ideas from different perspectives together to understand a real work practice may bring us closer to describing how everyday work contributes to safe operations, and to design for it.

Keywords. sociotechnical systems, safety, Resilience Engineering, FRAM, digitalisation

Living Labs: a forum for enabling co-creation between multi-disciplinary actors in the workplace?

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Background and purpose: Living Labs are promoted throughout the EU and beyond as being "user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings" (according to the European Network of Living Labs, ENoLL). In the logistics and freight transportation sectors, the AEOLIX project is implementing several Living Labs in order to investigate how digitalisation may improve transport and distribution of goods in multimodal networks. This paper investigates what a Living Lab actually is and how it may be used in this context.

Design/methodology/approach: Firstly, a literature study was undertaken to reveal how Living Labs distinguish themselves from other participatory approaches to design, and how their distinctive features may be utilised. Secondly, exploratory interviews and observations were conducted at two Living Labs, a multimodal freight terminal and a consumer goods distribution centre. The aim was to identify: which actors are represented; their understanding of the concept Living Lab; their motivation for participation and anticipated results; and their expectations for how work may be improved by the introduction of new ICT.

Results: The literature study showed a lack of consensus regarding the concept Living Lab. While it risks being seen simply as an alternative moniker for a demonstrator or test bed, some researchers argue that Living Labs may facilitate co-creation directly in the workplace, benefiting not only users, but also designers, developers, management, researchers and other stakeholders. Additionally, they suggest methodologies and tools for how this may be achieved. Interviews and observations conducted during spring 2017 revealed the extent to which the various actors in the Living Labs share this interpretation.

Discussion and Conclusions: This paper argues that Living Labs are potentially a valuable forum for enabling communication and co-creation between multi-disciplinary actors in the context of increasing digitalisation of sociotechnical work. One common feature, identified in both the literature and empirical studies, may be crucial to their success: the willingness of actors to actively engage in such a forum, combined with the expectation that participation will benefit their future work. Furthermore, the open and developing nature of Living Labs enables them to be tailored to the needs and goals of their participants, thereby improving the chances of success.

Keywords. Living Labs; co-creation; participatory ergonomics; sociotechnical work.

Formal and informal health and safety work in construction

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The construction industry is highly affected by occupational injuries and accidents, which emphasize the need for well-functioning proactive occupational health and safety management in the industry. New guidelines are continuously introduced by the Swedish Work Environment Authority (often based on European Union directives) and construction companies are obliged to work systematically and continuously with health and safety issues in the company and on construction sites. Despite company compliance many occupational accidents occur. The aim of this pilot study was to explore whether the informal health and safety management work in a major construction company was consistent with the formal health and safety management work. This included information concerning employees' responses to the health and safety work, as well as individual, group, and organisational factors that were found to affect the motivation to work safely. Issues relating to participation, commitment, and communication in the organisation when it comes to health and safety work, was also included. The pilot study highlight the importance of human and organizational factors for a successful health and safety work.

Seven semi-structured interviews were conducted in the construction company, corresponding to one person on each position in the line of house production: head of health and safety, department manager, production manager, project manager, local building site manager, safety officer and skilled worker. A small focus group interview including three supervisors was also conducted.

Interview results showed that the respondents in general where pleased with the company's health and safety work and they found the topic of health and safety to be under constant attention and up-to-date. It was clear that the focus was on rules, statistics and checklists. The concept of health and safety was associated with the use of safety equipment in order to avoid physical damage. Economical and time constraints were found to have negative effects on health and safety work. Insufficient planning leads to quick solutions and oversights, which in turn affect the work environment. The leadership was related to the outcome of the health and safety work. Team supervisors that lack knowledge and commitment had a negative effect on teams.

The construction industry consists of a homogeneous group of people that are aware of health and safety issues but act and think *too* much the same. The informal health and safety work is consistent with the formal health and safety work in the sense that you do what you should do, but nothing extra. It tends to be technical and a tick in a box in a list. New eyes, new ideas, and new opinions are needed in order for changes in health and safety work to be initiated and carried out.

It was found that the role of the safety officer could be developed, that supervisors often lacked experience and that there was a need for more education in planning and logistics. Further studies on these topics are encouraged.

Keywords. Construction, health and safety, proactive work, occupational injury.

Lean retail – implementations in stores

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Background and purpose
Lean has been implemented to varying degrees in different organizations and in different branches. Mass-producing manufacturing industries were early in this respect, and later followed by e.g. healthcare, authorities and municipalities. Presently, some stores are implementing Lean-inspired working methods. The purpose of this paper is to identify different ways of working with and implementing Lean in stores.

Methods
The methods used were case studies in 9 stores. The stores were visited and data were collected through observation of working methods and artefacts in the stores, interviews were conducted with employees and managers, and a questionnaire was answered by a sample of those working in the stores. Finally, documents were collected and photographs were taken.

Results
A few stores worked according to some the principles of Lean, and other stores had implemented some of the Lean tools. Other stores had statements of the values for the organization on display. Continuous improvement and 5S were two commonly used tools. Visualisation by using whiteboards and KPIs were also applied in several stores, and daily meetings between the store manager and the employees were also taking place in a few stores. Waste reduction has been used for a long time in stores handling fresh food, as well as substantial work in order to improve the logistics. These are aspects that Lean include, but were present in the stores before Lean was introduced.

Discussion with practical implications
Few examples of a long-term Lean tradition exist. Disseminating good examples that are also good for the work environment of the employees could support a more holistic way of working with Lean and improve working conditions in the future.

Conclusions
The use of Lean in stores is under development, and several stores have started to introduce Lean-inspired working methods, such as Continuous improvement, 5S, customer orientation, visualization, daily whiteboard meetings and waste reduction.

Keywords: Shops, Customer orientation, Work environment, Employees.

Hand Intensive Work: A proposed methodology for risk assessment, health examination and evaluation

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Background and purpose. The employer is responsible for the systematic occupational health and safety management (OHSM) and often turns to the occupational health services (OHS) for support. The OHS can provide medical expertise, and perform statutory health examinations (HEs). The HEs aim is to detect early signs of illness, protect vulnerable individuals and detect hazardous work environments. It is of great importance that HEs lead to improvement measures in the workplace and that the methodology facilitates evaluation. The Swedish Work Environment Authority is currently revising the provision that regulates HEs and are considering the introduction of a HE for workers exposed to hand intensive work. Since knowledge of the application of currently existing HEs is limited, it is of great importance to enhance the understanding of the implementation process so that future HEs may be well integrated with the OHSM. A methodology for HEs for workers exposed to hand intensive work (HE-HIW) has been developed. The HE-HIW includes risk assessment, health examination and feedback to employer.

The purpose of the project is to test and evaluate the proposed methodology in terms of feasibility (benefits and value to employers and employees) and the effects of work-related ill-health and improved work environment.

Design and data collection. The study is designed as an implementation study with an interactive approach. About 10-15 companies from different sectors (e.g. assembly, cleaning, meat packing), with at least 10 employees exposed to hand intensive work participate in the study in cooperation with their contracted OHS. The evaluation of the implementation process is based on the Dynamic Integrated Evaluation Model in order to achieve sustainability and integration in the organisational structures (e.g OHSM) . The data collection will begin autumn 2017 and includes interviews in groups and individually, document analysis, log books, and questionnaires.

Expected results. Results from the project are expected to generate knowledge about the process, barriers and facilitators for the implementation of a methodology for medical examinations in hand intensive work.

Keywords. Hand Intensive Work, Musculoskeletal disorders, Medical Examination, Risk Assessment

Physicians identity and loyalty: Implications for teamwork and the work environment

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Multi-professional teams are seen as beneficial for the work environment and necessary for sustainable care in complex healthcare environments. Physicians are usually considered to primarily be loyal to their professions. This can complicate operational management and change processes, especially if the goal is multi-professional cooperation, as required in some forms of teamwork. We have studied an intensive care unit at a Swedish hospital, where a LEAN-based approach to improve Evidence Based Medicine-compliance, process efficiency and multi-professional teamwork has been applied. The purpose of the study was to investigate how the physicians related to the multi-professional teams and how the organizations efforts to implement multi-professional teamwork affected the physicians.

Through a combination of in-depth interviews, shadowing of staff during full work-shifts, and document studies the change process and the work environment were explored, highlighting teamwork aspects. Five discussion-seminars with physicians from the unit, also provided data. Transcribed interviews and observation notes were analysed and conceptualized.

In the studied change process, efforts were made to establish shared values and norms across all the staff, regardless of professions. Focus was deliberately shifted from the individual to the team, both in immediate patient care and in competence build-up. The organization also redistributed leadership so that it was clearly shared among all present professions. As a side effect of the change process the physicians shifted their primary loyalty from the profession to the multi-professional teams and their organizational unit. This uncommon achievement was reported by several of the informants interviewed, and was clearly displayed in the work observed through shadowing. Also, the physicians claimed that their work environment had improved considerably as a concequence of them working in multi-professional teams.

The basis for loyalty and identity among healthcare professionals has traditionally been the profession, especially concerning physicians. Our findings of a change in loyalty and identity seems to be connected to engaging in multi-professional teamwork, under certain conditions. One factor that emerged as crucial was trust. Mutual trust between members of different professions appears to proceed the shift of loyalty from the profession to the team and the organizational unit. Further investigation of how trust and participation in leadership affects implementation and the effectiveness of multi-professional teamwork could uncover practical aspects regarding how such interventions should be organized.

Physicians' loyalty and identity can change from traditional profession-centred to a multi-professional team and organization centred. Such a shift seems to be supported by activities and leadership practices that build mutual trust. One component may be the development of values shared across all professions at an organizational unit. At the studied unit, a consequence of more multi-professional teamwork appeared to be an improved work environment for the physicians.

Keywords. Team-work, work environment, identity, trust, change processes, leadership

Acquisition of new knowledge in Swedish manufacturing companies – How could it be improved?

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Experience has shown that new research does not reach out to companies and organizations in Sweden as desired. The spread and application of useful research results was found to be limited to relatively few companies. The situation is similar across the EU according to investigations. This means that many improvement possibilities are missed and probably also increased profitability and competitiveness.
Nine extensive interviews among upper level management in nine Swedish companies were accomplished to investigate how new knowledge was acquired and implemented. The interview study included 18 semi-open questions about:
organizational relationships; decision levels; distribution of responsibility; cooperation between different departments; successful implementation factors; responsibility for ergonomics issues; management of assembly-related errors and conditions for effective knowledge dissemination.

The results showed that the small businesses lacked sufficient resources to manage major changes and that binding subcontractor agreements counteracted possible improvements of product design and assembly solutions. In some cases additional implementation support is probably needed to succeed because time-consuming change initiatives that were not highly prioritized could often not be sufficiently considered. A critical mass of knowledgeable people was considered crucial to manage implementation of new methods and working procedures. It was perceived difficult to find research reports of interest for the own business. Only one company had an ergonomics specialist involved in early development phases but this expertize was wanted by several companies. Eight of nine companies thought it would be useful to increase cooperation with universities and/or research teams.

There are different decision-making forums in different companies that decide on changes or implementation of new approaches and methods. Academic knowledge dissemination, implementation and need of (external) support therefore must be adapted to varying conditions in companies in order to be utilized to a much larger extent. Direct communication and local abutment is crucial.

Improvement proposals were developed for how to support dissemination and implementation of new knowledge. These were:

1. Compilation of easy to read summaries (including contact persons) distributed by research institutes and others conducting research, which companies could subscribe to (see 5. below).

2. Innovation/competence centers (knowledge transfer offices) for collaboration/networks between SMEs, universities and research centers of various kind; financing and consulting services for exploitation of research results including specialist staff to help identify and manage relevant knowledge with business potential.
3. Additional time and budget at the end of research programs intended for further dissemination of results and implementation assistance.
4. Targeted seminars and work-shops.
5. A web portal including useful information of latest research publications, upcoming work-shops, projects and others of interest.
6. E-learning for introduction and training in new working methods, tools and others of importance for knowledge transfer before implementation.

For all proposals a clear responsibility should be agreed and decided.

Keywords: Interview; Implementation; New knowledge; Ergonomics; Manufacturing; Improvement proposals

How do manufacturing companies acquire new knowledge? – Examples from nine Swedish companies

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Experience has shown that new research does not reach out to companies and organizations in Sweden as desired. The spread and application of useful research results was found to be limited to relatively few companies. The situation is similar across the EU according to investigations. This means that many improvement possibilities are missed and probably also increased profitability and competitiveness. In order to find the underlying reasons for this several Swedish companies were asked about participation in an interview study. Nine companies answered yes. Interviews among upper level management was made in order to explore how new knowledge was found and utilized. The interview included 18 semi-open questions about organizational relationships, decision levels, distribution of responsibility and cooperation between different departments, successful implementation factors, responsibility for ergonomics issues, how assembly-related errors were taken care of and conditions for effective knowledge dissemination.

The results showed that the small businesses lacked sufficient resources to manage major changes and that binding subcontractor agreements counteracted possible improvements of product design and assembly solutions. Time-consuming matters that were not highly prioritized could often not be sufficiently considered. In some cases probably additional implementation support is needed in order to succeed. A critical mass of knowledgeable people was considered urgent to manage implementation of new methods and working procedures. It was perceived difficult to find research reports of interest for the own business. Only one company had an ergonomics specialist involved in early development phases but this expertize was wanted by several companies. Eight of nine companies thought it would be useful to increase cooperation with universities and/or research teams.

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Keywords: Interview; Implementation; New knowledge; Ergonomics; Manufacturing

Physical workload in cleaning work – a comparison between hotel and hospital cleaners

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Background and purpose
Several studies have reported that the biomechanical workload is high among cleaners. The load includes strenuous, awkward and constrained postures and movements of the head, back, arms and wrists. The work is also characterized by low job control, and many workers are immigrants, who often have a fear of losing their job. The work is often sub-contracted; the workers employed by cleaning companies have few possibilities for job rotation. The business sector is under a competitive pressure, which may increase the quantitative workload of the employees. Musculoskeletal disorders are frequent.

In most studies the biomechanical load has been estimated from self-reports or from observations; both of these methods have limited reliability. In the literature, cleaners are often seen as one group (with homogenous conditions), although there are reports that specifically have studied the cleaning work in the hotel housekeeping industry, and found high biomechanical loads, but without using precise methods nor comparing to other cleaning work in the same study.

The purpose of this study was to compare the technically measured upper arm angular velocity (as a key variable) between hotel room cleaners and hospital cleaners.

Methodology
The right upper arm movements was measured in fourteen hotel room cleaners (all women, aged 22-57 yrs.) and in twelve hospital cleaners (7 women, 5 men, aged 31-57 yrs.) during an ordinary work day. A small tri-axial accelerometer with a built-in logger was attached on the skin on the right upper arm, just below the deltoideus muscle. The median generalized angular velocity was computed for the measured work time, excluding the breaks.

Results
The group mean of the median angular velocity was 92 °/s for the hotel room cleaners, and 68 °/s for the hospital cleaners. The difference was significant ($p < 0.001$). Both mean values were significantly ($p < 0.05$) above 60 °/s, i.e. one of the action levels from

Lund: ”Occupational and Environmental Medicine’s action levels for ergonomic workload”, published in 2016.

Discussion
This study indicates that hotel room cleaners have a higher workload than hospital cleaners. So far only one variable has been compared, and although the right arm velocity is known to correlate with the left side ditto and may correlate with shoulder muscular activity, other variables should be compared as well. There are few previous cleaner studies that have used accelerometers. However, we did one of hospital cleaners in 2007, where the corresponding mean velocity was 71 °/s, hence very similar to the 68 °/s of this study, and also lower than for the hotel cleaners.

Conclusion
The fact that all three of these velocities are above the mentioned action level, tells us that rotation between these types of work would not be a successful approach, since it would not decrease the level enough for hotel room cleaners and it would increase the exposure level for hospital cleaners.

Keywords: Hospital cleaner, hotel room cleaner, musculoskeletal disorder, accelerometer

From weather warning to personalized adaptation strategies to cope with thermal climate stress

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Climate change increases the intensity and frequency of extreme weather events. The impact of such events on human health and productivity is predicted to be profound. Heat waves and cold spells are major health challenges for workers, the elderly and other vulnerable populations, increasing mortality and morbidity. It is necessary for individuals and society to increase preparedness and adapt to climate extremes. Current climate services provide only environmental information. The consequences of thermal climate stress are determined not only by climate factors, but also by human thermoregulation capacity, individual characteristics, physical work intensity and clothing. For both warning and adaptation purposes, such climate services will be much more valuable for individuals facing adverse weather conditions if combined with individual factors and translated into adaptation strategies.

The present project with 9 partners from Sweden, Denmark and The Netherlands is funded by European Research Area for Climate Services (ERA4CS), and is to integrate climate service data with human heat balance models to develop personalized thermal evaluation tools, suggest adaptation strategies to cope with thermal climate stress. The existing and improved human thermal models, heat and cold stress indices including Wet Bulb Globe Temperature, Predicted Heat Strain, Predicted Mean Vote and Required Clothing Insulation are incorporated to develop a mobile phone App (ClimApp) to cover a wide range of thermal conditions. Researchers, stakeholders and end-users will be involved in the development process.

The ClimApp is used to evaluate body thermal responses and provides timely relevant guidelines for individuals, the public and private sectors to take decisions and actions to improve thermal resilience when adverse thermal environmental conditions

are expected. The effectiveness of the ClimApp will be assessed qualitatively and quantitatively at both individual user and European societal. Feedback will be utilized to improve the personalized climate service to maximize the impact and strengthen the integration of expertise from climatology, thermal physiology and thermal modelling to optimize adaptation strategies for climate challenges.

Keywords. Thermal climate; heat and cold stress; thermal physiology; personalized climate APP; adaptation strategies

Introducing MEROEX, a web-based remote meeting tool

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In any face-to-face meeting, communication and mutual understanding is achieved through factors such as talking, gesturing, referencing (objects) and making eye contact. Many of these factors are severely crippled when physical proximity is not possible and the meeting is held over the phone or video conferencing systems. Nevertheless, there is an undisputed value in succeeding with remote collaboration - saving money, energy, travel time while at the same time broadening the pool of potential collaborators.

MERCO (Mediated Effective Remote Collaboration) was a research project running 2014-2016. What factors influence success in meetings with at least one participant "calling in"? Can we create a solution for remote collaboration that enables and supports complex decision taking and creative processes? These were questions MERCO set out to answer.

Following a bottom-up process, where participating companies' local and remote meeting culture was studied through a contextual inquiry, a framework of how to improve remote meetings was shaped. Findings include a taxonomy of meeting types, what type of meetings occur most often, pain points of current (remote) meetings and assistive technologies. Factors for successful meetings were defined. One finding is the value of "Informality enablers", and the downside of using dedicated hardware (that locks a solution to e.g. specific room). These findings led to the choice of a browser-based solution, since browsers are omnipresent in the business landscape independent of operating system or device, be it desktop computer, laptop, tablet or phone.

The final prototype is a fully functional web-based remote meeting client, designed for intra-business and business-to-business communication. Compared to other web-based video-call services, MEROEX targets business-specific use cases identified within the project. The final interface has gone through multiple iterations of testing and refinement, with solutions based in (human) communications theories while utilizing "new" web technologies such as WebRTC. Features include collaborative agenda setting, sound recording with a tagging function, screen sharing, file sharing and a moderator's interface.

MEROEX will be field tested internally during the spring of 2017, with the aim of commercializing towards the end of the year.

Keywords: remote collaboration, video conferencing, remote meeting, telepresence

Enablers for improved collaboration in a remote meeting context

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In any face-to-face meeting, communication and mutual understanding is achieved through actions and enablers such as talking, gesturing, referencing (objects) and making eye contact. Many of these enablers are severely crippled when physical proximity is not possible and the meeting is held over the phone or video conferencing systems. Nevertheless, there is an undisputed value in succeeding with remote collaboration - saving money, energy and travel time while at the same time broadening the pool of potential collaborators.

In this paper, we propose two sets of factors identified throughout the Mediated Effective Remote Collaboration project (MERCO): "Communication facilitators in remote collaboration" and "Informality enablers". Communication facilitators consider the remote medium and what it could or should allow participants to communicate. Informality enablers are means to improve colloquial or relaxed rapport between colleagues or business associates that are geographically apart, using some form of remote collaboration tool or mediated communications. The factors were identified through literature studies and contextual inquiries (later explored through conceptual prototypes not presented herein). The factors presented could be used as a scorecard for an existing or proposed remote solution, or otherwise inform the development process.

Keywords. Remote collaboration, informality, remote meeting, telepresence

The effect of Volvo Dynamic Steering on bus drivers work environment

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The bus driver's work environment is demanding. Their work consists of several hours sitting in the driver's seat, being exposed to time pressures and traffic. Many bus drivers have complications due to these unhealthy working conditions, such as musculoskeletal disorders, stress and depression.

In order to improve the drivers work environment Volvo has developed a dynamic steering system (VDS). VDS reduces the vibrations in steering wheel, provides directional stability, self-centring of the steering wheel, and requires less steering wheel forces.

The VDS was introduced on Volvo Trucks in 2013 and on bus coaches in 2015. An introduction for city buses is planned for 2017. VDS consists of an electrically controlled electrical motor that is situated on the steering shaft. The electrical motor provides extra steering support and simplifies manoeuvres that are required during the driver's working day.

To evaluate the systems actual effect on the driver's health and the needed muscle activity during driving, an objective study was performed by VTI (The Swedish National Road and Transport Research Institute). 20 bus drivers participated in the study where they were to drive a bus in real traffic, both when VDS was activated and when it was deactivated. Electromyography from eight muscles (left and right biceps, triceps, trapezius and deltoids) was used to evaluate the steering effort and the driver's behaviour was also evaluated by video analyses and a questionnaire.

Three different manoeuvre types were included in the study; turning right in intersections, turning left in intersections and turning left in roundabouts. A mixed model analyses of variance (ANOVA) was used to compare muscle activity with and without VDS and to evaluate the differences between the conditions.

The results show that VDS significantly reduced the muscle activity needed, by an average of 15-25% and up to 70% in certain manoeuvres. The self-centring steering wheel, that assists the driver after a turn, was the most valuable VDS functionality in a city bus setting. The questionnaire revealed that the drivers highly appreciated the system and believed that VDS will reduce pain in the neck and in the shoulder.

In conclusion, VDS was appreciated by the drivers and reduced the amount of muscle force needed to manoeuvre the bus. The benefit of VDS depends on the type of

manoeuvre being performed. Future studies are needed to investigate if long-term usage of VDS will improve the drivers work environment and reduce pain in the neck, shoulders and lower back.

Keywords. Bus driver, work environment, electromyography

Dynamic work induced muscle activity rate change (MARC) and fatigue evaluation in muscle activity interpretation squares (MAIS)

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Background and purpose Muscle fatigue analysis from dynamic electromyography (EMG) data is not convenient compared with single and static muscular contraction. The study of muscle fatigue can be done with mean and median frequency (MDF) obtained from the power spectrum using Fourier transform. There is an established relationship between EMG amplitude (AMP) and isometric or sustained muscle action. The EMG signals are assumed stationary during isometric exertion due to a stable and constant force exertion and body posture. However, during dynamic exertion, the magnitude and direction of muscular force application may continuously change with body posture. This paper introduces the muscle activity rate change (MARC), especially muscle fatigue per unit percentile time to evaluate and interpret dynamic EMG data.

Methodology MARC is achieved by dividing the total working duration into ten equal length divisions (10%) of the total working period (100%), as time normalization. The equally divided each 10% duration dataset is then averaged to yield one data point (totally 10 data points) for both MDF in Hz and AMP in μV. The periodical average AMP and MDF changes per unit time represent the MARC. The 10% periodical average EMG activities change during repeated movements may give an estimation of fatigue by the relative changes occur in the measured muscles' AMP and MDF, which presented as MARC. The MARC values (both AMP and MDF) are combined to get one point for each tenth percentile and presented into the muscle activity interpretation squares (MAIS). MAIS is based on the *four* possible assumptions of muscle activities (AMP and MDF) change per unit time to evaluate fatigue from dynamic task. The increase in EMG amplitude and frequency results in: 1) muscle force increase. An increase in amplitude and a decrease in frequency indicates 2) muscle fatigue. A decrease in both the amplitude and frequency indicates 3) muscle force decrease. A decrease in amplitude and an increase in frequency indicates 4) muscle fatigue recovery. They are derived by the following equation:

$$\Delta = \frac{x_n - x_{n-1}}{\bar{t}/10}$$

where,

Δ is change in a selected parameter (AMP and MDF) over normalized time period;

x_n is the selected parameter (AMP and MDF) value at each normalized time point n;

x_{n-1} is the selected parameter value at a normalized time point n-1;

$\bar{t}$ is the average duration in seconds for the dynamic task;
10 is the total number of normalized time periods.

Results and Discussion Stair ascending fatigue compensation was observed with muscle power and speed reductions, which reflected in either *muscle force decrease* or *recovery* squares in MAIS during the self-preferred pace. Contrary, the MARC points were found in the *muscle fatigue* squares in the predetermined and controlled speed at 90% of VO_{2max} ascending pace on a stair machine in laboratory. Moreover, individual AMP and MDF analysis showed significantly increased and decreased, respectively, which supported the interpretations made by the MAIS.

Conclusions Stair ascending results suggest that MARC and MAIS are useful to interpret muscle activity changes per unit time during dynamic activities of the whole working duration.

Keywords. Muscle activity, Electromyography, local muscle fatigue, EMG.

The design of a new type of multimodal alarm display for a paper mill control room

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More complex information flows in industrial control rooms can cause distraction, confusion as well as sensorial and cognitive overload among operators, in demanding situations. New multimodal interfaces, which consider human capabilities and the affordances of our sensory modalities, may offer better solutions. Poor alarm management and design is a common issue. Auditory displays utilizing informative non-speech sounds have proven to improve effectiveness in various environments including industrial control rooms.

While sound can effectively catch and guide attention regardless of visual focus, as well as convey detailed information, the displayed information is lost if not repeated. Visual cues, on the other hand, can persist over time and offer greater spatial accuracy. Furthermore, a multimodal alarm display that combines visual and auditory cues gives the user a choice of preference, while being less sensitive to sensory masking, overload and impairments.

The aim of the present work was to develop a new type of multimodal alarm display to enhance effectiveness and acceptance in two paper mill control rooms. The design of the auditory cues followed principles described in previous work conducted at RISE Interactive. Visual cues were designed to complement and enhance auditory displays, without adding clutter in an already visually crowded workspace. One visual cue (”light jars”) provides spatial guidance and another type (”overview panels”) provides alarm overview. The auditory and visual displays use icons to convey source of alarm. These were derived from user associations identified in the user-driven design process. Concepts were developed iteratively with continuous feedback from operators in focus groups and workshops.

Prototypes of multimodal displays were installed in two control rooms (A and B) for long-term tests (A: 23 weeks and B: 10 weeks) involving 36 operators. In A, the auditory display was already in place (for around 4 years). The visual displays were added and the whole multimodal system was evaluated. In B, the auditory and visual displays were installed together in the beginning of this study. The effect of the displays were evaluated using rating scales and the method described by Van der Laan, Heino and De Waard at Traffic Research Centre, University of Groningen.

In A, the multimodal display resulted in a slightly higher mean score compared to the auditory display by itself, both in terms of usefulness (an increase from 0.7 to 1.1) and satisfaction (an increase from 0.5 to 0.9) measured on a scale form -2 to 2. In B, results measured by the same scale, show that both auditory and visual cues contribute to acceptance, both in terms of usefulness (auditory: an increase from 0.3 to 0.6, visual: an increase from -0.4 to 0.1) and satisfaction (auditory: an increase from -0.5 to 0.6, visual: an increase from 0.2 to 0.3). The results from the two studies are coherent and indicate that carefully designed multimodality in alarm displays may have a positive effect on acceptance and efficiency.

Keywords. Sound design, alarm design, multimodal alarm display, ergonomics

Aerobic workload in hospital cleaning work

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Background and purpose
A high aerobic workload has been found among cleaners. Full day group averages between 23% and 50% of the individual capacity have been reported. Hence, there are reports of workloads above the International Labour Organisation's (ILOs) recommendations of 30%. Moreover, high physical load has been associated with increased risk for cardiovascular diseases.

The aims of the present study were to evaluate the level of aerobic workload among hospital cleaners during an ordinary working day, to compare the full day results to similar studies, and to compare the work load among different work tasks.

Method
Twelve cleaners (7 women, 5 men) participated in the study. A heart-rate band (Team 2; Polar, Kempele, Finland) was used to monitor the heart rate throughout the workday. Then the relative aerobic workload was calculated as a percentage of the heart rate reserve (%HRR), which is a validated objective measure of relative aerobic workload. Each cleaner was observed by a researcher who registered the duration of each cleaning task. The tasks included: mopping, vacuum-cleaning, changing trash bins, cleaning stairs, wiping, making beds, cleaning bathroom, and transportation (walking).

Results
The group average of the full workday aerobic workload was 22 %HRR. The tasks 'making beds' and 'cleaning stairs' were associated with increased workload levels of 37 and 25 %HRR, respectively; however less than 4% of the total worktime comprised these tasks. The other cleaning tasks showed in average 20-21 %HRR, and hardly differed from the level measured during coffee and lunch breaks (20 %HRR).

Conclusions
The average aerobic workload (21 %HRR) was significantly below the recommended highest ILO-level of 30 %HRR. It was just below the results in a previous similar study of Swedish hospital cleaners, as well as in studies of other categories of cleaners. Although the aerobic workload was low, biomechanical load from postures and movement velocities may still induce risks of musculoskeletal disorders.

Keywords: Energy expenditure, metabolic workload, physical workload, heart-rate measurements.

Introduction of an activity based workplace (ABW) The effects on health/discomfort and stress/ influence using a Self-assessment tool

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Introduction

Activity Based Workplace (ABW) is becoming more and more interesting and popular due to the digital and technical development which enables you to work with computer, laptop, smartphone where you want, often with cloud support. This also enables our working outside the office.

The ABW office is cost-effective for the employer with less space per employee. Advantages for the employee are a more flexible working alone or with the colleagues needed for the specific task. Disadvantages for the employee are changing different workplace.

It may be an ergonomic challenge as repetitive strain injuries (RSI) are common by computer workers and all different new workplaces may not be ergonomic optical.

Fits the ABW for all tasks in the organization? Will stress increase when you lose your own workplace and have to find a new one every day?

What is the effect of the introduction of the ABW on comfort, health/discomfort and stress/influence? Studies show a clear correlation between perceived comfort, load and the development of symptoms. Can these be applied also on the ABW?

Objectives

Ergonomhuset AB has developed a digital self-assessment tool called Your Workplace.

The self-assessment tool contains general questions of comfort (chair, table, screen, keyboard, mouse, noise, lightning), health/discomfort (physical complaints) and stress/influence using various rating scales.

The purpose of this study was to evaluate if there is any change in comfort/health/ stress when working in an ABW-office compared to a traditional office with individual adjusted workplaces.

Method

Self-assessment of perceived comfort, discomfort and stress was given to 48 people at a company 4 months before, one month and eight months after the ABW was built. Immediate feedback after the completion of each person who filled out the form was given in a green-yellow-red diagram.

The company deals with products for public spaces and the officials were divided into three groups; sales, sales support and administration.

A background questionnaire was given about working situation, variability of the posture and tasks and physical problems.

A follow up questionnaire extended with questions of how it felt working in the ABW was given.

Results and conclusion

Results are reported for the whole group. Details could vary between the groups.

After reconstruction, some overall improvement was experienced by both comfort and load/discomfort. Stress is perceived as slightly increased.

At follow-up, comfort felt slightly better on almost all points. The load increased especially for the shoulder/arm. The combined stressors increased, they felt more stressed with shift from yellow to red, while slightly more had time to complete their duties and ability to influence their situation, which is positive.

Cognitive stress and distraction can be seen at work in open office environments. The suggestion is that the administrative and similar regular concentration tasks are performed at fixed, shielded and ergonomically designed workstations.

As the environment also was open for customer visits, planning of special visiting hours was recommended so that work could be performed undisturbed and be terminated.

Keywords: Activity Based Workplace (ABW), Digital Self-Assessment tool, Stress, Computer ergonomics, Repetitive Strain Injury (RSI), Influence, Comfort, Health

VERAM, a risk assessment method for visual ergonomics

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VERAM, Visual Ergonomics Risk Analysis Method, is a valid, reliable, practical and easy to use risk assessment method for evaluating the visual environment. With this method, the risk factors in the visual environment is detected and interventions implemented to reduce the occurrence of symptoms related to poor ergonomics among workers can be evaluated.

The visual environment can affect our wellbeing in many ways. Glare from luminaries or windows within the visual field can cause disability glare and discomfort glare. Glare while performing tasks on the computer causes visual fatigue and leads to strabismus measured by fixation disparity (more difficult for the eyes to focus). Strabismus leads to eyestrain and eyestrain can lead to musculoskeletal disorders. Non-visual effects, such as flickering lights can cause eyestrain or headaches/migraines. Insufficient visual ability can lead to increased workload and contribute to eyestrain and musculoskeletal disorders, which in turn can lead to sick leave. As humans, we need daylight to get a normal circadian rhythm. The visual environment must be designed to allow natural light coming in, but have the ability to prevent disturbing light.

No method for assessing the visual environment along with the individual's subjective strain has previously existed. Employees from occupational health departments (75 individuals/assessors) have used the developed visual ergonomics risk analysis method at several workplaces. Before using the method, they were given a course in visual ergonomics and learned to use the method.

VERAM consists of two main parts. The first part is a subjective questionnaire

with questions regarding the workers problem such as eyestrain and headache, but also their rating of the visual environment.

The second objective part is performed by the assessors and consists of:

- measuring the illuminance and luminance
- rating of the visual environment and different risks (risk for glare, flicker, work task, daylight, work posture etc.)
- Feedback from the subjective part, the light measurements and the ratings
- Recommendations

To increase occupational health and reducing sick leave, a good visual environment is required. This includes sufficient illuminance, a good luminance ratio, no glare from luminaires or windows, no flicker, and a good visibility of the task. Education in risk analysis of the visual environment is essential for many different occupations such as lighting designers, ergonomists, working life inspectors, optometrists, to ensure a better understanding of the impact on wellbeing that the visual environment have. The main purpose of this study is to develop a risk analysis method for the visual environment and to increase awareness and knowledge ergonomics. VERAM will be presented at NES 2017.

Keywords: VERAM, visual ergonomics, risk assessment

Improving the digital work environment: Designing new interfaces for product specifications using eye movement measurements

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Background and purpose: Electronic product specifications, as used by the manufacturing industries, provide a ubiquitous example of digital documents containing complex information that also require high levels of comprehension. Previous research on digital work environments suggests that the combination of complex informational content and inefficient interaction affordances exposes IT-workers to considerable levels of cognitive load, which may contribute to comprehension loss and mental fatigue. New interfaces for electronic product specifications using physiological measurements to evaluate readers' document interaction and comprehension is being developed within an on-going collaboration between the human and design sciences, and representatives of Swedish industry.

Design/methodology/approach: This project started out by conducting surveys about how users interacted with current specifications in PDF format, and how producers of specifications would like to use visualizations to facilitate interaction. Based on the interaction problems revealed, a new web-based specification format of was developed organized as a set of interlinked web pages. Ten participants were requited to solve a number of interactive tasks using both versions (i.e. a within-subjects design). The users' visual interaction was recorded using eye-tracking equipment. The effects of the web-based format were evaluated by defining a number of interaction measures: eye movements, efficacy of navigation, and task performance.

Results: The results indicated that several attentional indicators of cognitive load were reduced by the intervention (fixation duration, pupil size and saccade count). Similarly, critical indicators of effective navigation were affected positively (task duration). Reading comprehension was similar across document formats. Furthermore, users considered the web-based specification as a more flexible mode of interaction.

Discussion and practical implications: The results of the present research show that several interaction outcome measures can be significantly improved by providing users with a web-based product specification format that allows for more flexible modes of interaction and navigation compared to traditional PDF format. Thus, eye movement measurements can provide data for evaluating the visual interface and guide new iterations in the design process. This research provides an evidence-based interdisciplinary approach of improving the cognitive ergonomics in digital work environments.

Keywords: Eye-tracking, interaction design, IT-work, product specifications, visual interaction.

A sociotechnical perspective on the use of DaVincirobot at a large Norwegian Hospital

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Background and purpose: Recent decade, the DAVinci robot, being a remotely controlled surgical device, has been increasingly in use at many hospitals in the western world. In Norway there are in 2017 about 10 DaVinci robots. Studies show that adoption and use of health technologies are embedded in organisational and societal constructs. The aim of this study is to explore how the DaVinci robot changes work organisation and daily practice, by using a sociotechnical perspective, more specifically the SEIPS-model, combining sociotechnical work system with work processes and outcomes.
Design/methodology/approach: The study is a qualitative interview study at a large Norwegian Hospital. 13 informants were interviewed. These were clinicians (physicians and nurses) and managers at different levels, all informants being in some way involved in implementation and use of this technology. The interviews followed an interview guide with open questions. The interviews were transcribed verbatim and anonymised. The analysis was performed by categorizing the material according to the different aspects of the Seips model, considering external factors, work system and the work processes. This analysis emphasises the work system and the work processes involving the robot; e.g. how work processes are perceived when involving the DaVincirobot compared to open or laproscopic surgery.
Results: Tentative analysis of the interviews show that the DaVinci robot has impact on the work system configuration and work processes, being different than other surgery as described by the informants. Work intensity, communication methods and use of skills seem to be the most prominent differences compared to ordinary surgery within the work process. The analysis further points to work system configuration including the technological domain being requirements of additional technology, task domain being other task distribution as well as new routines and organisational domain due to requirements of training, and support functions needed.
Discussion with practical implications: The results show that the DaVincirobot entail changes, in configuration and work processes. These changes should be considered to further improve the quality of care.

Keywords. DAVinciRobot, Sociotechnical system theory, SEIPS-model

Autonomy at work, do we need a new understanding?

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Background and purpose: Since the Democracy Program in Norway in the 1960s, autonomy has developed to become a fundamental pillar in the in what is labeled the Scandinavian working life model. Workers autonomy is regarded as a both a legal right and a mean to achieve other goals like efficiency, democracy, healthy working conditions, etc. From a research perspective, autonomy is seen as a core aspect with work, reducing negative aspects (Wu, Luksyte, & Parker, 2015). However, high autonomy is also suggested to be a burden in todays' working life, being a stressful obligation having to take control over the work performance (Hvid, Lund, & Pejtersen, 2008; Kalleberg et al., 2009). Hence, we need to reconsider our understanding of autonomy. The aim of this study is to explore how autonomy employees in three different companies, with different core tasks, organisation and external relations, understand autonomy.
Study design: The study design is an explorative qualitative case study, with three different case companies. One company is delivering welfare services. One company is doing real estate development and the third company is doing consultancy. Totally 34 interviews were performed. The informants' educational level ranged for vocational education to masters' degree. The interviews followed an interview guide with open questions. The interviews were transcribed verbatim and anonymised. The text-analysis was restricted to answers to the question what is freedom at work is (as a proxy for autonomy). A content analysis was performed using the software NVivo.
Results: The analysis revealed nine different categories considering the understanding of freedom in a working context. Six categories reflect positive or neutral understandings. The largest categories were "*trust and lack of being controlled*" and "*influences on how to organise the work*". Other categories were "*freedom when handling externals*", *involvement in higher-level decisions*", "*professional development and creativity*" and "*individual regulation of working hours*". The categories reflecting negative associations were "*lack of structures in organisation of work*" and "*the importance of individual characteristics*". Finally, one category is reflecting an ambivalence in freedom, called *"predictability*". The categories being termed positive / neutral reflect general opinions about freedom, being more traditional and based on intuitions. Categories reflecting negative associations / ambivalences relates to specified aspects with the work environment.
Discussion and conclusion: The results are in line with recent research showing that autonomy is perceived not only as positive. The important finding is however, how personal experience matters in defining the negative aspects of autonomy. This is important knowledge, as employees may not necessarily perceive the negative aspects before it is too late, when experiencing conflicts or sick leave.
Keywords: autonomy, work organisation, stress

Responsible Research and Innovation (RRI) – enhancing ethical design and engagement of stakeholders for the development of new technologies

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The European implication in the context of research and development is called Responsible Research and Innovation (RRI). The Engagement, Open Access, Gender Equality, Ethics, Science Education and Governance are presented as critical dimensions for the RRI.

We have picked up and combined the main ingredients (RRI requirements, dimensions, elements or pillars) and give them a short description from practical view for implementation of these ingredients to the actual research and innovation work performed by various stakeholders:

Governance/Responsiveness: The governance model of RRI has to be taken into account in the beginning of the project design. The management structure of the project defines how the RRI aspects are taken into account during the project. The management structure and the work plan of the project reflect both the more general requirements of the resource provider (i.e. funding program of company, public entity), more specific requirements of the funding call or initiative and requirements that are rising from the intentions i.e. what the researchers want to achieve with the project) of the project designers.

Anticipation: It is a vital part for any project in order to be able to abstract the future consequences in some level (both positive and negative). Anticipation can be performed in many ways for various purposes. Sort of anticipation for technological development projects is very often done nowadays with scenario-based design approach. This is usually done in order to find the main technical and user-related requirements for technologies and practises but is widely used also to examine societal issues in relation to the R&D.

Participation/engagement/inclusion is regarded generally currently as one of the main elements and tasks in R&D and there is a strong emphasis by funding organisation to increase the volume and visibility of this activity. The meaning and practise in the real world naturally varies a lot and the benefit and true impact of this activity is still not well explicitly argued. The quantity, quality and specific focus or purpose related to the methods/tools that are used in participation is not usually well justified or it is hard justify due the nature of this activity. Participation and engagement also are relevant aspects in the project internally and in close relation to the governance and structure of the project.

Reflexivity is naturally very hard for the projects as it is also for anyone. External point of view might help to establish a situation where one's (individual, organisation

or project) own framing of the context can be examined as objectively as it is possible. Naturally reflexivity already requires a certain attitude to the world when one's own framing can be revealed, discussed and even questioned. Indeed, in our opinion all other dimensions of RRI need be active also if and when authentic reflexivity can be achieved (if ever).

Keywords. Responsible Research and Innovation (RRI), Ethics, Participatory Design, Human-Driven Design

Expert user perspectives of the Ergo-Index model for analysis of work tasks

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This paper presents the results of a user study aiming to test and evaluate an updated version of the Ergo-Index model for analysis of work tasks from both an ergonomic as well as a production performance perspective.

In order to reduce the risk of musculoskeletal disorders (MSD) and work related ill-health, it is important to understand the effects of the physical load and intensity, working posture, exposure and recovery time, and how these factors interact. The updated version of Ergo-Index enables the assessment of these factors, allowing for different work-methods to be analysed and compared before deciding on appropriate design and performance of work procedures and organisation.

The purpose of this study is to test and evaluate an updated beta version of Ergo-Index, with focus on face validity, inter-rater reliability and usability. The evaluation was performed with 15 expert users with a background as ergonomists or work environment engineers. The users were introduced to the beta version of Ergo-Index software and given a step-wise instruction on how to perform the evaluation of four different work situations, illustrated in short video films. The users were first given the task to assess type (lift, push or pull), range, height and exposure time of the work situations. As a last step, the users answered a written questionnaire on how they perceived the usability of the model.

The results show that the assessments of lifting work have the greatest inter-rater reliability. Especially when assessing exposure time, but also type, range and height. As for the usability of the model, most users gave neutral answers to the survey questions on how easy or difficult they found assessing the various work tasks. Also, the users highly agree that using the model alone is sufficient regarding riskassessment of different types of work. Additional free-text comments do however indicate that several of the users found it difficult to use the model and requested better instructions and training opportunities. Further development of the model should therefore aim for a design with improved guessability and learnability. In conclusion, the present state of the Ergo-Index model is seen by the users suitable as a first screening method when assessing work tasks from an ergonomics and production performance perspective. Further development is needed to improve accuracy of work tasks involving push and pull, and to increase usability and reducing the need for detailed instructions of how to use the Ergo-Index model before final release.

Keywords. Ergo-Index, ergonomics, risk assessment, physical load, exposure time, usability, recovery, inter-rater reliability.

Ergonomic improvement in the handling of briquettes and pellets samples
A case study at the experimental hall at SSAB Europe in Luleå

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The load on the musculoskeletal system during the past decade been the dominant cause of work-related disorders. Musculoskeletal disorders are present in virtually all industries. Manufacturing is one of the industries that are particularly vulnerable to musculoskeletal injuries. According to a working environment survey conducted on behalf of the IF Metall has almost every third member musculoskeletal injuries, the most common causes of problems are stressful posture, heavy manual handling and stress at work.

The experimental hall is part of the laboratory section in the Department for Technology & Process Development of SSAB Europe in Luleå. Within the experimental hall director conducted tests on iron pellets, briquettes and other materials used in steel production. Work on the tests of the substances at the experimental hall is an important part of the production chain, the company is dependent on a functioning quality control in order to deliver a high quality product.

In conjunction with the risk inventory of manual handling of the experimental hall arises the need for improvement. The frequent manual handling with lifting heavy buckets sample between stations creates the risk of developing repetitive strain injuries among staff. A project group was aimed at improving ergonomic conditions.

The purpose of the study was to identify the manual handling of briquettes and pellets samples and to improve the flow from an ergonomically perspective at the experimental hall. The goal was that the results of the study could be used as a guide and inspiration for continued improvement with the support of the provision of systematic work.

The questions to be answered were; How can the manual handling at the workplace be reduced? How can the different flows in the workplace linked to improving ergonomic conditions? How has the systematic approach available on the company influenced the improvement work?

An ergonomic analysis was used to get answers to questions based on the type of work being investigated. Three different methods were selected; KIM (Key Item Method), QEC (Quick Exposure Check) Ergonomic and value stream analysis. The results of the risk assessments prior to the intervention, as well as the symptoms questionnaire that staff at the experimental hall had to answer revealed a consistent overall peak level due to frequent heavy lifting, combined with poor posture.

Based on the results of the risk assessments a layout proposals was developed by the project team. The results of the risk assessments for intervention as well as the inconvenience survey showed that the ergonomic conditions at the experimental hall improved significantly.

The study showed that; manual handling has been reduced by the project team developed lifting tools. By reducing the distance between the workstations, the various flows been linked, resulting in improved ergonomic conditions. The company's systematic approach has been the common thread in the improvement process. The recommendations given for further ergonomic improvement of the company were preferably; support and anchoring at the management level, participation in the working group, delineation and prioritization of corrective and preventive risk inventory through active systematic work.

Keywords: Systematic work environment management, Manual handling, Ergonomics intervention, Work environment management in industry

Communities of practices as means to develop creativity at work

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Background and purpose,
To cope with the frequent changes healthcare professionals must be creative. A Community of Practice (CoP) is a relational work community based on voluntary participation by practitioners of a particular work (e.g. intensive care unit nursing or maintenance of machine X) that interact and improve their practice. CoP are known for inducing a propensity to develop knowledge and foster creativity as practitioners interact and build relations, share ideas and discuss experiences.

Communities of Practice are often developed as a part of knowledge management initiatives. However, knowledge about how to develop CoP is still incomplete. This papers reports on an intervention study that contributes to the CoP field through the design and test of a method for CoP development within operations. The study contributes with knowledge about the design of a CoP start-up process and about connecting the CoP with the organization.

We propose a method to develop CoP and the method is tested in a blood analysis unit at 'Nordsjællands Hospital' in Denmark and the effect on creativity is evaluated. In order to develop the CoP the following interventions took place: The manager was introduced to CoP theory. The practice was operationalized narrowly as employees performing a specific operational task frequently and experiencing recurring problems. A voluntary CoP facilitator was identified and introduced to CoP theory. She then invited her colleagues to participate in the CoP. The facilitator arranged the start-up workshop where CoP participants were introduced to the timeline, the purpose of the CoP and templates to support collaboration. The facilitator arranged the following CoP meetings.

Design/methodology/approach
CoP level was measured at baseline and at follow-up (13 weeks after the intervention). Interventions were initiated just after baseline measurement. Process performance data and the procedure describing the practice were collected at baseline and at follow-up.

The 'Event Modifier Assessment Method' was used to control for effect modification by identifying events both part and not part of the intervention and estimating their effect on CoP.

After the intervention period the CoP development method was evaluated.

Results
The CoP participants had a creative collaboration and implemented improvements by drawing on their tacit and explicit knowledge. For example was the work process redesigned based on what 'felt' right for practitioners.

Discussion with practical implications (if applicable)
The study provides practitioners with an approach to organizing knowledge sharing within operations but practical circumstances such 24/7 production and changing shift patterns raises new questions about the viability of CoP in this is setting.

Conclusions
The method led to a CoP where creative collaboration took place but evaluation of the method shows that further research is needed. Also the questionnaire need further testing.

Keywords. Communities of Practice, knowledge sharing, creativity.

Analysis of Wrist and Elbow Motions of Grapes-Harvesting Tasks

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Background and aim: The grapes farming workers have to various different kinds of manual tasks, which include handling heavy materials or repetitive manual tasks in non-neutral postures. In particular, they have to repetitively use the scissors in order to harvest the matured grapes with the arms elevated over the shoulder height. These repetitive works seem to be the risk factor of musculoskeletal disorders in the wrists and arms, though there lacks of investigating how much the risk factor exists in the tasks. In this study, grape harvesting workers' postural workload was evaluated by means of measuring the motions of wrists and elbows. The aim of the study is to investigate objectively the repetitiveness and non-neutral postures in the wrist and elbows during harvesting grapes.
Methods: The wrist and elbow angles and the upper-arm motions of grapes-harvesting workers were recorded and analysed to investigate the characteristics of the agricultural working postures. Five agricultural workers (4 males and 1 female) participated in this study. Two electronic goniometers, attached to the workers' right wrist and elbow, were used in recording flexion/extension and deviation angles of the wrist and the elbow flexion angle while they carried out their normal harvesting tasks. Their tasks were classified into 7 different subtasks so that the subtasks could be compared in terms of the characteristics of upper-arm motions. In the analysis, average and 10th, 50th, and 90th values of amplitude probability distribution function (APDF) were calculated as the representative angles.
Results: In the comparison among subtasks, it was shown that the wrist deviation angles were significantly different between subtasks. For the flexion and extension angles of the wrist and elbow, the significant effects were shown in the 10th values of APDF. In the subtasks in which the workers usually use the scissors, the workers took more extreme wrist postures as compared to other subtasks.
Conclusion: The grape harvesting tasks were shown to be involved with high risks of non-neutral wrist postures, which need the measures to decrease the risk levels by adopting ergonomically designed scissors or work environments.

Keywords. Grapes-harvesting tasks, motion analysis, wrist and elbow postures, electrical goniometer.

Acknowledgement. This work was carried out with the support of Cooperative Research Program for Agricultural Science & Technology Development (Project No. PJ01001703) of the Rural Development Administration of South Korea.

Prediction of body core temperature with heart rate variability – a pilot study

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Background There has been a social need for evaluating real-time body core temperature for workers who are obliged to suffer extreme heat strain in their working place. Heart rate is not only easily measured through smart wearable system but also showing a strong correlation with body core temperature. Minimizing complicated intervention with various factors, e.g. cardiovascular health, is still regarded as an important task that has to be completed for actualizing an accurate real-time heat strain monitoring system. Heart rate only contains simple information about pulse frequency, whereas heart rate variability (HRV) provides more sophisticated analysis and has been used an indicator for compromised health. The thermoregulation effect on heart rate variability has been summarized, while there are only few reports on human exposures representing the relationship between HRV and increased body core temperature.

Aims This study was planned to explore the relationship between heart rate variability and body core temperature and to investigate which variables are most appropriate to be used in predicting body core temperature from heart rate for a practical application in the smart wear system to prevent workers' heat-related illness.

Methods One female subject was recruited and completed two experimental trials in this study. Air temperature and humidity in the climatic chamber was 25 °C and 40 % RH when participant wore firefighters' clothing and equipment, while it was 33 °C and 40 % RH with sportswear. The experimental protocol started with 10-minutes resting that continued with three 10-minutes cycling passes at 100 W of work load with 10-minutes breaks in between each pass, and followed by 1-hour recovery outside of chamber at room temperature (~21 °C). Rectal and skin temperatures and beat-to-beat interval (Polar Team2, Polar Electro, Finland) were continuously monitored throughout the whole protocol. Time domain analysis (e.g. SDNN, rMSSD), and frequency domain analysis of HRV were conducted with Kubios HRV 2.2. Subjective responses of perceived exertion and thermal sensation were recorded.

Results There was a significant correlation of rectal temperature with rMSSD (r=-0.740, p=0.014), but not with SDNN. The power of very low frequency (VLF; > 25 s cycle length) tends to show positive correlation with rectal temperature (r=0.614, p=0.059), whereas the power of high frequency (HF; 2.5 to 6.0 s cycle length) presented negative correlation with rectal temperature (r=-0.635, p=0.048).

Discussion and conclusions VLF is supposed to be affected by temperature regulation and humoral systems, whereas HF is primarily modulated by cardiac parasympathetic innervation. These results imply the greater contribution of decrease in parasympathetic tone could provide a cue to predict rectal temperature in a hyperthermic state. It was also supported by the relationship with rMMSD which reflects parasympathetic regulation of the heart. VLF is known for being affected by cold stimuli and hypothermia, but the current results implied the greater association with HF and rMSSD with hyperthermia. The continuation of this study with more subject could be directly utilized for developing a reasonably accurate predictive equation for core temperature, and thus, heat stress from pulse signal.

Keywords. Heart rate variability, heart rate, body core temperature, heat strain, smart wearable device

Driving Simulator Studies – Opportunities to Elicit Important Knowledge from Experienced Truck Drivers

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Driving simulators are used for fundamental research as well as a tool in product and system development. A common purpose is evaluations of technical solutions and their impact on, for instance driver performance or distraction. Driving simulators allow for controllability, reproducibility, standardisation, and easy access to objective data. They also provide opportunities for systematic evaluations of a larger number of new, conceptual designs, evaluations which would otherwise be difficult to accomplish. However, evaluations in driving simulators have been questioned. Unrealistic driving behaviours may be triggered and a lack of realism may affect the opinions of users. At the same time this subjective data is crucial in order to develop solutions that fulfil users' needs and requirements. The paper argues the importance of collecting this data and the particular contribution of experienced (professional) drivers. The basis is a series of driving simulator experiments performed within the project *Future Layouts for Driver Positions and Visual Information in Trucks* (FUDVI). The project aims to develop further knowledge on drivers' (choice of) driving postures in different traffic environments and how postures are influenced by cab design features, such as Camera Monitoring Systems (CMS) compared to traditional rear-view mirrors and alternative locations of in-vehicle information compared to traditional instrument clusters. In the simulator experiments, experienced truck drivers drove pre-defined routes, with new conceptual layouts and reference layouts respectively, while their choice of posture was video-recorded and head locations tracked by a sensor. Having completed a driving session, they were interviewed to share their experiences. Results obtained from the analyses of posture and head locations were subsequently compared with answers from the semi-structured interviews. The analysis of the interviews showed that the drivers had the ability to reason both strengths and weaknesses of the design concepts. They could relate to their professional experience as well as their actual needs. In addition, the semi-structured interviews allowed the drivers to associate and propose ideas that could improve safety and wellbeing in the cab. The findings from the interviews were also necessary when interpreting the video data and comparing the behavioural effects of the respective concepts, and generated further ideas that would otherwise be missed. Moreover, experienced truck drivers showed the ability to ideate different scenarios and discuss improvements to the designs as well as solutions on this basis. Thus, using expert users allow valuable voices to be heard and convey a new dimension to simulator studies, acknowledging users as 'subjects' with fundamental knowledge and experience of task and use context, rather than 'measurement devices' only. The collection of objective data and qualitative feedback from expert users can continuously build a database of systematically proven knowledge regarding concepts and behaviour effects.

Keywords: Driving simulator, truck cab design, evaluation, CMS, rear-view mirrors

Seating Pressure Distribution for Different Chair Types

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Background and purpose Complaints related to supportive and locomotive areas of the body are one of the main reasons for sickness from work. Neck and back pains especially have increased to a remarkable level to prevent sufferers from being able to work. Normal seating positions result in the delivery of large-scale pressure levels over the thighs, buttocks and genitals which weakens the circulation in soft tissues and the legs. The purpose of the study was to investigate the different pressure levels caused by eight different chairs, and the distribution of this pressure between the thighs, buttocks and genitals.

Design Nine volunteers participated in the study (five women and four men). The average age of the subjects was 32 years (range 21-55 years). Before any pressure measurements took place, the knee and hip angle for each test subject was fixed in such a manner so that it remained at an angle of 135 degrees for each of the different saddle chair. Each test subject's eyes were covered so that they would not be able to see which particular chair they were sitting on at any moment. They also couldn't see the different chairs that were being used for the study beforehand. Seating pressure levels were measured using the Tekscan pressure mat (Tekscan Advanced ClinSeat DB, v.5.64C, Tekscan Inc, Boston MA, USA) during 20 seconds and the pressure mat was also calibrated according to the weight of the test subject.

Results In the measurement of seating pressure levels for eight different chair models, the smallest pressure area was found when the subject was sitting on Chair G (the Salli Twin) for all test subjects. Seating pressure was especially notable around the area of the genitals. For all test subjects, pressure levels around the genitals whilst seated on the split-seat saddle chair, Salli Twin, was the lowest when compared to the other chair models.

Conclusions Of the chairs that were included in the research, the split-seat and height-declination adjustable Salli Twin places seating pressure over the smallest area of the body. Pressure is not aimed over the pectineal line or the genitals, so that blood circulation in tissues and the metabolism in the relevant areas remain active. The seating position is naturally straight and individuals' legs do not go numb even while they have been seated for longer periods of time.

Keywords. Seating pressure, saddle chair, chair ergonomics.

Development of a summation method to estimate clothing insulation and thermal comfort based on clothing design – a preliminary analysis

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Clothing insulation is one of the basic parameters that affects human heat exchange with the environment. There are available standard methods, e.g. EN 15831, to measure individual clothing items' and combinations' insulation. Another international standard (ISO 9920) presents databases and allows summing individual items insulation. However, it does not account for many effects that occur when dressing the clothing combination. For example, summation suggestions do not consider the effects of tucking shirts into pants, compression of the inner layers by the outer ones etc. Also, the database in standard is presently much based on western clothing.

An aim of this study was to define important clothing textile and design parameters that affect insulation of the clothing combinations based on available clothing studies and databases. Such an overview would support preparations for improving the summation method, that allow for more accurate risk assessment and selection of appropriate protective, functional clothing for work tasks in any environments, thus, diminishing the risks for thermal stress.

The methods included the review of available clothing research where detailed data on clothing parameters was available. A revision of accessible databases was carried out. The available data from studies on clothing items summation and combinations testing was evaluated, and if needed re-calculated in order to estimate the benefits of the planned work.

The presently used summation method allows in certain cases up to and even above 30 % difference between calculated and measured insulation values of the clothing combinations. For advanced modelling of human exposure it is too large error. A calculation error of less than 10 % could be acceptable, while less than 5 % would be preferable. A variety of parameters were defined that are of interest when taking up the work with improvements of the summation method, such as body shape, clothing fit and size. Also, draping, the number of layers and their stiffness and compressibility, but also layers' position in the clothing system does affect the summation outcome. Databases on dynamic effects on clothing indicated that length of the freely hanging clothing layer(s) has a strong impact on clothing ventilation.

Choice of textiles and clothing design affects thermal insulation, and insulation changes under dynamic conditions are in the standard not fully accounted for. The present evaluation did list a number of parameters that have major influence on

clothing insulation and that should be considered when preparing new algorithms for summation of individual clothing items.

Keywords. Thermal insulation, textile properties, clothing design, summation method, clothing piece, clothing ensemble.

Enhancing the collaborative design of safety management practices in education

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Work demands at schools are continuously changing. Digitalization and curriculum renewals, for example, are reshaping the methods and objectives of work. Parental challenges and socio-economic problems within families have increased, and these often overshadow teacher-pupil and teacher-parent interaction in practice. From the safety perspective, this means that in addition to teaching, organizations and employees now have to be able to manage disturbances and adapt their actions to varying circumstances. Although the challenges to safety and well-being are currently widely recognized, the safety management practices of schools are still in need of development. In this study, our interest lies in proactive safety management and anticipation, and in managing the occupational safety and health (OSH) of employees in particular.

The aim of recent new safety paradigms, for example Safety-II thinking and resilience engineering, is to emphasize the resources of individuals and organizations for proactively and reactively handling safety risks in complex and changing environments. These paradigms turn the focus of safety management from eliminating risks and failures to advancing flexible and successful actions, also in unexpected situations. Safety work thus requires anticipation, learning, and understanding everyday activities and potential design flaws and functional drawbacks.

The change workshop (CW) is an Activity Theory-based intervention method that aims to promote collective learning and the transformation of work activity. The CW, which is widely used in organizational interventions, helps build a shared understanding of everyday activities, which according to new safety paradigms is a prerequisite for safe work. A CW intervention follows the Vygotskian idea of double stimulation, which means that researchers (facilitators) collect and select relevant data to mirror everyday work situations, and offer participants tools and models to analyse the data in order to create a joint view of the work activity, deepen the understanding of its problems, and to find ways in which to overcome the systemic causes behind these problems.

The aim of the study presented in this abstract is to analyse the collaborative development of safety management during the CW intervention, which will be conducted among principals and OSH actors in a city organization (CityX) during 2017. Our data will consist of transcribed discussions from three CW sessions. Our particular interest lies in collective learning during the intervention, and thus we ask: How do the workings of CW enhance the collective view of changing work and deepen the understanding of safety demands and challenges? How can the participants design proactive practices and tools accordingly? We will contribute to recent safety research

by offering concrete methods for enhancing the development of safety management in line with new safety paradigms.

Our paper is based on the Safety Promotion at Education (EduSafe) project (2016–2018), which is funded by the Finnish Work Environment Fund.

Keywords. Safety-II, Resilience, Education, Activity Theory, Work development.

Development of the online course "Work and Technology on Human Terms

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Background and purpose The technical universities in Sweden offer basic courses in human factors engineering, ergonomics, work science and related topics. The aim of the courses is that the students acquire knowledge and skill, in order to, in future position as product developer, production engineer, manager or leader, design products and workplaces with consideration to human abilities and limitations.

In collaboration with five Swedish technical universities, Prevent has produced an e-learning course based on the existing textbook "Work and technology on human terms".

An e-learning not only provides availability but also other educational opportunities compared to a traditional textbook or lectures. Thus the purpose is to enhance the quality of the existing traditional university courses in the subject, as well as to create new courses. E-learning might attract more students for the subject, not only in engineering programs, but also in programs of economics and human relations. The parties of the labour market also see that e-learning is a suitable tool for professionals, to strengthen their skills in work science and human factors engineering.

Method/Approach The production was organised in a project managed by Prevent together with a producer of e-learning. The organisation of the project had five subprojects with 25 direct members. Furthermore a large number of businesses, leaders, employees, researchers and safety engineers participated in filmed sequences and interviews. The project was implemented in four phases; 1) Needs analysis and design, 2) Script, 3) Production (filming, illustration, animation and assembly), 4) Implementation with an ongoing reconciliation and continuous testing.

Results The outcome of the project is a web-course in English covering:

1. Introduction – Human-Technology-System.
2. Psycho-social and organisational environment.
3. Physical environment.
4. Information and interaction in technical systems.
5. Methods and design processes.

6. Economic and legal conditions (in Sweden).
7. Four workplace cases for practical application of the knowledge.

Totally it takes approximately 15-20 hours to conduct the whole web-course.

The teaching material largely consists of filmed reportages and interviews with researchers and professionals in different businesses. Theoretical context and models are illustrated in animations. The course is available free of charge and the student can start and stop the training independently of other students. It also includes self-correcting knowledge tests.

The universities and others can use the entire e-learning or choose parts of it as a teaching material in their own courses, supplemented with for example laboratory exercises and case studies.

The intention is that the course will be of use not only in the Nordic countries but around the whole world. The aim is that the course should contribute to develop more safe and healthy workplaces so people not only can maintain good health during their working life but also be able to retire in good health.

Keywords MOOC, MassiveOpenOnlineCourse, Ergonomics, Work environment, Human-Technology-Organisation

The Sacurima COST Action: Towards a Better Safety Culture in Agriculture

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This new EU COST Action aims to explore reasons why agriculture worker's well-being lags behind other sectors, and why some countries have been more successful than others in reducing agricultural injuries and illnesses. Agriculture is one of the most hazardous industries in the EU, measured by work-related injuries, illnesses, disabilities and deaths. Statistics and studies show great differences in national injury and illness rates, as well as approaches and support for prevention of these adverse outcomes. Only few successful interventions have been found in systematic reviews.

Understanding of the determinants of safety culture is lacking and consequently, well-informed actions to improve health, safety and risk management cannot be made. This COST Action will 1) evaluate health and safety programmes and approaches on the national level, 2) identify knowledge, attitudes, behaviours and priorities among farmers regarding safety, health and risk management, 3) identify effective measures for training and integrating vulnerable populations (including refugees) into the agricultural workforce, 4) develop means and indicators for monitoring progress and evaluating the impact of interventions on injuries and illnesses in agriculture, and 5) disseminate results to stakeholders and the agricultural community.

The Sacurima COST Action will produce benchmarked and evidence-based recommendations to inform and guide national initiatives and efforts. The results will be made available to the scientific community, policy makers, vocational training, administrative and insurance personnel, farmers and practitioners working towards better social sustainability and safety culture in agriculture. The COST Action will also create new European and international research networks. Further information on the COST Action is available at http://www.cost.eu/.

Keywords. Agriculture, Safety Culture, Risk Management.

A Holistic Approach to Healthy Indoor Environment

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The quality of the indoor environment is determined by many factors: indoor-air-quality, thermal comfort, light, aesthetics, sound etc. These factors are further influenced by the outdoor-environment, building design, people, behaviour, building quality and even more global factors, e.g., the concern of energy consumption, sustainability, policies, socio-economic impact and considerations etc. It is also known that the quality of the indoor environment may have significant impacts on human health, productivity and learning capability. Such impacts will in return influence the society, buildings, policy making etc. Indoor environment is not an independent phenomenon.

It is difficult to achieve a healthy indoor environment from only one perspective without an understanding of the broader picture. Therefore an inter-disciplinary research theme named "Healthy Indoor Environment" has been created at Lund University. The scientists included in this theme covered multiple disciplines: engineering, medicine, psychology, microbiology, natural sciences, aerosol science, ergonomics, architecture, building physics, building materials, materials and services, energy science, and acoustics.

The aim of the research theme was to create a cooperation platform focused on healthy indoor environments and to gain a more complete picture of the many complexities associated with the indoor environments by bridging different research areas and study their complex interactions. System analysis and complex thinking were applied by taking into account of the contributions from stakeholders related to indoor environment and their complex interactions. It also seeks to locate important directions and focuses of the future research. The overall goal is to improve our understanding of how to create a sound and healthy indoor environment.

Keywords. Indoor Environment, Health, occupants, inter-disciplinary research, systems analysis, complex thinking

Informal caregivers' perceptions of their physical load issues and safety

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Informal caregiver (later used term 'caregiver') does not have an employment but has signed an informal care agreement with the care receiver's municipality of residence. He gives informal care for elder, disabled or seriously ill relative, or for child with special needs. Caregiver can leave their job, can be in working life or retired. He helps the care receiver with activities of daily living (medication, takes care of basic needs for someone who is not able to do these things alone and takes care of the household). With an increasingly aging population, the role of caregiver has been recognized as an important one, both functionally and economically.

As studies usually focus on the mental health of the caregivers, this survey consisted of 9 open-ended questions of both mental and physical well-being. The Internet-based survey was shared through the channels of the Central Association of Caregivers in Finland. The main interest of the survey was to get information about well-being and safety of caregivers and get information to innovate good practices to improve the quality of life of caregivers.

Due to the sharing channels of the survey, it is not possible to say for sure what the response rate is. However, for example the Central Association of Caregivers in Finland has approximately 2,000 followers in their social media site and the survey was there. Altogether 154 respondents answered the survey. 91% (140) of the respondents were women and 9% (14) were men. The average age for the whole group was 50.3 year and the average time as a caregiver was 8.1 year.

The focus in this study is on the questions "Tell us about a situation when you had a feeling of insecurity" and "Have you hurt yourself physically while acting as a caregiver? How?". The answers were divided into specific themes by applying open coding by the researchers. The main results for the first question were that 32% (64) of the respondents have felt insecurity when they worry about the care receiver (e.g. when the care receiver had seizure and the respondent was not able to help), 18% (35) have felt insecurity when there is uncertainty about treatments or with finances, 15% (30) have felt insecurity when their own well-being is in a bad state, 14% (27) have not felt insecurity and 11% (21) have felt insecurity when they or others have been threatened by the care receiver. For the second question, the main results were that 52% (80) of the respondents answered that they have not hurt themselves physically and 42% (65) have

hurt themselves physically (e.g. back issues or some sort of violence).

In this study the focus is on physical health. From the answers can be seen that 11% of the caregivers have feel threatened physically by the care receiver and 42% have hurt themselves physically in some way. It is important to discuss caregiver's physical health in addition to mental health. The follow-up research will focus on how to reduce the caregivers' physical load issues.

Keywords: Informal caregiver, well-being, physical load, physical health

How not to run into a wall: A comparative experiment of Movement in Virtual Reality

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Background and purpose. Numerous studies suggest that head mounted Virtual Reality (VR) displays can induce motion sickness and disorientation. A contributing factor is the mismatch between the physical space dimensions and the virtual environment (VE). When the VE covers a larger area than the physical space, then a supply function is needed to increases the VE movement range. Two commonly used movement techniques are drag/floating, and teleporting. Drag/floating can induce motion sickness whereas teleporting can cause disorientation. Thus different discomforts emerge depending on the movement technique. The goal of this study was to investigate this issue and to develop a new technique that avoided both motion sickness and disorientation.

Design/methodology/approach. The research was composed of four components. First, existing VR movement techniques were benchmarked. Second, the benchmarking results were presented at a workshop with Scania's Driver Vehicle Interaction Group where new techniques were discussed and a subset of potential techniques defined. Third, from the workshop data, three techniques were selected and implemented; Drag/Floating, Teleport, and a novel technique (Concept). Fourth, a 2x3 within-between study was conducted with twenty-four participants. Participants completed two tasks within a VE as fast as possible. Variables manipulated were Distance Moved (Long, Short) and Movement Technique (Drag/floating, Teleport, Concept). Of interest were motion sickness (measured via the Simulator Sickness Questionnaire), disorientation (map positioning), efficiency (time to complete), and ease-of-use.

Results. Results indicated that Teleport best supported ease of use and induced comparatively minimal disorientation.

Discussion. Based on the data, Teleport was the optimal technique. The favourable results for Teleport could be due to either that the teleport technique was the easiest to use, and therefore participants did not need to focus on the movement technique itself, or because features of the technique reduced discomforts. In comparison, Concept appeared too complex for participants.

Conclusions. We suggest that the teleport movement technique is currently today better than the two other techniques tested. Further investigation into the teleportation technique and how it can be further improved is encouraged.

Keywords. Virtual Reality, Interaction, Movement, Motion Sickness, Disorientation

Speakers' comfort and voice use in different environments and babble-noise. Are there effects on effort and cognition?

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Background and purpose Speakers have been shown to be able to predict the speaker-comfort of an environment. Teachers have high vocal demands in their everyday work. Previous research indicates that teachers with voice problems make use of the room-acoustics differently than their voice-healthy controls. Hence, a beneficial acoustical work environment is crucial especially for teachers with voice disorders. Despite this, the perspective of the speaker is rarely taken into account in classroom design and acoustical treatment. The aim of this study was to investigate what vocal changes healthy speakers and speakers with voice disorders do in different acoustical environments and noise conditions, and how they perceive the vocal effort. A further aim was to investigate the listeners' perception of the speakers and the spoken message and also the listeners' ratings of the listening effort. *Design/methodology:* The study has a within-subjects design. Nine female speakers, voice patients and voice-healthy controls were exposed to four controlled, acoustical "environments" mounted in the same room: 1. stripped; 2. wall- and ceiling mounted absorbents; 3-4 as 2 but with extra ceiling absorbents and in two positions. The speakers were equipped with a voice-accumulator and simultaneous voice recordings were performed during 3-5 minutes of free speech and a structured task: description of a fictive map. The speakers were recorded in three noise conditions in each setting: silence (28dBA), classroom noise (60 dBA); day-care noise (75 dBA). A panel of listeners were sitting at fixed positions in a classroom set-up. Both listeners and speakers rated effort on VA-scales. The recordings were later analyzed by an expert panel. *Results*: There was a co-play between the rooms and the subjectively assessed vocal- and listening effort. The speakers' ratings of effort and the voice analysis were aligned and showed that there was a significant difference between the rooms regarding perceived effort, and the voice parameters grade of voice disorder and press. The "room" with no or little acoustical treatment was considered as the most vocally favorable. There was also a correlation between vocal effort and cognitive strain. *Discussion:* This result support previous findings that a well-damped room gives too little support to the speaker. Hence, the speaker's comfort is reduced and vocal health is jeopardized. The results indicate that the speakers' effort taxes cognitive capacities which might hamper communication at large. *Conclusions:* This knowledge may contribute to the understanding of vocal load and also to the area of

classroom acoustics, speakers' comfort in general and also hopefully, to the area of classroom design.

Keywords. Voice, speakers' comfort, teachers, voice ergonomics, classroom acoustics.

Innovative Training Networks for Interactive E-Learning and Application of Ergonomics of the Remote Evaluation of the Grafts in Organ Transplantation

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Background and purpose: The process to build a better safety culture, improve outcomes, make evidenced decisions and enhance personalization in Organ Transplantation (OT), starts with an effective understanding of the effects when human factors engineering refer to the remote evaluation of the quality of the grafts. The project refers to Prometheus pn:2003016 technology, method and clinical standard analysis integrated with Innovative Networks for Computer Assisted Collaborative E-Learning among specialists in the procurement phase of (OT) for training in the clinically applied ergonomics of the remote evaluation of the grafts and in the pre- and post- grafting and pre-transplant decision making and planning with a prospect to integrate with Hyper-computers and learn Big Data analytics and computing.
Design/methodology/Results: The tele-medicine device Prometheus pn:2003016 integrated with the Hyper-computer ARIS (IBM) of the Hellenic Ministry of Education for implementation of Big Data analytics in the Tele-Radiological Tele-Pathological, Tele-cytological, Tele-Microbiologic and Tele-molecular evaluation of the grafts in the procurement phase of OT for informed decision making about their quality and acceptability in simulating inter-hospital interactions and for benefiting from Big Data analytics in OT. **I.** Experimental clinical simulation of the remote evaluation of solid thoracic and abdominal grafts basing on a clinical scenario, processed between the Aretaieion University Hospital of Athens and the transplant unit of the Hippocrateion University Hospital of Thessaloniki on 28.06.2016, as a real-time prospective trial under the auspice of the research program of ''Excellence'' of IKY. In this context the Hippocrateion Hospital of Thessaloniki simulated the recipient hospital and processed the real time uterus graft tele-microbiologic evaluation, in cooperation with the department of pathology of the Medical School of Athens for real time pre- and post-grafting tele-cytological and tele-pathological evaluation of the uterus graft, and with the radiological team of the Attikon University Hospital for pre-grafting real time tele-radiologic evaluation of all abdominal grafts. Integrated analysis of reliability of the remote evaluation of the Liver, Pancreas, Renal and Uterus grafts according to the clinical scenario before and after retrieval confirmed the high diagnostic accuracy of the method for each graft according to its pathology (Inflammation/infection or/and Injury/trauma, or/and Neoplasms/ Cancer)-:Liver:Accuracy=97.5%, Pancreas:Accuracy=95.1%, Kidneys: Accuracy=97.6%, Uterus: The dynamic pre-grafting tele-cytology and tele-microbiology of the Pap-smear of the cervix of the uterus confirmed an accuracy of 99%. **II.**Another experimental interactive collaborative learning trial of the remote

evaluation of Heart and Lung grafts on 08.09.2016, confirmed the high accuracy for the remote diagnosis of pathology of the Lungs: 94.1%-97.1% and of the Heart: 90.9-100% and attested the high feasibility and reliability of innovative networks for Prometheus pn:2003016 supported collaborative learning to minimize the diseased grafts and benefit from Big Data analytics in OT world-wide. *Discussion with practical implications and Conclusions.*:Ergonomics of Innovative Training Networks for Interactive E-Learning of the remote evaluation of the quality of grafts and decision making about their acceptance is feasible and reliable to be instructed remotely and interactively, while integration with Big Data analytics E-learning may sustain a surveillance for minimization of diseased and damaged grafts and optimize quality in OT.

Keywords. Transplantation, Remote Evaluation of Grafts, E-Learning, Collaborative.

Reliability of Applied Ergonomics of a New Mobile Clinical Unit for Remote, Specialized, Multidisciplinary and Personalized Service for Cancer and Diabetes Complications Integrated Prevention, in Developing Countries

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Background and purpose: Reliability analysis of applied ergonomics of the clinical operations of a new mobile clinical unit (MCU), tele-medicine and cloud based technology and method for remote, specialized, multidisciplinary, holistic and personalized process and service for general for cervical and breast cancer for women and prostate cancer for men and for special for diabetes related complications primary, secondary and tertiary prevention with an emphasis on diabetic foot and amputations in developing countries, on three dimensions of effectiveness: 1.Medical outcome (effectiveness), 2.Cost-benefit analysis of resources and 3.Fulfilment of the personalization issue. *Design/methodology/Results:* The experimental process based on two partners (a non-specialist doctor or a nurse in the mobile clinical unit in four places in the periphery of Hellas and a specialist doctor in the diabetic foot clinic DFC). The partners were linked with each other via a cloud tele-medicine network. Applying the aforementioned technology and method, specialists from the diabetic foot clinic examined the digital medical record enriched with digital photos of the diabetic foot and ulcers of the examined diabetics from August to September 2015. Fifty (n=50) participants -who were located in three different rural places in Hellas- who, during the session, first under-took general related to their gender prevention guidance for cervical, breast and prostate cancer prevention and then special for diabetes related complication primary prevention (diabetic foot, obesity, quit smoking, cardio-circulatory, ocular, neurologic, psychiatric). Then only diabetics examined clinically and in case there was a high risk patient for amputation a telemedicine approach, applied. The majority of patients were pensioners (n_1=23).The 60.0% of the participants were females. Only, 6.9% of women had ever undertaken Pap-test or mammography and only 22.0% had ever been subject of massive prevention. All participated in the general prevention session and about n_2=29 were finally examined. Almost 50.0% of the participants were diabetics and the 65.5% of them were females. The mean age of the patients was 65.9y. There were seven (n_3=7) remote interventions -out of the 29 local clinical examinations- while four (n_4=4) of the examined diabetics were in high risk for amputation. All seven remote interventions prevented complications while four (n_2=4) very possible amputations were finally prevented (in one year and a half

follow-up). Analysis showed a cost-effectiveness of the MCU operations (p=0.008). *Discussion and Conclusions.:* Reliability analysis of applied ergonomics in the clinical operations of the new MCU showed high feasibility and reliability in terms of effectiveness. The latter is attributed to the lower cost of resources and operations as well as to the capacity to recoup expenses and increase local capital by preventing leg amputations and mainly by saving expenses for disability pensions if tertiary remote interventions are successful.

Keywords: Mobile Clinical Unit, Tele-medicine, Prevention, Diabetic Foot

Could the use of unstable, shock absorbent work shoes reduce musculoskeletal discomfort? A pilot study among employees in a large supermarket

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Background Symptoms from the lower back and lower extremities are very common among workers exposed to work tasks including long term standing and /or walking.

Purpose The purpose of the study was to investigate whether the use of an unstable and absorbent shoe, MBT (Massai Barefoot Technology), could decrease self-rated discomfort in the lower back and lower extremities among workers in a large shopping mall in Sweden.

Method 70 workers with perceived discomfort in feet, legs, back, shoulders and/or neck volunteered to test, MBT, an unstable and absorbent, shoe for 5 months. Among the employees 35 workers were selected at random by the company to participate in the study. 35 workers were used as the comparison group. Both groups rated their perceived discomfort in 13 different areas; in neck, shoulders, upper back, lower back, pelvis, hips/thighs, knees, calfs, heels, ankles, feet, on a scale of 0-10. Frequency of tension/fatigue was also rated in 3 areas, neck/shoulder, back and feet, at baseline and at follow-up after 5 months. In the intervention group 25 participants completed the study. In the comparison group 10 participants completed the study.

Results In the MBT-group there was a decrease in discomfort with statistical significance where $p<0,01$ from baseline to follow-up in most of the estimated areas as well as in frequency of tension/fatigue. In the comparison group there was no significant difference from baseline to follow-up.

Conclusion The decrease in discomfort in neck, lower back and lower extremities was confirmed in the MBT-group after using the MBT shoe for 5 months. In the comparison group there were no confirmed differences from baseline to follow-up. MBT, an unstable and absorbent shoe, can be used to lower the discomfort among workers in walking and standing work tasks. It can also be used by physiotherapists as an adjunct to treatment.

Keywords: Work shoes, musculoskeletal, pain, discomfort, foot, knee, hip, lower extremities, low back pain, walking, standing

Are well-being and joy at work related to age?

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Background and purpose:
According to Slovenian legislation, older workers – aged above 58 – are a group protected from being fired. We tried to identify differences between two groups and the most important griping points for retaining workers' joy and well-being for the whole senior working period.

Method:
Questionnaire of actual availability (QAA):

- 47 items with 5 point scale
- Composed in 7 subscales of well-being
- Self-estimated levels of fatigue and well-being
- Based on AH model
- Validation: 20000 Slovenian workers

Sample:

- Service workers: 1884 (1400 female, 484 male)
- Age: all above 50
- Origin: 3 financial institutions
- Education: secondary education (majority of them)
- Younger workers: age between 50 and 57 (1646 workers)
- Older workers: age above 58 (238 workers)
- Data: results from QAA during normal (average) working day

Results:
Average level of well-being in both groups is in the interval of adequate well-being, but in the youngest group the variation is higher and values are slightly higher than in the older group.

Average younger workers (50-57) report more fatigue, less joy and lower well-being. Difference in perception of well-being includes more parameters; the most important difference is in perception of psychical fatigue. In this group, variability is also bigger due to more differences between workers.

In individual interviews we identified root causes of lower well-being among workers. Identified root causes are possible griping points for interventions in creation of work that is pleasant and attractive for all age groups.

The most important root causes for lack of joy at work are education, position, fear of losing a job, menopausal problems, motivation, lack of flexibility and poor adaptation.

Conclusion:

Joy at work depends on the age. Younger workers (50-57) are the most vulnerable group – they are not protected, they have to work for additional 10 years, they have to adapt to new technologies, procedures and new working reality. To increase their competitiveness, they need special concern in training procedures, because they have to learn new tasks. Despite some disadvantages of younger workers, employers have to be aware of the fact that these workers still have some competitive advantages.

For future working environment, long lasting adaptation and retention of adequate flexibility is crucial. Workers in services have to get adequate support in creation of their competence on the job market. They have to be aware of their advantages and benefits of their experience. But they also have to be aware that their flexibility depends only on them. Different age groups at work need adoption of new work organization. More skilled tasks should belong to older service workers; tasks demanding fast adaptation are more tailored for younger workers.

Special concern has to be given to creation of working teams where each worker has possibility to realize his/her competences to the maximum. The consequence is work offering long-lasting adequate well-being and joy.

Keywords. Well-being, service work, flexibility, younger workers, older workers, work restructuring

Computer Work and Environmental Stress

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Background and purpose

Exposure to glare during computer work is visually demanding and may lead to eye symptoms (Wolska and Switula 1999, Thorud, Helland et al. 2012). Direct glare has previously been shown to increase trapezius blood flow (Mork, Bruenech et al. 2016). Further, glare exposure has been linked to decreased reading performance (Glimne, Brautaset et al. 2015) and alternations in fixation disparity (Glimne, Seimyr et al. 2013).

To elucidate the effect of glare, this study investigated how direct glare and psychological stress influences trapezius blood flow, sitting position, blink frequency, moods and symptoms.

Design

Forty-three healthy women (21.4 ± 2.4 years, mean ± SD) with normal binocular vision participated. Informed consent was obtained.

The participants performed four 10-minute computer tasks (counterbalanced design) with different stress requirements:

- Low stress (LS)
- Visual stress (VS)
- Psychological stress (PS)
- Visual and psychological stress (VPS)

The computer task was proof reading conducted at a visually and ergonomically optimized workstation. Visual stress was induced as direct glare, and psychological stress as time-, efficiency- and evaluation pressure.

Trapezius blood flow was measured using photoplethysmography. Head and back angles were continuously registered using dual-axis inclinometers.

Symptoms (eye-, head- and neck/shoulder symptoms) and psychological stress indicators (positive/negative state moods; i.e. stressed, strained, concentrated, satisfied etc.) were recorded using visual analogue scales (VAS). Blink frequency was registered throughout PS and VPS through filming the participants (psychological stressor).

Results

The direct glare exposure throughout VS and VPS resulted in increased muscle blood flow in trapezius, compared to LS. This effect was not apparent with exposure to psychological stress. Development of eye tiredness was also significantly greater in VS and VPS compared to LS, and in VS compared to PS. In all conditions, eye tiredness correlated positively with self-reported negative moods and neck pain, and negatively with concentration.

For PS and VPS the participants blinked significantly less during the first minute, compared to the rest of the work sessions. Additional, a higher increase in blink frequency from the first minute to the rest of the computer session was found in VPS, compared to PS.

With psychological stress exposure (PS and VPS), the participants leaned their back significantly more forward, compared to VS. They also bent their head more forward in VPS, compared to LS and PS. There was no correlations between posture and trapezius blood flow.

Discussion

Results indicate that direct glare exposure during computer work affects trapezius blood flow, blink frequency and development of eye symptoms. Further, eye symptoms are associated with negative mood, neck pain and the womens' concentration.

Psychological stress made the participants lean forward during computer work. Adding visual stress, they also bent their head more forward, probably to avoid the glare source. However, the study indicates that changes in sitting posture may not explain the observed increase in trapezius blood flow during visual stress exposure.

Conclusion

Exposure to stress factors during computer work affects young, healthy women. Organization of computer workstations should try to minimize potential environmental stress.

The study was supported by grant from the Norwegian Extra Foundation for Health and Rehabilitation / Spine Association Norway.

Keywords. Computer work, direct glare, psychological stress, eye symptoms, blinking frequency, sitting posture, trapezius blood flow.

Is the Importance of "fun at work place" underestimated? – A cross-cultural perspective on work environment factors for creativity performance

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Work environment is a complex blend of different factors which jointly affect the creativity performance of employees. Traditional focus of creative work performance is related to creative personality. However the personality itself is only a part of the whole picture of creativity (McCoy & Evans, 2002). Work environment as blend of physical environment, social interaction, organizational structure and different activities plays important role in employees' abilities to generate creative content. As creative personality itself is not the only drive of creativity, importance of socio-organizational work environment was introduced. Recently increasing number of researches is talking about the role of physical work environment. As the new economy is driven by fast changes, the need for new ideas and innovative solutions is recognized as an important challenge and opportunity as same time. To be able to answer to this fast changing business world increasing number of world leading companies are considering the importance of "fun at work place" for creative performance. This concept introduces work space that is full of fun supporting activities which create atmosphere for employees to feel free in expressing themselves, but not blocked or constrained to think, innovate and generate new creative solutions.

This approach started in Silicone Valley during the dot-com era when increasing number of start-up companies appeared on the market (van Meel & Vos, 2001). Many of the companies recognized as *The 100 Best Companies to Work for in America* have made having fun as part of their corporate mission (Levering & Moscowitz, 1994). The trend suggests that "fun at work place" concept has started in USA and is well recognized and well accepted in the USA. This raises the questions "is the importance of fun at work place underestimated and differently accepted in different cultures?".

This research aims to understand the differences in current level of application of factors from physical work environment, socio-organizational work environment and

fun at work place on sample of ten countries. Primary research in form of written questionnaire has been distributed in the ten countries among MBA students with working experience. They were asked questions about their current and ideal work environment in terms of factors which create physical work environment, socio-organizational work environment and fun at work place.

Furthermore the research supports understanding of employees' perception of ideal work environment in each of the ten countries in terms of presence of those factors for support of creative performance. Result applications are very pragmatic and applicable in terms of managerial practices. Results can be used as basic platform for improvement of current work environment toward achievement of ideal environment for creative support. Furthermore results can serve to researches and practitioners for better understanding of position of "fun at work place" element of work environment in the perception of employees. Based on the research results further action toward spreading the importance of "fun at work place" for creativity support can be taken.

Keywords. Fun at work place, Creative work performance, Work environment, Cross-cultural perspective

Assessing the Digital Work Environment: a Case Study of Digital Transformation in Higher Education

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Background and purpose
The on-going digital transformation provides many opportunities but there are also risks of negative effects on the workplace. A successful digital transformation requires insight into the status of the digital workplace. While other aspects of healthy workplaces are rather well understood, research relating to digital transformation and organisational ergonomics is still limited.

This study has the overarching purpose of analysing existing tools in order to shed light on current best practices. This has been done as part of an action research project focusing on a large-scale implementation on an administrative system for student affairs in higher education.

Methodology
The study was designed as a combination of: analysis of data from the organisations business information systems, interviews with administrators and a survey sent to 322 of administrators within the organisation (with a response rate of 54%) . The survey utilised established survey tools for examining ICT in the workplace; the UsersAward survey, a survey tool from Prevent, and the well-known System Usability Scale (SUS). The support-demand-control model was used as an interpretative framework. This being part of an action research project, it has also been possible to trace some of the effects of the results in practice and discuss their actionability. Preliminary results indicate that on a strategic level assessing the digital work environment provide valuable input. Yet, on a more direct level the results from the survey tools are harder to convert into action.

Results
The results indicate high demands on staff, driven by service level as well as technology gaps. Control also varies and here results indicate that job experience is really important. This can be a challenge as a number of administrators will retire over the next few years and will be replaced with new staff that might lack similar experience. While the support organisation was rated high, what was lacking was the higher-level support from management.

Discussion
The main contribution of this paper is related to the application of tools for assessing the digital workplace. The study also contributes towards strategies for improving

organisational ergonomics and resilience during digital transformation: The first is to acknowledge the changing role of the workers, in this case the administrators. The second is to develop networks that allow for support and development of best practices between departments. The third is to provide high quality support.

Conclusions

Existing survey tools do provide insight into the digital workplace but there are also blind spots that need to be addressed. Further research is needed and a next step will be a closer examination of the tools used and possible alternatives/extensions to these.

Keywords. digital work environment, survey tool, digital transformation, digital workplace, action research project, survey result

Intervention for a sustainable and rewarding extension of working life

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The workforce is aging in many countries and many organisations and businesses need to keep their older workers to ensure competence, continuity and quality.

The objectives of this study was to increase the knowledge on how to make the working life sustainable for all ages and how to keep older employees' competences and motivate them to work in an extended working life.

Method: An intervention study was conducted autumn 2016 - spring 2017, including six research-led education meetings and organisational development work from the participants. The participants was managers and HR-personal from municipalities and SME in south Sweden. The first five meetings as scheduled as education with lecturer, case discussion and homework. The meetings were based on results of the research programme "A longer working life" and the participants' perspectives and followed principles of action research where researchers and participants jointly formulate research questions and explore possible solutions. The themes for the meetings were: Statistics and theories regarding sustainable working life and older employees, EU and Work Environment authorities' priorities regarding extended working life, Action plan for health-promoting workplaces, Social insurance and Labour agency support for seniors, Mental retirement or sought senior talent. The last meeting was devoted to the evaluation of the intervention and the future planning for the participating organisations regarding their ongoing work to implement a sustainable attitude for older employees.

Result: The participants, the researchers and lecturer had inspiring discussions to develop the potential of different activities for their older and experienced employees. The participating managers and HR-personal spread their newfound knowledge from the intervention project in their organisations and in their networks. These effects were followed up by research by meeting notes, surveys and interviews.

Conclusion: The study proved to be successful in raising practical issues and both sharing and developing knowledge to improve the opportunities for a longer working life. Research group and its participants have established a partnership that will continue in several ways, such as teaching and new research applications.

The intervention study was part of a larger research program at Lund University and Gothenburg University with funding from Forte.

Keywords: Intervention, older employees, sustainable working life participation, working life.

Using children in research regarding safety and comfort of restraint systems in cars

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In Europe, car accidents are the leading cause of injury and death for children, in spite of effective protective systems today. Main causes are usage of wrong type of protective system for the child's age or height, or no belt usage at all. Other factors are also significant, such as misuse (incorrect mounting of the booster-seat or improper belt fit) or incorrect sitting posture during crash. With better understanding about children's attitudes regarding safety systems and their choice of sitting postures, improvements of comfort and safety aspects of the systems can be made.

The purpose of this paper is to show how children can contribute to further development of their safety systems, by involving them both as object and subject in research. As object their anthropometric measures are important (size, shape), belt fit, sitting posture and behavior inside the car during drive. As subject their attitude, acceptance and comfort experience regarding protective systems are significant.

The methods used to involve children in safety research were focus groups, usability tests and on-road drives. In focus groups their attitudes regarding car safety and protective systems were investigated. In usability tests the type of misuse of the protective systems were studied when buckling up. In on-road drives children's activities, sitting postures and seat belt positions were evaluated by video recordings and anthropometric measures were taken to correlate to posture and belt fit. Their comfort experience during drive was collected by subjective estimations in questionnaires, and by interviews. In total about 20 children (7-8 years) joined focus groups, 150 children participated in usability tests (5-10 years) and 40 children (5-15 years) participated in on-road drive studies.

The results showed that focus group discussions are valuable for finding children's opinions, but they need to be mentally mature and participate together with friends to be able to express their real thoughts. If only verbal information was given about a topic their responses were hesitant, but if pictures were shown they gave more free expressions. If they could try real safety concepts in a car for a few minutes, they stated clear opinions, especially about comfort issues. The results from usability tests showed large misuse for all ages of how to attach and use the seat belt correctly together with the booster-cushion. The objective results from on road drives showed that children were occupied with a number of activities that positioned them in unfavorable postures in case of a crash. The subjective evaluations showed that during shorter sessions (30 minutes) of on road driving children perceived rather much discomfort, but for longer sessions (1-3 hours) the discomfort decreased and their opinions changed about which system was most attractive.

The conclusion is that involving children in research gives valuable information, especially about comfort aspects and design issues of how to buckle up and use the system correctly. Comfort is highly important for acceptance and affects chosen posture and belt fit. Ergonomic product development is vital, i.e. possibility to adjust the protective system for variation in size, natural siting and posture changes, as well as careful consideration regarding comfort issues of head and torso support, seat cushion, leg support and belt geometry.

Keywords. Children, comfort, car safety, evaluation methods, ergonomics design

Simulator training for improved excavator operator performance

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Excavator operator is a creative profession that optimally combines solid crafts-manship with modern technology. It requires extensive training to become a skilled expert in this high-risk profession. Professional training simulators are useful tools for education and training of machine operators in construction, transportation and agriculture. Simulator technology enables a safe and effective training environment for a low cost in a non-polluted way as a complement to training in authentic vehicles.

The purpose of this study was to further develop a track excavator full-scale training simulator. The simulator should be used to improve the trainees' skills and performance in regard to safety, quality, economy and environmental sustainability. The goal was to identify tacit knowledge and key parameters that characterise a skilled excavator operator and then develop instructive simulator training assignments to improve these skills for different user groups. The assignments should be appropriate for student training, repeated training as well as for evaluation of competences and driver performance when selecting new employees at construction sites. Literature studies, interviews with instructors, students and professional expert drivers, observations at construction sites, and focus groups with simulator developers were used as data collecting methods.

The key parameters found for being a skilled excavator operator were divided into physical and mental capabilities. Regarding physical abilities coordination, reaction time, fine motor skill and peripheral vision are most important as well as possibilities to reach and grab various operating devices such as levers, knobs and regulators. Regarding mental capabilities attention, perception, ability to concentrate and simultaneous capacity are essential, which in over-all can lead to achieving high situation awareness.

About 30 different metrics were invented for registration of physical and mental abilities in real time in the training simulator. Advanced algorithms were developed for continuous evaluation of combinations of metrics to find hazardous behaviour, environmental sustainable operations and high quality operations. This resulted in three final scores describing achievement of safety, quality and economy when executing a training task in the simulator. At maximum 100% could be achieved for each score, where 75% was set as good acceptance. When executing a task, the students are provided with continuous feedback on the screen about their present success rate regarding safety, quality and economy.

To evaluate if the new way of presenting results were successful, a usability test was undertaken with two students and two experienced instructors performing an advanced digging task in the simulator. The results showed that the participants became more motivated and enthusiastic than before, due to the continuous feedback of their performance and the possibility to understand what to improve. The possibility to compare results from time to time individually as well as informal competitions between students could make them gain better skill in a shorter time. To conclude, presenting results of how well you perform excavating tasks in a safe way with high quality and good economy as well as understanding how improvements of performance can be done are important aspects for the student's adaption to real working situations.

Keywords. Excavator simulator, physical skills, mental skills, performance, safety

From conflict to operational efficiency: an exploratory study on conflict management guidelines

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Even if managers can devote up to 42% of their working time dealing with conflicts (Dana, 2001; Katz & Flynn, 2013; Thomas & Schmidt, 1976), conflicts at work and their ineffective management constitute one of the most important psychosocial stressors for the quality of work life and the organizational productivity (Roberts, 2005). This is partially due to the lack of conflict management systems or their formalism (i.e grievance systems with standard processes of completing a grievance form) which in many cases creates more conflicts than solves them (Katz & Flynn, 2013). Moreover, researches have shown that conflicts at work remain largely unrecognized as one of the most significant costs in many business (Dana, 2001). These researches revealed that conflicts are a decisive factor in at least 90% of terminations, including voluntary resignations.

Yet, there are also "stimulating conflicts" that can be source of creativity (Hackman, 2002) and "good conflict" encourages constructive debates and creates effective solutions (Toegel & Barsoux, 2016). Knowing successful teams are likely to be proactive in anticipating the need for conflict resolution and develop conflict resolution strategies (Behfar, Peterson, Mannix, & Trochim, 2008), it seems necessary to empower managers and employees to benefit from conflict resolution. For instance, mediation methodologies and techniques to improve interpersonal communication such as Non-Violent Communication (NVC) (Rosenberg, 1983, 2003) have been studied in a variety of settings like schools, hospitals, or prisons (Juncadella, 2013). In the field of work organization and management we find a growing literature on the design of protocols to support discussions about conflicts in the workplace (Detchessahar, 2013; Falzon, 2014). Nevertheless, such techniques require prior training and coaching so they are rarely implemented in a sustainable way in companies. In fact, most of the organizations lack knowledge on the tools and methods for conflict resolution process.

In this context, we conducted a survey among 56 professionals of various ages, professional experiences and business sectors. We describe the major impact of conflicts on well-being and efficiency and we show the participants felt abandoned from the companies functions in half of the situations described and that no tools were implemented for solving these issues.

This paper presents the results of an exploratory research designed to study the processes involved in conflicts in organizations. Also, we sought to identify the existing conflict management systems and methods in the corporate environment.

Our project aims to develop technologies improving conflict management processes, considering the complexity of conflicts and the process of their development. Moreover, our solution integrates artificial intelligence models to help professionals (employees, managers, human resources, etc.) anticipating and managing conflicts from the analysis of everyday work situations.

Keywords: Workplace conflict management, sustainable working life, upcoming technologies

Factors to consider when implementing patient online access to their electronic health record

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Government and public agencies in Sweden have promoted the expansion of eHealth. The strategy behind this effort is to increase quality of care, efficiency, patient empowerment and patient safety, and one of the most important civic eHealth services is patient online access to electronic health records (EHR). By 2017, all of Sweden's inhabitants will be able to access their EHR from somatic care through the Internet and thus read clinical notes. In 2015 Region Skåne was the first county council in Sweden to implement patient online access to their EHR as a civic service, for adult psychiatric care patients. Earlier research shows that initial implementation of the service in somatic care raised both questions and resistance among involved healthcare professionals. Thus, for an implementer, there are many factors to consider and it may be difficult to choose and prioritize among them; on the other hand, there is little knowledge about what healthcare professionals think is important when implementing a civic service in healthcare. The aim of this study is to present and discuss what healthcare professionals think is important to consider when Region Skåne implements patient online access to EHR in psychiatric care.

The material presented derives from a full-population web survey, distributed to employees in adult psychiatry in Region Skåne just before the introduction of the service. The response rate was 29% (n = 871). In one of the question in the survey, respondents were asked to choose five out of eleven factors that they thought might affect the implementation of the service. Thereafter they were asked to rank these five factors and assign the most important factor five points, the second most important factor four points and so on.

Overall, the results show that the most frequently chosen factor was *Evaluation of patient online access to their EHR*, but *Patient safety* was the factor with the highest total score and also the highest mean value. Furthermore, it is interesting to note that the factor receiving the lowest score was *a support line for the employees*; this factor has the lowest total score and lowest mean value. The results also show that different professional groups consider different factors to be important in the implementation process.

The conclusions are firstly; that healthcare professionals care about the implementation of civic services even though the technology does not change towards them. Secondly; that the healthcare professionals consider not only factors that affect their own work to be important but also factors that are related to patients' interests. Thirdly; it is important for implementers to be aware of that civic services can affect the healthcare professionals work even if the service is only aimed at patients. It is thus important to consider factors related to both patients and professionals when

implementing a civic eHealth service, even if the service is aimed at only one of these groups.

Keywords. Implementation, Healthcare professionals, eHealth, Psychiatry, EHR

Industrial Designers' activities and Ergonomics application in SMEs

Analysis of the footwear manufacturing companies at neighborhood Restrepo in the city of Bogotá

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In recent times, the small and medium-sized companies (SMEs) constitute the highest percentage of industrial organizations in many places of the world, always being one of the most important production forces. However, SMEs suffer difficulties mentioned by many studies, for example the works of Kraus and Schutte, who detected a limited resource management, low management skills, low market penetration, excessive bureaucracies, etc.

In that sense, for the industrial design community it is very important to know which the role of industrial designers in SMEs is. An active participation of industrial designers can influence in a determinant way, in internal as external factors of this kind of organizations, such as the quality of products and processes, protection of the environment, health of its workers, technological, productive and innovation capabilities, industry positioning, among others. Accordingly to the study of characterization of design in Colombia, carried out by the National University of Colombia, and the Ministry of Commerce, Industry and Tourism, design practices in the organizations can function as a "lever" to allow "SMEs to incorporate innovation schemes or improve good practices… improve their productivity supported on product and production processes design, boosting a real productive transformation".

However, the mere presence of industrial designers in the SMEs is not enough to improve their dynamics. For this, it's also necessary a transcendental change in the management of the different levels of the organization. There is now a great variety of organizational management tools and models, created from disciplines as diverse as

engineering and administration, which purpose is to help SMEs to overcome their difficulties in order to improve their general conditions, increase their productivity and promote their growing and development. This research project is focused particularly on tools provided by Ergonomics, because this discipline has, since its fundamentals, a close bonding with Industrial Design.

This research project is intending to characterize the participation of industrial designers at SMEs, and to establish if that participation contributes to improve the performance of organizations thanks to the application of Ergonomics. For this, a documental research has been made, taking documents about the inclusion of design and ergonomics in SMEs in different places of the world, also, there are surveys and interviews to be applied with designers, businessmen and experts in the industrial design, ergonomics and SMEs subjects. This study is being carried out in the footwear manufacturing companies from the neighborhood Restrepo in the city of Bogotá (Colombia), because in these companies there is a great variety of processes in whose Ergonomics can be applied at different levels, such as product, production and management design.

Despite the fact that this research project is currently on the phase when tools for recollecting information are being designed, in the documentary revision it has been found that, independently of their location, SMEs are characterized for a low linking with designers, low investment in design department, management improvisation, and silent design. In what it respects to ergonomics, most of the studies are concerned about occupational health and safety, but not too many of them study ergonomics' relation with design inside productive organizations.

Keywords. Industrial Design, Ergonomics, SMEs, footwear, manufacturing companies

Ergonomics and Aesthetics – conflicting challenges in a user-centered design process

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When filling a petrol truck at a gas depot, big heavy hoses are carried to the truck and attached with significant manual force. The couplings are engineered to be robust, safe and spill free, but not much has yet been done to make them ergonomically promote a healthy long term use without pain in wrists and shoulders for the user.

MannTek produces and market couplings for the chemical and petrochemical industries. Their couplings come in different sizes and material, due to a big variety in needs and industrial applications. In their quest to develop a new design for their coming generation of couplings, they had identified ergonomics as the main focus, seeing potential for innovation in this field. By introducing a product with improved ergonomics, they aim to improve the users' experiences and at the same time differentiate themselves from the competitors.

In our presentation, we will describe the challenges of the design project, and how we achieved an ergonomically an aesthetically improved product through a user-centered design process. A multidisciplinary team from Zenit Design worked in collaboration with ergonomic specialist Jane Ahlin, Ergo@Work, Ljungskile. By filming and interviewing users on gasoline distribution sites, we could analyse the user scenarios and track the critical moments of the operations. Among other things we noted the amount of quick changes in the two-handed grip, that users had to do to manage to rotate the coupling 120 degrees until it locks. We made several steps of prototyping different design concepts, starting with early ideation visualisations in corrugated cardboard and modelling clay. For the following prototypes, we did real material simulations by casting aluminium handles from 3D-printed masters. We tested and evaluated in a simulation rig with the proper liquid pressure and realistic angles. From this we understood the importance of balancing the couplings, minimising weight, optimising the visual ergonomics etc.

On top of the ergonomic studies, we had to investigate how aesthetics could enhance an ergonomic expression, in order to "sell the story". This was done by simply letting the test group point out an "ergonomic look" among different designs.

The thorough research and concept development has resulted in not one but two designs that MannTek decided to set in production. One of them with a unique and completely different form factor than anything else on this market.

In our presentation, the following questions are addressed:

- What are the challenges when designing an ergonomic handle for a heavy-duty industry application?
- How do we research and get the right information from the customers and the actual end users?
- How can an ergonomic design build a new position for the corporate brand? What are the possibilities and difficulties?

The MannTek ergonomic couplings project reflects the challenges you meet when designing a product for a significantly challenging environment. Durability demands and physical limitations sets very hard frames for the design. Research methods are important to gather the right information from all the different stakeholders; the company's technical department as well as sales and marketing, customers as well as actual end users. But there are also aesthetical conflicts in aligning a soft ergonomic look and feel with an industrial corporate identity and a product heritage that speaks of robustness, reliability and traditionally industrial heavy-duty.

Keywords: Ergonomics, Design, Product development, User research.

The Role of Ergonomics in the Development of Innovative Solutions

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The Health and Safety Authority is a regulatory body in Ireland and it has a duty to ensure that employers identify, assess and reduce musculoskeletal health risks in line with regulatory requirements. The aim of this project was to produce a publication which would demonstrate how ergonomics good practice can help businesses to reduce the risks of musculoskeletal health risk, improve performance and foster innovation. In order to achieve this the Authority made contact with external stakeholders who had developed examples of ergonomic good practice and agreed with them a process for documenting the good practice case studies. The case studies were structured in order to illustrate the problem solving process, the consultation process, the use of ergonomic risk assessment tools, the solution development process which included the introduction of engineering interventions to reduce musculoskeletal health risk. The outcome of this project was the production of a publication on ergonomic good practice in the Irish workplace which showcased examples of innovative engineering solutions put in place in workplaces which were cost effective and improved worker health and increased productivity. The publication was made avaialble to industry and it was placed on the Health and Safety Authority website where is was available to download. If ergonomics is to be accepted as a credible science it is essential that practical case studies in a workplace setting are disseminated in order to illustrate how the use of ergonomic risk assessment tools and skills can create the appropriate environment for effective data collection on tasks, critical analysis and solution development. Following consultation with industry it was concluded that this publication on ergonomic good practice was a useful tool in raising awareness of ergonomics and the need to address musculoskeletal health risks in the workplace.

Keywords. Ergonomics, risk factors, innovative, engineering.

Predictors of work ability among women on long-term sick leave due to musculoskeletal pain

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Background: Musculoskeletal pain is one of the leading causes of sick leave (SL), especially among women in Sweden and in other western countries. It is, therefore, important to know which health- and work-related factors are associated with work ability (WA) among women with long-term musculoskeletal pain.

Purpose: The aim of this study was to determine whether there is any association between self-efficacy, anxiety, depression, sense of coherence, job strain, support at work, pain intensity, physical activity, beliefs to be back at the same work, coping strategies, and WA.

Methods: A cross-sectional study was conducted on women with long-term pain who were on SL. *Inclusion criteria:* (i) age 18-65 years, (ii) SL: ≥ 1 months, (iii) SL: ≥ 50%, (iv) pain in neck, shoulder or back (≥ 3 months), and (v) understanding Swedish. *Exclusion criteria:* (i) rheumatoid arthritis, (ii) multiple sclerosis, (iii) stroke, (iv) cancer, (v) Parkinson, (vi) bipolar disease, (vii) schizophrenia, (viii) pregnancy. In spring 2016, self-administered questionnaires were sent out to 600 women who were receiving time-loss benefits according to the Swedish Social Insurance registers. Out of these, a total of 208 participants responded and were included in the analysis. For assessing the predictors and the outcome, seven instruments were used: General Self-Efficacy, Hospital Anxiety and Depression Scale, Demand-Control-Support Questionnaire, Sense of Coherence, Multidimensional Pain Inventory, Coping Strategy Questionnaire and Work Ability Index. Two of the predictors, physical activity and beliefs to be back at the same work, were measured by single questions. Multiple linear regression analyses were performed to detect which of the factors were associated with WA.

Results: Women who more strongly believed that they would return to the same work within 6 months had higher WA (β= 0.39, $p < .001$), whereas women with higher pain intensity (β= -0.28, $p < .001$) and higher job strain (β= -0.12, $p < .05$) had lower WA. The results did not change when age, cohabitant, economic situation and social support were controlled for in the analysis. The regression model was significant ($p < .0001$), and its adjusted R- square was 48%.

Discussion and practical implications: Women's positive beliefs are associated with higher WA in accordance with previous studies. Our study also found that pain intensity and high job strain are associated with reduced WA. The results suggest that health care providers and employers should take women's beliefs to be back at the same work into account for supporting them to return to work. Furthermore, the focus of rehabilitation program should be on women suffering from high pain intensity to increase WA.

Conclusion: This study showed that beliefs to be back at the same work, pain intensity and job strain might be predictors of WA. Further studies are needed to identify if these predictors are also important for WA among women with long-term pain who are at work.

Keywords: Factors, ability to work, sickness absence, women and pain

Feasibility of a new device to assess neck posture and movement in field studies

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Background and purpose

In epidemiological research, exposures such as repeated actions and awkward postures have been associated with risk of work-related musculoskeletal disorders (WMSDs). However, the exposure is usually self-reported or estimated by an observer, where rather rough exposure levels are used. This poses difficulties to determine the exposure risk associated to WMSDs.

To better understand the relationship between exposure and risk of WMSDs, there is a need for more precise and objective assessment methods. There now exist a number of small, easy to manage and low-cost devices e.g. the IMU, especially the HAM (www.gcdataconcepts.com) with a built-in logger, which allow for whole day exposure registrations. For neck assessments, using the HAM-IMU would enable objective measurements of postures and repetitive movements, exposures frequently related to WMSDs in e.g. forklift drivers.

The aim was to test the adequacy of using HAM-IMU sensors to collect data and to compute neck exposure in field-studies.

Methods

An initial comparison of the HAM-IMU data to kinematic data computed with an optical capturing system was performed in a laboratory setting. One HAM-IMU, taped on a headband in the central front of the forehead, and two reflective markers, one at the top of the HAM-IMU and the other at the headbands' opposite back side, were used to compute neck kinematics. The test-subject sat on a chair with the back leaning to the back-support, and turned the head to the right and to neutral position with different velocities.

To test the adequacy of head orientation measurements, two HAM-IMUs, one placed in centre of forehead and the other between the scapulae on the back, were applied on a test-subject to monitor neck movements. First, the subject performed three head movements: extension/flexion, left/right rotation and left/right lateral bending.

Second, a simulated forklift driver work-task was conducted, including driving forward, turning around, driving with vibration exposure and driving backwards with head rotation. Lastly, the initial three head movements were repeated in the same order as before. The simulation was videotaped to enable comparison between HAM-IMU data and observation assessment. To compute neck angles, an internal quaternion orientation solution, based on sensor fusion of accelerometer and gyroscope data, was used.

Results
Comparison between HAM-IMU and optical capturing system showed that neck angular velocity correlated very well (with a difference of one decimal) between the two systems. A slight difference between the systems (approx. 4 degrees) was seen in angular displacement of the neck. In the simulation test, neck movements derived from the HAM-IMU sensors matched well with video observations in all tasks.

Discussion
The HAM-IMUs are easy to manage and small which makes them advantageous to use in whole workday exposure registrations. The high correlation in angular velocity with the gold standard method, and the face validity in the simulation test, indicate that the HAM-IMUs may advantageously be used in field-studies for measurement of neck postures and movements in forklift drivers.

Conclusions
The tested method for assessment of forklift drivers' neck exposure seems promising, however, further validation with more subjects is needed.
This study was supported by EIT Health.

Keywords Neck exposure, technical measurement, objective assessment

The RAMP Tool for Risk Management in Manual Handling: A Seven Year R&D Project

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Background and purpose
In 2010 a research and development (R&D) project started after an initiative from a large global company. They needed a free, systematic musculoskeletal disorder (MSD) risk assessment and management tool, focused on manual handling. The development of the RAMP tool (*Risk Assessment and Management tool for Manual Handling – Proactively)* was therefore initiated, and the progress has since then been presented at several NES-conferences. The objective of this paper is to present the result of this 7 year R&D project: the digitalized RAMP tool and courses on the tool.
Methodology
A participative methodology in close co-operation between researchers and practitioners at companies has been used. The participating companies and the methodology, including the base for the development, ranging from scientific papers to user feedback, and evaluations will be described at NES 2017.
Results
The R&D project has resulted in the freely accessible RAMP tool consisting of four parts: RAMP I, RAMP II, the Action module and the Results module. A broad range of MSD risks are assessed, the results from assessments are visualized in a novel way and risk reducing actions for risk management are supported. The digitalised version has recently been released. Further, three massive open online courses (MOOCs) for professionals on the RAMP tool are under development, and will also be presented.
Discussion
The discussion focuses on the need of and dissemination of freely accessible methods such as RAMP, and how to enable users to acquire sufficient knowledge to use them.
Conclusions
In conclusion: The project has resulted in a new tool for MSD risk management in manual handling jobs, the RAMP tool. Evaluations of the tool show that it is regarded as usable from different usability aspects. It is argued that the upcoming online MOCCs may contribute to provide adequate knowledge for proper use of the tool.

Keywords. musculoskeletal disorders, risk assessment, risk reducing measures, risk communication, digital tool.

Commissioned Education on Work Environment

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For better or worse, work plays a major role in both the psychological and physical well-being in peoples' lives. Work can be a source of meaning, joy and self-fulfilment, or a cause of distress and illness. This holds true even in wealthy parts of the world, with long traditions of research and governmental actions to achieve good work environments. In Sweden, for example, an average of 35 people die every year in work-related accidents, and in 2016 roughly one in five (22%) had some type of work-related disorder that reduced their capacity to work or carry out daily activities in the home.

The causes depend on complex interactions among environmental demands and organizational and individual resources. Academic research has contributed considerable knowledge about the central aspects of these interactions by explaining different outcomes or how to actively prevent accidents and a variety of illnesses. However, this knowledge is not always effectively communicated to the surrounding community. To create safe and sustainable work environments that boost productivity and individual well-being requires knowledge and competencies from a wide array of research fields. Along with the constant and fast pace of change in actual work environments as well as policymaking, this makes it difficult for private companies, governmental agencies and other organizations to keep up with current research and legislation. In this respect, the Centre for Work Environment and Leadership (Arbetsmiljöhögskolan, AMH) at the Department of Design Sciences at Lund University can function as a bridge between the research community and society, connecting researchers to ongoing societal challenges.

From this point of view, AMH can be seen as a doorway to a wide network of researchers with deep knowledge of the relevant aspects of work environment issues, ranging from "soft" issues such as leadership, organization, risk management, learning and labour legislation, to "hard" topics such as buildings, indoor environments, air quality, lighting and digital tools. AMH arranges tailor-made education, ranging from shorter lectures to credit-awarding courses, developed in close dialogue with the customers.

At this conference, we would like to highlight and discuss the challenges and possibilities of translating and communicating research results in the work environment field to relevant educational opportunities. We invite conference participants to a discussion of both the best and worst practices.

Keywords: Work environment, education, competence, working life.

E-health as a support for staff in home health care: Where are we today and where are we heading?

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With increasing numbers of aging and chronically ill patients the amount of care performed in patients' homes is increasing. Nurses working in home care carry out most of their work alone in the home, lacking support of their peers and access to appropriate information. This puts pressure on the individual nurse and affects the work environment. In recent years, the use of e-health has increased. Many e-health services have focused on patients' needs while it is unclear how far the municipalities in Sweden have reached in using these services as a support for home care staff. Here we present results from a survey with the aim of investigating this.

A survey consisting of 10 main questions was sent to the 264 municipalities in Sweden responsible for home health care. The survey contained open free text questions regarding currently used, planned, and discarded e-health services. The survey was explorative in the sense that we purposely did not present any e-health services a priori. It was thus up to the respondents to interpret what services to include. The free text answers were analysed with inductive qualitative content analysis with the help of QSR Nvivo 10©.

144 (55%) municipalities answered the survey. In total, approximately 50 e-health services were identified. Widely implemented services today include *national patient overview*, *mobile documentation*, *digital list of medications*, *digital locks*, *digital personal safety alarms,* and *night cameras.* Within the coming year, the use of *digital signing* and *digital medical lockers* appears to increase, while the high implementation pace concerning *night cameras* and *mobile documentation* appears to continue. Some services, such as *mobile apps for educational purposes,* were only tested in a few or single places. Other services had been tested but discarded, mainly due to technical problems or a too immature technical solution.

E-health can transform the way work is performed and it is thus important to take into account the effects it may have on the nurses' work environment. Positive effects might be decreased stress levels from having digital access to information or colleagues for support. Another effect might be increased control from the employer through digital documentation. Services that have been tested locally may have a potential of being supportive and efficient on a national level. The results will be used as an input to discussions and workshops with home care staff on benefits and risks that e-health services can pose on staff and other implications for practice.

The survey showed that the implementation of e-health services as a support for staff in home health care is on-going. Some services are implemented on a broad national level while others are evaluated on a more local level. Nevertheless it is highly

important to lift the discussion of the effects of these services on the work environment. By scrutinizing these examples we hope to increase the understanding of how e-health services can support nurses in home health care in a sustainable and efficient way.

Keywords. Home health care, e-health, work environment, staff

A comparison of human factors evaluation approaches for nuclear power plant control room assessment and their relation to levels of design decision specificity

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Nuclear power is a high-risk industry where safe operation is crucial. A nuclear power plant is operated from the central control room, a system composed of physical structures, personnel, and organisational structures such as work routines. In a development process, the possible values of design variables are successively constrained, i.e. design decisions are made. When successively narrowing the solution space through the application of constraints, the design decisions made are more and more specific. The natural order in a development process is to gradually move from more general to more specific design decisions. Many design decisions must be made during the development process to form a nuclear power plant control room system that supports safe operation. Evaluation is an activity that can be used to navigate among this multitude of design decisions to ensure that the design achieves the desired effect. The ideal is to evaluate constraints on design variables as soon as they are set, in order to avoid having to reconsider the constraints on underlying design variables. For this to be possible the evaluation approach used must be able to assess design decisions at different levels of specificity. The purpose of this paper is to compare utilised approaches to evaluate nuclear power plant control room systems and explore how they relate to design decisions at different levels of specificity. The method used was a review of academic literature. The literature review showed that formative evaluation approaches for design decisions of higher levels of specificity are less common and not described in as much detail as summative evaluations for lower level design decisions. This gap has to some extent been addressed by academia, but guidance can be further detailed and improved, for example by further investigating evaluation approaches utilising system representations available in earlier project phases (when more general design decisions are normally made). If design concepts can be evaluated earlier in the development process, changes are easier and cheaper to implement. There is a need to further develop methodologies and methods suitable for formative evaluation of design decisions at higher levels, and to assess their applicability for control room system evaluation.

Keywords. Nuclear power, control room, human factors, evaluation method, development process, design decision, early evaluation.

Motor function characteristics in supermarket cashiers with and without low back pain

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Background and purpose. Low back pain (LBP) is one of the most frequently suffered musculoskeletal disorder among seated supermarket cashiers, affecting their work ability. Supermarket cashiers work in Estonia in sitting position at the counter. It is known that working in sitting positon for a long time causes different health problems, while other indicators as monotonous work and lifting different loads are influencing physiological and ergonomic wellbeing. The aim of the present study was to evaluate motor function characteristics in female supermarket cashiers with and without LPB.
Design and methods. A total of 133 female supermarket cashiers (aged 18-63 yrs, mean age 36 yrs) volunteered to participate in this study. Cashiers work almost whole workday (9.6 hours per day) in sitting position at the counter. The Nordic questionnaire was used to evaluate the level of subjectively perceived LBP. Motor function characteristics in laboratory conditions were measured in cashiers with LBP (n=13) and without LBP (n=10). Maximal isometric voluntary contraction (MVC) force of back extensor muscles were measured by back dynamometer. Static standing stability was assessed on force plate. The spinal curvature in the sagittal plane was recorded using panthography. The back active range of movement (aROM) was measured by goniometer. Physical activity was assessed by Baecke habitual physical activity and self-administered questionnaires.
Results and discussion. Of the measured cashiers, 64.7% perceived LBP, 53.2% neck pain, and equally 45.6% perceived elbow and shoulder pain during in the last 6 months. In the last 7 days cashiers perceived pain in low back (43.6%), neck (40.5%), and in elbow (36.7%). Low back is the most problematic body region in cashiers with sedentary lifestyle. MVC force of back extensor muscles was 23.8% lower ($p<0.05$) in cashiers with LBP compared to asymptomatic cashiers. Cashiers with LBP showed larger ($p<0.01$) anterior-posterior sway during standing when eyes were open, and larger ($p<0.05$) medio-lateral sway when eyes were closed compared to asymptomatic cashiers. Cashiers with LBP showed greater ($p<0.05$) angle of thoracic kyphosis and less ($p<0.05$) aROM during back rotation to left than cashiers without LBP. Only 27% cashiers were physically active, performing regular leisure time sports. Baecke physical activity scores were lower in cashiers group with LBP.
Conclusions. In supermarket cashiers with low back pain, motor function characteristics are lowered as compared to asymptomatic cashiers. They have mainly sedentary lifestyle, and their habitual physical activity is low. Cashiers and employers should follow ergonomic workplace guidelines and do regular physical activity to prevent LPB.

Keywords. Low back pain, supermarket cashiers, musculoskeletal disorders, seated working, sitting position, workplace ergonomics

Joy in creating improvement of the psychosocial environment through workflow analysis

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Background and purpose
Hospital employees experience growing work pressure due to an increase in patient demands and economic constraints. Communication and coordination problems across professions in the organisation often constitute important factors for the work pres-sure. We have developed and tested P-lean which is a methodology focussing on value stream mapping (VSM) which can facilitate improvement of the psychosocial work environment. The aim of this presentation is to describe and discuss the results from this project.
Design
The project was developed and implemented in a collaboration with researchers, management and staff at a large university hospital in Denmark. The University hospital has 690 beds and covers both emergency and elective treatments. It has 4400 employees divided into 25 departments. The VSM mapping was redesigned to fulfil the needs of a psychosocial working environment assessment tool, and renamed to workflow analy-sis workshops. A pilot and five wards intervention programs were completed. Partici-pants across professions pinpointed problematic work process in each ward and organ-ised three workshops which based on VSM analysed, developed solutions and evalu-ated the outcome. Between the workshops the wards produced facts about the work processes through observations and registrations of daily work.

The P-lean methodology was based on a programme theory where the key mechanisms were the building of motivational resources based on a shared learning process about daily activities across professions. Another key point was to provide shared concrete and transparent data about work processes which on one hand provided the platform for the development of relevant improvements and on the other created visible improvement areas and results. This program theory was evaluated through systematic interviews and observations.

Results
The results from all five intervention wards showed that they all carried out the planned thorough workflow analysis, and they assessed the process and the results from the workshops as a valuable method to improve the work processes across professions. Moreover, the participants experienced the workshops as engaging and funny. It was especially appreciated that potential interpersonal conflicts could be moved to find solutions in the organisations of work tasks on the micro level.
Discussion and conclusion
The involvement of employees in workflow analysis, with additional observation and registration of work resulting in action plans and the subsequent follow up seems to be a feasible way to work with the problems related to both the psychosocial work envi-ronment and the inefficiencies related to constrained communication between the pro-fessional silos of the hospital. The results also indicate that outside facilitation is need-ed for successful achievements.

One of the constraints for the full benefit of the P-lean methodology presented in this paper is the lack of experience with cross-departmental issues such as the way wards transfer patients from one ward to another. Despite the successful results from the cross professional workshops, the possibilities to work across organizational boundaries outside the hospital department seem to be difficult.

Keywords: Healthcare, cross-professions, lean, psychosocial working environment, relational co-ordination, value stream mapping, workflow analysis

European Ergonomist Certification

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The Centre for Registration of European Ergonomists, CREE, was established in 1994 by the ergonomics societies in Europe that were recognised by the International Ergonomics Association, IEA. It confers the professional title "European Ergonomist" to designate qualified and experienced members of the profession. European Ergonomists are to be found in most European countries, today some 500 persons in 18 countries. The quality of their professional practice and their education has been peer-reviewed and they must adhere to a professional Code of Conduct.

Certification with the Eur.Erg. title guarantees that the ergonomist has:
– a broad education in ergonomics at university level
– at least three years of practical experience as an ergonomist
– continuously developed his or her skills in ergonomics.
– prolongation is needed after five years

European Ergonomists are professional ergonomists who, in professionalism and practice, have a knowledge of the principles of ergonomics and of the relevant human characteristics in the areas of anatomy, physiology, psychology and social organisation, as well as knowledge of how the physical environment affects people. Applicants for this qualification must also demonstrate knowledge in statistics, experimental design, equipment and methods to investigate, modify or design situations and equipment for ergonomic benefits. Requirements are described in the CREE document Minimum Requirements.

Obtaining the title Eur.Erg. is evidence of the high level of professional standing. Professional standards also help ensure the growth and development of the profession. Requiring work to be done by a registered European Ergonomist assures the professional quality of the ergonomist and work performed. It is also a mean facilitating a common understanding on international level in project cooperation etc.

Finnish persons apply to the Finnish National Assessment Board. Persons from Sweden, Norway, Iceland and Denmark apply to the Nordic Assessment Board, assigned by the Nordic Ergonomics Society, NES, https://www.eurerg.eu/about-cree/cree-council-representatives/).

Via the CREE Council representatives information is found on needed documentation, fees, requirements etc. On the EHSS website detailed information and forms are found in Swedish, http://www.ergonomisallskapet.se/auktorisation.html

Keywords. Ergonomics, certification, CREE, European Ergonomist.

Comparison of subjective risk about occupational accident occurrence for construction workers by age

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In the Japanese construction industry, the occurrence rate of occupational accidents for young workers and older workers is high. On the other hand, according to the data of the Ministry of Health, Labour and Welfare, most accidents relate to workers' risky behaviour. Whether a worker commits or avoids risky behaviour is affected by the subjective risk, which determines to what degree he or she may have an accident. Therefore, the characteristics of the subjective risk of young workers and older workers may be different from those of other age groups. This study aims to compare the subjective risk by age and grasp the characteristics.

A questionnaire comprised of 19 items was handed out. Respondents filled out their profile, then evaluated the risk that they and other average workers, respectively, from 20 years old to 70 years old, in 10 year-intervals, would get injured by a fall to a lower level within the next year (an 11-point scale; from not at all likely to extremely likely). Furthermore, they also evaluated cuts and abrasions in the same way.

Respondents were 16 to 74 year old construction workers. 805 answers about a fall to a lower level, and 784 answers about cuts and abrasions were divided into 6 age groups (the 20 year olds group to the 70 year olds group) and then analysed.

With regard to the risk of the other average workers in each age group, respondents evaluated in a similar way for both types of accidents. The 30 year olds group to the 60 year olds group evaluated the risk of 20 year olds, 60 year olds and 70 year olds highly. The 70 year olds group evaluated the risk of 20 year olds and 70 year olds highly. On the other hand, the 20 year olds group evaluated the risk of older workers highly, but the risk of 20 year olds lowly. With regard to their own risk compared with the average other risk in the same age group, respondents in all age groups evaluated their own risk significantly lower than the average other risk in the same age group regardless of the type of accidents. In addition, the difference between their own risk and the average other risk in the same age group, for older groups was larger than that for younger groups.

Consequently, the 30 year olds group to the 70 year olds group seem to recognize the risk by the lack of experience for young workers and the risk by aging for older workers. However, the 60 year olds group and the 70 year olds group evaluated their own risk lower. This suggests those groups consider the risk by aging for older workers, but don't recognize it as their own problem. On the other hand, the 20 year olds group evaluated both their own risk and the average other risk in the same age lowly. This group doesn't seem to recognize the risk by the lack of experience for young workers.

Keywords. Subjective risk, Age, Construction workers, Optimism bias

Meeting to GO – we can walk IT out
Design of Mobile System Supporting Work Meetings while Walking

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Background and purpose
Over the recent decades we have seen a gradual shift towards less physically active and sedentary work-environments in many occupations and professions. This change has been partly due to technology and work-organizational development focused on efficiency and safety. Low levels of physical activity and sedentary behavior are one of the major societal challenges today due to its negative impact on health. The purpose of this case study and the design of the MeetingtoGO system are to explore ways to expand possibilities for physical activity to be integrated in work meeting, a way to explore alternative to sedentary work-meetings.

Design/methodology/approach
Participatory design PD has been guiding the research. The motivation for PD as research approach are both, that movement-capacity seems weak in relation to knowledge work to speak for itself until the results of a sedentary and inactive lifestyle is communicated through discomfort, diseases and that we placed the design-research in real settings. Put in Participatory Design perspective ”the body affected by a design should have a say in that design process”. In close collaboration with the end-user we have iteratively designed the prototype, tested and evaluated through, semi-structured interviews and analysis of video-recorded tests situations.

Results
Results are reflections from the participants after using the prototype. Some shared below:

> “ I wonder if it would be okay just to walk by yourself – sometimes I need time to think to come to a conclusion how to approach a work-task” (P13)
>
> “Clumsy awkward cumbersome – you do not want to walk and hold the smartphone in your hand” (P11)
>
> “I thought that it would turn into a social chat and that we would not discuss the actual agenda for the meeting” (P15)

Discussion with practical implications (if applicable)
The aim of studying and designing methods to integrate physical activity into work is to take advantage of the positive effects, both the cognitive and the physical health-related benefits. To not use physical activity as an add-on, as a separate activity to work-practice. Issues about interactions modalities – the technology should be non-

intrusive in order not to disturb the conversation or the walking activity. Could the technology be trusted, could the worker rely on work to be done although performed in a different manner? These are among the results that guided the design.

Conclusions
In this paper we have presented a working prototype – the *Meeting to GO* concept. It is an interactive system aiming at supporting work-meetings while walking. The concept was developed, tested and evaluated during 18 month in a participatory design project. Part of the concept was well perceived, but the working prototype did not fully meet the user-expectations. Non-intrusive interaction, issues of trust, issues of selection of documented material, methods for change of work-practise are the most important design-implications generated during the case study. These design implications have provided us with knowledge on how to further develop Meeting to GO in order for it to become a sustainable work-practice for some work-meetings.

Keywords. Physical activity; Interaction Design; User Experience

Sitting and Seating: Past, Present and Future

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The oral presentation does not cover a scientific paper about the subject of sitting and seating. It reflects the personal view and experience of the author. It gives a general overview of sitting in working situations and the seating solutions that have been, are and will be designed. The author tries to to link to the holistic ergonomics/human factors approach. In that perspective a chair or any other object that people sit on is part of the system. It should be considered as a tool or artefact that should fit the needs of the user in a specific context.

Chairs and other sitting devices have been the subject of design and study from very old days (4000 BC) to futuristic envisons. Experts from different disciplines have contributed to the knowledge field: architects and designers, medical specialists, biomechanic experts, ergonomists and even organisational experts.

Still, sitting is associated with musculo skeletal issues through static work load and general health problems due to physical inactivity. Sitting solutions are seeking for a compromis between stability and support on one side and movement and activity on the other side. A major design issue is to provide sitting devices that fit all users. It has lead to multi-adjustable chairs that are difficult to understand and to control by the user. Aspects of comfort are explored since that influences the user experience dramatically.

The current world of sitting and seating is dominated by large chair manufactering companies that follow international standards on chair design. But the current world is changing rapidly towards a more holistic approach that fits the ergonomic/human factors principles better. However, discussions are troubled by believers of movement (for it's own sake) and prevention of inactivity against believers of proper support or seating characteristics to achieve the best possible posture. This has led to situations where chairs were banned in the design of office environment and a revival of sit to stand desks in Europe which can introduce new issues.

Since the way we work is changing gradually in many working situations, new ways of body support will find their ways to the market. The integration of sitting solutions in the work process will be complemented by connective smart technology that can support multiple stakeholders in their needs.

The author concludes that there is a future for sitting and seating and it is more related to ergonomics/human factors than ever.

Keywords:

sitting,user experience, biomechanics, sedentariness, movement, comfort, product design,chairs, office ergonomics, smart technology

Essential non-technical skills for adult intensive care staff in managing unplanned extubations

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Background and Purpose. Unplanned extubations (UE) are an infrequent occurrence in adult intensive care units (ICU); however, they present a unique challenge to nursing and medical staff in safely securing the patient airway under varying circumstances of staff skill mix and ICU experience. This study aimed to provide a human factors systems work analysis and qualitative evaluation of ICU staff in a National Health Service (NHS) Hospital Trust to inform the development of a mastery learning programme for UE response and management.

Methodology. A hierarchical task analysis (TA) for the management of UEs in orally intubated and tracheostomy patients was co-created with clinical experts in anaesthesia and critical care. The TA was shared with twenty-one ICU nurses and doctors ranging in seniority and airway training who were interviewed about their experiences with UEs and the sociotechnical and contextual factors affecting their clinical practice and decision making.

Results. Interview findings provided comprehensive understanding of the clinical tasks, essential personnel, and the equipment and information necessary for responding to UE incidents. Both nursing and medical participants reported a reliance on staff skill mix and teamwork to coordinate response in UE situations. Leadership of senior nurses and doctors was essential to explicitly verbalise directions to junior staff members; however, individual situation awareness and unspoken tacit knowledge of roles and responsibilities also informed UE response.

Discussion. The experiences of Nottingham ICU staff revealed the essential nature of non-technical skills that are employed to cope with uncertainty in experience level and technical knowledge of team members who will respond to an UE event. Skill gaps were identified in some participants due to inconsistent training and lack of familiarity with UEs and reintubation procedures. Identification of staff coping skills, teamwork, leadership, task allocation, and communication are required for the development of a mastery learning programme for adult ICU staff for UE and airway management.

Conclusions. This study can be used to upskill both nurses and doctors in UE response, enhance organisational learning, and improve timeliness and safety in UE rescue based on a holistic understanding of all tasks and non-technical skills involved.

Keywords. Unplanned extubation; non-technical skills; task analysis; critical care

Task Analysis - An Integrated Model For Elicitation, Modelling And Risk Behaviour Assessment

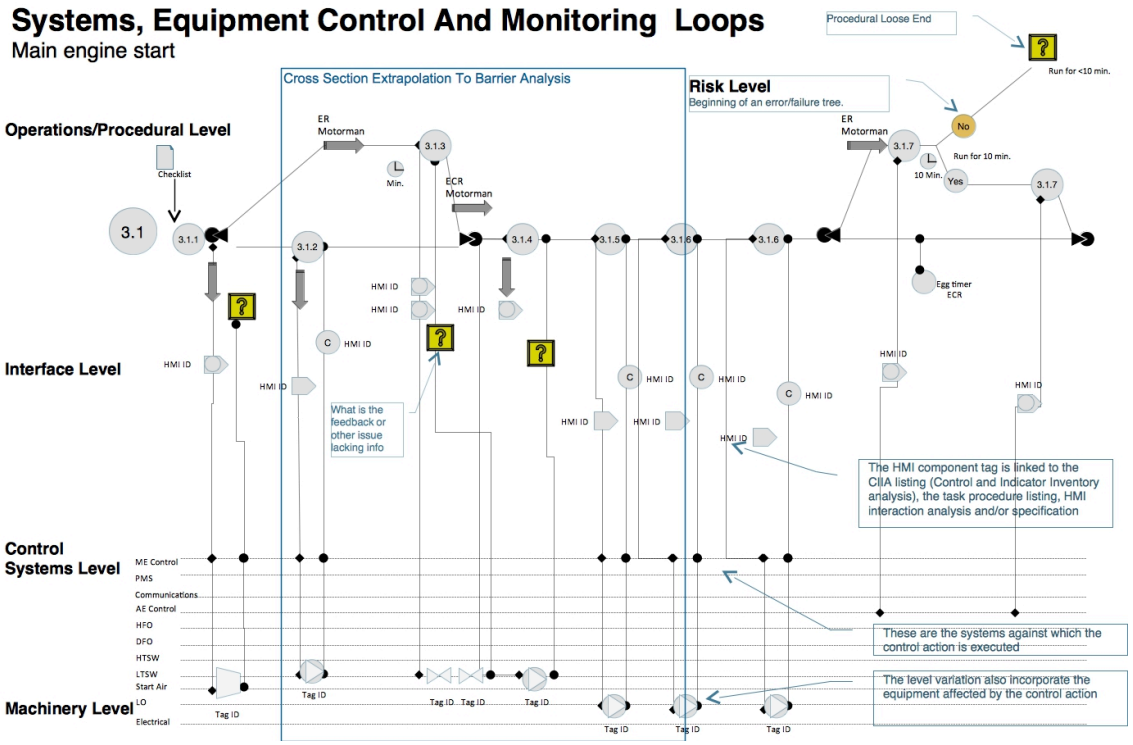
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Background and purpose: During the years working as an independent consultant, the question of performing task analysis has always reared its head in the discussions, project planning and project execution. In the human factors evaluation of existing situations or the design development of new control centres or systems, an essential step is an accurate mapping and analysis of the activities performed by personnel and equally important the tools/systems supporting those activities. The trick is acquiring information and presentation in a comprehensive form providing a good overview of interdependencies and permitting traceability throughout the process. There are many task analysis methods from which the practitioner can choose. A primary question is can one integrate and streamline these individual techniques into a more integrated model providing a higher level road map, particularly in regards to ISO 9000 requirements for traceability.

Design/Methodology And Approach: Since the late 80's, and in conjunction with various projects and the further development of RigMet, MarMet and GenMet methodology toolkits, such an integrated model has been successively refined as the Operations/Process/Work Flow Modelling (OPWFM) technique. It is an integration of several individual techniques including state transition, fishbone modelling, risk tree analysis etc. The driving principle behind the integrated model is ISO 6385 – Ergonomic Principles For The Design Of Work Systems.

The model is linear in nature representing the overall process, which the tasks comprise. It may represent the nature of tasks and variations of these during a shift in a control room or the watch on a bridge deck etc. This is the primary operations/task layer.

The model incorporates several underlying linear layers including, the interface layer (including communications), the control systems layer and the equipment layer. This basically models who does what, with what task tools and against which objects. This also facilitates the extrapolation to barrier analysis. The illustration below demonstrates the structure of the model.



Results: The result is a graphic model that incorporates i.e.:

- Process states, procedures and actions
- Potential process state and task disruptors
- Operator decision points, task path options, multiple/parallel paths
- Error trees and retrieval options
- Information inputs/outputs
- Operator actions against physical HMI devices and components, tools and task aids
- Systems and equipment being controlled and involved in a given task procedure
- Interfaces against other internal or external organisational entities
- Critical time factors

Conclusions: The technique has been developed and refined over 30 years and has been applied to various research and commercial projects and for different application areas – from software interface development to evaluation of existing control centres – on land and at sea. It provides the main reference to additional detailed analysis techniques employed in a given project as well as providing a uniform point of departure for projects consisting of a larger context. It also provides an effective means of reviewing the task analysis by employing a more comprehensive task modelling.

Keywords. Task Analysis, Human Factors, HRA, Work Systems

Uncertainty in monetary cost estimates for assessing working postures using inclinometry, observation or self-report

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Background In order to optimize cost-efficiency when collecting posture data in field studies, accurate cost data are needed. A few studies have assessed costs of different measurement methods, but they did not address the uncertainty of the cost estimates. Information on the uncertainty of cost estimates is key input when deciding which method to use.

Aim This study aimed at assessing the uncertainty in estimates of costs for collecting posture data by inclinometry, observations and self-report.

Method The study was based on data collected at a Swedish paper mill (Heiden et al. 2017)[1]. Using a model developed by Trask et al. (2014)[2], costs were calculated for measuring trunk and upper arm postures of twenty-eight workers during three full shifts using inclinometers, observations from recorded videos, and workers' self-reports from a questionnaire. For each measurement method, the uncertainty of the actually observed total cost was assessed by determining the range of costs between an assumed best case (lowest cost) and worst case (highest cost) using scenario analysis.

Results Observation was the most expensive method (€41499) and also showed a large uncertainty in the cost estimate (€19089 – €87154). Self-reports had the lowest cost (€9156) with the smallest uncertainty (€3941 – €27473). The overall cost for inclinometry was €16851 with best and worst cases €8567 and €60313, respectively. The actual costs of inclinometry and self-reports in the conducted study were reasonably close to the best case.

Discussion In their study of flight baggage handling, Trask et al. (2014) concluded that inclinometry was more expensive than observation when measuring trunk and arm postures. In the present study, we found observation to be the more expensive. Given the uncertainty in cost estimates, both results are plausible. Notably, in Trask et al (2014), video recordings were restricted to 4 hours, whereas in the present material, video recordings covered full 7- to 12-hour shifts. The time allocated to collecting video material for observations will significantly affect the cost comparison of methods, and

[1] https://doi.org/10.1093/annweh/wxw026
[2] https://doi.org/10.5271/sjweh.3416

this may serve as an example that further investigations of separate cost components for each method are warranted.

Conclusions Based on a meticulous cost assessment, we found that cost estimates for observation of working postures were the most uncertain, followed by inclinometry and self-reports. A better understanding of data collection costs and their uncertainty, and thus of how to properly identify an optimal measurement method, requires a deeper analysis of the cost model, and of the contributions of separate cost components to the overall cost.

Keywords Scenario analysis, exposure assessment, method comparison, cost calculation

Long-Time Voice Accumulation During Work, Leisure and a Vocal Loading Task in Groups with Different Levels of Functional Voice Problems

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Field-studies of vocal function using voice accumulation at work and during leisure time has become an important source of knowledge within voice health research. E.g. teachers with high everyday vocal loading have been examined. As of yet little research has focused on everyday voice use and voice ergonomics of patients with a clinical diagnosis of functional dysphonia, nor has everyday voice use been compared to a vocal loading task.

Objective: Examine vocal behavior and self-assessed vocal health in a population with differing voice ergonomics, including patients with functional dysphonia, under three different conditions: a. work, b. leisure and c. a vocal loading task.

Methods/design: Longitudinal controlled, clinical trial, mixed models. Vocal behavior and self-assessed vocal health was examined in fifty (n=50) female subjects in four vocal subgroups during 7 days' voice accumulation accompanied by a voice health questionnaire. Vocal subgroups were ordered according to everyday vocal load/ dose and vocal complaints: n=20 patients with functional dysphonia, n=10 women with high occupational vocal load with voice complaints, n=10 women with high occupational vocal load with no voice complaints, n=10 voice healthy controls with low everyday vocal load. Accumulation time was divided into three conditions: a. time in a vocal loading task b. time during work and c. time during leisure. During the voice accumulation the following parameters were measured: a. relative phonation time (%), b. phonatory sound pressure/voice level (dB SPL), c. ambient noise level (dB SPL) and d. phonatory fundamental frequency (Hz). A voice health questionnaire tracked vocal health through a. specific voice problems assessed with 10 voice health questions and b. general voice problems, assessed with a 100 mm visual analogue scale.

Results: Relative phonation time was very similar in all vocal subgroups across conditions, with the vocal loading task scoring significantly higher than the other two conditions, and work scoring significantly higher than leisure. Voice and noise sound pressure levels were also significantly higher in the vocal loading task. Vocal behaviour differed between groups. Women with voice complaints and high everyday vocal loading spoke more and at higher fundamental frequency than voice healthy controls. Patients with functional dysphonia reported voice problems across all conditions. No other group reported voice problems during leisure.

Conclusions: Patients with functional dysphonia do not speak more than others. Vocal loading is not only dependent on prolonged phonation time at high intensity levels, it seems also to be reliant on voice ergonomics, as prolonged phonation time at

high fundamental frequencies increases vocal loading. The results may also explain why people with voice problems associated only with their work environment do not seek voice therapy.

Keywords. Voice ergonomics; Vocal loading; Functional dysphonia; Long-time voice accumulation

Recovery from heavy vocal loading in women with different levels of functional voice problems

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Objectives: Voice problems. Track recovery time of self-assessed vice problems following a vocal loading task imposing vocal fatigue. Explore if patients with functional dysphonia are worse affected by vocal loading and if they take longer than others to recover.

Methods/design: Longitudinal, case-control, clinical trial. Fifty (n=50) female participants in four vocal subgroups on a spectrum of everyday vocal loading and functional voice complaints, including n=20 patients with functional dysphonia, took part in a clinical vocal loading task, inflicting vocal fatigue through loud speech in ambient noise. Short-term recovery was explored through self-assessment of unspecified voice problems every 15 minutes for two hours following loading. Long-term recovery was tracked through self-assessments of specific voice symptoms during 3 days following vocal loading. Effects of heavy vocal loading were evaluated through acoustical and perceptual analyses of voice recordings and assessments of digital imaging performed pre and post vocal loading.

Results: Patients with functional dysphonia did not return to baseline for unspecified voice problems within 2 hours of vocal loading and they were worse affected by vocal loading than other groups. Women with high everyday vocal loading with no voice complaints identified vocal loading more evidently than other groups. Long-term recovery took 7–20 hours for all groups.

Conclusions: Short-term recovery is slower for patients with functional dysphonia and they report more voice problems following a vocal loading task than others.

Keywords. Voice ergonomics; Vocal recovery; Functional dysphonia; Self-assessed voice problems

Content and quality of questionnaires for assessment of physical functioning in neck disorders – A systematic review of the literature.

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Valid and reliable instruments are required in order to determine effective interventions in the treatment of musculoskeletal disorders (MSD). Today, there is a lack of consistency in use of self-report outcome measures in research and practice, which makes it difficult or impossible to compare treatment effects. The questionnaires differ widely, in content as well as quality. The focus of present study was on assessment of physical functioning among people with MSD in the neck. The aim was to investigate how physical function is assessed in people with MSD in the neck. Specifically we wanted to determine: - Which questionnaires are used to assess physical function in people with musculoskeletal disorders in the neck? - What do those questionnaires measure? - What are the measurement properties of the questionnaires?
The study was performed as a systematic literature review in order to identify articles presenting the questionnaires and psychometric tests of them. Items included in the questionnaires were classified according to the "International Classification of Functioning, Disability and Health", ICF. Thereafter, all psychometric tests of the different questionnaires were analysed with respect to relevant quality indicators using the "Cosmin checklist". Included in the final analysis were 10 questionnaires and 32 articles presenting psychometric tests of them. The analysis revealed that questionnaires for measuring physical functioning in neck disorders differ substantially in items and extent to which their psychometric properties have been evaluated. Most questionnaires contained only the ICF-components *body functions* and *activity and participation,* more often *activity and participation.* The most psychometrically tested questionnaire was Neck Disability Index. Remaining questionnaires were tested in fewer studies and only some of the properties in the Cosmin checklist were tested for most of them.
Questionnaires for assessment of physical function in people with neck disorders tend to focus more on the ability to engage in activities of daily life than on physical function as such. Furthermore, the measurement properties of the questionnaires have usually been evaluated in few studies. It is vital to measure aspects that are of importance for the individual wellbeing and ability to function in work and daily life when evaluating neck disorders. However, to increase the validity of the results in clinical and research studies, it is also important to include the most relevant aspects of physical function. We recommend more psychometric testing of the questionnaires, especially those that cover important aspects of the ICF categories. To ensure coverage of important aspects, validation of the questionnaires against patients and practitioners is needed.

A review and analysis of this kind makes it easier for researchers and clinicians to select the most suitable questionnaire for their own purpose, based on the content and quality of the questionnaire.

Keywords
Questionnaire, measure, neck, ICF, psychometrics.

Scientific evidence suggests a changed approach in ergonomic intervention research

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Background and purpose: The systematic review by Westgaard and Winkel (2011) concludes that ergonomic interventions have limited musculoskeletal and mental health effects in a long-range perspective while rationalization has predominant negative health effects. The negative impact of rationalization on ergonomics seems to be due to reduction of non-Value Added Work (non-VAW), which offers less risky exposures compared to VAW (e.g. Kazmierczak et al 2005; Jonker et al., 2013; Ostensvik et al., 2008; Palmerud et al 2012). This has been called "the ergonomic pitfall" (Winkel 1989; Winkel & Westgaard 1996). We therefore need more research on tools and methodologies that allow concurrent tuning of performance and wellbeing in a rationalization process. The aim is to increase sustainability of production systems; i.e. the joint consideration of competitive performance and working conditions in a long term perspective.

On this background, participatory approaches and tools have been developed for simultaneous consideration of ergonomics and health promotive conditions in rationalization processes, e.g. Ergonomic Value Stream Mapping (ErgoVSM) (Jarebrant et al 2016) and Kaizen (von Thiele Schwartz, et al. 2015).

However, also participatory ("horizontal") rationalization processes, such as VSM, may suffer from negative interaction with "vertical" processes for cost reductions so that the positive effects of improved processes may be eliminated by top-down processes that demand more work to be produced with fewer people (Winkel et al 2015). This creates an "innovation pitfall" (cf. Neumann et al submitted).

Thus, a key issue in the improvement of organizational sustainability is the extent to which dialogue between key stakeholders takes a systems perspective. Dialogue is needed to support engagement and keep balance between resources and demands; i.e. horizontal dialogs at floor level and vertical dialogues between top management and floor level. This kind of governance through dialogue, based on trust, has been named "practice-servant governance" and is associated with increased engagement among professionals and teams (Dellve, et al 2016).

Dialogue-based change processes may be more common in the Nordic countries compared to other parts of the world. "The Nordic Model" has evolved gradually over a period of over hundred years in the light of our special historical

circumstances. The Nordic model has been the subject of extensive discussions and studies (e.g. Schiller et al 1993). The broader concept of "The Nordic model" is somewhat more difficult to define, but includes "gentlemen's agreement" and trust between the parties. Recent studies show that the Nordic countries occupy worldwide leading positions regarding social capital (Svendsen & Svendsen 2006) and this may have played a key role as a fuel for engagement among workers (Strömgren, 2016). This may, in turn, have contributed significantly to the impressive economic growth in these countries (Olesen et al 2008).

Conclusion: Scientific evidence suggests increased research focus on tools and methodologies that improve dialogues between vertical and horizontal change processes to increase organizational sustainability. The Nordic countries may offer good opportunities for development of a "Nordic Model for sustainable systems". We are at present preparing for a Nordic multicentre study along these lines.

Keywords. Organizational sustainability, social capital, organisational redesign, implementation.

A pilot study of using smart clothes for physical workload assessment

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Background and purpose

Work with high-energy metabolism is a known risk factor in working life, which may lead to physical and mental fatigue in short term, and musculoskeletal disorders and overexertion accidents in long term. The International Labour Organization (ILO) has suggested that the average physical workload for an 8-h workday should not exceed 33% of the individual's maximal aerobic capacity, VO_{2max}. Considering the cost and convenience, estimating energy expenditure (EE) from heart rate (HR) has been commonly used in numerous studies. However, HR can be influenced by various factors such as stress, food intake, activity mode and environmental conditions. Especially at low-to-moderate levels of activity, HR is not a good predictor of EE, while pulmonary ventilation has been demonstrated to increase linearly with increased EE at these levels.

Technology innovations have offered opportunities for estimating pulmonary ventilation and energy expenditure using impedance pneumograph with textile electrodes embedded in clothes. In this pilot study, we aim to compare the precision of EE estimated separately by impedance pneumograph and electrocardiograph (ECG) using a smart vest against a reference measurement by indirect calorimetry during simulated working activities.

Study design

The subject was informed of the aims of the study and gave a written consent to participate. The test started with a 20-min resting period in lying position. Then five different simulated work activities were performed, including office work, painting work, postal delivery work, meat cutting work and construction work, each lasted 10 minutes with 5-min breaks in between. Finally, a submaximal test was performed on a treadmill until the subject reached 85% of age-predicted maximal HR. During the tests, oxygen consumption (VO_2) was measured by a computerized metabolic system (Jaeger Oxycon Pro, Germany) with a facemask. ECG and impedance pneumogram were measured by a smart vest with embedded electrodes (developed by University of

Borås, Sweden). Relative measure of pulmonary ventilation (VEr) and HR are extracted from impedance and ECG signal respectively. Individual VO_2/VEr and VO_2/HR relationships were determined during the treadmill test.

Results

In general, EE estimated from VEr (EE_{VE}) had a higher precision than it estimated from HR (EE_{HR}) compared to the reference measurement (EE_{REF}), but the precision was lower during substantial arm movements. The root mean squared error (RMSE) of EE_{VE} compared to EE_{REF} was 2.92 ml/min/kg, and was 3.88 ml/min/kg of EE_{HR} compared to EE_{REF} during all work activities. The percentage error of EE_{VE} (9.1%) was smaller than EE_{HR} (18.7%) compared to EE_{REF} for total EE in five simulated work activities.

Discussion and conclusions

In this study, we introduced a smart textile system for physical workload assessment. The impedance pneumography showed a great potential to estimate pulmonary ventilation and VO_2 during low-to-moderate intensity activities, in comparison to HR monitoring. In the future, to combine the pulmonary ventilation and HR data to improve the precison of the energy expenditure estimation will be explored.

Keywords: Energy expenditure estimation, pulmonary ventilation, heart rate.

Just shake it off: Is the human body tailored for whole body vibration?

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Agricultural, mining, construction, and transportation workers commonly experience whole body vibration (WBV). WBV is a risk factor for many chronic health conditions including low back pain and balance disturbances. WBV may also negatively affect human performance, which can lead to fatal and non-fatal occupational injuries and accidents, including equipment-related injuries, falls, and vehicle collisions. Current WBV exposure guidelines were designed to prevent long-term development of musculoskeletal disorders and discomfort; however, it is uncertain whether these standards protect workers from short-term effects. Evaluating current WBV standards for their utility to minimize human performance deficits (and associated accidents, errors, and injury) will require more knowledge of the relationship between WBV and human performance.

Eighteen participants were recruited to undergo 60 minutes of realistic all-terrain vehicle (ATV)-derived WBV, at four different vibration intensities, simulated with a 6-degree of freedom hexapod platform. WBV intensities were based on guideline thresholds for long-term health, specifically the "Exposure Action Value" (EAV) and the "Exposure Limit Value" (ELV). A mechanical shock condition consisted of shocks superimposed on EAV at 1-minute intervals. During the control condition, participants were seated on the stationary no-vibration ATV simulator. Before and after each condition, a test battery of cognitive, sensorimotor, and physical measures were collected. This presentation will focus on a sub-set of measures: rating of headache/discomfort using a visual analogue scale, postural sway, and psychomotor vigilance task (PVT). To test differences between pre/post measures in each condition, pre/post differences for each condition were submitted to either a paired t-test or Wilcoxon signed-rank test. To determine differences between conditions, normalized pre/post changes were submitted to a one-way repeated measures ANOVA and Tukey-Kramer post hoc test, or Friedman's test and Wilcoxon signed-rank post hoc test.

Vibration intensity may influence cognitive and sensorimotor performance. We observed statistically significant pre/post differences in rating of headache/discomfort in low vibration ($t=-2.44$, $p=0.03$) and high vibration ($t=-2.91$, $p=0.01$) conditions. PVT mean reaction time ($t=-3.27$, $p=0.005$) and median number of lapses ($S=-42.5$, $p=0.002$) were significantly higher after high vibration. Postural sway significantly increased

after low vibration (t=-2.88, p=0.01) and high vibration (t=-2.57, p=0.02) conditions. Differences between conditions was limited to PVT median number of lapses, where pre/post changes were significantly higher during the high vibration condition compared to control (F=2.58 p=0.05, control vs. high: p=0.037).

Whole body vibration did not induce acute effects any more than quiet sitting without WBV. Therefore, WBV may not be necessarily fully responsible for acute sensorimotor or cognitive effects. However, pre/post effects amplified with increasing vibration intensity. Surprisingly, we did not observe pre/post differences in the shock condition, which may be due to increased variability of participant posture to attenuate or compensate for shock exposure. Further research on the effect of exposure intensity and duration is required to support these findings.

Keywords. Whole body vibration, Human performance, cognitive and sensorimotor effects, international health standards

The combined multi-system effects of whole body vibration and physical and/or mental work demands

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Whole body vibration (WBV) is highly prevalent in agriculture, mining, construction, and transportation. There is strong evidence for the longer-term effects of WBV, including increased risk of low back pain and visual/vestibular disturbances. However, there are few investigations on the acute effects of occupationally-relevant WBV on biomechanical, sensorimotor, and cognitive systems. Also, since many occupational roles involve both physically and mentally demanding tasks in addition to WBV exposure, the combined effects of these tasks is pertinant to health and performance. This study investigated the effects of occupationally-relevant WBV, and explored the combined effects of WBV exposure and physical, cognitive, and concurrent task demands.

Sixteen participants were recruited to undergo 30 minutes of realistic ATV-derived WBV simulated with a 6-degree of freedom hexapod robot. WBV exposure was combined sequentially with four conditions: (1) physically demanding work, (2) mentally demanding work, (3) concurrent physical and mental work, and (4) a seated control condition. A test battery was recorded at four periods: beginning of the session, after the first 15-minute task condition, after 30-minutes of WBV, and after a second bout of the 15-minute task condition. Test battery measures include: self-perceived low back discomfort using Borg's 6-20 RPE scale, postural sway, maximum voluntary back extension contraction, blink frequency, and heart rate. For each measure, measurement data at the four time periods were submitted to either a repeated measures analysis using a general linear mixed model approach or Friedman's test.

Trends of significant measures during the control quiet condition indicate increased body discomfort, but decreased blink frequency and heart rate after WBV. During the physical condition, perceived exertion increased after both bouts of physical activity but decreased after WBV. This trend was also observed with postural sway, blink frequency, and heart rate. Maximum back extension force significantly decreased after physical activity and increased after WBV, but did not recover to baseline levels. The mental condition led to significant increases in body discomfort after the first 15-minute bout of seated Stroop test that further increased after WBV;

heart rate decreased after WBV. Finally, trends from the concurrent condition were similar to the physically demanding work task: perceived exertion and heart rate increased after the two bouts of concurrent activity but decreased after WBV.

Findings suggest that the effects of seated WBV in combination with physical, mental, and concurrent work demands were not additive. From a work arrangement and scheduling perspective, there is a beneficial effect of WBV as a means to increase task variation. However, excessive WBV alone might lead to increased discomfort, and in the longer term poses a risk for the development of musculoskeletal disorders; therefore, prolonged WBV exposure may not be a sensible long-term solution.

Many occupations are non-routine and involve a mix of work activities, such as WBV and tasks consisting of physical, mental, or concurrent demands. While this study contributes to a growing area of the combined effects of multiple work demands and exposures, future research should be devoted to better understanding these complex interactions.

Keywords. Non-routine work, whole body vibration, task demands, work scheduling and arrangement

Visual communication for improved safety learning and safety culture in mining industry

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This paper presents results from the research project *AIM4S (Attitudes, Insights and Motivation for Safety)*, conducted in collaboration with a Swedish mining company and a game developer company. At the collaborating mining industry, safety is highly prioritized. Although strong focus on safety, accidents still occur. Reasons could be deficiencies in safety information or an inadequate safety culture. With purpose to increase safety communication the mining company had introduced visual artefacts as complement to written safety instructions. The aim of this study was to investigate how employees and subcontractors at the mining company perceived their safety at work and if safety at work could be improved by visual artefacts.

Twelve employees at the mining company and two subcontractors were interviewed. The participants were asked how they perceived the safety culture at work and the effectiveness of five different visual artefacts. The visual artefacts were so called silent boards, silent movies, a documentary movie, posters, and an interactive training environment. The interactive training environment was new and designed by the game developing company as part of the project AIM4S. The other artefacts were invented by the mining company and had been displayed or used at the company for some time.

The results of this study revealed a discrepancy between knowing the safety routines and actually applying them. A perception of non-easily accessible safety equipment was a critical factor when it came to neglecting safety routines. Some employees also adventured safety if the routines were perceived to be in conflict with personal comfort. Although the employees, and to some extent also the subcontractors, felt well aware of the safety routines, they were all positive to more reminders and the use of visual artefacts. The perceived purpose of the artefacts differed. For learning purposes a documentary movie or interactive training environment were considered most effective. Silent boards and silent movies were perceived effective as reminders. The documentary movie was the only artefact considered effective when it came to increasing risk awareness and motivating safe behaviour. The documentary described a real accident at the mining company and the closeness to the own work and the strong emotions were described as important and effective. The documentary gave an understanding of how easily accidents could occur and what the effect could be.

A conclusion of this study was that visual artefacts could improve safety learning and increase motivation to follow safety routines.

Keywords: Visual communication, safety at work, work related accidents, safety culture

Exposure and risk quantification for improved relationship assessment in occupational investigations

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In occupational investigations the aim is to identify the risk for harmful conditions, and then through different measures reduce the risk to an acceptable level. However, it is not the risk that is determined even if it is said so, but rather the exposure, either as load level or as load dose. Ideally then the exposure can be related to injury outcome through dose-response relationships and a risk measure obtained. Unfortunately, established dose-response relationships are seldom available. Instead agreed classifications of exposure are used as a risk indicator for action.

There are a large number of more or less reliable methods available to identify and assess exposure, many of which are qualitative, based on judgement of observations or use quite coarse estimations such as the traffic light scale. This in turn does not result in very precise characterisation of the exposure. It is similar on the effects side where the symptoms are denoted verbally and therefore not easy to quantify. Even if the different methods used have much in common, they do not give simply comparable results. Therefore it gets hard to systematise the information and use it to establish precise relationships between cause and effect or to perform deeper analyses aiming at for example better understanding of injury mechanisms.

New possibilities for more precise assessment of exposure have become available in recent years. Through development of transducer technology, signal conditioning and recording equipment as well as computer based analysis software more occupational investigations can be based on direct measurements with reliable and precise assessment of exposure. Another possibility is to use the simulations of work that are done more or less routinely in early phases of production preparations using computer manikin software. This software permits kinematic as well as kinetic assessments so that postures, movements, gravitational loads and acceleration forces can be determined and used as exposure variables.

There should be an increased use of quantitative data in occupational investigations. Also the variables to be used in exposure quantification must b agreed upon. This is not an easy task however as workload can be characterised by so many variables. Another issue is to try to reduce the variation in terminology by improving the definitions of the terms used and also develop a methods standard. In this way the relationsships between exposure and effect could be formulated in quantitative termas. These issues will be further elaborated in the paper.

Keywords. Exposure, occupational risk assessment, dose-response, standardisation

Work environment challenges and participatory workplace interventions on passenger ships

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Work place conditions are known to affect employee health, safety, well-being, and job motivation. In what can be labelled the 'cycle of success', the working environment for service personnel may also affect service quality, customer satisfaction, and in the end, have an impact on a firm's financial performance. Previous research shows that personnel within the service department (working in the hotel, cleaning, restaurant and shop departments) display a greater degree of perceived exhaustion, job stress and fatigue than other positions on board. Catering crews also report a lower sense of identification with the seafaring occupation.

The study presented in this paper is part of a larger research project investigating physical, organisational and social working conditions, job motivation, and sick-leave for employees working in the service department on board Swedish flagged passenger ships. This paper focuses on the findings related to the physical work environment. The aim is to identify physical factors of special importance for the occupational health and safety, and if it is possible to discern health-promoting factors to counterbalance the risk for accidents and ill-health. The project adopted a mixed methods approach and the findings are based on interviews, observations, survey data and social insurance statistics concerning sick leave longer than 60 days.

The main findings show that important physical work environment factors in the service department are largely related to high physical load, and time pressure experienced by the employees. The design of workplaces and equipment is one of the cornerstones for a sustainable work environment. It can either be a factor that increases the risk for ill-health, stress and frustration, or it can become a precondition for a work environment characterised by a good fit between worker, environment and organization. As the examples in this paper illustrate, participatory design practices open the opportunity to foster employee engagement in workplace design and can be used to transfer control to the workforce, enabling employees to influence and improve their own work environment significantly.

Keywords. Ergonomics, physical load, employee participation, participatory design.

Preventing workplace violence and threats among professional cleaners – how not to be in the 'wrong place at the wrong time'

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Professional cleaners work in a complex work environment, subjected to various physical and mental loads. The study presented in this paper is a part of a larger project aiming to further the knowledge about cleaners working conditions, and to develop and disseminate methods and practical measures for an improved work environment. Specifically, the purpose of this paper is to identify the most common types of work related threats and violence directed at cleaning professionals in Sweden, and in which context these incidents occur. The overall aim is that with increased knowledge of underlying causes and contributing factors, it is possible to suggest preventive measures to eliminate, minimize, and mitigate effects of occupational threats and violence.

To provide an elaborated understanding of the problem domain, a mixed methods approach was adopted. The study is based on analysis of official Swedish occupational accident and injury statistics related to threats and violence of cleaners; research interviews with relevant stakeholders; observations and interviews with professional cleaners during workplace visits, as well as a stakeholder workshop with invited representatives of cleaning companies and employee representatives.

The results show that some workplaces and working conditions are particularly prone to threats and violence. Examples include cleaning of public transport facilities, such as metro and train stations, in stairwells, at schools, hospitals and other healthcare facilities. Also, transport to and from some workplaces is perceived as an elevated risk, especially when working at remote premises, during late evenings, night or early mornings. Perpetrators of threats and violence are often known to the victim, such as a customer or a colleague. Effective prevention measures can be found at an organisational, technical and individual level. By organizing and planning the cleaning work in time and space, the risk that an employee happens to be in the 'wrong place at the wrong time' can be reduced, and solitary work can be avoided as far as possible. Cleaners must have sufficient knowledge of how the cleaning work can be carried out as safely as possible and how to act when threatening or precarious situations occur.

Keywords. Work related violence, work environment, cleaning, work organization.

PART II

BOOK OF FULL PAPERS

Investigating digitalization of work processes in a network of organizations: a framework for analysis

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Digitalization and advanced information technology offer new, innovative possibilities to organize work in networks. In this research project we aim to analyse and evaluate the actual changes in work processes and organizational structures when taking into use new ERP systems in a network of organizations. The changes of work and organizing are investigated using the model of activity system and the concept of service/production logic as analytical tools. In this article, we discuss the operationalization of these theoretical frames and measures, and give examples of their application in the case of wood procurement process.

Keywords: Digitalization, IT systems, ERP, Activity theory, Activity system, Service/production logic, Work process, Network, Change

1. Introduction

Digitalization and advanced information technology offer new, innovative possibilities to organize work in networks. However, often technological development is a (long) way ahead of the structural, organizational and other social innovations needed to make use of the novel technologies (Miettinen et al., 2008, Perez 2002, Alasoini 2003). Even today, principles of the mass production prevail in the management, structures, and division of labour of organizations (Hamel et al., 2007). This may lead to difficulties and deficiencies in using the new digitalized devices, systems, platforms and other instruments as tools in the service and production processes. Thus, organizations need a new operational model, or logic, for production and services to fully exploit the possibilities of the digitalization.

In this research, we aim to analyse and evaluate the actual changes in work processes and organizational structures when implementing new Enterprise Resource Planning (ERP) systems in a network of organizations. We analyse how employees make sense of the changes and develop new ways of working that exploit the new ERP systems. Instead of focusing on user experience as such, we investigate the work activity as a continuously developing system and ask, how the new ERP systems shape the activity and support renewed work processes. At the same time, the organizations are striving for new operational models as a strategic step of development in the use of digital tools – thus, the emerging new production/service logic forms the larger context for change of every day work in these networks. The research project is ongoing, and it is conducted in two different branches, forestry and accounting, during 2017-19. In this article, we focus on the case of forestry, and more specifically, on the wood procurement process.

We use the cultural-historical activity theory and the methodology of Developmental Work Research (DWR) (Engeström 1987, 2000; Virkkunen and Newnham 2013) for investigating and analysing work changes as a systemic, on-going process, combining practice-level changes with larger organizational transformations.

Next, we will explain the theoretical frame and concepts, and demonstrate their use in the preliminary analysis of the change of forest operator's work in the production planning and control of the wood procurement process.

2. Theoretical frame and concepts

2.1 Transformation of operational logic as a context for work changes

The operational logic (cf. 'concept of an activity', Virkkunen 2007) is defined here as a shared, combining pattern of production or service entity including, for example, management systems, technological choices, division of labour, and learning systems. Logics constitute the rules and conventions, or "organizing principles" of a particular activity (Seppänen et al., 2015). The idea of logic shifts the focus from particular elements and relations to the entire system of functioning, and on how different elements and relations are part of that entity. The functional quality, e.g. the effectiveness of production, is affected by how consistently different elements and sub processes follow the ultimate logic of the entire system.

Examples of different kind of logics are the logic of mass production with hierarchical structure and rationalization, flexible mass production based on self-organizing teams and continuous improvement, and co-configuration based on networks and close collaboration with customers (Victor and Boynton 1998; Virkkunen and Newham 2013). Though this kind of general types of logics can be classified, each organization creates its own path of development and specific logic of production that can be inferred through analysing what kind of principles are manifested in daily processes, situations and practices.

The full exploitation of the digitalized tools calls for social innovations also in the organizational level: the prevailing logic and structure of production should be transferred. In this research, the participating organizations are striving for new models that are based on shared information, collaboration and division of work in networks.

2.2 Work activity as a unit of analysis

The DWR offers a model of activity system to investigate work (Engeström, 1987; see application in Figure 1). The model describes the basic structure and elements of work: who are the actors in the work (subject); what is the object they aim to affect and transfer into outcomes during the work process; what kind of tools they use in this process; who others are involved (community); how are the tasks divided (division of work) and what kind of rules are guiding and controlling the work.

The concept 'object of work' is used to denote the durable, collective meaning and motivating force of work activity, and defines what is produced, for whom and why. It connects and helps to prioritize the shorter-term goals and actions relevant to the ultimate outcome of the work activity. The other elements of the activity system, i.e. the tools, rules, community, and the division of labour should support and adapt to the

evolving object to ensure fluent work. However, considering the systemic nature of the development, changes in other elements of the activity system (e.g. introducing new IT-tools, ERP systems) may also induce a process of transformation in the object and the entire activity system. To ensure that important relations and interactions are covered, the activity system is seen as the smallest possible unit of analysis in the DWR approach.

In this research, we hypothesize that new ERP system will affect the work in many different ways: it is a novel tool that introduces new kind of tasks and modifies the way old tasks are accomplished; it enables new kind of division of labour and requires new kind of skills and knowledge. The ERP is shared among different organizations and it thus enlarges the community, changing the work towards integrated and networked processes. It may affect the roles, rules, and instructions of the community, e.g. through different kind of user-roles for the ERP system. It forms a new kind of integrated data bank, and may thus offer possibilities for new kind of information-intensive services and outcomes. Thus, an entire renewed work activity with new features of object may emerge. During this research, this kind of changes, connected to larger development of the operational logic, will be described and analysed using the activity system as a tool.

3. Application of the frame: examples

We use the case of production planning and control of the wood procurement process, and specifically, the work of forest operator, as an example in demonstrating the use of the theoretical frame and concepts as analytical tools. The description is based on preliminary analysis of interview-data. In the figure 1, the change of forest operators' work is represented using the model of activity system.

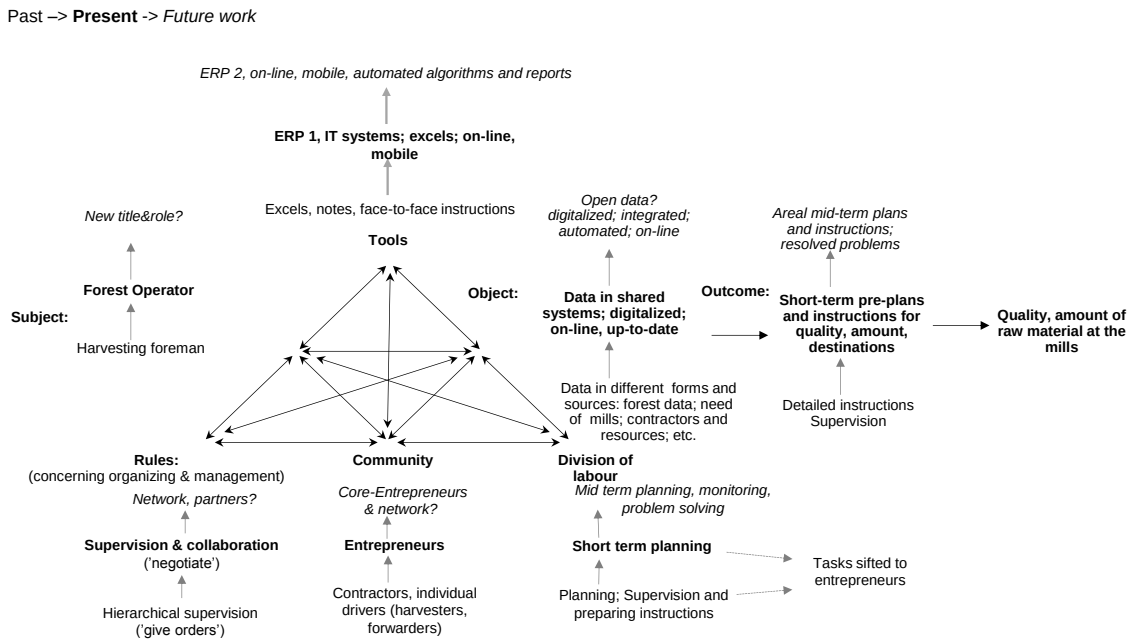


Figure 1. Past, present and future work of the forest operator in the production planning and control of the wood procurement process, depicted with the model of activity system (Engeström, 1987).

The production planning and control in the wood procurement process includes combining information about the stands marked for cutting, raw material needs of the mills, locations, and contractors' capacity, to make plans and instructions for cutting and logistical operations, in order to ensure the right amount and quality of raw material in the right time for each of the sawmills, pulp mills and other industrial users in the supply chain.

Previously the forest operator (subject), with the title of 'harvesting foreman', produced *detailed* harvesting *instructions* for contractors and harvester and forwarder drivers (outcome), using different kind of data systems, notes, and own excel and calculation sheets as tools. The practical supervision included often face-to-face interaction or phone calls with contractors or individual drivers (community).

Nowadays the forest operator, instead, produces short term (2-3 days) *pre-plans and sets targets* on quality and amount of timber for harvesting enterprises. The enterprises then internally fine-tune the plans for specific harvesters (changed division of work). The tools for planning comprise shared data systems (ERP 1), with more detailed, on-line and continuously updated data, though personalized excel and calculation sheets are still used, too. The main interaction with different actors in the process is carried out via mobile and on-line information systems, and occasional direct contacts are predominantly between the forest operators and entrepreneurs, who then further inform their drivers.

The next technical development step in the planning of the wood procurement process is the implementation of the ERP 2 system (new tool). The ERP 2 will use algorithms and data in the more integrated IT systems to produce automated plans, instructions and reports. This integration will emphasize the responsibility of each actor to ensure correct raw-data and information in the systems, to be used for the coordination of the entire procurement process. These developments will further change the role, tasks and outcomes of the forest operators: their tasks will include *monitoring* of the systems and *problem solving* in case of disturbances or exceptions, and presumably extend the planning period into couple of weeks as well as enlarge the scope of instructions into *areal plans*. This, further, will leave more decision opportunities for the entrepreneurs to plan their harvesting processes and optimize their own business.

The elaboration above shows how the information technology has enabled new logic of operation and major organizational changes in the wood procurement process (see also Rules, Community and Division of Labour, Figure 1). The previously hierarchically supervised contractors have step by step become professional entrepreneurs with new means and decision opportunities to optimize their own business. A key prerequisite for this has been the shared information system of the procurement network, as the important data concerning stands marked for cutting, short term plans and schedules are (becoming) available also for the entrepreneurs. The new operational logic of the procurement process is, thus, accomplished by several independent companies operating in close collaboration and using shared on-line computer systems for coordination and planning of the processes in the network (Figure 2; a more detailed analysis of the previous developments can be found in Ala-Laurinaho et al., 2009.). This

transformation is still on-going, and it remains to investigate what kind of new possibilities the ERP 2 will open up.

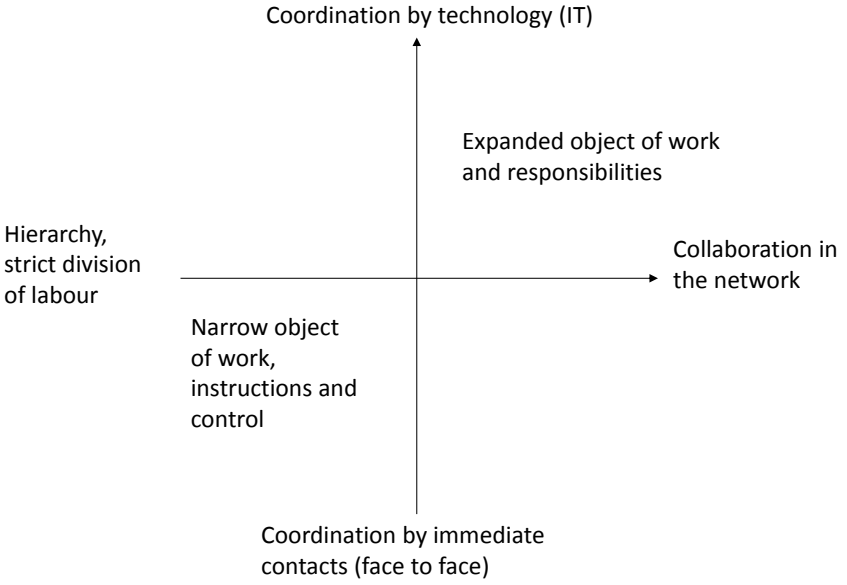


Figure 2. Transformation of operational logic of the wood procurement process.

4. Conclusions

The ERP systems provide a central tool for implementing networked and integrated operational logic in service and production processes. Such logic requires that the data and, further, constructed information and knowledge are available for all parties in the organization and even in the network of organizations. Such open information creates also preconditions for innovative development of processes and products by the employees, contractors, customers and other actors in the network (Kesting and Ulhøy, 2010). Furthermore, there is also a need to create collective understanding of the systemic interconnections between changes in the everyday work of the different actors and the activity of the entire network, in order to enhance participative development of the new operating logics and practices (Ala-Laurinaho et al., 2017). This resembles the ideas of employee-driven innovation and workplace learning that emphasize importance of collective reflection and inquiring of work situations (Høyrup, 2010).

The framework of this research supports the analysis of work changes in the larger context of organizational transformations. Collaborative, participative process of analysis and development should also enhance the role of all parties as actors of development, and promote taking small steps of practical improvement as well as more radical leaps in the context of entire organizational change.

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Digitization of Technical Information for Fighter Aircraft Maintenance

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The work environment for fighter aircraft maintenance was studied, with focus on the digitization of a Line Maintenance Checklist (LMC). It contained various procedures used when an aircraft is cleared for take-off and landing. This study aimed at extracting and describing requirements for a potential future digitization of the LMC. Methods used included observations and interviews of users working with the LMC. Also, a persona and scenarios were created, as well as a prototype evaluated with five participants. The results reveal requirements on the hardware of the digital LMC, including the ability to be charged at all times, being sturdy, being able to work with it in different light conditions, not being too heavy and not being too big to fit in a leg pocket. Non-physical requirements found include the need for memory support, but also further support potentially available by new technology, such as aid for searching information. To conclude, the study was successful in extracting and describing requirements for a digital LMC. However, further studies have to be conducted to further understand specific hardware aspects, broader interaction aspects as well as organizational aspects that were only briefly examined in this study.

Keywords. Digitization; Maintenance; Fighter Aircraft, Observations; Interviews

1. Introduction

Flight technicians at the workplace keep their most valuable technical information in a binder – Line Maintenance Checklist (LMC) – in their leg pocket. Due to updates, the font in the binder decreases, consequently decreasing the readability. This study has focus on analysing the viability of a digitized LMC as a means to address this issue.

The technical information regarding the studied aircraft contains all the information about the aircraft and is divided into different publication packages. A publication package is a collection of publications: PDF documents containing information about a certain procedure, for example changing the tires. Instructions in a publication often reference some other publication or publication package, therefore the publications are connected through hyperlinks in order to easily navigate between them. One of the publication packages is the Aircraft Maintenance Publication (AMP) containing information needed to maintain the aircraft, such as how to do repairs or prepare it for a flight. The AMP in turn is made up of several publication packages, one

of which is the Line Maintenance Instructions (LMI). It contains the various procedures used when an aircraft is cleared for take-off and landing. The clearing for take-off and check after landing is called the turnaround process. The turnaround service manager is responsible for this and is therefore the flight technicians' supervisor.

In order for flight technicians to access the instructions when working with an aircraft, the PDF documents from the publication package are printed and placed in plastic sleeves in binders. The LMI contains a great deal of information and, when printed onto A4 sized papers, fills up a thick binder. Since flight technicians should know the procedures by heart they do not need to carry the LMI with them, which would also be highly impractical considering its size. However, technicians need some form of aid to be certain that all necessary procedures have been performed. Due to this, an abbreviated version of the LMI exists, the Line Maintenance Checklist (LMC). The LMC, is significantly smaller, consisting of A6 sized pages in plastic sleeves, and fits in a flight technician's leg pocket. Therefore, the full-sized LMI always stays in the air dock and is only used if the flight technicians need detailed instructions.

Information in the LMC is updated three or four times per year. Updates can include corrected instructions or deviations concerning certain circumstances etcetera. Every flight technician has their personal LMC binder they are responsible for updating. The frequent updates to LMC has led to an increase in its thickness due to more information being added instead of not only replacing the old text. As the binder needs to fit in the flight technicians' pockets for easy transportation and accessibility, there are size limitations. The result of this is text with small font size and a cramped layout to keep the amount of pages down. This is considered to be a short term solution that potentially could lead to low readability.

The PDF files that make up the publication packages are interconnected by hyperlinks to aid navigation. This functionality is lost when the publications are printed on paper, which makes navigating between sections hard seeing that there is no other information other than the publication ID to guide the technician.

Previous research suggests that digitizing the LMC is a viable solution. Drury, Patel and Prabhu (2000) have found that using digitized work cards (similar to the instructions in the LMC) used in aircraft maintenance can be a significant improvement to paper-based work cards. Furthermore, they state that computer-based work cards can surmount limitations of paper-based work cards. In the case of the LMC, one of such limitations is the inability to navigate via hyperlinks in the paper-based binder. Other research has concerned development of information support solutions for complex technical systems using eMaintenance (Candell, 2009). The potential improvement areas may include smaller font and the troubles flight technicians have navigating the LMC.

2. Method

To gain an understanding of the requirements on both a future digital LMC and the current LMC, several methods were used. First, observation of the LMC and an unstructured interview with a turnaround service manager and two technicians. After that, interview questions were developed from the insights gained during the observation.

Personas and scenarios were created to lay the groundwork for the tasks and requirements the prototype should support. After making two personas, one was considered to be more representative to the participants of the study. Two scenarios were created, also based on the results from interviews and observations. The first scenario describes the aircraft turnaround process and the flight technician being unsure of how to perform a certain action described in the LMC. The second scenario describes the flight technician performing an acceptance check and wanting to look up an encountered fault code. The scenarios were then specified into requirements for the digital version of LMC, on which the prototype was based. The prototype was designed using user interface rules. The prototype was evaluated using System Usability Scale surveys and a think-aloud test.

Four observers, whom all have experience conducting ethnographic research studies, conducted the observation. Two flight technicians in action were observed, with the expectation to find out how the LMC is used. The observation took place at a flight test department, where the aircraft are parked in an air dock. This is where the flight technicians work on them and most of the servicing takes place. The main part of the observation took place inside the air dock but also to some extent outside. Before the observation begun, a brief introduction to the aircraft and the clarifying procedure was held by the turnaround service manager. This greatly facilitated the observation, as the observers were able to better understand the technicians' terminology. The observers also received clarifications from the process manager and a subject matter expert. During the observation, the observers split up into two smaller groups which focused on one technician each. Field notes about the location, the technicians' actions and what was said, were carefully conducted. After the aircraft was received and parked in the air dock, the observers were able to ask questions. In addition to the two flight technicians, an unstructured interview with the turnaround service manager was conducted on the same occasion.

An unstructured introductory interview with the process manager was conducted in order to get a basic understanding of the structure of LMC and LMI and their usage. Subsequently, interview questions for the flight technicians were created. These questions were used as a resource during the observation and it turned out that some changes to the interview form needed to be done. The main focus of the structured interviews was on the usage of the LMC and the technicians' thoughts about it. The main interviewer led the interview and focused on keeping it going while others focused on taking notes. Two separate interviews were held with two technicians at the same time, thus four interviewees in total. The interviews took place at the flight test department and at the delivery and modification hangar. After the interviews, a meeting was held where the group members' field notes from both interviews and the observation where compiled and compared. The topics that reappeared in the various field notes where prioritized and considered more important. An additional interview with the process manager was held in order to get a better understanding of the organizational structure surrounding the LMC and to better understand what factors might affect the adoption rate, aiming to answer the second and third research question. The interviews were semi structured and recorded after the consent of the interviewee. Each interview was transcribed.

The prototype was evaluated at the flight test department and at the delivery and modification hangar with a total of five users. The users worked as flight technicians or in technical support, with an average work experience of 26.5 years. The evaluations were conducted with one user at a time, for a maximum time of 30 minutes. Each session started with the group members introducing themselves and the project briefly. The process and purpose of a think-aloud test was then described and the testing began after receiving informed consent from the user. There were two researchers present, one acting as test leader and the other as secretary. The first screen of the prototype was showed and the user was asked to answer some first impression questions. Later, the user navigated the prototype to solve the two tasks, which were presented one at a time. The first task involved navigating to the 'fault code search' menu. The second task was to navigate to a category of the technical information and find instructions for testing the hydraulic system. The user's reaction to and path through the prototype was recorded. After the tasks were completed, the user was given a form to document age, work title, years of experience and some information about preferred operating systems or smartphone, tablet and computer. Lastly, the user filled out a SUS survey, based on the version found in Sauro & Lewis (2012), translated into Swedish.

3. Results

It was found through observation that the daily use of LMC was limited. Since the technicians are experts in their field and work with the same type of aircraft over a long period of time, they no longer need the memory support that the LMC provides to the same extent. However, pictures and personal notes were sometimes expressed to be needed to be added in the back of the LMC, which were used as a complement to the instructions in it. The notes could for instance describe fault codes that were not listed in the LMC and pictures of procedures that were not explained in detail. When talking about a digital version, the technicians expressed that being able to find explanations for fault codes and search in the text would be a big improvement from the paper version. The wish to search for information is founded in some details being hard to find. In particular, one section of the LMC is dedicated to deviations that apply under specific circumstances, which could be difficult to find although being of high importance. When servicing an aircraft during the turnaround process, the technicians work in pairs, each pair having their own routine. There is no fixed order that every pair follows even though they all go through the same procedures. One technician stated that while working with the same type of aircraft, you develop your own habits and find a routine that is comfortable for you. The main concern had to do with the accessibility of the LMC. Since it is used in several different situations, it needs to be sturdy enough to handle various tough weather conditions like heavy rain or bright sunlight. Additional concerns were to endure being dropped on the floor or being used with greasy fingers and getting dirty. From the interview with the process manager, it was found that a potential transition to a digital LMC would likely take a few years, with a transition period where both the paper and digital versions would be used. The role of LMC is heavily dependent on whether or not the user is an expert or novice. An important part of LMC is that the information is available in the right version.

Something that is missing in LMC is fault codes, leading to that the aircraft are sometimes stopped from lifting when a problem would be okay to fly with, which is costly. The smaller parts of the technician's ability to absorb the information are readability, worries, note taking and checklist. LMC's role is, according to the technicians, invaluable and the most important part of keeping the aircraft in the air. It is a big support and functions as a memory list. They mostly use LMC before or after a task. If a problem occurs and the technician does not have LMC with them, they described it as professional misconduct. LMC is usually kept in the technicians' leg pocket or in their personal metal cart. All of the participants were experts. On the other hand, units of the military also use the LMC and there are more flight technicians there that are novices. According to the interviewees, the military units use LMC more frequently. The experts interviewed reported that they have worked with the same aircraft type for years. Therefore, LMC is seldom used. In fact, the flight technicians that were observed did not have LMC with them. Technicians reported using LMC when they were doing an uncommon procedure or when encountering an unexpected problem. Information availability is concurrent with the technicians' goal to stay updated with the newest information. Making sure that they use the newest version is every technician's own responsibility. "How do I know that it's the right version?" was a question that appeared. Another factor refers to the ability to find relevant information. Currently, the technicians are expressing a need to deciphering which deviations apply in a certain situation. This is considered an important function of the LMC. Furthermore, in the paper version the technicians can also put a marker or keep their finger between pages to easily navigate back to where they were, this is something to consider in a digital version. Also, there is the ability to find more detailed information. In its current state, the technicians cannot access this information from the LMC, but need to get the big binder that contains the LMI. If the aircraft is in the air dock this is often not an issue, but the LMI is often not brought. Fault codes are generated when something on the aircraft malfunctions. A limited number of fault codes are explained in the LMC, but technicians reported that there is a need for explanations of more. If the technician does not know how to resolve a fault, they often take the aircraft back to the air dock or switch planes since they are unsure of the fault's consequences. This warrants a need to search for fault codes. If they could determine the consequences of a fault earlier, time and money would be saved. The goal of searching for fault codes is to determine whether the aircraft is ready. Readability is also important. In the current LMC, the text is rather small. The technicians use their fingers to follow along in the text while reading. They report that it sometimes is hard to find the information in LMC. The technicians work with oil and sometimes in cramped spaces, and are worried that the hardware would not handle the requirements. Mainly, they are concerned about holding the digital LMC being a task in itself, while another technician is doing the actual work. The technicians were also worried that the only way of navigating the LMC would be swiping, as if in a PDF document on a tablet. Also, they were worried that the tablets would need to be charged frequently. The LMC contained no pictures, as there is simply no room for them, despite being something that is useful for the technicians. Because of this, some technicians expressed the need to insert their own pictures to support certain

procedures in the back of the binder. Similarly, some expressed the need for a personal list of fault codes or other notes in the LMC. However, this is not allowed since the information is not certified. Note taking on the pages with procedures is also not allowed because it overrides the certified information. The technicians proposed a checklist function. They emphasized that the level of detail needed to be relevant; i.e. not too high or too low. A checklist where two flight technicians can cooperate in real time was also suggested by the group, and the users seemed positive to that possibility.

There were certain aspects of the prototype that seemed confusing to the users and that were described in sceptical terms – the main issue being a list-inlay. Most users had trouble figuring out how to navigate them and seemed frustrated by this. Users described it as having too many clickable levels, and wished for a simpler way to access the information. One user did not see the need for a list inlay and would prefer to see all of the information at once. Navigating the prototype in general was somewhat troublesome as users also struggled to find how to enter the LMI and how to access the main menu from the various pages. They did not see the small button that was meant to be pulled down or clicked to reveal the slide-down menu. Another issue was that only the arrow was clickable on some headings in the list inlay, which was inconsistent with other headings where the entire coloured field was clickable. Despite this, users seemed positive to the design as a whole. The home page containing the menu was praised as being simple, easy to use, and brilliant and users appreciated its resemblance to the original design of the LMC binder. Users also liked the idea of being able to search for fault codes and wished for a global search function. They liked the idea of being able to add personal notes as well as being able to activate a check list function. In short, some aspects of the navigation were confusing and seemed unnecessarily complicated, but users liked the concept of the prototype. They described it using words such as familiar, really clever, handy and as being a great first step along the way. The overall SUS score mean was 80.5, with a standard deviation of 7.79.

4. Discussion

From the gathered observation and interview data, it was found that the flight technicians were positive to the idea of a digitized LMC. They also had several ideas and suggestions for new functions that could be beneficial in their daily work. Initially, some concerns about digitizing the LMC arose, with high demands for availability and reliability as the most pressing concern. A digital device, in contrast to the paper version, needs electricity to run. Because of the availability requirement, a situation where the LMC is needed but shuts down due to low battery levels cannot be allowed to happen. This situation can be avoided by having a device that allows for easy replacement of batteries or that a paper version is available in the hangar as a backup. Another issue related to the hardware aspect is its fragility. The technicians are worried that the LMC would need to be carefully handled and that it should not get dirty. Due to the job requirements, and hence the requirements on present and future LMC, it will not be possible to keep LMC out of harm's way. A suggestion is therefore to consider a rugged device for the digital version. For tasks that involve oil, the technicians usually print disposable LMC pages, so that option must not be limited by

a digital LMC. Another physical requirement is that the hardware cannot be bigger or heavier than the binder is today. There are also other requirements on LMC that apply to its function in the technicians' every-day work routines. If a technician encounters a problem that they do not recognize or need to perform a rare procedure, they need more information. To solve the problem quickly, the navigation on LMC needs to work well. This includes minimal loading time for all pages and making sure that LMC saves the reading position. In the current version loading times are non-existent and navigating back to a previous page is done by putting a marker between pages. These are important factors for the LMC and need to work well in a digital version. LMC serves as a memory support. This leads to that the readability of LMC needs to be high so that the technicians can go over the text quickly. Even though the technicians in the study were experienced in their field, there will eventually be new employees who might need memory support in the beginning of their employment. To support this, the checklist function is a proposed improvement. Of course, to make sure that the experienced technicians' way of working is not obstructed by this, the checklist function must be optional, this making sure that both new and experienced employees can use the LMC as a memory support. Another requirement relating to every-day work routines is that the technicians need image support for certain procedures, which is not included in LMC. This is the reason for including a connection to LMI in the prototype. Another thing relating to the quick navigation of LMC, is the ability to search for a certain procedure or fault code. To support this, a search function for fault codes was implemented and tested in the prototype. The technicians were happy with the concept of searching for fault codes. The evaluation of the prototype showed a wide range of results. Firstly, the SUS mean was above Sauro's (2011) score for above average usability: 68. In contrast, the results from the think-aloud test did not show good understanding of the navigation of the prototype. However, the users liked the concept the prototype displayed and could see themselves using it in the future. This might have led to that the users rated the prototype high to ensure that the idea of a future digital LMC was not discarded. After the evaluation the prototype was improved. The improvements on the prototype included changing the drop-down menu to a menu button, making the arrows for the headings in the list inlay smaller and change their directions, adding a global search option to the menu bar, making the hyperlinks to the LMI clickable and blue, adding bigger line spacing, increasing the text size, adding a picture icon on the rows where a link to the LMI is present, closing the servicing and preliminary requirements headings in the category and open the other headings, changing the heading colour of the open nested list inlays to grey and the ones that can open and close to a lighter colour if at a lower hierarchy in the category.

5. Conclusion

The results showed that there are requirements on the hardware that could store a digital LMC. This includes that the LMC needs to be charged at all times, sturdy, available to use in various lighting and not too heavy or too big to fit in a leg pocket. Other than the physical requirements on LMC, there are two main requirements on a digital LMC. The first is memory support, just like the current LMC works. It is

important that this function is transferred to a digital LMC so that it is as available as the current version. Also, a sub-requirement to this is that the functions of the digital LMC should be compatible with the current LMC to increase the rate of adoption. The second requirement on LMC is that the flight technicians lacked functionality in their current work tasks; which consists of further support. Sub-requirements to this includes access to pictures, but most importantly: the ability to search for key terms and fault codes.

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Management practices as enabling factors to promote safe behaviour on construction projects

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In order to gain a better understanding of construction management practices and intervention plans to ensure safe and healthy work environments at construction sites, semi-structured interviews were conducted with site managers and safety officers. Results show that a system perspective on managing risk and safety in companies needs to be applied. Management commitment to safety and support in safety work have a key role, as well as their ability to communicate safety issues with staff. Workers participation concerning safety and safety work is vital. Safety and health work faces strong competition due to e.g., fierce competition in the sector and time constraints in projects.

Keywords: Management practices, Construction, Unsafe behaviour, Safety culture

1. Introduction

Construction attracts risk because of the temporary and dynamic nature of the workplace in which workers are, on the one hand, exposed to hazards and, on the other hand, have the potential to expose others to hazards. Initiatives and innovations to promote positive safety behaviour in the workplace are not only necessary to protect workers, but are also important at the level of the organisation. Individuals must be motivated to comply with safe working practices and to participate in safety activities (Neal and Griffin 2006). Efforts to influence the beliefs and attitudes of employees and thus motivate them to engage in a proactive safety behaviour may fail if the environment is non-supportive (Peters 1991). In high risk industries, there are evidence to support the individual's willingness to make an effort to enact safe behaviour with management commitment and attitude to safety (Zohar 1980, Neal and Griffin 2006, Donald and Canter 1994). In these organisations, where safety is a concern, employees reciprocate by complying with established safety procedures and participate in safety activities if they believe that such behaviour will lead to productive outcomes (Griffin and Neal 2006).

Management commitment was a prerequisite of successful initiatives aimed at improving the state of safety in organisations. A review and thematic analysis of safety climate factors by Flin et al. (2000) found that management was central to 72% of the

studies. The safety culture, a sub-set of the overall organisational culture, is believed to be a key predictor of safety performance. Managers must create a positive safety culture and an open atmosphere of learning in which errors and incidents can be openly discussed without blame or recrimination. Mearns et al. (2003) claimed that the general themes that emerges in safety management practices are: genuine and consistent *management commitment to safety*, including: prioritization of safety over production; maintaining a high profile for safety in meetings, personal attendance of managers at safety meetings and in walkabouts; face-to-face meetings with employees that feature safety as a topic; and job descriptions that include safety contracts; *Communication about safety issues*, including: pervasive channels of formal and informal communication and regular communication between management, supervisors and the workforce and *Involvement of employees*, including empowerment, delegation of responsibility for safety, and encouraging commitment to the organisation.

The safety commitment of the management must result in observable activities on the part of the management and must be demonstrated in their behaviour as well as their words (Hofmann et al., 1995). Well documented safety rules and procedures and its enforcement by supervisors and managers can improve safety behaviour of workers. Safety practices require the intervention of management and all the work force. Inspections may work as interventions leading to changes in safety practice and changes in outcomes. Cheng et al. (2004) suggested that through safety inspections, senior management can demonstrate their commitment to safety and this will in turn encourage and remind the workers to work safely. There are mixed debate on the issue on the use of incentives, awards and recognitions to promote safe behaviour. The use of these efforts to motivate employees to perform safely can add interest to the hazard control programme of an organisation (Hagan et al., 2001), enhance self-protection action on the part of the workforce (Cohen et al., 1979) and can help modify behaviour (Vredenburgh 2002). In contrast, studies by Haines et al. (2001) and Hinze (2002) found that projects that implemented monetary incentives possessed higher accident rates compared to those projects which did not adopt monetary rewards. Likewise punishment like imposing fines is not an effective way to reduce accident rates (Hinze 2002, Teo et al., 2005). A study performed by Rasmussen et al. (2006), revealed that interventions of management change workers' attitudes from caring about individual's safety to caring about group's safety. Importantly, Mohamed (2003) suggested that organisations should provide a medium to communicate their safety policy into a clear set of goals and objectives and addressed the importance of effective communication in order to cultivate an organization's culture (Vredenburgh 2002).

1.1. Research Aim

This study was part of a larger study and had the aim of gaining a better understanding of construction management practices and intervention plans to ensure a safe and healthy work environment at construction sites. The study required the examination of both sides of the motivational continuum - constructs that encourage and constructs that discourage safety participation.

2. Research Method

The study presented in this paper represent a part of a larger study. The larger study focus on identifying and examining the proximate set of contributing factors most likely to have an influence on workers' decisions about participation in unsafe behaviour and to compare their perceived influence in relation to specific unsafe behaviours. Research methods adopted were a questionnaire survey for skilled workers and an interview study for management at construction sites. The study presented here focus on the interview study. The study was conducted in southern Skåne, Sweden, with seven out of nine companies participating in the larger study. Respondents in the interviews were five contractors and two sub-contractors. Interviews were performed to capture the companies' systematic work environment activities and intervention plans.

A semi-structured interview guide were created and applied in all interviews which included site managers and safety officers. The advantage with semi-structured interviews is that it is relatively flexible method. The interviewer may ask appropriate questions to the respondent, as it is important for a further explanation of a question or for further understanding in an area concerned (Bryman 2015). In addition, this interview technique enables the respondent to be able to shape their responses in a more open way (Bryman 2015) and the respondent can also control the development of the interviews. All interviews were recorded with the respondent's consent to ensure reliability of the study and not to lose important information. When there were ambiguities in the interview material, the authors have turned to the respondents to clarify and ensure that the information provided was correct.

3. Results

The following are the results from the interviews performed with site managers and one safety representative.

3.1. Do you experience strong support for work environment issues from the top management?

All companies received strong support from top management on work environment issues. They work actively with the working environment to ensure a safe working place.

3.2. Do you face any dilemma when balancing safety and other factors such as budget and time plan?

All respondents agreed that one should never balance safety with other factors. But in practice sometime it does occur. Having too much focus on health and safety may result in losing a bid due to the higher price competition. The client is uninterested with the soft parameters - everything is basically about the price. The client is not prepared to pay for safety, but he/she thinks it's a positive effort from entrepreneur who wants to invest in safety.

3.3. What are the contributing factors that determine a success of health and safety in a construction project*?*

Planning, coordinating, collaborating and communicating well with the staff, working collaboration between safety officer and site manager, performing risk analyses for each

work activity (at least one week before), listening to problems experienced by the staff, participating in projects as much as possible, having positive minded people around, a calm and positive leader in order for it to work well, everyone should feel they are important at the workplace, strong support and strong commitment from the management team.

3.4. Do you have a reward system for those who work well with health and safety?
No company had a reward system in place for acknowledging good safety practices.

3.5. Do you have a displinary system for those who violate rules and safety at work?
Most companies issue an oral and/or written warning for violators. Only one company took photos as evidence of violations. Few companies even claimed they were harsher when it comes to their own workers violating the safety rules. For sub-contractors, they usually issue a written warning. All companies provide rehabilitation and treatment for those who abuse alcohol and drugs. The harshest displinary action was for bullying. All companies had a strong policy on this matter where the offender can be fired.

3.6. How do you work with the following safety interventions to improve health and safety at the workplace?
Routines to promote health and safety at the workplace (daily, weekly and monthly)
A majority of the companies have a daily routine where the site manager and supervisors walk through with craft groups the daily preparation (e.g. work methods) that is the basis for safety. Only one company practices morning exercise before work start. At all locations, a personal electronic identification is a valid security check. Weekly meetings with the management team are held highlighting what had been done during the week and what is planned for the coming week as well as dealing with issues include the working environment (incident reporting, updating the safety data sheets and checking training certificates). Only certain projects include a skilled worker at the meeting. All sites performed safety inspection rounds once a week. Only one company sends out a monthly internal newsletter to all employees with the latest information and issues. Out of the seven companies, only one implemented safety audits.

Operations planning
Operations planning applies to all new tasks, recurring work that has not been performed for a while or when needed. There were different ways to start the work preparation depending on risks - were you go through the risks of the tasks to be performed and how to carry out the tasks. Not all companies document their operations planning. This process is performed together with assigned skilled workers, supervisors and safety representatives. It should be prepared a few weeks before the task commence and sent to everyone who will participate.

Safety rounds
All companies perform safety rounds at least once a week with the site manager, supervisors, representative from the assembler/sub-contractor and sometimes health

and safety coordinator. Most companies work with the templates but some write it down as minutes from the rounds.

Health and Safety Plan
A health and safety plan is required by law and is available on the site bulletin boards and workstations. It must be updated accordingly by the health and safety coordinator.

Site layout
It must be updated accordingly and available on site, including the bulletin board and workstations.

Risk analysis
The risk analyses are available in the health and safety plan. Sub-contractors must submit their risk analysis before starting the work. Risk analyses should be performed during the preparation of the operations planning. Discussions on risk analyses should be included in weekly meetings.

Work environment procedures for apprentices
All companies except one had written procedures for apprentices. These included basic information about safety, security, on working alone, on adequate training to use machines and equipment and working under supervision. All apprentices must sign that they have read the general rules and may be penalised if they violate rules.

Work environment procedures for sub-contractors
All sub-contractors received information about the health and safety plan, prove their competence for the work they undertake, and must follow the general rules and other safety information at the workplace. The sub-contractors must submit a risk analysis before they start working. They have the same routines for reporting incidents and accidents as everyone else at the site.

Work environment procedures for posted workers
Not all companies welcomed foreign labour on site claiming that it caused too much difficulty especially in terms of communication. For the companies that hired posted workers, the only requirement was that at least one person in the group must be able to speak English. All important information including the general rules were translated according to the language required (one company had it in 8 different languages!).

Work environment procedures for the newly employed/new on site?
All companies had a start kit for new employees which included all routines and company policies, the watching of safety videos, an introduction to the project, go through the site layout plan and work environment rules. Only one company (sub-contractor) had no practical routines for new employees despite having a written procedure.

4. Analysis and Discussion

In general, all the companies demonstrate a genuine and consistent management commitment to safety where they communicate about safety issues and engage employees. This in agreement with Mearns et al. (2003) claiming that these are general themes in safety management practices. There are observable activities on the part of the management and according to Hofmann et al. (1995), this is another indicator of a strong safety commitment. Many safety interventions methods are obvious in all companies, either mandatory required by regulations: health and safety plan, risk analysis; or by voluntary initiatives: documented work methods, safety rounds, site layout, health and safety regulations for apprentices, sub-contractors, posted workers and newly employed/new on site. Surprisingly, there were no incentives initiative for safe behaviour while there are disciplinary actions for breaching safety rules and regulations. It cannot be concluded if this is positive due to many scholars still debating on the issue of reward and discipline to motivate employees to perform safely.

Achieving an accident free work environment is the main aim of all companies and this is evident in their practices. Despite claiming strongly that safety can never be compromised with budget, it still faces strong competition with time. The usual conflict of having a site manager who is also a safety coordinator may trigger this issue of balancing between time and safety. There is also the conflict where companies feel that allocating a budget for health and safety in a project bid will result on losing the bid due to high competition.

According to the interviewees, there were two types of motivational continuum, constructs that encourage and constructs that discourage participation in health and safety to promote an accident free work environment. The constructs are as follows:

Motivating constructs

- Well-functioning planning of the work
- Good coordination at the workplace
- Cooperation and good communication with the staff
- A functional collaboration between safety coordinator and site manager
- Risk analyses are performed before each task (at least one week before),
- To listen and be responsive to staff
- Participation in the project as much as possible
- Have positive minded people around
- Have a calm and positive leader for it to work well and
- Everyone should feel important at the workplace with strong support and personal commitment from the entire management.

Constructs that discourage participation

- Lack of communication with other contractors such as sub-contractors and posted workers
- Poor or lack of implementation of routines despite evidence of written documentation
- Client unwilling to invest in safety despite acknowledging the benefits of it.

5. Conclusions

The aim of the study was to increase knowledge about construction management practices and intervention plans that ensure a safe and healthy work environment at construction sites. The aim was also to get better understanding about factors that affect and create risk behaviour among skilled workers at construction sites. From interview results, the following conclusions can be drawn about the proactive safety and health work at work sites and on how to create a working environment that is more efficiently and avoids unsafe behaviour among skilled workers:

- In order to prevent risk behaviour among skilled workers within construction companies it is needed to take a systems perspective on managing risk and safety. This means that it is necessary to include several organizational levels in a company such as individual, group, work site and management levels as the antecedents for risk behaviour exists concurrently on the various levels.
- Management commitment to safety and support in safety work have a key role. Increased workers participation and increased influence among staff concerning safety and safety work is vital. Unjust blame must be avoided and to work for increased trust among colleagues and management.
- Promote a good work site planning and orderliness, show clear responsibility in safety and have a management with good ability to communicate and have a dialogue with staff e.g. about safety and safety work.
- Safety and health work and engagement faces strong competition in companies due to fierce competition in the sector, time constraints in projects, lack of safety commitment from construction clients, and the use of lowest bid price in tenders.

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Use profiles in Activity-based Flexible Offices – A case study

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The aim of this paper is to investigate whether the users in an Activity-based flexible office (A-FO) follow the intended desk-sharing policy, and further explore if any use profiles and patterns emerge regarding workstation choices and preferences. Survey data was collected at a case organisation in Sweden. From all the 66 employees that had been relocated and received the survey electronically, 46 respondents completed the survey. The majority of the respondents followed the desk-sharing policy and did not claim workstations. Motives for switching workstations and workstation choices were related to the nature of respondents' activities (e.g. temporal conditions), as well as their preferences.

Keywords. Activity-based workplaces (ABW), desk-sharing policy, non-territorial office, office design, use profiles, use patterns, survey

1. Introduction

Activity-based flexible offices (A-FOs) are non-territorial offices in which different work zones are available for the users to choose from based on their activities or preferences (Wohlers and Hertel, 2016). Relocating to A-FOs usually involves shifting from having own workstations to sharing workstations (Vos and van der Voordt, 2002). This involves implementing a desk-sharing or hot-desking policy, i.e. users are expected to remove their belongings and free up workspace for their peers (Danielsson and Bodin, 2008).

Earlier studies on A-FOs highlight that some office users do not conform to the desk-sharing policy in A-FOs and claim workstations either by leaving their belongings (Appel-Meulenbroek et al., 2011; Brunia et al., 2016; Hirst, 2011; Tagliaro and Ciaramella, 2016) or by using the same workstations in consecutive days (van der Voordt, 2004). The extent of claiming by leaving belongings is observed in A-FO studies, varying between 28% (Appel-Meulenbroek et al., 2011) to 50% (Hirst, 2011). The extent of claiming by using the same workstation also varies between high, e.g. more than 70% (Hoendervanger et al., 2016), to low e.g. 14% (Meijer et al., 2009). These results highlight that users in each case study may vary in the extent to which they make use of their flexible office and share workspaces. Furthermore, the variations indicate that some of the A-FO cases are more successful than others in maintaining a desk-sharing policy as intended.

The aim of this paper is twofold: (i) to investigate whether the users follow the intended desk-sharing policy in an A-FO, and (ii) to identify if any use profiles and patterns emerge regarding workspace choices.

2. Study design

2.1. Setting

A survey was developed for data collection at a case organisation in Sweden that had relocated to an A-FO in 2016. The case organisation was a global company developing furniture and interior solutions for offices and public spaces. The study was conducted in three units of the case organisation working with (i) marketing and communication, (ii) sales, and (iii) Brand/Range/Design and Product Information. Prior to relocation, the case organisation had conducted analyses of employees' activities and mapped their needs and requirements in the planning and design process. The motives behind this relocation were to move the three units together, improve collaboration and contribute to higher creativity and motivation as well as to create a showroom of an A-FO work environment for their visiting customers. The A-FO comprised of a variety of workplaces for solitary and collaborative work with different focus levels e.g. strictly quiet zones for high-focus work.

2.2. Procedure

Prior to relocation, the research team held an introduction for all of the employees informing them about the study. The employees were also encouraged by the management to partake. The survey was sent electronically six months after relocation to all the 65 employees who had been relocated. The survey addressed several aspects regarding respondents' work conditions, work activities, knowledge transfer and use profiles. This paper only concerns aspects regarding the respondents' use profiles. As shown in Table 1, the measured items were compliance with clean-desk policy (Q1-2), compliance with desk-sharing (Q3-4), frequently used work zones, and motivations behind the choices of work zones (Q5-6). The data analysis involved descriptive analysis of Q1-Q4, and bottom up content analysis of the qualitative data gathered from Q5-Q6.

2.3. Participants

A total of 46 respondents completed the six questions regarding use profiles resulting in a response rate of 70% (n=65). Their ages ranged from 29-55 years with a median age of 44 years. Approximately 66% were women and 34% were men. A majority, 76% of respondents stated medium-sized Open Plan Offices (OPOs) with 10-24 employees as their office type prior to relocation. There were also those (10%) who had worked in small OPOs with 4-9 employees. Less than 10% moved from large OPOs with more than 24 employees and less than 5% moved from a cell-office.

Table 1. Survey questions regarding use patterns

Desk-sharing patterns	Measured in terms of degree of compliance desk-sharing policy (Q1-2), switching frequency in consecutive days (Q3), and during a workday (Q4). • (Q1) How often do you leave work-related belongings on a workstation overnight? Using an ordinal seven-point scale, ranging from (1) "never" to (7) "always". • (Q2) How often do you leave personal belongings a workstation overnight? Using an ordinal seven-point scale, ranging from (1) "never" to (7) "always". • (Q3) How often do you sit at the same workstation as you did the day before? Using an ordinal seven-point scale, ranging from (1) "never" to (7) "always". • (Q4) Nr of times per day spent on switching workspaces.
Frequently used zones and motivations	The respondents specified workspaces in the A-FO that they used most. • (Q5) Choose the five work-zones that you use most in you're A-FO? (Multiple-choice question with a list of different zones available to them). • (Q6) The respondents indicated their motivations behind their workspace choices indicated in Q5 in an open-ended question.

3. Results

3.1. Claiming and switching patterns

A majority of respondents, 98%, indicated that they did not leave any personal belongings or work material at workstations overnight. Furthermore, the majority of the respondents, 87%, reported that they did not use the same workstations in consecutive days. The distributions of claiming workstations (i.e. nesting) and switching frequency are shown in figure 1. They number of times they reported switching workstations during a workday varied between 0-6 (Figure 2). The majority of the respondents indicated that they switched workstations on a daily basis, while a minority (4.8%=2 respondents) indicated that they never switched workstations.

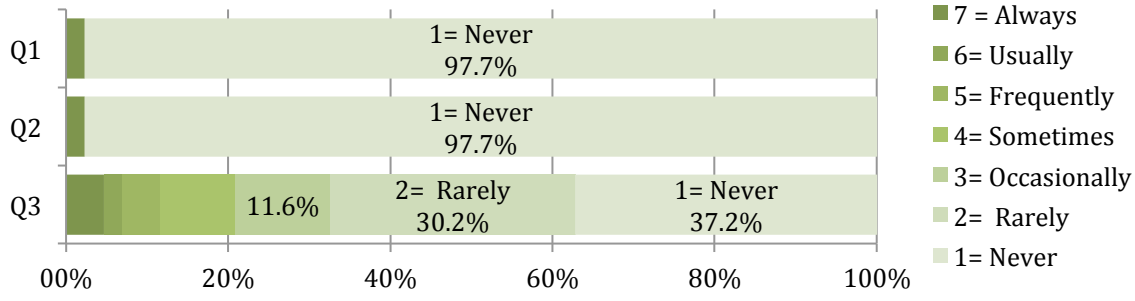


Figure 1. Results regarding nesting and switching behaviour (Q1-Q3)

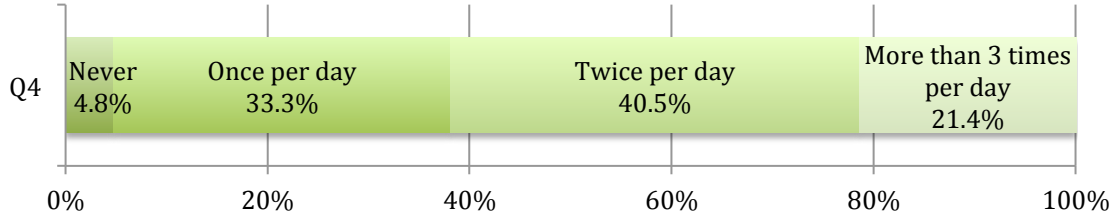


Figure 2. Number of times per day spent on switching workspaces.

3.2. Workstation choices: top preferences and use patterns

The six working zones available in the A-FO: Zone 1: strictly quiet spaces for high focus and long-term solitary work. Zone 2: Semi-quiet spaces for short-term solitary work. Zone 3: lively spaces for low-focus work. Zone 4: mixed workspaces for both solitary and collaborative work. Zone 5: enclosed meeting and phone rooms. Zone 6: open spaces for collaborative work. Among the 6 working zones, the low-focus zones, the enclosed zones for meetings and phone calls, and high focus zones were reported as the most frequently used (Figure 3).

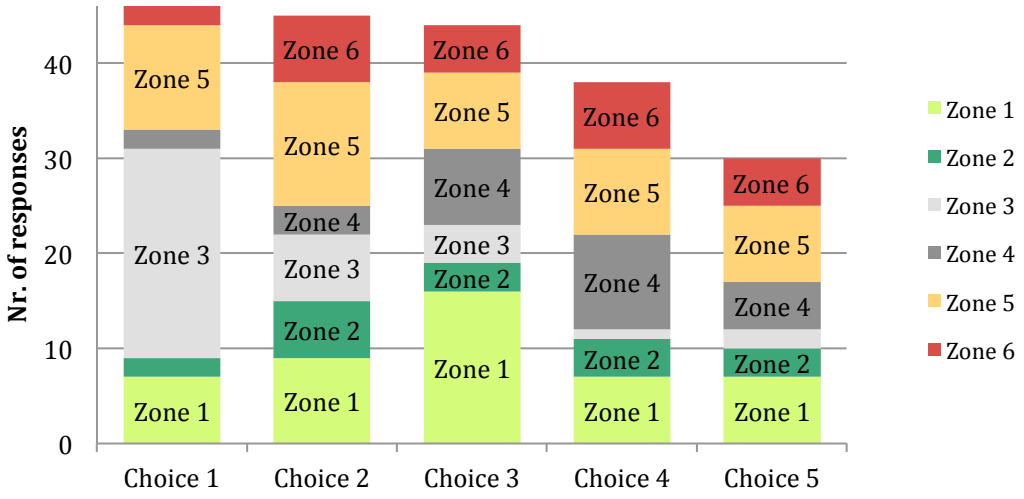


Figure 3. Top 5 frequently used work zones.

Two patterns were identified that described the respondents' choices of workstations based on a combined score (median) of their work zone choices: (i) those mostly using zones intended for solitary work, and (ii) those mostly using zones intended for collaborative or mixed work (Figure 4). Furthermore, the respondents were divided into three groups, i.e. those who mentioned using the quiet zones (i) once, (iv) twice or more, and (v) none, among their top 5 choices of workstations. Approximately 60% (n=28) of the respondents indicated the zones for collaborative work more among their most frequent choices. In fact, 26% of the

respondents (n=12) did not mention strictly quiet zones at all among their choices. Among the 40% (n=18) who used zones for solitary work more frequently, some mentioned using strictly quiet zones once among their most frequent choices, while others mentioned it two or more times.

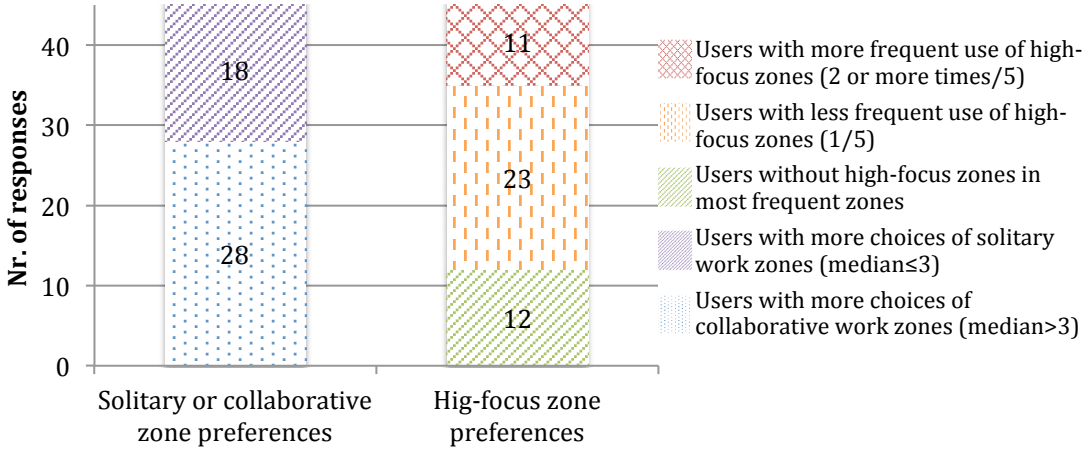


Figure 4. Use patterns related to workstation choice (The top 5 frequently used spaces indicated by the respondents).

3.3. Motives for choice of work zones

The motivations behind choices of workstations were categorized as: (i) temporal motives, i.e. duration of use depending in the work tasks at hand, (ii) work requirements, i.e. booked meetings and phone calls, (iii) level of concentration, (iv) physical interactions, e.g. access to height adjustable furniture, availability of screens or other tools, (v) social motivations, e.g. exchanging information, working side-by-side, (vi) ambience and likings, i.e. lively or serene atmosphere, and (vii) other motives. Work requirements, ambience and level of concentration were the frequently mentioned motives (Table 2).

For zone 1, the most number of reported motives were "serene ambience", "work requirements and the ability to avoid distractions (figure 5). Zone 2 was mostly used for short-term activities and communication and collaboration with colleagues. Zone 3 was mostly used for its lively ambience, undemanding activities and physical interactions i.e. the access to height adjustable desks. Motives for using zone 4 ranged from serene to lively ambience, and from avoiding distractions to collaboration. For using zone 5, work requirements i.e. booked meetings or phone calls were the main motives. Lastly, zone 6 was mostly used for communication and collaboration.

Table 2. Categories of motives indicated for choice of work zones.

Motives behind workspace choices.	**Nr. of times mentioned**
Work requirements: booked meetings and phone calls	42
Ambience: lively (open, movement, stimulating), serene (enclosed, secluded, calm, private), liking	27 (17 serene, 10 lively), 6 liking
Level of concentration: tolerating/avoiding distractions	25 (12 to avoid distractions and 6 to avoid distracting, 7 undemanding work)
Social interactions: Collaboration and communication	19
Temporal motives: short-time activities	17 (9 short-term, 8 time-demanding activities)
Physical interactions (height adjustable desks, treadmill, screens)	8
Other (Lunch, Pause, etc.)	8

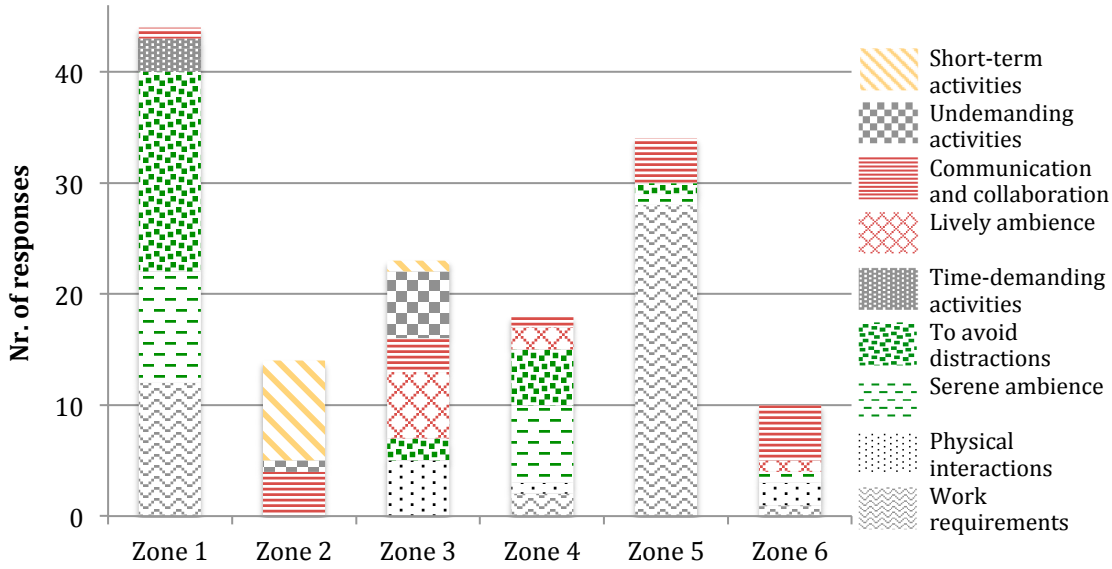


Figure 5. Motives indicated for choosing different work zones.

4. Discussion

The first aim of this paper was to investigate whether the users follow the intended desk-sharing policy in an A-FO. The results showed that the majority of the users complied with the desk-sharing policy and refrained from claiming workstations both explicitly (i.e. they did not leave their belongings on workstations), and implicitly (i.e. they avoided nesting and switched workstations on a daily basis). The second aim of this paper was to identify if any use profiles and patterns emerge

regarding workspace choices. Two patterns were identified that describe respondents' choices of workstations: (i) those mostly using zones intended for solitary work, and (ii) those mostly using zones intended for collaborative or mixed work. Furthermore, the respondents were divided into three groups, i.e. those who did not mention quiet zones in their most frequent choices, those who mentioned it once, and those who mentioned it twice or more. For the latter groups, avoiding distractions, time-demanding activities, and a "serene ambience" was the main motive for choosing quiet zones. On the other hand, low-focus zones were mainly used for undemanding activities, availability of ergonomic furniture, and its "lively ambience". These findings highlight that the A-FO solution was used as intended and furthermore the solution matched employees' activities since it was based on the case organisations' analyses of the employees' activities during the implementation process.

The high rate of compliance with clean-desk policy (97%) found in the case organization is in line with some studies and contradicts with other studies. For example, Appel-Meulenbroek et al. (2011) found that 28% of users claimed workstations in an A-FO, while Hirst (2011) reported that 50% of the workstations were claimed while by leaving belongings behind. Furthermore, about 61% of the respondents in this study indicated that they switch workstations between 2 and 6 times per day. The high frequency of switching workstations per week or day is in line with some case studies (e.g. Meijer et al. 2009), and in contrast with others that report a low switching frequency (e.g. Appel-Meulenbroek et al., 2011; Hoendervanger et al., 2016; Qu et al., 2010). Motives for claiming workstations and nesting seem to be coupled with homogenous work activities (Hoendervanger et al., 2016), users' work units and roles (Tagliaro and Ciaramella, 2016), problems with setting, wrapping up, and moving things around, and proximity to colleagues (Hoendervanger et al., 2016; Qu et al., 2010). However, these factors did not apply for the users in this case study. First, the respondents belonged to three different work units with different roles and responsibilities and no unit-specific patterns were demonstrated. Second, the identified use patterns and motives behind workstation choices indicate a mix of users with homogenous and heterogeneous work activities who all switch workstations on a daily basis. Third, the problems with using printed documents and setting up workstations may have been resolved and addressed during the implementation process (cf. Brunia et al., 2016). Fourth, the A-FO solution seems to have suitable capacity and proportion of collaborative and solitary workspaces.

5. Concluding remarks

This paper presents a case study of an Activity-based Flexible Office (A-FO) in which the majority of the respondents complied with the desk-sharing policy and did not claim workstations in neither explicit nor implicit ways. The main contribution of

this paper is the identified use patterns regarding workstation choices and further, a mapping of users' motives behind their choices. The identified patterns relate to: (i) user profiles whose most frequently used workstations were in zones intended for either solitary or collaborative work, and (ii) the extent to which strictly quiet zones were chosen. These findings highlight that the A-FO concept was used as intended and conceived during the implementation process. Investigating use patterns that emerge after relocation can be used as a tool for evaluating the concept and identifying potential mismatches with the design intentions.

The identified motives behind workstation choices indicate a fit between the different workspaces and the users' ongoing work activities as well as their preferences and likings. More specifically, users' choices of workstation were related to temporal conditions and organisational requirements of work, the level of concentration needed to carry out work, and the need for collaboration and information exchange. Finding fitting workstations for different solitary and collaborative activities may have positive consequences for work conditions both on individual and group level.

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AFoU – a network for sustainable working life and development

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The aim of this paper is to describe and reflect on the development of the Swedish network AFoU (Workplace related R&D for sustainable working life). The overall goal with the network AFoU is to strengthen research contributing to sustainable working life, research that makes significant improvements, and future organizations characterized by competitiveness, quality and renewal through good working conditions. AFoU was started in 2015 and it consists of researchers from different disciplines, practitioners and representatives for unions and employer organizations. The network strives to combine high-quality research with practical use. This is achieved through collaboration between different stakeholders and across disciplines, thereby co-creating new knowledge that is needed to meet current and future demands.

Keywords: Workplace related R&D, Workplace development, Competitiveness, Quality, Innovation, Co-production, Knowledge, Work environment

1. Introduction

Working life is rapidly changing along with changing market and societal demands, increasing globalization as well as technology development. Although the changes in working life constitute a risk of impaired working conditions for employees, the changes will also enable increased possibilities for improvement of working conditions. In order to stay – and also to increase – competitiveness, it is important for organizations to develop their business, operations, and workplaces with skilled, healthy and motivated personnel. To achieve sustainable working life and sustainable development in organizations, there is a need to take several stakeholders' perspectives into account. Employers have a primary interest in efficiency, productivity and competitiveness, but also to create innovation and development. Employees want safe, good and equal working conditions, and opportunities for development and learning. Customers and users demand quality and reliability. In this area of potential tension, further research is needed to gain knowledge of future trends and challenges in organizations and their impact on working conditions, connections between working environment and competitiveness, and how to achieve sustainable development in organizations.

The aim of this paper is to describe and reflect on the development of the Swedish network AFoU and its strive to strengthen research and increase knowledge for development of future attractive and sustainable workplaces in combination with

sustainable development and competitiveness of organizations. The abbreviation of the network AFoU (in Swedish 'Arbetsplatsnära FoU för hållbart arbetsliv'), stands for 'Workplace related R&D for sustainable working life'.

2. Why a network for workplace related R&D for sustainable working life?

The AFoU network is a national open arena in Sweden, bringing together researchers, practitioners, labour market parties, and financiers who have the same interest in development of workplaces with actors and organizations striving for competitiveness, innovation and quality through good working conditions.

The network AFoU is a dynamic effort with the following purposes:

- to place working life research and innovation at the forefront of public and policy practice
- to increase the research arena through expanded possibilities by new research funding programmes
- to carry out workplace demand-driven R&D based on labour market parties' identified workplace challenges, knowledge gaps and future R&D needs
- to generate knowledge, which when implemented, leads to competitiveness, quality, and innovation through good working conditions
- to create new interactive collaborative activities between researchers, labour market parties, practitioners at workplaces, in research projects, industry and public organizations
- to create synergy effects by collaborating with other networks
- to contribute to design of research methodology to combine high-quality research with high relevance for practice

Other potentials for the network AFoU are that the members and member organizations constitute vital distribution channels for research results and initiation of new research. The overarching drivers and common objective defined by the AFoU network is 'Competitiveness and innovation through good working conditions'. To gain in-depth knowledge of these areas, research has to be carried out in close collaboration between practice and research in interactive forms – from problem formulation to dissemination and application of results. The network AFoU has identified eight quality criteria for research projects enabling combination of high-quality research with a high relevance for practice, see Figure 1.

a) Interactive ways of working – Research with and for the workplace, early involvement
b) Proactivity – The strive to prevent rather than remedy problems and poor health
c) Collaboration with union and labour parties – Workplace driven research based on labour market parties' needs
d) Research in partnership – Collaboration between companies, public organizations and research, creating partnerships without bias
e) Multidisciplinary – Different research perspectives, different workplace perspectives

f) High degree of applicability – Solution-oriented research, low threshold for practical application
g) Transparency during, under, and after the projects – Two or three-way communication from the beginning, dialogue, follow-up, and continuous feedback
h) Balance between different stakeholders' interests – Integrity, taking several perspectives from different interests into account

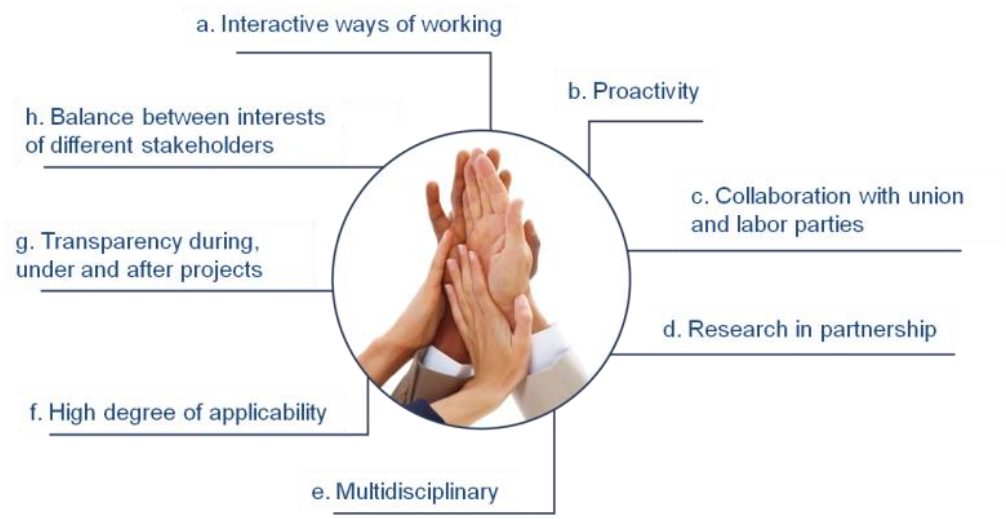


Figure 1. Quality criteria for workplace related research

3. Initiation and development of the AFoU network

3.1 Start-up, November 2014 – April 2015

The ideas behind the network AFoU were raised during discussions addressing workplace related research in Sweden combining issues related to working life, innovation, quality and competitiveness. These discussions were held during the period of November 2014 to April 2015 by researchers from HELIX VINN Excellence Centre, Linköping University, Swerea IVF, KTH Royal Institute of Technology, Luleå University of Technology, University of Borås, Lund University, and the programme director and chairman of ProduktionsLyftet. The potential of development of a new national network was then highlighted.

During this period, the collaboration increased from eight to 15 members who during four meetings set the direction for the new national network, made an overall inventory of working life researchers and research organizations in Sweden, and held additional dialogues with different actors. An important issue was that this collaboration should 'fill a gap', specifically strive towards a 'win-win' situation, and be complementary to other networks. The former president of the labour party IF Metall, also the chairman of ProduktionsLyftet, was assigned as the chairman for the AFoU network.

3.2. Anchoring phase with labour market parties and formalization of the network AFoU, May 2015 – February 2016

The most important part in the further process was to anchor the network ideas and objectives with the main organizations of the labour market parties in Sweden. For this process, a working committee was organized including the chairman of the network AFoU, a representative from Swerea IVF and one from HELIX VINN Excellence Centre, Linköping University.

During this period, additional people from different organizations with interest in and knowledge about working life issues joined the network and became part of the AFoU steering group that held network meetings every second month. The members were highly motivated and participated in the development and start-up activities, for example:

- Development of a program description of the network ideas in public communication material, including a common vision for research, quality criteria for workplace related research, R&D project ideas, etc.
- A letter signed by the AFoU members to the Swedish government's research proposal highlighting research areas that needed to be addressed
- Development of an annual process for the network

The annual process for the network included (and still includes) an annual AFoU dialogue seminar with key actors from main organizations of the Swedish labour market parties, research funding organizations, etc. The process also includes an annual loop to identify the needs prioritized by the labour market parties, practitioners, and workplaces in different sectors. Key issues are then followed up in network workshops, in which initiatives are taken to new activities.

The first AFoU dialogue seminar was held in October 2015 hosted by Svenskt Näringsliv. It was an important milestone as the main organizations for the labour parties in Sweden (LO, Svenskt Näringsliv, the Swedish Association of Local Authorities and Regions, Saco, TCO and the Swedish Agency for Government Employers) at this seminar committed to appoint representatives for a reference group for the network AFoU.

The strategic dialogue resulted in identification of future development needs of research related to future work and workplaces. These were followed up and processed in an operational network workshop in November 2015.

During this period, the network AFoU increased from 16 to 50 members, representing 18 organizations.

3.3. Growth and future development of the network, from March 2016 and onward

The organization of the network AFoU includes a reference group, a steering group, and a working committee. The AFoU reference group has representatives from the main organizations of the labour market parties. There are four to six meetings per year with rolling hosts. At the meetings, needs are identified and prioritizations are made for the network activities and development.

The AFoU steering group plans and develops activities based on the reference group’s priorities. At each meeting there are rolling research presentations and rolling

responsibilities for practical issues. The AFoU working committee carries out the strategic and coordinating work where the AFoU chairman, HELIX Competence Centre[1] at Linköping University, and Swerea IVF are represented.

The network has at present limited public funding, why each member invests in his/her own engagement. The operational work in the working committee is funded by Swerea IVF´s strategic programme – 'Industrial work environment/ Sustainability' during 2015 – 2017 and by HELIX Competence Centre during 2016 – 2020.

Several network activities have taken place or are planned for during this phase, for example:

- Dialogue seminars
- Network meetings
- Creation of collaboration teams for spinoff activities, new R&D projects, etc.
- Development of a project portfolio, an inspiration folder visualizing different research projects and their results, which are relevant for practitioners
- Updated communication material
- Contribution to research funding calls and governmental investigation regarding working life research
- Dialogue with the Labour Ministry
- R&D collaboration activities with the platform Sustainable Work (2017)
- Public web and member working platform on the web (Swerea, 2017)

During this period, the network AFoU has increased from 50 to approximately 120 members, representing over 30 organizations (spring 2017).

4. Results – identified research needs and approach

Since 2015, the number of members in AFoU has increased continuously. One current strive is to reach a balance between representatives from different sectors, members working in private companies and public organizations, union representatives and researchers.

A number of research areas have been identified for the network, areas where there is a current need for further research about consequences for working life:

- Globalization
- Digitalization and automation
- Continuous improvements and change processes
- New organization structures, outsourcing and privatization
- Psychosocial issues, stress and leadership
- Diversity and inclusion
- Competence supply and learning

For all research areas above, it is important to also have an international perspective as well as focus on how research results can be applied in practice. The latter is strived for by having an approach of co-producing knowledge in an interactive approach between research and practitioners. It involves knowledge development in two systems, the

[1] HELIX VINN Excellence was restarted and renamed in 2017 (Berglund et al., 2017).

research system and the practice system, both resulting in new valuable knowledge. Co-production requires a systematic contact between the two loops of knowledge production, see Figure 2.

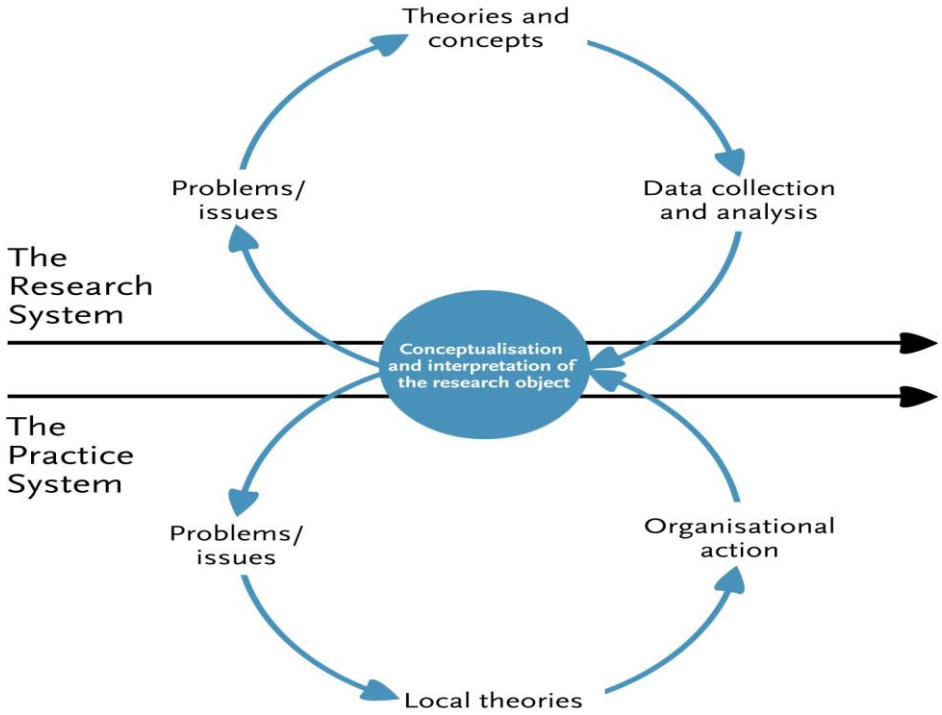


Figure 2. Co-production of knowledge through collaboration between researchers and practitioners (Svensson et al., 2015)

So far, AFoU has resulted in new cross-collaboration between research fields and sectors through different activities, such as dialogue seminars and workshops with different topics. Examples of topics have been 'digitalization' and 'diversity in working life'. Work groups have also been formed as a result of the network meetings, groups that collaborate in research and/or making new research proposals. Furthermore, an initiative has been taken to create synergy effects by collaborating in new ways between existing projects. This network-collaboration model is applied within the theme of 'Smart improvement work', where four research projects have identified potential advantages of collaborating with each other and organized a first joint workshop to learn from each other as well as initiate new common activities to fill knowledge gaps in further research.

5. Discussion and conclusion

The basic idea in AFoU is research characterized by co-production of knowledge and synergy effects through collaboration in the AFoU network. This includes collaboration between individual network members and research projects. Individual projects contribute with valuable results, but collaboration between projects and actors can create much more. AFoU may here constitute a platform to create synergies and

concrete collaboration to gear up the possibility to reach out with results and make greater impact.

The AFoU-network is an open arena for collaboration between different actors – researchers, practitioners (industries, public organizations), labour market parties, financiers, including collaboration within and between projects and other networks. Current efforts for further development of AFoU include how to involve intermediaries to reach more practitioners and strengthen the AFoU initiative. Other ongoing work is to fully implement and evaluate the developed network-collaboration model for synergy effects. There are also a number of questions related to how to ensure practical benefits of workplace related R&D. These questions guide the forthcoming development of AFoU:

- How are R&D problems formulated in collaboration with the problem owners?
- How can the interactive processes in workplace related R&D be further developed?
- What prerequisites are needed to make workplaces ready for workplace related R&D?
- How can results from workplace related R&D be more available and 'user friendly'?
- How can quality of workplace related R&D be assessed so that also implementation is prioritized?
- How can different sectors and branches learn from each other?
- How can different stakeholders' interests be taken into account through collaboration instead of conflict?

In a future state, the network AFoU may play an important role in identifying trends and challenges by creating and developing regional and national workplace fora. The network may broaden and deepen workplace related research with continuity and strength, no matter targeted appropriations and investments. AFoU has the potential to constitute a bridge for adaptation, development and innovation in working life. By that it can contribute to fill an identified gap between research, development and implementation in working life research in Sweden (Abrahamsson, 2017).

Through a national effort and collaboration within the network AFoU, new opportunities may be created for: identification of problems and obstacles at workplaces and translation into future research areas; finding solutions that create value for all stakeholders; long-term and sustainable strategic development; co-operation at a local, regional, and national level; and making knowledge about workplace related R&D available.

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HELIX Competence Centre – Knowledge for Sustainable Working Life

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The purpose of this paper is to describe HELIX Competence Centre at Linköping University and its work to contribute to sustainable working life. Research in HELIX Competence Centre is based on an interactive approach between researchers from different disciplines and partner organizations, including industrial organizations, public organizations, labour market organizations, and civil society organizations. The research programme includes four research themes: 1) Sustainable development processes in industrial production systems; 2) Growth and development in small enterprises; 3) Sustainable, innovative, and coordinated health and welfare processes; and 4) Diversity and inclusion in working life. Other activities include seminars and partnership meetings with different topics and a yearly HELIX day. The research and activities led by HELIX Competence Centre constitute an approach to integrate social and economic sustainability, produce scientific knowledge, and add value to practice in the partner organizations.

Keywords: Interactive research, multidisciplinary, partnership approach, organizational development.

1. Introduction

Working life of today is affected by changes such as increased globalization, digitalization and changing demographics. Globalization implies potential new markets, but also increased competition; digitalization opens up opportunities for development, while at the same making demands on changes for organizations and individual employees; and an increasingly older population along with decreasing resources in the public sector requires new ways of organizing welfare. There is thus a strong demand to increase productivity in several domains. Other emergent issues include increasing fragile employment relations and the need to find means to achieve diversity in the working population. Many organizations find it challenging to create sustainable organizations that meet the described changes and at the same time ensure employee health, support diversity, and facilitate learning. Although efforts have been made to meet these challenges, there is still a gap between research, development and implementation in working life research in Sweden (Abrahamsson, 2017). The Swedish government has also paid attention to the consequences of the ongoing changes in Swedish working life, and the need to look at the impact of the responsibility for working life issues has been highlighted (SOU, 2017). One possible way to meet the

challenges and find improvements and solutions is through collaboration between different stakeholders. This is a means that has been applied within the Swedish Model during decades. The model had its peak during the 70s and 80s with the social partners contributing to funding and implementation of working life research (Håkansta, 2014). The model may also be regarded as an approach for joint efforts by researchers and practitioners, including representatives for both employers and employees, to collaborate on solving working life problems in practice. This paper highlights a complementary, collaborative way in which current working life challenges are addressed.

The purpose of this paper is to describe HELIX Competence Centre at Linköping University and its work to contribute to sustainable working life. HELIX Competence Centre is a research centre financed by the Swedish Agency for Innovation Systems VINNOVA. The vision of HELIX can be described as 'knowledge for sustainable development in organizations'. Its overall goal is to contribute with significant scientific knowledge while also adding value to practice.

2. Approach

Research in HELIX Competence Centre is based on an interactive approach between more than 30 researchers from different disciplines and partner organizations. The disciplines represented are behavioural sciences, management, business and public administration, entrepreneurship and innovation, as well as health and work sciences. The researchers belong to three nodes: Linköping University, KTH Royal Institute of Technology, and Swerea IVF.

The partner organizations include private industrial organizations, public organizations, labour market organizations, and civil society organizations. The latter include e.g. an organization that provides advisory services to different cooperatives and an umbrella organization for idea-driven, non-profit providers of welfare. In all, these five domains constitute the Penta-HELIX partnership approach, see Figure 1.

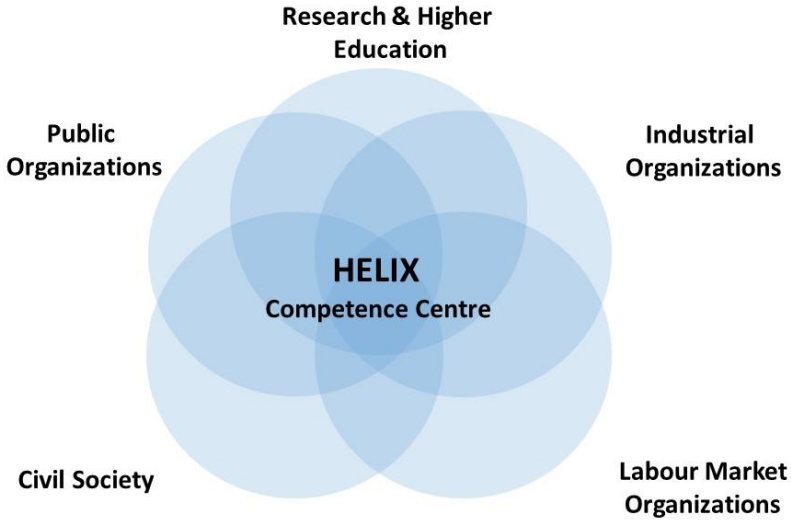


Figure 1. Close partnership collaboration in the Penta-HELIX model (HELIX, 2017)

Problems and issues are identified in dialogue between the researchers and the partner organizations. This is done within the interactive research approach (Svensson et al., 2015). This implies that knowledge is co-created by actively participating practitioners and researchers, who have different roles. The researchers work in the research system with problem formulations, theories, data collection and analyses. The practitioners, on the other hand, belong to the practice system and search for knowledge and methods to solve problems in their organizations. In the interactive approach, these two systems are linked through regular joint discussions and interpretations by the researchers and the practitioners, see Figure 2. The outcome of these discussions and interpretations are fed back to the next cycle of research and work practice.

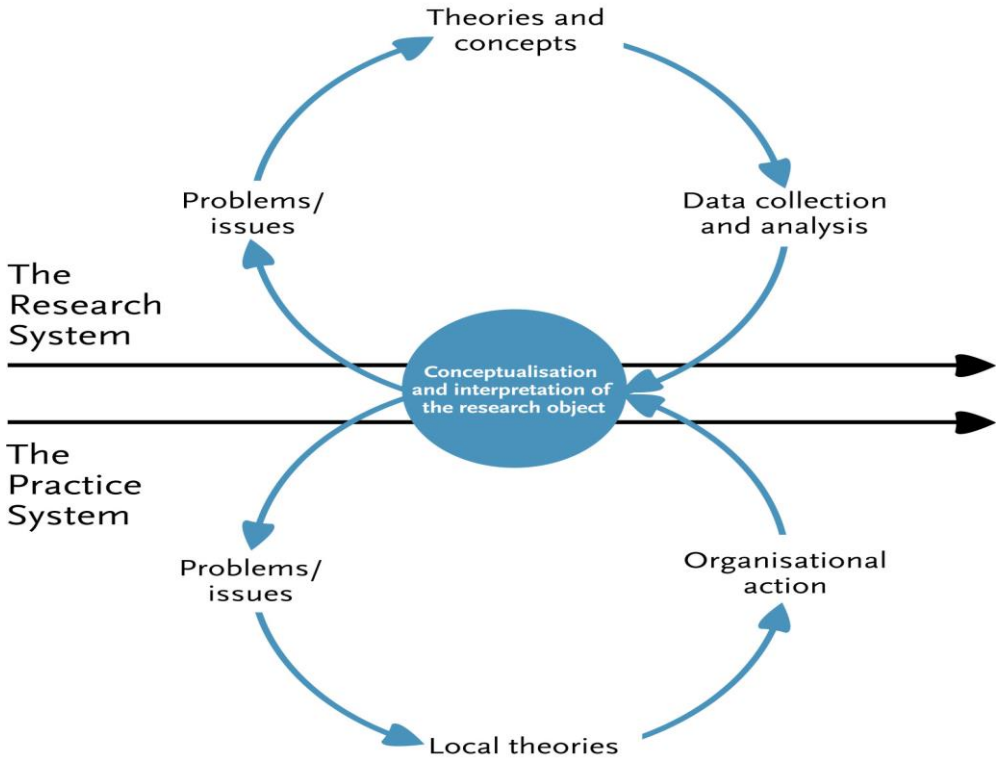


Figure 2. Interactive research approach (Svensson et al., 2015)

3. Results

HELIX Competence Centre started in 2017 and is granted funds for five years. HELIX Competence Centre has a background in and is a further development of the earlier HELIX VINN Excellence Centre, which was active for ten years at Linköping University.

As the overall goal for HELIX is to contribute with significant scientific knowledge as well as adding value to practice, a number of different activities are organized. These include several interactive research projects, collaboration with other research groups outside HELIX, and HELIX Academy to contribute to practitioner learning. HELIX also supports and drives the development of networks for

practitioners, e.g. within quality management, and for both researchers and practitioners in the network AFoU (Berglund et al, 2017).

3.1 HELIX research programme

In order to meet the challenges of current changes in society, the research programme that has been developed for the next years includes the following four research themes (see also Figure 3):

1. Sustainable development processes in industrial production systems; focussing on organizational and technological change due to societal changes, competition, globalization, and digitalization
2. Growth and development in small enterprises; focussing on the development of sustainable workplaces, management, leadership, and the small enterprises' interaction with other types of organizations
3. Sustainable, innovative, and coordinated health and welfare processes; focussing on the challenges of inter-sectoral collaboration in healthcare, new forms of co-creation and collaboration, learning and training in simulation-based learning environments, etc.
4. Diversity and inclusion in working life; focussing on how diversity and inclusion can be achieved through organizational structures, self-employment, and support from authorities and civil organizations

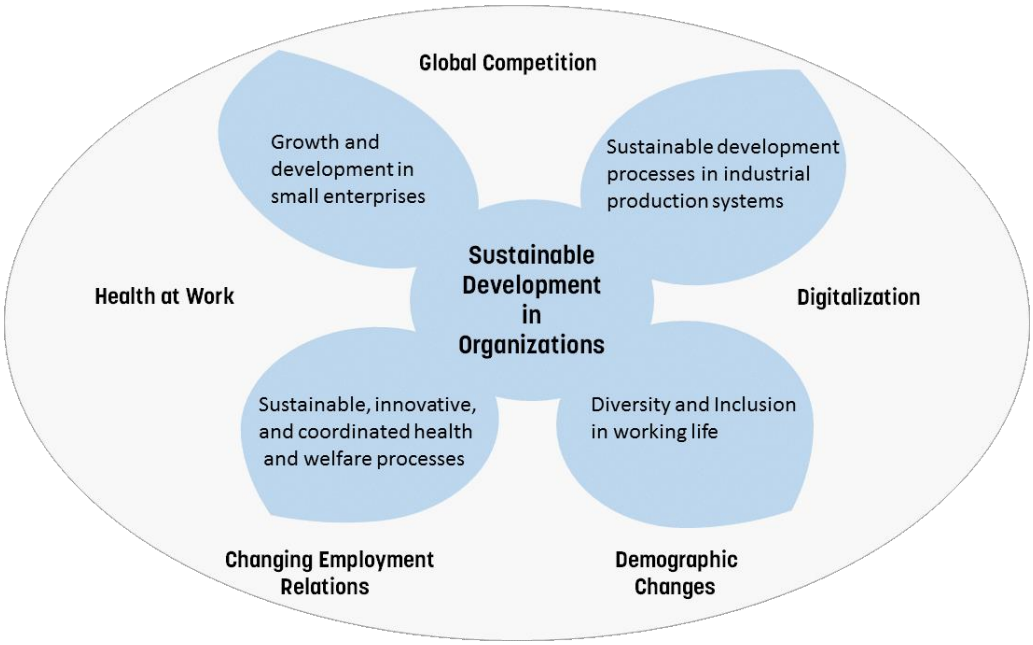


Figure 3. HELIX research themes meeting the challenges of society changes

3.2 Interactive research projects

Several interactive research projects have started and others are in their initial stages. Examples of ongoing projects are 'Leadership for development and learning',

'Organizing for diversity', and 'Science parks as intermediaries for regional development'.

As described above, interactive research is based on collaboration between the researchers and practitioners. The structure of this collaboration varies depending on the project and contextual conditions. There are a number of different ways for the practitioners to participate in interactive research projects. The practitioners may:

- Contribute to formulation of research problems
- Contribute with 'research data'
- Participate in and contribute with networks
- Participate in exchange of experiences, projects, and feedback seminars
- Participate in HELIX Academy activities
- Participate as researchers, e.g. as an industrial PhD candidate
- Receive students for project or thesis work
- Distribute knowledge from projects in their own organizations
- Be a 'critical friend', that is contribute with alternative perspectives, question, and challenge

3.3 HELIX Academy

Other initial activities include seminars and partnership meetings with different topics and a yearly HELIX day. The HELIX Academy is a developed arena for sharing of knowledge, experiences, and dialogue for people working at all levels in organizations and across different domains. The HELIX Academy contributes to training and stimulation of development activities for practitioners, and it also constitutes an additional arena for joint activities with practitioners and HELIX researchers. Some examples of activities and topics that have been performed and/or are planned are:

- Courses for practitioners, e.g.
    - Sustainable leadership with Lean
- Seminars and workshops, e.g.
    - Trust-based management in public organizations
    - Future work – challenges in work organization and research
    - Co-production of knowledge in research
- Partnership meetings with relevant topics, which are identified as the partnership develops, e.g.
    - Poster presentations of ongoing HELIX projects

Other activities offered by HELIX are for practitioners to participate in academic research at the university during a period of time and arrangements where HELIX researchers spend time at individual partner organizations.

4. Discussion and conclusion

HELIX Competence Centre has a background from ten earlier years as research centre at Linköping University. This means that it is firmly established and known by earlier partners and a number of stakeholders for working life issues. Some significant changes and development have taken place in the new research centre. In order to

increase national impact, the two other nodes outside Linköping, KTH Royal Institute of Technology and Swerea IVF, were created. This also contributed to strengthening research and development of sustainable production and Lean as well as reaching out to SMEs all over Sweden. Another change in the new HELIX was the addition of civil society organizations in the partnership model (thus changing from Quadruple to Penta-HELIX). Acknowledging that the civil society organizations play an increasingly important role within the public sector, both as welfare producers and as employers, this group was considered important to include as contributors to find solutions for sustainable organizations.

Reaching out geographically and to several sectors is important to achieve impact. Another important aspect is to include intermediary organizations in HELIX. There are several intermediary organizations within current HELIX, such as Swerea IVF and civil society organizations. These constitute collaborators to find solutions as well as significant information channels for distribution of research results. The development of HELIX Academy is a further means to increase impact, being a way to involve more practitioners in further activities arranged by HELIX.

Meeting the challenges of today's working life requires collaboration between several stakeholders, and there is a need for further development of methods to reach out and involve more practitioners at all levels. This has a potential to increase learning as well as the impact of research on working life.

HELIX Competence Centre aims at being a part that makes a difference in working life. Its research and activities constitute one approach to integrate social and economic sustainability, produce scientific knowledge, and add value to practice in its partner organizations.

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Ergonomics activities in the product development process

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Ergonomics and human factors (E/HF) has an important role throughout the whole product development process, but the scope and content of E/HF work differs depending on the phase of the project. The aim of this paper is to describe ergonomics activities in the product development process, with special focus on the purpose of ergonomics activities in different parts of the process. As a base for the description the ACD³-framework is used.

Keywords: Ergonomics, Human Factors, Product Development Process

1. Introduction

During the development process of a product, a variety of design variables are gradually determined to constitute the final design. For products that require input from many different types of expertise, the development process must be led and structured so that this expertise can be involved in a timely manner and with the appropriate level of influence over design decisions. In many design decisions, and consequently in many design activities, ergonomics and human factors (E/HF) professionals have an important role to ensure effective and safe human use. Therefore, the involvement of E/HF expertise has great potential to support the development of useful, usable products, thanks to the discipline's overall goal to improve both human well-being and system performance in parallel.

Design decisions drive the development process and can be made at different levels of detail - from higher system-level issues like the intended use and technical principles, down to low-level specifics like the colour of buttons and size of screws. Depending on the nature of the product development project, some of these design decisions may not be actively made – as examples at both extremes, not all projects will aim to change the product's overall purpose or use, while others will not call into question the assumption that the product can be built of anything other than standard-supplier components. But in all development projects, an awareness of the fact that design decisions should actively be made can be a great benefit to design teams. To prepare for and to make these decisions, the design process involves different types of design activities (such as analysis, synthesis and evaluation) that support the process of making design decisions at all detail levels.

Many methods and tools to support a user perspective exist within the E/HF field – these vary in scope, focus and detail level as the product development nears the realization stage. Within the process, E/HF work results in increased knowledge of the

users' needs, the interaction with the product's interfaces, and enablers and pitfalls that may support or hinder access to the product's intended functionalities. However, it is all too common that E/HF expertise is involved too little or too late, resulting in suggestions for change that come too late to be deemed economically or practically feasible, and thus limited leverage of the expertise. To gain appropriate influence, E/HF professionals must foster a strong collaboration with other roles and professionals involved in the product development process. It must therefore be clarified how E/HF fits into product development work and what benefits it can give to the project as a whole.

To this end, this paper argues that the product development process must be described in a way that clarifies how E/HF work can be integrated with the other parts. This is to avoid the risk of separate parallel design processes with lack of communication (aka "silo thinking"). To support this description, an existing systems-theory based framework for product development, ACD³, is used to provide a language for the different conceptual parts of the main process and how the E/HF expertise at each stage must shift in scope and character across the phases of the product development process. Table 1 provides explanations of the terminology used in this paper.

Table 1. Terms used in this paper to clarify the relation between E/HF activities and the product development process

Term	**Definition**
Design activities	Specific goal-oriented activities carried out by designers/developers for the purpose of identifying, assigning value to and communicating *design variables*.
Design variables	A design variable is a property related to the product that can be specified from the point of view of the designer.
Design decisions	A design decision is made when the possible value of a design variable is constrained. A design decision eliminates other solution variants once the choice is made.
Development work	The gradual formation of a product, technical system or service, with its starting point in a defined problem or a need. Development work is performed in a development process.
E/HF activities	The use of ergonomics and human factors-related knowledge, methods and tools to optimize the use- and user aspects of the product development.
Machine	Term from the ACD[3] framework signifying any human-made artefact, such as a product, tool, production system, workplace, IT system, vehicle, clothes, furniture, etc.
System view	Viewing of the product as a system at a specific level of abstraction, focusing on the relation between objects on that level.
Technical development	The portion of product development that is purely concerned with setting and fulfilment of requirement specifications to optimize technical performance.

2. The product development process according to Activity Centred Design

ACD³ is a comprehensive framework that structures the development of products based on a systems view and the philosophy that design decisions should (ideally) be made on many abstraction levels; and if they are not made intentionally, they will still be constrained by chance, circumstances and coincidences.

The ACD³ framework (Bligård et al., 2016, Berlin and Bligård, 2016, Bligård, 2015) is intended for use in product development projects to manage decisions and activities that should be addressed among the different professional roles in the process. The

framework visualises a clear structure for where certain design decision types belong, but allows flexibility in the work sequence so as not to inhibit the product development team's innovation and creativity. The three main objectives are:

- Clarify which design variables need to be considered
- Provide a coherent and structured overview of the development work
- Liberate human resources for creative work by clarifying the decision-making

2.1. The ACD³ process

This paper focuses on development process within the ACD³ framework. ACD³ divides the product development process into five distinct phases, within which design activities take place to identify, determine and communicate the design variables. The first phase, *Needfinding*, focuses on formulating the problem, describing the needs and designing the desired effects. The second phase, *Design of use*, concerns how the product is intended to be used to achieve the effects. The third phase, *Overall design*, deals with the product's technical architecture, which enables the intended use. The fourth phase, *Detailed design*, focuses on finalising the design of the product's interface and physical shape. The fifth phase, *Structural design*, deals with the design of the product's internal structure and function. Table 2 shows which principal design decisions that need to be made at which system view during the five phases.

Table 2. The five phases of the ACD³ process

Phase	**System view**	**Principal design decisions**	**Example: vacuum cleaner**
Needfinding	Socio-technical system	The effect that the machine is intended to achieve within the context	A cleaner home
Design of use	Human-machine system	The use of the machine by humans	Manually moving the device when cleaning
Overall design	Machine system	The technical architecture of the machine	An electrical motor that sucks air through a filter
Detailed design	Machine interfaces	The interaction between human/context and machine in details	Design of the physical form and user interface
Structural design	Sub system	The technical elements of the machine	Structural design of the motor, the dust bag etc

Even though the process is described in distinct phases, the work at different detail levels is often carried out iteratively and in parallel. This means that activities in several phases can and should take place in parallel rather than sequentially, and should be iterated both within and between the phases to arrive at well-grounded design decisions that fits into the product as a coherent whole at that particular detail level. When partial design decisions to be made early within the phase are dependent on design decisions made later in the same phase, iterations may be necessary to ensure internal coherence. This kind of iteration within a phase is also a good way to use ACD³ in a project managed with milestones, i.e. when it is more difficult to iterate between the phases. Iteration between the phases may also be needed, since new information emerge later in the process that creates a need to be reconsidered earlier made design decisions (hard to know everything from the beginning).

3. Integrating E/HF activities into the process

Across the previously defined phases of a product development process, E/HF work has a natural role to play in supporting the overall product development work. Work carried out by E/HF professionals typically includes investigation, generating design alternatives and evaluation activities. In general, the emphasis of the E/HF work gradually shifts from investigation, via designing, to testing and validation throughout the development process. However, it is important to note that E/HF activities may be needed to some degree even when they are not emphasised. E/HF activities involve continuous data collection from users and observing the use as a base for guiding design decisions. The data collections in the later phases are also to a lesser extent in content compared to the earlier phases. Furthermore, E/HF activities involve continuously evaluating the appropriateness of design decisions against the use and with users.

The following subsections will first describe each of each phases in the ACD³ process (which prescribe a shift in perspective in each phase to define increasingly detailed requirements) alongside appropriate E/HF activities within each of the phases. The phases are summarized at the end in Table 3, which specifies specific tasks that E/HF professionals should be involved in within each process phase.

3.1. Needfinding

The purpose of the first phase of the ACD³ process is to investigate and determine how the context and surrounding environment place demands on the solution and how the solution in turn will affect the context (i.e. design the effect). Another purpose is to investigate and determine what the user values and requires of the solution, which leads to the formulation of a high-level requirement specification.

The focus is on the effects that the user wants to achieve and the problems the user has in reaching them, thus the development work is user-centred. This phase considers the entire socio-technical system that the product will be introduced into, with a particular focus on the users of the solution (where "users" refers both to those who directly use the solution, and those who indirectly benefit from its effects). The main design output from the phase is the formulation of the desired effect that the solution is intended to achieve in its context, while the main requirements from the phase specify the needs that the human-machine system must fulfil.

The main objectives for E/HF professionals in this phase are to identify requirements from the users and the use situation, how the environment affects and places demands on the future product and how the product should affect its environment. The output is then to formulate system effect goals from a user perspective. Furthermore, ergonomics approaches can support the development e.g. by evaluating existing products as a form of benchmarking.

3.2. Design of use

The purpose of the second phase is to investigate and determine which *use* (defined as purposeful human-machine interaction) will meet the defined needs and consequently provide the intended effects, as well as to investigate and determine which overarching (technical) solutions are needed to enable the use.

The focus in this phase is on the use activity, making the work use-centred and the system level view is the human-machine system as a whole (i.e. this phase "zooms in" relative to the previous socio-technical system). The main design output from this phase is the intended use of the machine, while the main requirements from the phase specify requirements stemming from the use that are needed to reach the system goals (and consequently attain the effects).

The main objectives for E/HF professionals in this phase are to specify the tasks that the user performs when using the product and to define requirements based on the intended use (which may include usability and aesthetic aspects).

3.3. Overall design

The purpose of the third phase of the ACD³-process is to investigate and determine the machine's technical structure that can achieve the intended effects; this includes investigating what constitutes a good user interface for the machine and determining the main principle of interaction, aesthetics and form.

The development work in this phase is technology-centric. The main design output from the phase is the technical architecture (i.e. the machine structure divided into parts) that satisfies the intended use elaborated by the previous phase, and the main requirements from the phase specify the demands that the machine must meet in order to enable or afford the intended use.

The main objectives for E/HF professionals in this phase are to participate in and support the design of solution concepts for the physical form and user interface for the product, as well as supporting the formulation of detailed design requirements.

3.4. Detailed design

The purpose of the fourth phase is to investigate how the machine will interact in detail vis-à-vis the user and towards other parts of the socio-technical system, as well as to investigate how the technical subsystems of the machine will work together (i.e. design the machine's interactions with the user and the environment).

Consequently, the focus of the phase is the machine's physical exterior and the development work therefore becomes interaction-centered. The system under consideration is the external structure of the machine, i.e. how the different parts of the machine together constitute the whole. The main design outputs from the phase are the user interface and physical form of the machine and the main requirements from the phase focus on the various parts of the machine in order for them to fulfil the interaction and function as a technical whole.

The main objectives for E/HF professionals here are to support the finalization of the design and to support the design of use manuals and instructions.

3.5. Structural design

The purpose of the fifth phase of the ACD³-process is to investigate and determine how the machine's technical elements (subsystems) should be constructed in detail and investigate and determine how the machine will be manufactured (choose the principle of production to allow for manufacturing preparations).

The focus in this phase is the inside of the machine and the system under scrutiny is the machine's totality of internal subsystems. The main design output from the phase is a complete technical design specification of the machine and base for setup of manufacturing in the form of e.g. drawings, assembly instructions, etc.

The main objectives for E/HF professionals here are to support the development work by testing prototypes appropriately to ensure correct ergonomics and functionality and to assess the performed activities in relation to principles for good ergonomics and human factors.

3.6. Summary of the process and respective tasks and roles

Table 3 below summarizes how E/HF fits in the development work as defined by the ACD³ process, and what outputs can be expected from each phase. Throughout the whole development work, E/HF activities also include data collection from the users and the use as a basis for the design decisions.

Table 3. Specific tasks for E/HF professionals to take part in and/or lead during the ACD³-process

Phase	**Tasks for E/HF professionals**	**Focus and outputs**
Need-finding	- investigate and describe main problems that justify the product's existence - investigate the delimitations of the development work - investigate and describe stakeholders - investigate existing machines - investigate existing use and users - describe intended use and users - set system goals (effect goals) - investigate and identify needs from use and users	*The users of the solution* - Description of the intended effects of the machine - Specification of needs that the machine must meet
Design of use	- perform in-depth analysis of system goals - design the intended use of the machine - explore ideas for interaction, aesthetics and forms - investigate and specify use and user requirements - develop guidelines for usability and aesthetics - evaluate the designed use with users	*The use* - Design of the use - Overarching technical principle
Overall design	- analyze what is needed to enable the intended use clarify central design variables for the machine - generate suggestions for the interaction overall - specify system requirements for the machine as a whole - develop design guidelines for detailed design - evaluate overall design with users	*The technical architecture* - Description of the machine in parts - Specification of requirements that must be met to afford the intended use

Detailed design	- design the human-machine interaction, i.e.
	  - design the physical form and the user interfaces
	  - design the manuals and technical documentation
	  - design the training (for use)
	- evaluate detailed design with users
		The interaction
		- Description of the user interfaces and physical form
		- Specification of requirements on interacting machine parts

Structural design	- test of the structural design - verification of the structural design - final risk analysis of the structural design - validation of the structural design - evaluation of the completed E/HF-work	*The machine's subsystems* - Complete technical design specification - Specification of manufacturing requirements

4. Discussion

The purpose and scope of E/HF activities vary throughout the development process. At the beginning the focus is on understanding the user and the use, in the middle on supporting the design of the solutions, and in the end on testing and evaluating solutions from an E/HF perspective. This paper has used a framework (the ACD[3]) to clarify how and when E/HF work can be integrated throughout the product development process, by matching the outcomes of E/HF-activities to decision-support needs in the development work. Identifying and clarifying the purpose of E/HF activities is meant to raise the awareness of how E/HF work supports the planning and the implementation of the development work as a whole; both in terms of helping to clarify the possible space of design solutions, and in order to ensure explicit definition of how the design possibilities are gradually constrained towards a final solution. But to enable a development project to get the greatest leverage from E/HF expertise, additional aspects need to be considered, as discussed in the following sections.

4.1. Competence and staffing

Since the E/HF knowledge and competencies needed in the beginning of a process are not the same as those required at the end, it is important to map out types of E/HF activities that should be performed in the phases. This mapping should then be compared to the available E/HF-competence that exists within the organisation. If there is a mismatch and more competence is needed, it can be solved in three ways: 1) by educating existing or hire new staff, 2) hiring consultants, or 3) adjusting the E/HF-work to fit the competence of the organisation. If ignored or done inaccurately, the result of the mismatch may be a less useful product, or that resources may be used sub-optimally. Also, it is not enough to identify the need for E/HF-work and which persons in the organisation should perform these activities. In order to be able to perform the E/HF-work successfully, knowledge of suitable methods and theory from the ergonomics / human factors discipline is crucial. The description of the E/HF activities in development work proposed in this paper is not aimed to remove the need for E/HF-competence; on the contrary, it is meant to clarify and emphasize the need for such competence.

4.2. The guiding nature of E/HF activities

The guiding nature of E/HF activities is often the hardest to communicate to project management, since it can be hard to quantify the benefits of letting E/HF have a prominent, proactive role in development projects. Product development is often initiated by the emergence of a new technical solution, a possible new market or the emergence of a new problem/need. However, regardless of initiation, E/HF activities play a central role to ensure successful *use* of the machine and consequently enable the intended effects. These activities include the work of clarifying and describing the overall purpose of the machine, which frames the entire development work and provides significant input to the other disciplines in the development process. For this reason, E/HF activities should be performed early in each phase of the development process so that input can be leveraged. It is also important that other disciplines participate to an appropriate extent in these E/HF activities to ensure the quality and

integration of the results; e.g. software developers should be involved in the design decision regarding the user interface to ensure acceptance of the underlying reasons.

4.3. The role of the ergonomist

It is important here to view E/HF as an engineering discipline, as it is the design and its properties that are the focus of the E/HF work. More specifically, the E/HF work objective is to design the human-machine system to achieve the intended effects. It is therefore important to clarify how E/HF relates to system performance and efficiency, both in the final product and in the development project. E/HF should therefore not be regarded as a Human Resource (HR) or an occupational health discipline, or be equated with operational competence (e.g. that users intrinsic have E/HF competence) . The E/HF professional should work in close collaboration with system engineers and system architects to maximise the benefits of E/HF activities. Also, since it is in the *use* of the product that much of value for the user/customer emerges, the E/HF professional becomes a natural link between the marketing and management functions, who focus on customer value, and the other engineering disciplines, who focus on the product. For example, Institoris and Bligård (2014) showed that Human Factors can contribute to Lean Product Development by offering an approach that continuously considers the user and the use throughout the whole product development process. To clearly analyse human behaviour as part of the value proposition for a product would benefit the final design of the machine. However, the E/HF professional should not carry out all the E/HF activities independently; instead, the majority of the work should be integrated into the development process and carried out together with the project team.

5. Concluding remarks

Clarifying the need for and purpose of E/HF activities, increasing opportunities to raise awareness of E/HF benefits and integrating E/HF work into development work mean that more competences can be effectively involved, that user- and use-centered decision support is better utilized, and that duplication of work can be avoided. To achieve this, it is important to have sufficient E/HF competences and staffing in the organization, and to recognise the guiding nature of E/HF activities. It is also important to regard E/HF as one of the engineering competencies, since E/HF helps with ensuring system performance and efficiency. In the end, doing this means that better machines (that reach the intended goals) can be developed more efficiently.

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Virtual test persons based on diverse anthropometric data for ergonomics simulations and analysis

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This paper describes a study where diverse anthropometric data is included in the process of generating data for a group of virtual test persons. Data on body size, strength and ROM were either collected on an individual level or predicted and synthesized and then used in cluster analyses to generate six unique virtual test persons. Results show that the method is able to generate detailed virtual test persons which enables more realistic and accurate simulations, as strength and ROM data is included into the motion prediction algorithms used to generate motions.

Keywords: Virtual, test persons, diversity, Digital Human Modelling, strength, range of motion, cluster analysis

1. Introduction

In a design process, good ergonomics is achieved when the capabilities of humans match the demands made by the product, workplace or system. Digital human modelling (DHM) tools enable simulations and analyses of ergonomics in virtual environments, particularly at early design stages when the product and workstations often only exist in a virtual format (Chaffin et al., 2001; Duffy, 2009; Hanson et al., 2012). Restrictions in the physical interaction between humans and systems can often be connected to body dimensions of the users. Several methods have been developed for the consideration of body size related anthropometric diversity in design (Meindl et al., 1993; Speyer, 1996; Bittner, 2000; Dainoff et al., 2004; Brolin et al., 2012). The most frequent referenced and used method is the boundary case method in where cases are defined as points located towards the edges of a population distribution (Dainoff et al., 2004).

However, the human-machine interaction is not only affected by the size and proportions of a user but also other physical user characteristics, e.g. muscle strength and joint range of motion (ROM) (Frey Law et al., 2009). Due to the low correlation between and in-between different groups of variables, especially for ROM variables, the boundary case method has shown to have limited use when applied on data of body size, strength and ROM (Brolin et al., 2014). Instead, cluster analysis have shown to be an appropriate alternative as it enables the generation of distributed test cases with different body size, strength and ROM, and indeed also other capability measures when

data is available (Brolin et al., 2016). Cluster analysis is done by grouping a set of objects in subsets called clusters in such a way that objects in the same cluster are similar to each other and objects in different clusters are as dissimilar as possible (Kaufman and Rousseeuw, 2009). The data that comes out of a cluster analysis of anthropometric data could be used as the basis to construct more detailed user characters or personas, often used in product design, software development and human computer interaction studies (HCI). Personas is a user representation approach that supports descriptions and communication about users' abilities and requirements (Pruitt and Grudin, 2003). Each persona is given a name and is described with different personal characteristics and background details and serves as representations of real users throughout the design process (Cooper, 1999). Adopting the concept of personas in the context of DHM tools can result in computer manikins becoming DHM Personas, as exemplified in (Högberg et al., 2009). This paper describes a study where diversity in body size, strength and ROM, is included in the process of generating data for a group of virtual test persons for the digital human modelling tool IPS IMMA, using cluster analysis.

2. Methodology

The procedure for generating virtual test persons (Figure 1) for the IPS IMMA tool starts with obtaining body size, strength and ROM data. Cluster analysis needs to be performed on raw data on an individual level and to achieve this, prediction and synthesizing of missing population data needs to be done (Brolin et al., 2016). Data on ROM, age, sex, stature and body weight were extracted for adult individuals from a U.S. database provided by CDC (Centers for Disease Control and Prevention) (Soucie et al., 2011). This data, on an individual level for 266 women and 210 men, formed a basis to predict and synthesize additional strength and body size data.

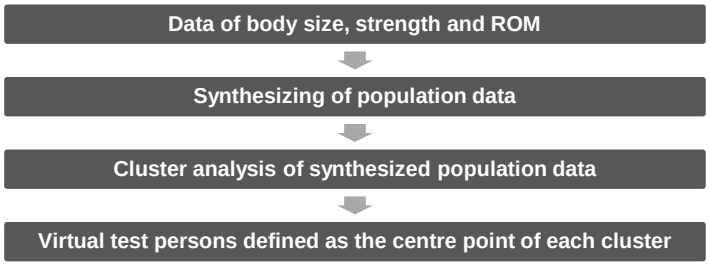


Figure 1 Procedure for generating virtual test persons by synthesizing and clustering of data

2.1. Synthesizing of population data

Strength data was predicted using previously published regression equations (Andrews et al., 1996) with gender, age and weight as predictive variables. The variance of the predicted strength data was also estimated by adding a stochastic component to each predicted measurement. These stochastic components was based on the partial correlation coefficients and the partial standard deviation (Brolin et al., 2017). In this case the partial correlation coefficients were unknown but estimated to 0.415 and 0.425 for female and male data respectively. This was done iteratively to give an average value, for the final correlation coefficients between different strength measurements, similar to the average values of the correlation coefficients presented in Brolin et al. (2014), which originates from Shklar and Dvir (1995) and Mathiowetz et al. (1985). The partial standard

deviation which is the same as the root mean square error (RMSE) could be calculated for the given regression equations as

$$RMSE = \sqrt{(1 - R^2) \times \sigma_c^2},$$

where the coefficient of determination, R^2 is given for each regression equation (Andrews et al., 1996) and σ_c is the combined calculated (Dunlap, 1937) standard deviation values for all three age groups and both sexes. The regression equations presented in Andrews et al. (1996) are limited to an older population (50-79 years). Therefore the estimated strength for each individual younger than 50 years was adjusted using the estimated strength of a 50 year old person and the average of the regression coefficients provided by Lindle et al. (1997). This gave an additional equation for each sex (female = f and male = m) as

$$Strength_f(age) = Strength_f(50) \times (0.7804 + 0.0161 \times age - 0.0002 \times age^2),$$
$$Strength_m(age) = Strength_m(50) \times (1.0114 + 0.007 \times age - 0.0001 \times age^2).$$

Additional body size data was predicted using individual based descriptive statistics from Swedish anthropometric data (Hanson et al., 2009) using a synthesizing procedure presented in Brolin et al. (2017). The prediction of additional body size data used body weight and stature as predictive variables. As in Brolin et al. (2017), to better consider positively skewed distributions such as width and circumference measurements a method presented and included in the software PeopleSize (2008) is used, in this study together with body weight data from National Health and Nutrition Examination Survey (NHANES) (U.S. Centers for Disease Control and Prevention, 2008).

2.2. Cluster analysis of synthesized data

The process of predicting, estimating and synthesizing data gave a dataset of 46 variables on an individual level, necessary for generating digital manikins in IPS IMMA. The synthesized data was used in cluster analysis where the clustering algorithm was set to give six unique distributed cases and each case was given by taking the average value of all individuals belonging to a specific cluster. The sex of each case was determined as either female or male and the age of each case was rounded to nearest integer. To solve the problem of grouping objects into clusters a number of different types of algorithms exist such as hierarchical based, optimization based and density function based (Everitt et al., 2011). In this study hierarchical clustering was used as it was found, through initial analysis, to be the most appropriate algorithm as it gave the diverse distributed cases and spanned a big range of percentile values.

2.3. Visualisation and simulation

The resulting virtual test persons were visualised using the software MakeHuman (MakeHuman, 2017) and its functionality to generate mesh models through the definition of a number of variables. These variables could be defined using the data from the cluster analysis. In future versions of IPS IMMA, mesh models generated in MakeHuman, or similar software, will be possible to directly import into the IPS IMMA software.

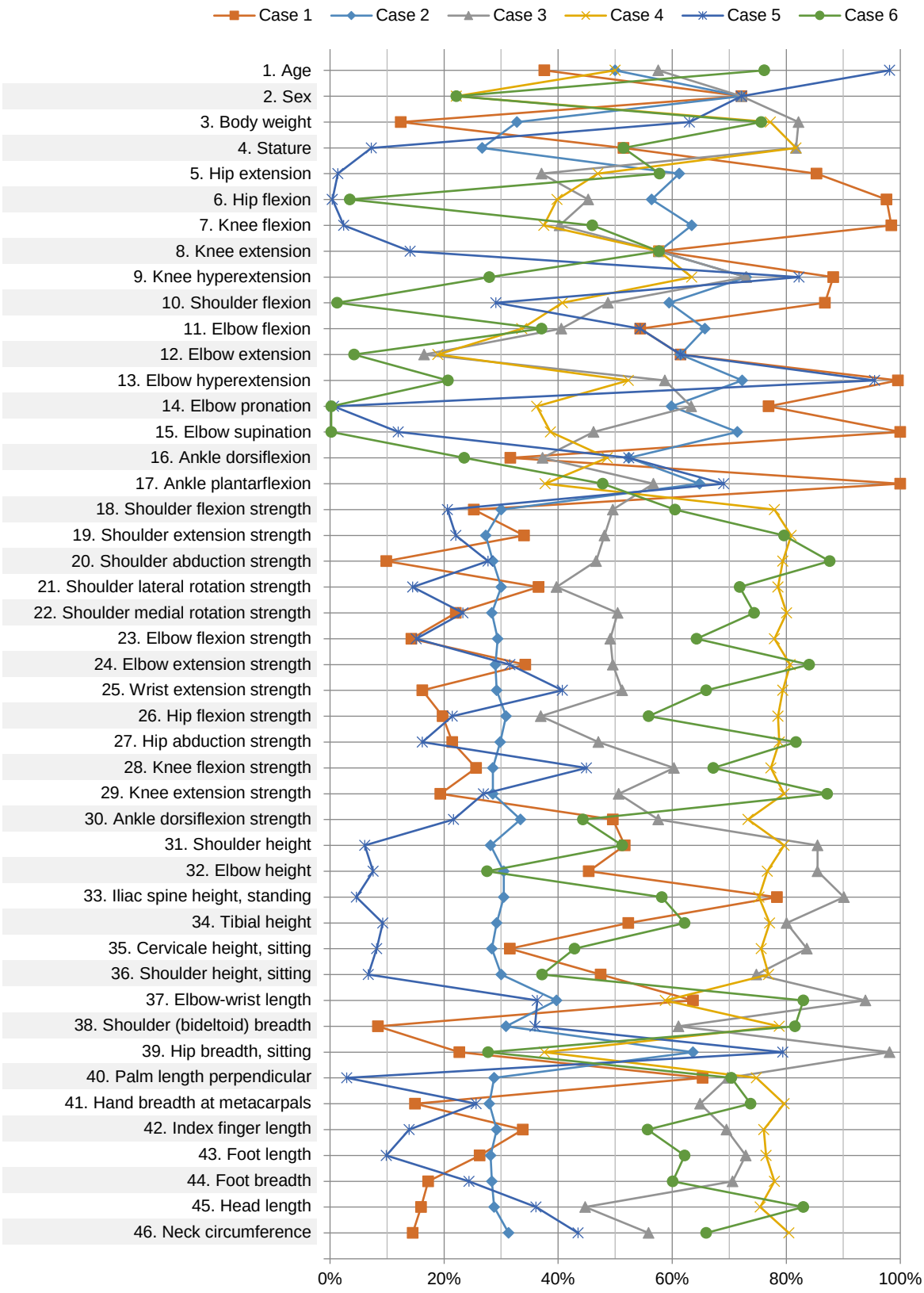


Figure 2 Visualisation of percentile values and percentile range for each variable and each case generated by the clustering algorithm (For percentile values of the variable sex: 75% is a female individual and 25% is a male individual)

To further evaluate the generated virtual test persons two of them were used as digital manikins in a dynamic simulation in IPS IMMA. In IPS IMMA the manikins were visualised as through a biomechanical model consisting of rigid links and joint centres. Maximum joint torques were calculated based on the joint strength and link length for each body part. Maximum joint torques and angles were then adjusted for each manikin. The simulation in IPS IMMA consisted of a case where the manikins were instructed to lift down a 5 kg oil tray from a truck. During the simulation, extreme joint angles and high joint torques were penalized and minimized through an ergonomic comfort function.

3. Results

The data for the generated virtual test persons were assessed visually, through so called percentile plots, to evaluate how the test persons represented the diversity of the synthesized population (Figure 2). These percentile plots enables evaluation of how big part of the diversity of the population that is considered, how well the generated test persons are spread throughout the distribution and if two or more test persons are similar. The results show that the cluster technique is able to produce distributed cases, of different age, gender, body size, ROM and strength, which covers a big part of the diversity of the population.

The visualisation of the virtual test persons in MakeHuman (Figure 3) shows that it is possible to quickly generate realistic looking digital models. When used in simulations the digital manikins shows difference in movements (Figure 4) and joint torque actuations (Figure 5) where a shorter and not so strong manikin is forced to use more of its strength and more extreme joint angles.



Figure 3 Visualisation of virtual test persons 4 and 5 as digital models in MakeHuman (MakeHuman, 2017)

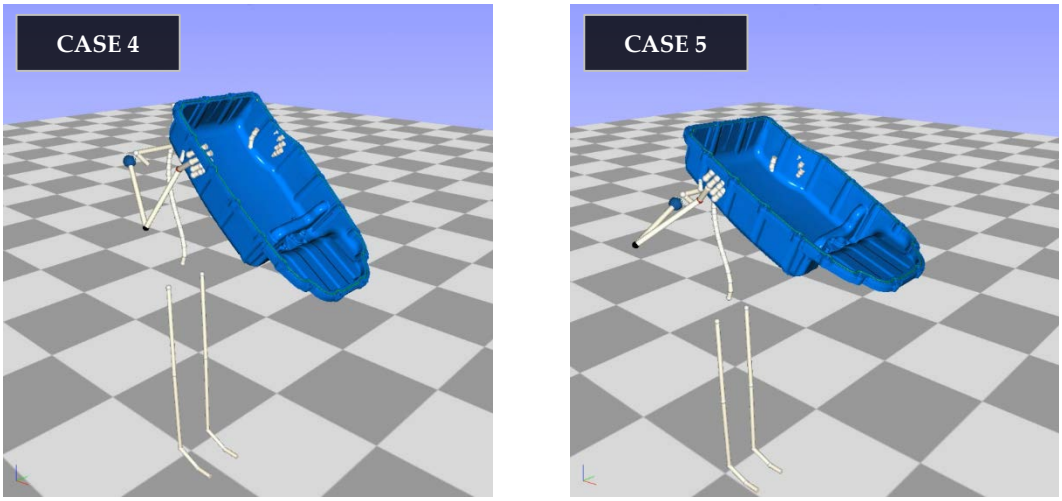


Figure 4 Visualisation and simulation of virtual test persons 4 and 5 as manikins in IPS IMMA

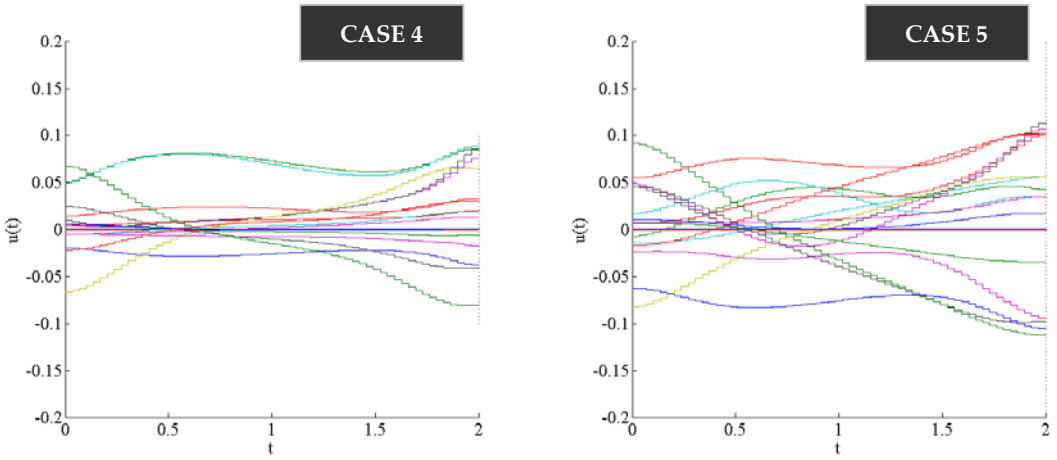


Figure 5 Visualisation of joint torque actuations during the simulation with manikin case 4 and 5 in IPS IMMA

4. Discussion

From the different visualisations of the generated virtual test persons it is possible to conclude that the methodology is able to produce data for virtual test persons that can be used within a digital human modelling software to consider not only diversity in body size but also strength and ROM. From the visualisation of percentile values and percentile range it is possible to conclude that the hierarchical clustering algorithm generates cases that are spread out over the distribution and thus considers a big part of the diversity of the population. No cases are very similar to each other and the cases are at the same time evenly spread out throughout the distribution. The generated and synthesized data is not representative for any real population since it is a mixture of data from different sources. It would be favourably if the original raw data could have been acquired from one and the same source for all 46 variables. However, few such comprehensive studies have been done and none is freely available, which indicates the need for more studies that considers body size, strength and ROM simultaneously. Still, the synthesized data is useful in this study to show the applicability of the method.

The use of cluster-generated virtual test person according to the presented method does not ensure that a certain percentage of the targeted population is accommodated. Still, as the cases can represent diversity in a range of user characteristics, they are argued to be valuable test cases during evaluation of design concepts. These more detailed test cases show that it is possible to achieve more realistic and accurate simulations, as strength and ROM data are included into the motion prediction algorithms used to generate motions in IPS IMMA. More accurate simulations with detailed data such as joint torque actuations enables more comprehensive evaluations of the biomechanical load but also point to the need for limits on such values.

5. Conclusions

Results from the study show that it is possible to use cluster analysis to generate data for virtual test persons that can be used within a digital human modelling software to consider not only diversity in body size but also strength and ROM. These more detailed test cases shows that it is possible to achieve more realistic and accurate simulations, as strength and ROM data are included into the motion prediction algorithms used to generate motions.

6. Acknowledgements

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Can ergonomics help companies to design sustainable workers careers paths ?

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This text presents the results of an ergonomic research on the professional paths of operators affected by WRMSD in a French large aeronautical company. The results provide answers, particularly concerning the factors facilitating the reallocations, the reassignments temporalities and the risks related to the executives turnover. The presentation of these results in the company initiated reflections and actions at several levels of the company, in order to promote the prevention of WRMSD and the construction of constructive career paths.

Keywords: Sustainable career path, Time charts, Company memory, Musculoskeletal disorders

1. Introduction

The research field is a 700 employees factory (including 300 operators) specialized in production of composite parts for aeronautics industry. Activity in the workshops presents some specificities, useful to understand the framework of this study:

- The parts produced are vital for the aircraft safety. In consequence, operators are expected to work with high quality,
- Given the level of quality required, operators have undergone specific training to aeronautics, and pass certifications to work on a particular product reference,
- In general, there is little turnover of operators,
- Finally, the production can be described as "industrial craft": it is industrial sector, but work is very manual with cycle times from 1hr up to 500hrs, and operators have a real know-how, recognized by all.

Furthermore, in 2012, an internal medical investigation survey revealed that 26% of operators work daily with joint pain in the upper limbs and 39% in the back. Moreover, the company management encountered increasing difficulties to durably reclassify workers most affected by Work Related Musculoskeletal Disorders (WRMSD). This observation resulted in two research questions:

- To what extent were the career paths of workers with WRMSD unsustainable?
- To what extent ergonomics could help the company to build sustainable career paths, especially for workers with WRMSD?

2. Approach and methodology

Several researches have shown that prevention approaches obtains fragile results if only immediate difficulties are overcome (Vezina, 2010; Wells, 2009), which is partly explained by the complex temporal decay of pain manifestations (Aublet-Cuvelier & al., 2006 ; Silverstein & al., 2006). To take account of the situations complexity, various researches in safety and health at work (e.g. epidemiology, occupational medicine, applied ergonomics, etc.) encourage medium- and long-term temporal approaches to integrate the fluctuating nature of WRMSDs (Aublet-Cuvelier & al., 2006 ; Gaudart, 2014 ; Plouvier & al., 2011). Completing clinical ergonomic analysis of work situations with a diachronic approach of WRMSDs would therefore be a contribution to prevention (Buchmann, 2009 ; Cole & al., 2002).

In this perspective, the researcher worked with the occupational physician of the site. This doctor has been in the company for more than 20 years; he knows each one of the operators, the history and culture of the company, which can be useful to understand the operators career and health care paths.

Data collection process took place in two phases:

1. The researchers asked the occupational physician to search in operators medical records, all the operators reclassified between 2004 and 2012 because of WRMSD. According to the occupational physician, nine operators fulfilled these criteria. These nine operators were the population of the study.
2. The medical records of these nine operators were analyzed more finely: Due to ethics reasons, only the occupational physician had access to medical records. The researcher asked to him:
    - To extract from medical records all data related to joint pain (pain location, intensity, treatment ; care ; work methods to try to regulate pain), production changes, and assignment changes.
    - To complete these written comments by oral remarks, analyses, or to answer questions that the researcher asked in order to better understand the situation.

The physician's verbalizations and his exchanges with the researcher were fully recorded (2h50), then transcribed and subjected to a systematic thematic analysis. The result of this exploitation has taken the form of chronological operators career path reconstructions (one per operator) tracing for each the history of the evolution of pain and assignment changes. Then, the coded categories were crossed, compared, or grouped. The results below show some clarification of research questions.

3. Results

The data analysis reveals several results particularly useful ton understand the career paths construction.

3.1. Number of alarms for joint pain recorded in the medical record, before the first reclassification

Graph 1 below shows the number of alarms for joint pain reported by operators or recorded by the occupational physician and recorded in the medical file before an

effective reclassification. Multiple alerts are noted, essentially between 3 and 8 with a maximum at 18.

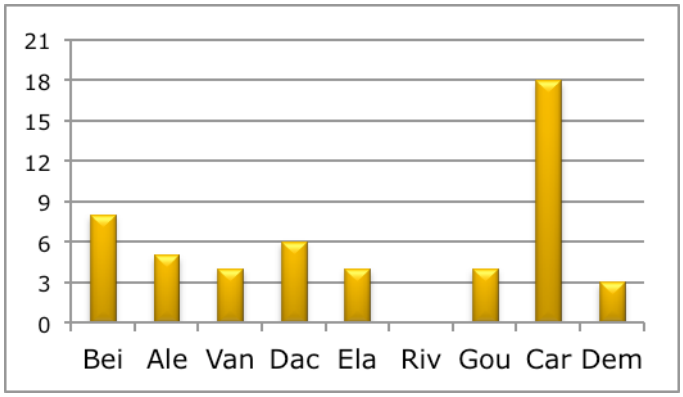


Figure 1: Number of alerts in the medical file before the first reclassification.
(in abscissa: the 9 operators, on ordinate: number of alerts for pain)

3.2. Delay (in years) between the first alert and the actual reclassification.

Graph 2 below shows variable temporalities before the initiation of a reclassification: essentially between 1 year and 5 years, with a maximum at 17 years.

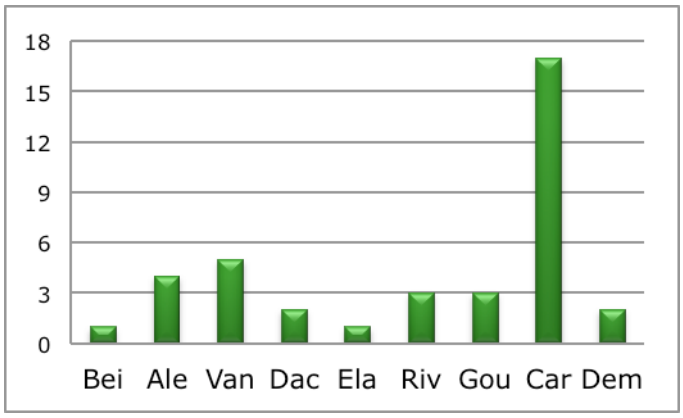


Figure 2: Deadline (in years) between operator first alert and reclassification.

3.3. Age and seniority in the company at first reclassification

The graph 3 below shows that reclassifications affect elders, but also young people: four operators aged 49 to 52 years, with considerable length of service (15 to 33 years); but also four younger (24 to 35 years) with significant seniority (5 to 13 years) in the factory.

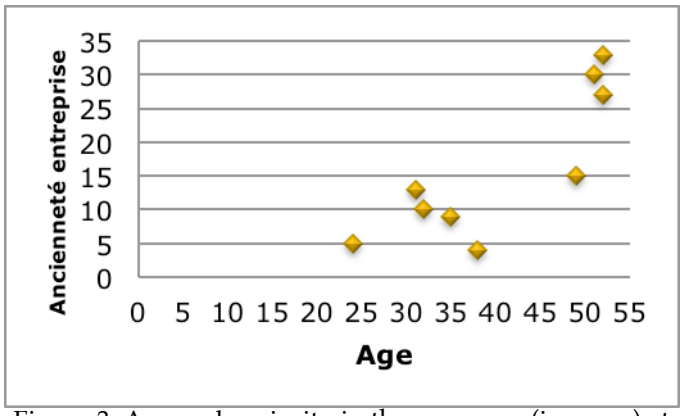


Figure 3: Age and seniority in the company (in years) at first reclassification

3.4. Number of assignment changes due to reclassification

Data in the figure 4 below show that a reclassification is rarely final: for each of the 9 operators, between 3 and 6 assignment changes are recorded over the period considered.

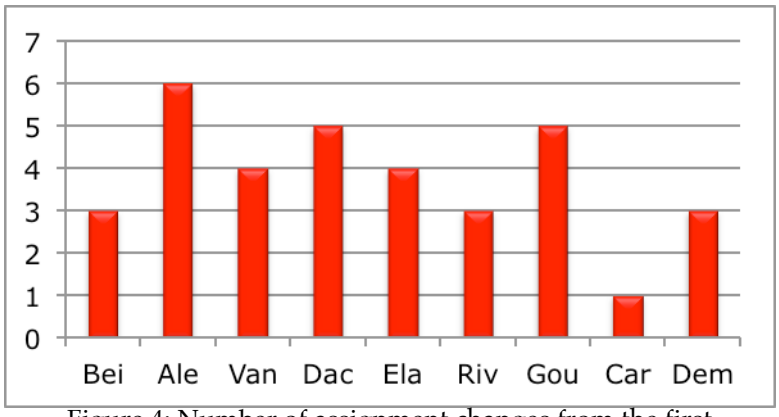


Figure 4: Number of assignment changes from the first reclassification

3.5. Number of assignment changes, for joint pain reasons

Figure 4, above, shows that once an operator changes positions, it becomes mobile. But, this result says nothing about the reasons for which the operators changed. We therefore looked in data for information about the motives of assignment changes. Surprisingly, assignment changes are not all linked to joint pains: some of these changes are not all related to an attempt to prevent joint pain, and sometimes even doesn't integrate their existence: among the assignment changes (red+black on the

figure below), some assignments aim at allowing operator to shelter from constraints that he can no longer stand (red part), but others respond to production needs that may not permit to treat the WRMSD (black part).

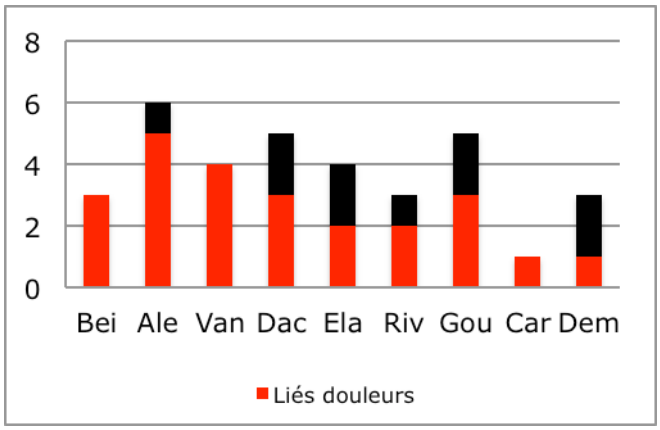


Figure 5: Number of assignment changes related to pain (red) and other reasons (in black), from the first reclassification

4. Discussion : designing sustainable professional careers, a complex compromise

Regarding to our results, a sustainable reclassification path integrates, at minimum:

- An operator with old, persistent and long-lasting joint problems
- Availability of a job compatible with the physical limitations and the skills of the operator
- Production requirements at the workstation envisaged by management
- Recruitment and training of an operator replacing the operator touched by WRMSD and leaving the workstation

The difficulty to meet these four points altogether partly justifies that there are in this factory so many operators with joint pains but so few reclassifications.

Our results also call for a discussion on the reclassification processes themselves:

- They fuel a questioning on the temporalities of taking into account the health fragility manifestations: 2 views can be hold; one for a rapid reclassification, before the situation deteriorates; or another which tends towards a “decantation period” linked in one hand to the joint problem evolution monitoring, in order to assess its severity and urgency (especially since researches has shown that the evolution of MSD is not linear (Aublet-Cuvelier & al., 2006 ; Silverstein & al., 2006)); and in other hand to the fact that in this company many positions require training and certification, and therefore it is not easy to move operators. Regarding to this results, in this company the main strategy adopted seems to be taking the time to follow the evolution of the WRMSD, while starting collectively (i.e. occupational physician, supervisor, operator himself) to think about a reclassification that combines at best health status and skills. During this period, the collective pays attention to movements or projects in the workshops that may create the opportunity for a reassignment, before the WRMSD become too serious.

- The first point above is articulated with the observation that a process of professional reclassification is part of a long-term process (marked by several assignments attempts (fig. 4 and 5) to achieve a satisfactory result). But the pitfall in a long-term process is "the loss of memory". In fact, the company executives turnover (supervisors, executives, human ressources, etc.[1]) disperses knowledge about workshops history and operators history or career path. This loss of memory is manifested, for example, in the following two ways:

- An operator touched by WRMSD is reclassified on a workstation in line with his WRMSD, which allows him to work without pain. He no longer complains. But a few months later, the hierarchy of this operator changes. The new supervisor is not aware of the reasons which led the operator to this workstation. Then one day, for production needs, the operator is changed from his workstation without taking into account his past WRMSD, and quickly pain reappears.

- The loss of knowledge about the very constraining workstations: the reconstruction of the career paths made it possible to identify that on a specific cutting station, in a 10 years period, 3 operators have passed, and have been touched by WRMSD. The successive supervisors, having no knowledge of this workstation history, have never started a real improvement project to stop the "WRMSD production phenomenon" on this workstation.

5. Conclusion

The introduction of this paper investigated the factors behind professional paths of operators affected by WRMSD, and the role that ergonomists could play in the construction of sustainable career paths. This research provides answers, particularly concerning factors facilitating reallocations, reassignments temporalities and risks related to the executives turnover.

These results were presented to the company top management. It followed three changes in the way the company operates:

1. Creation of a permanent working group composed by a representant of human resources service, production management, risk prevention management, occupational health. This group has two missions: individual follow-up of employees affected by joint pain, and workstations improvements of the operators most affected by WRMSD.
2. The call for an ergonomics research team to work on the operators professional paths. Particularly, characterization of the professional paths of weakening, or on the contrary of the health construction.
3. Impulsion of a top management reflection on the limits of a too quick managers rotation, with an awareness that the turn over of the managers favors the loss of memory or the trace of certain arbitrations, with the consequent loss of projects consistency, both in terms of system performance and working conditions. And so this loss of memory is clearly not favorable, neither for production nor for a WRMSD sustainable prevention.

[1] In 4 years, the researcher has experienced 2 site managers, 2 production managers, 3 Human ressources managers, 3 quality, sécurity and environment managers, and a rotation of a fraction of supervisors every 6 months.

Thus, this research reinforces the idea that ergonomics can accompany executives in the construction of a sustainable working life:

- By showing the links between work, activity, health and skills,
- By reconstituting and mobilizing the "memory" of the company, with the aim of drawing on its experience to prepare its future.

Despite this encouraging findings, there are limitations to this case study: on one hand, to achieve accompany company executives, it is necessary to build a strategic positioning closest to the executives, which is sometimes difficult. On the other hand, the results are supported by a single case study; it is therefore necessary to replicate the method to other sectors and other situations, to improve the results.

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An Investigation on Intergenerational Communication Barriers: the Difference in Speech Communication between Elder and Younger People

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Communication plays an important role in both daily life and workplace. Moreover, population aging has been a global trend, and Taiwan has also been an aging society since 1993. Therefore, issues related to elderly are becoming important. However, previous studies related to elderly communication mainly focused on issues discussing healthcare and doctor-patient communication, fewer studies investigate intergenerational communication regarding the elderly. This study put focus on the daily speech communication between elder and younger people to investigate the communication barriers and the causes between different generations.

Semi-structured interviews were used to collect data, and then analyzed and generalized the communication barriers and the causes between elder and younger people from interview contents. The results showed that there were ten factors that might result in communication barriers being extracted from interviews. Different generation perceived different situation as causes of barriers. Barriers from young perspectives were: paying respect to elders so that forcing themselves to enjoy the communication, and elders always being too talkative and holding on their own views. While the elders thought the main barriers between two generations were their difference in knowledge and opinions, and the young also holding on their own views.

This study found some barriers and different perspectives between young and elder generations but had yet to provide solutions. Future research can further investigate the strategies to minimize the intergenerational communication barriers, and enhance conversational quality and satisfaction.

Keywords. Communication, Intergenerational Communication, Communication barriers

1. Introduction

Communication is indispensable in our daily life. Interpersonal communication is one of numerous communication modes. It contains at least two people to establish the relationship. And people in the communication all have influence on each other (R. F. Vederber, K. S. Verderber, & Sellnow, 2008；Lane, 2010；Wood, 2010).

In addition, population aging has been a global trend in both Eastern and Western countries. According to National Development Council in Taiwan (2014), Taiwan has also been an aging society since 1993. Owing to the increasing population of elderly people, issues related to elderly are becoming important. In our daily life, we inevitably have more chances to interact with elderly people. However, communication gaps might happen among generations because of the differences on life experiences and values.

Recent research interest in intergenerational communication has been increasing, while most of them put focuses on discussing healthcare and doctor-patient communication, few focused on the daily speech among generations. However, the relationship between different generations is quite important and the effect of each communicator on the conversation could not be neglected. So the purpose of this research is to investigate the barriers and causes of daily speech communication between elder and younger people through interviews.

2. Methodology

To further investigate the intergenerational communication barriers and causes, the qualitative approach was chosen. The research aimed to know what people regard as communication barriers and how these barriers happened from both young and elder people's perspectives.

2.1. Participant

There were 16 young (20- to 35-year-old) and 16 elderly (over 60-year-old) participants with normal speech capacity and ability to communicate in Mandarin taking part in the interviews.

2.2. Procedure

Participants were first asked to sign the informed consent to know the contents of this research and give the permission to be videotaped in the interview. Secondly, the semi-structured interview was conducted to learn of their experiences of communication barriers and also their perspectives or suggestions for improvement of the communication barriers. Questions were aksed by the researcher. During the interviews, participants were encouraged to express more. Moreover, researcher explored topics in futher detail accodring to participants' response.

2.3. Data analysis

After interviews were finished, all the contents of interviews were translated into verbatim transcriptions. 'Open coding' approach was first applied. Every fragment of texts related to research questions were intercepted to form several initial descriptions of communication barriers. Then the 'axial coding' approach was used after some descriptions showed up. The related descriptions were classified into one concept and

then 11 factors were extracted from those concepts. Finally, all factors were then generalized into 5 categories of communication barriers. Furthermore, the percentage of the times that each factor has been mentioned to the total number of participants was also recorded.

3. Results

3.1. Participant's characteristics

There were 16 young participants being interviewed, whose mean age was 23.56, and 16 elderly people, whose mean age was 72.19. Half of them were male, and half female. All participants were with normal speech capacity and ability to communicate in Mandarin taking part in the interviews.

3.2. Communication barriers

All expressed communication barriers were extracted and generalized into 10 factors and 5 categories. Followings were definitions of each category. And the mentioned percentage and details of each category and involved factors are described as Table 1.

Other centred. This category indicated that the coping communicative behaviour was due to communicators' concern about others when communicating.

Self centred. It indicated that people only concern about themselves when communicating. This category contains three factors.

Inability to achieve communicative goal. It covered some situations that were difficult for the communication to continue or to achieve desired goals.

Lack of interaction and connection. In this category, communicators did not have mutual connections between their thinking and behaviour.

Others. This category contains some barriers that were caused the individual differences, which only contained 'Difference in knowledge and thinking'.

Table 1 Ten factors and five categories of communication barriers

Category and factors	Detailed descriptions	%
Other centred		**71.88**
Respect others	Communicators' natural communicative behaviours are due to the respect to others.	40.63
Force themselves	Communicators' communicative behaviours are reluctant or against their intention owing to the considerations of others.	31.25
Self centred		**62.5**
Hold their ground	Someone insists on his/her own opinions.	34.38
Self-perform	Someone speaks in his/her way regardless of the situations or other's feelings.	18.75
Express directly	Express own thoughts directly without considering others' feelings.	9.38
Inability to achieve communicative goal		**37.5**
Difficult to communicate	Two communicators cannot participate in the interaction equally or cannot continue the	25

	communication.	
Difficult to understand	The words or sentences were not expressed clearly so that cannot be understood (related to communication skills).	12.5
Lack of interaction and connection		**15.63**
Topics did not strike a chord with each other	No interest in topics or cannot experience that situation and feelings of others due to the difference on field of experience.	9.38
Lack of performance	Communicators have few chances interact with the other.	6.25
Others		**15.63**
Difference in knowledge and thinking	Differences on knowledge, thoughts, or values caused by the individual differences among people.	15.63

Note: % = (times the factors being mentioned/ number of young and elder interviewees)*100

The research also investigated the communication barriers from two generations' view. There followed the factors that caused communication barriers in young and elder respectively. We can see the results from Table 2.

Young people revealed the most frequent communication barrier category they faced when talking with people in same generation was 'Inability to achieve communicative goal'. This category contained 2 factors, which were 'Difficult to communicate' (25%) and 'Difficult to understand' (6.25%). Those situations were young people thought themselves could not understand the other, the other did not intend to understand them, and misunderstandings between two people; Then were some problems related to 'Self centred' . For example, young people express their idea directly or argue with peers when two people have different opinion. This might lead to conflicts; The last one was 'Others'. Young people thought different thinking and unable to achieve common sense also communicative problems for them.

Then were barriers young peopele mentioned when they communicate with elders. The two most frequent category young people mentioned were 'Other centred'. There are 2 factors in this category, 'Respect others' and 'Force themselves', which counted 81.25% and 62.5% respectively. Young people always hold in high respect to elder people because of their age. It resulted the thought that they cannot disrupt the conversation, have to avoid having quarrels with elders, and tend to be a listener instead of equally interacting during conversation. Sometimes young people even forced themselves to do something contrary to their mind; the following frequently mentioned category was 'Self-centred', which also contained 2 factors'. One was 'Self-perform', whose percentage was 37.5%. Elder people love to speak in their way, such as rememberng their past and complaining something related to themselves. The other barriers was that young people thought elder people always held their ground; Besides, 'Inability to achieve communicative goal' was also frequently mentioned in the interviews. The factor was 'Difficult to communicate' (43.75%). Young people revealed

that elder people always give irrelevant answers to their questions, talk repeatative topics, and do not leave time for the young speaking, so it is difficult to successfuly disscuss something with elders. These communicative behavior might make young people feel not so good.

Table 2 Communication barriers from young and elder people's perspectives

	Communicate with young people	Communicate with elder people
Young perspective	● **Inability to achieve communicative goal** ■ Difficult to communicate *(25%)* ■ Difficult to understand *(6.25%)* ● **Self centred** ■ Express directly *(18.75%)* ■ Hold their ground *(6.25%)* ● **Others** ■ Difference in knowledge and thinking *(18.75%)*	● **Other centred** ■ Respect others *(81.25%)* ■ Force themselves *(62.5%)* ● **Self centred** ■ Self-perform *(37.5%)* ■ Hold their ground *(12.5%)* ● **Inability to achieve communicative goal** ■ Difficult to communicate *(43.75%)* ● **Lack of interaction and connection** ■ Topics did not strike a chord with each other *(18.75%)* ● **Others** ■ Difference in knowledge and thinking *(18.75%)*
Elder perspective	● **Others** ■ Difference in knowledge and thinking *(43.75%)* ● **Self centred** ■ Hold their ground *(37.5%)* ● **Lack of interaction and connection** ■ Lack of performance *(12.5%)*	● **Self centred** ■ Hold their ground *(12.5%)* ● **Others** ■ Difference in knowledge and thinking *(6.25%)*

Note [1]: % = (times the factors being mentioned/ number of young or elder interviewees)*100

Note [2]: Categories printed underlined are common barriers in both generations

Then are three factors that elder people regarded as barriers existing in their communication. When elder people communicate with young people, they expressed only three factors. They thought the majority of barriers were caused by 'Difference in knowledge and thinking' (43.75%). Moreover, young people always refused to concede defeat, so elder people thought young people holding their ground (37.5%) a factor caused barriers. The last factor was 'Lack of performance' (6.25%). Elder people revealed that they are afraid of being isolated from young people because of the advance of technology. Besides, elder people also shared their experience of greeting to young neighbour but get indifferent reply.

Elder people also mentioned 2 communication barriers with people in the same generation. One was 'Hold their ground' (12.5%), which categorized in 'Self centred', and the other one was 'Difference in knowledge and thinking' (6.25%), categorized in 'Others'.

Overall, there were three common intergenerational barriers according to the results of interviews, which were 'Self centred', 'Lack of interaction and connection' and 'Others'. Those categories were printed in italics in Table 2.

4. Discussion

The research aims to investigate the barriers and causes of daily speech communication form both elder and younger people's perspectives. The results showed that there were 10 factors and five categories that lead to intergenerational barriers. Here are two themes that this section is going to discuss. First is that why 'Respect others' and 'Force themselves' only appeared when young people communicate with elder people. Second are some comparisons between communication behavior in previous research and new-found communication barriers.

Previous studied indicated that 'respects' could reflect 'filial piety' and improve wellbeing of elder people (Cheng & Chan, 2006). While in this research, too much respect might result in sense of distance between two communicators. The openness and depth of conversation would be limited. Furthermore, in order to make elder people feel the conversation was good and comfortable, young people always make some responses that contrary to their mind. Especially in Chinese society, children tended to think 'white lie' better than facts (Fu et.al, 2010). However, the finding of this research found that although elder people satisfied with the conversation, young people, in fact, was not so comfortable.

In addition, partial results were similar to Williams and Garrett's findings in 2002. In Williams and Garrett's study, they categorized 'Did not act like self' into 'Discomfort' category, which was similar to our results that young people thought forcing themselves to do some communicative behaviors made them uncomfortable. However, there were some discrepancy between Williams and Garrett's findings and ours. In Williams and Garrett's research, young people thought it was elder people forced them to be attentive during conversation, while in our research, young people themselves forced themselves to be involved in the conversation. The difference might due to the culture difference between Eastern and Western. Taiwanese had the rooted notion, respect the elders (Lin, Zhang, & Harwood, 2004), so that young people tended to accommodate their communicative behaviour automatically. They did not think their accommodation was forced by elder people.

5. Conclusion

The study attempted to access the intergenerational communication barriers and causes of daily speech communication. The results revealed 10 factors and 5 categories of communication barriers. One of significant finding was that both young and elder people regarded having interaction and connection is important during communication. However, young people sometimes forced themselves to do unnatural

behaviour or be more passive when communicating with elder people due to respect the elders and the notion of ‘filial piety’. This may make the conversation less conversant so that both generations cannot merge into the situasion and feel unsatified with the conversation.

According to the results, good communication must be established on mutually understanding each people’s perspectives and needs, not force self to feel uncomfortable, and too strike a balance. Followings were some suggestions for improving intergenerational communication: (1) Despite of listening to elders only, young people should reply timely. (2) When communicating with young people, elder people should consider the difference of life experiences and background between the other and self, and also consider the other person’s interest of a topic to avoid talking enthusiastically but the other people did not appreciate. This might reduce the communication satisfaction.

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Age and Gender Influences on Pedestrians' Situation Awareness

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Nearly seventy percent of pedestrians who were killed in traffic accidents in Taiwan in 2013 are elder people according to the statistics by National Police Agency. It is suspected that poor situation awareness (SA) might be one of the causes that lead to the tragedy. The main purpose of this research is to investigate the age and gender influences on levels of SA between elder and younger pedestrian groups. Thirty elder and thirty younger participants with identical gender ratio attended the experiment. Situational Awareness Global Assessment Technique (SAGAT) was used to measure their objective SA while Situation Awareness Rating Technique (SART) is applied to evaluate subjective SA. According to the results of ANOVA, we detect neither gender nor age influence on SART, whereas both gender and age effects are significant on SAGAT task. In terms of age influence, male subjects have better performance than the other on SAGAT task, but their SART scores are similar with females. It seems that different SAGAT performance might related to driving/riding experience. With regard to age influence, elder participants have similar scores with younger ones on SART questionnaire, while they perform worse than younger group on SAGAT task. We speculate elderly might not be fully aware of their declined abilities, or they think these deteriorations would not threaten their safety. So they get similar scores with younger people on SART questionnaire. Nonetheless, their worse performance of SAGAT task indicates the influences of these declined abilities. We conclude that the discrepancy between subjective and objective SA is the reason of elder pedestrians' vulnerability, and driving/riding experience could somehow enhance SA. Based on the conclusion, we could improve elder pedestrians' safety by reducing the differences between their subjective and objective SA. Additionally, drivers play crucial roles in traffic accidents as well as pedestrians. The future study could further compare the SA between drivers and pedestrians. With this, we could address the problem of elder pedestrians' vulnerability much well.

Keywords: Pedestrian safety, Situation Awareness, Situational Awareness Global Assessment Technique (SAGAT), Situation Awareness Rating Technique (SART)

1. Introduction

Taiwanese statistics reveal that elder pedestrians make up the most vulnerable road-user group. Nearly 70% of pedestrians who were killed in traffic accidents are elder people who over 65 (National Police Agency, Taiwan, 2014), but they only represent

11% of Taiwanese population (Department of Statistic, Taiwan, 2014). The disproportionate percentages raise the issue of elder pedestrians' safety. It is suspected that poor situation awareness (SA) might be one of the causes that lead to the tragedy. The main purpose of this research is to investigate the age and gender influences on levels of SA between elder and younger pedestrian groups.

1.1. Age-related deficits and pedestrian safety

On one hand, elder people are the most experienced road users. On the other one, some of their abilities decline with aging. These age-related deficits might threaten their road safety. For example, the declined visual ability makes them hard to identify moving objects (Owsley and Mcgwin, 1999). Hence, elder pedestrians fail to take vehicle speed into account while making crossing decisions (Dommes et al., 2013). They only concern about the distance of oncoming vehicles. This way to make decision gets them into extreme danger because they cannot estimate the time of approaching vehicles accurately. Additionally, elder people need longer time to accommodate focus due to decreased lens elasticity, so they consume much time on observing road situation (Dunbar et al., 2004).

Cognitive ability declines with aging as well. The speed of transmitting information between brain and neurons gets slower as people get older (Tournier et al., 2016). Consequently, elderly needs much time to make crossing decisions. Noise inhibition is another kind of cognitive ability. It's difficult for elder people to ignore unrelated visual information, so they fell down more frequently than others (Anstey et al., 2009).

Physical ability is another ability changes with ages. The raising body fat percentage of elderly weakens their Skeletal Muscle strength (Tournier et al., 2016). The weaker the Skeletal Muscle, the slower the walking speed and the higher the falling down- risks (Asher et al., 2012).

Self-awareness is the ability that elder people are aware of their declined abilities, and then make adjustments to maintain safety or task performance (Dunbar et al., 2004). Under most circumstances, elderly are not utterly conscious of their changes. This accelerates their danger on the road. Once they sense their age-related deficits, they would adopt more conservative crossing strategists than ever before (Holland and Rabbitt, 1992). However, although they realize deteriorations, their adjustments are not certainly helpful for their safety. These worsen situation sometimes (Avineri et al., 2012).

1.2. Situation awareness

Endsley (1988) defines SA as, "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". Three-level model is what she (1995b) developed to further explain SA. This model comprises three hierarchical levels, each level is necessary precursors to the following one. From the lowest to the highest, these levels are: perception, comprehension, and projection. Perception level refers to the perception of elements in the environment, and comprehension level means to understand the meaning of them. Finally, based on the information from previous

levels along with people's own knowledge and experience, they could project the elements from current status to the near future. This indicates that they could predict the future state of the elements, and this process takes place in the last level- the projection level.

Situational Awareness Global Assessment Technique (SAGAT; Endsley, 1995a) and Situation Awareness Rating Technique (SART; Taylor, 1990) are the two SA measurements we use. SAGAT is an objective assessment. It involves the administration of SA related probes during the occlusion. Typically, the screen is randomly occluded in the process of task. Afterward, experimenters ask subjects some SA queries regarding the current situation, and the problems are developed based on three-level model. The direct nature is the primary advantage of SAGAT, whereas it is always criticized for intrusion on task.

SART is a subjective approach. It contains ten questions on seven points rating scale. Each question represents a dimension of SA. While scoring, these ten dimensions are assigned into three categories: demand, supply, and understanding. Table 1 shows the composition of SART. Formula 1 is used to derive overall SART score. Non-intrusion on task is the major advantage of SART. However, whether subjects can accurately evaluate their own SA is questionable.

$$\text{Score} = \text{Understanding} - (\text{Demand} - \text{Supply}) \quad (1)$$

Table 1
Composition of SART

Category	Dimension
Demand	Instability of the situation Variability of the situation Complexity of the situation
Supply	Arousal Spare mental capacity Concentration of attention Division of attention
Understanding	Information quantity Information quality Familiarity of the situation

Since researches reveal that SA levels are significantly different between males and females, gender might be a role on SA (Rosenbloom et al., 2015). Hence, not only age but also gender is concerned in present study.

2. Methodology

2.1. Participant

There were 30 younger and 30 elder participants with identical gender ratio attended the experiment. Younger subjects were those who aged between 20 and 30, and elder ones were all over 65 years old. Furthermore, we set up some restrictions to ensure the normal visual ability of participants. Their (corrected) visual acuity should be 1.0 at

least, and without these four kinds of eye disorder: Amblyopia, Glaucoma, Keratoconus, and Macular Degeneration.

2.2. Material

According to the Taiwanese official report, there were 28 fatal pedestrian accidents occurred in 28 places in Hsinchu City during the past 6 years. We selected 9 of them to take the videos. Figure 1 showed how we edited the videos. We took video in 300 seconds at each selected place, and then chose two 30 seconds-segments used in hazard perception test and SAGAT task. So there were totally 18 short videos.

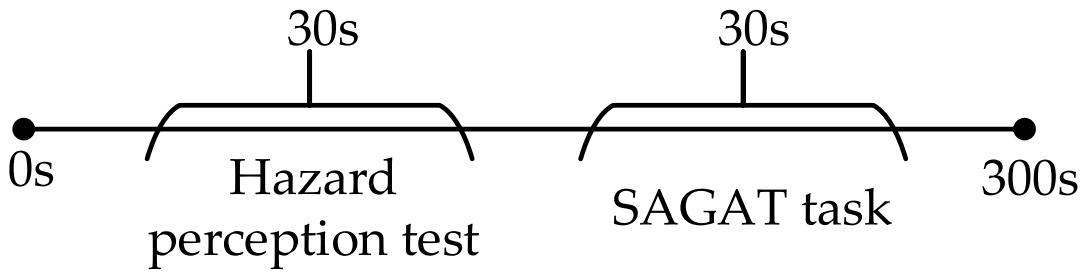


Figure 1 Example of video editting

2.3. Procedure

The experiment could be divided into three parts in order: introduction, hazard perception test, and SAGAT task. In the first part, we implemented visual acuity test to confirm subjects' qualifications. As soon as they were ensured, we asked them to sign the informed consents and proceeded to next part.

In hazard perception test, participants stared at the fixation point at the beginning of each trial (see Figure 2). This move was set to ensure every subjects look at the same point and thus to avoid experimental bias. As the figure showed, we stopped the video unexpectedly, and then required subjects to point out potential risks under current situation. Potential risk was what pedestrians needed to notice while crossing, or they might get into danger. The evaluation of potential risks was depended on previous literatures (see Table 2). After hazard perception test, we asked subjects filled in SART questionnaire and moved on to SAGAT task part. In summary, two dependent variables were measured in this part: the accuracy of potential risk detection, and the scores of SART.

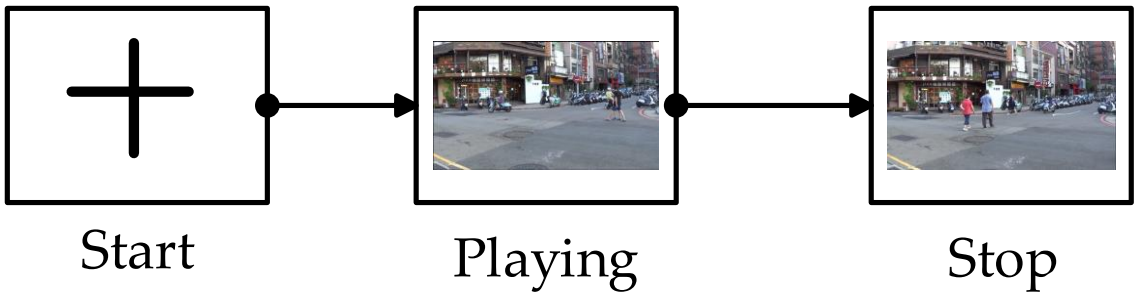


Figure 2 Procedure of hazard perdeption

The procedure of SAGAT task was similar to hazard perception test. We requested participants to gaze at the fixation point and stopped the video out of a sudden, but shut down the screen this time (see Figure 3). Therefore, participants no

longer watched the scene and needed to answer some SA-related queries during occlusion. The dependent variable was the accuracy of these queries.

Table 2
Items of potential risk

Item	Source
Road type	Tarko and Azam, 2011
Traffic signal	Gårder, 1989
Road marking	Zegeer and Bushell, 2012
Vehicle	Tarko and Azam, 2011
Pedestrian infrastructure	Zeeger and Bushell, 2012

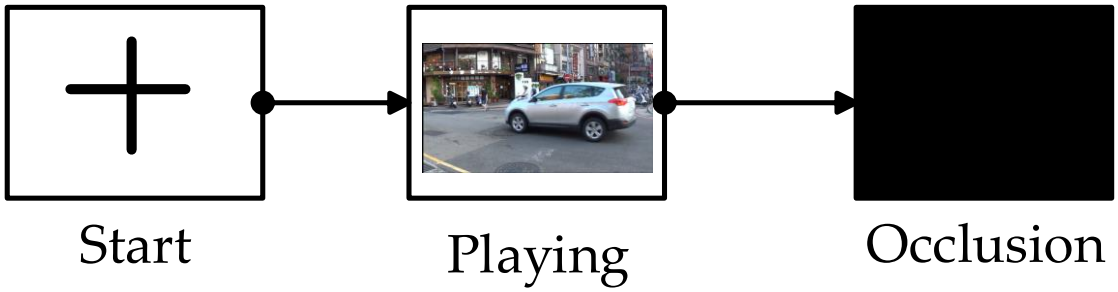


Figure 3 Procedure of SAGAT task

3. Results

The independent variables we manipulated were the gender and age of subjects, while the dependent variables we measured were the accuracy of potential risk detection, the SART scores, and the accuracy of SAGAT queries. We would elaborate the results of these dependent variables in this order.

The analysis of potential risk detection indicated neither interactive effect ($F(1,56)= 3.631$, $p= .062$) nor gender effect ($F(1,56) = 0.009$, $p = .923$). It only revealed age effect ($F(1,56) = 15.783$, $p < .01$). Therefore, younger subjects had significantly higher accuracy than elder ones (see Figure 4).

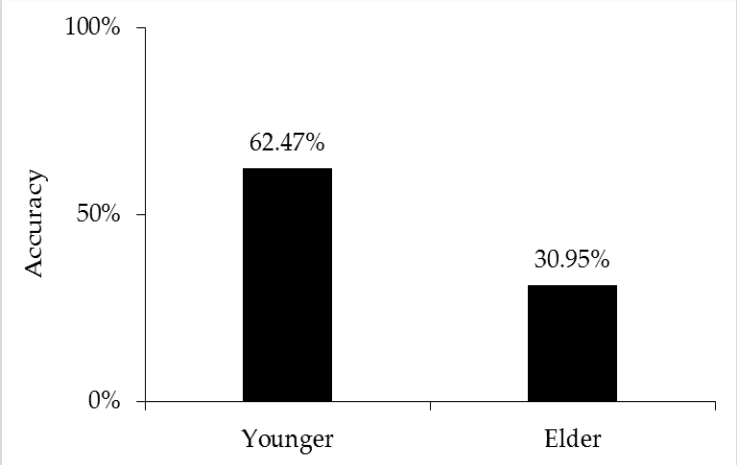


Figure 4 Mean accuracy of potential risk detection

The following analysis was about SART scores. The results of ANOVA showed nothing significant: interactive effect ($F(1,56) = 0.546$, $p = .463$), gender effect ($F(1,56)= 0.414$, $p = .523$), age effect ($F(1,56) = 1.363$, $p = .248$).

The final one was the accuracy of SAGAT queries. There were four levels of theses queries: perception, comprehension, projection, and overall. The results indicated that none interactive effect reached significant level among all the SA levels. In terms of gender effect, male subjects had higher accuracy than females on projection ($F(1,56) = 5.027$, $p = .029$) and overall ($F(1,56) = 4.175$, $p= .046$) levels, while they showed similar performance on perception ($F(1,56) = 3.159$, $p= .081$) and comprehension ($F(1,56) = 3.088$, $p= .087$) levels (see Figure 5). With regard to age effects, youger subjects had significantly better performance on each level of SA (see Figure 6) : perception ($F(1,56) = 50.546$, $p < .01$), comprehension ($F(1,56) = 70.673$, $p < .01$) , projection ($F(1,56) = 47.35$, $p < .01$), overall ($F(1,56) = 67.155$, $p < .01$).

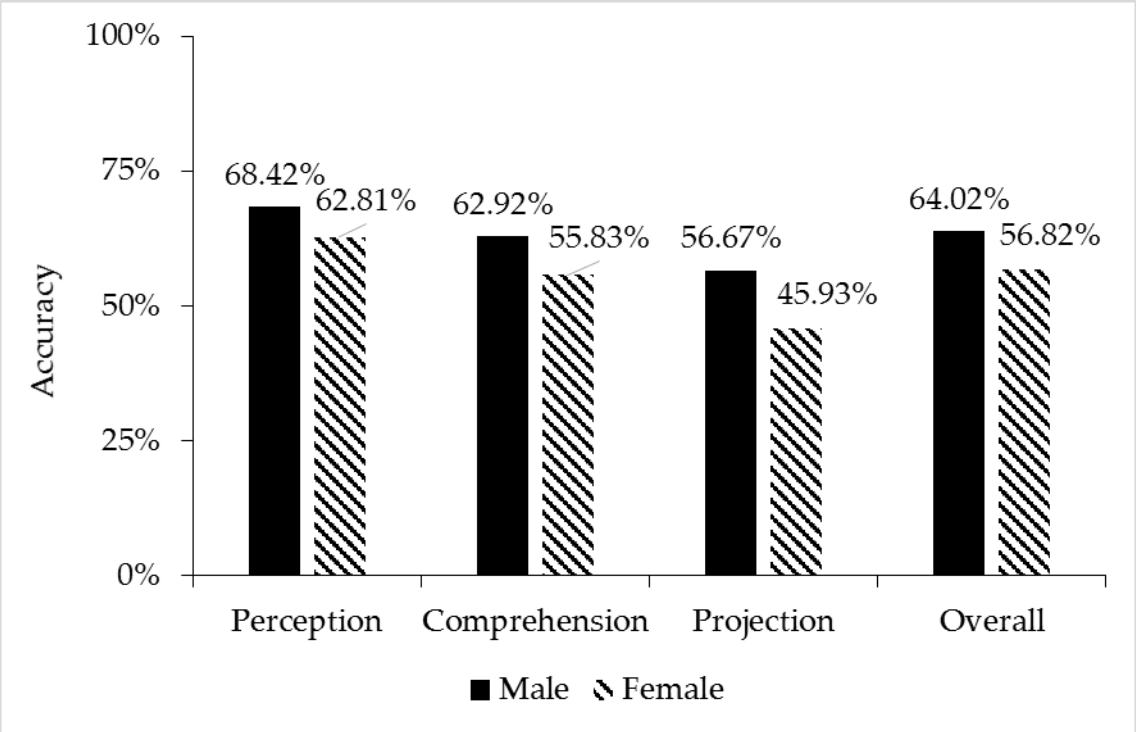


Figure 5 Mean accuracy between male and female subject

4. Discussion and conclusion

The purpose of this study is to investigate the age and gender influences on levels of SA between elder and younger pedestrians. In terms of gender influences, their SART scores are similar, while males show significantly higher accuracy on both projection and overall SA levels on SAGAT. The results might be related to their driving/riding experience. Since males tend to drive/ride more frequently, they have plentiful road experience and are able to predict future situation.

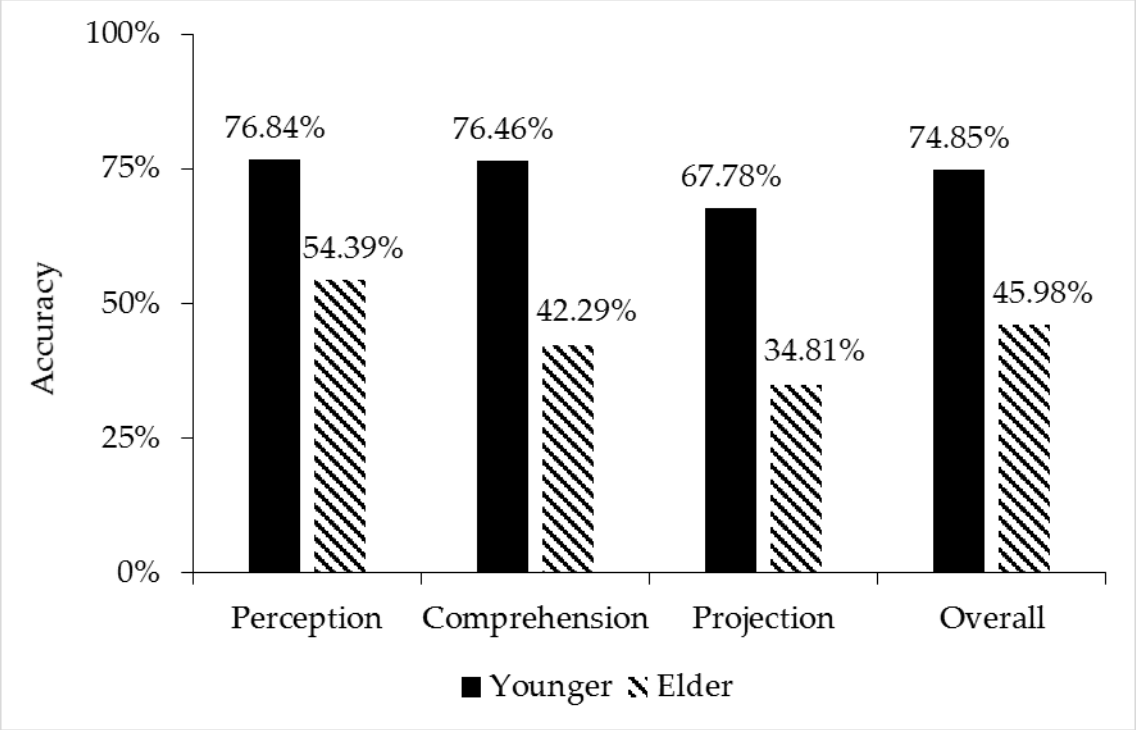


Figure 6 Mean accuracy between youger and elder subjects

Even though SART scores are not different between younger and elder groups, younger people have more superior performance on every SA levels on SAGAT. This results might be due to insufficient self-awareness of elderly. They might not be fully aware of their declined abilities, or they doesn't think these deteriorations would threaten them. So they have similar scores with younger people on SART. However, age-related deficits would actually influence their road safety, so they have worse SAGAT performance. Their problems on SAGAT task might lie in attention distribution. Since there are too many elements on the road, elderly have problems on inhibiting irrelevant ones and selecting the crucial ones. So, they have troubles with selective attention. Moreover, most of the queries that elder subjects answered correctly are related to traffic signs. They might have troubles with divided attention as well, because they cannot pay attention to two or more elements simuntaneously.

In conclusion, the discrepancy between subjective and objective SA is the reason of elder pedestrians' vulnerability, and driving/riding experience could somehow enhance SA. Therefore, their safety could be improved by extending the duration of red and green lights. With this, elder pedestrians have much time to observe road situation. Additionally, drivers play crucial roles in traffic accidents as well as pedestrians. The future study could further compare the SA between drivers and pedestrians. With this, we could address the problem of elder pedestrians' vulnerability much well.

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Discrepancies between intended and actual use in Activity-based Flexible Offices - A literature review

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The purpose of this paper is to provide an overview of the literature addressing A-FOs, with a focus on use patterns and work conditions. The findings show that A-FOs are not always used as intended: territorial behaviours and nesting habits were recurrent in several studies. In this regard, understanding employees' job characteristics is essential for optimal configuration of A-FOs, e.g. the type, attributes and number of workspaces. Additionally, employees´ needs, spatial factors and implementation processes require special attention in order to provide supportive office environments.

Keywords. A-FO, Activity-Based Flexible Offices, use patterns, work conditions, literature review, office design, office layout, flexible workspace.

1. Introduction

Activity-based Flexible Offices (A-FOs) also known as Activity-based Flexible Working (A-FW) has its origin at the beginning of the 90´s and gained great popularity over time (Lanks 2014; Parker, 2016; Van der Voordt, 2004). A-FO concept consists on a shared working space designed to provide the workers with a range of heterogeneous office sceneries, where furniture settings, design, architecture, building technologies, etc., are optimised to support specific activities in the best possible way at each moment (Appel-Meulenbroek, 2015; Wohlers & Hertel, 2016). Thus, activity-based flexible workers are encouraged to switch among workstations to find the most convenient setting for them within the office, or even work remotely from external locations like home (Vos & Van der Voordt, 2001).

Benefits of A-FOs such as occupancy-cost savings are still in discussion. On the one hand, the possibility of increasing the workstation-employee ratio over 1:1, represents an opportunity to reduce the total area occupied and consequently the allocation of resources needed (De Bruyne & Beijer, 2015). On the other hand, such criteria can limit the ability of office users to choose a suitable work setting type simultaneously (ibid.). Implementation of A-FOs impacts organisations on different levels such as leadership, management, work modes and communication technology (De Paoli et al., 2013) and pose diverse challenges to

their users such as privacy and communication trade-offs (De Been & Beijer, 2014). Thus, understanding case-specific and contextual aspects is of crucial importance.

A large number of studies on office buildings address different aspects of the work experience separately e.g. optimisation of productivity (Agha-Hossein, 2013), dimensions of comfort such as temperature, air quality, lighting, acoustics, etc. (Newsham et al., 2013), ergonomics (Whysall et al., 2006), different aspects of satisfaction (Kim and de Dear, 2013), psychosocial aspects of work (Herbig et al., 2015) and more recently emphasizing the connections with environmental impact and costs (Singh et al., 2011). Relevant literature reviews (De Croon et al., 2005; Wholers & Hertel, 2016) regarding the effects of diverse office concepts -including A-FO- on employees, have provided significant findings. However, the magnitude of those effects differ dramatically among cases, impacting the acceptance of A-FOs among the employees and the extent to which relocation goals are achieved (Brunia et al., 2016). This reveals that key aspects of the conceptualisation and exploitation of the workspace might have been neglected in some cases.

The aim of this paper is to provide an overview about A-FO case studies, focusing on employees' use patterns of the workspaces and their work conditions, in order to make the gap between concept and implementation of A-FOs visible.

2. Method

The procedure for the search and selection of relevant material began with the exploration of two databases: Scopus and Web of Science. The inclusion criteria was case studies about A-FOs in relation to their implementation, usage and employees' work conditions. Given the relatively recent expansion of this office typology, the timeframe determined for the searches was 2000 – 2016.

Further criteria for filtering at the first stage was: a) Fields of search: title, keywords and abstract; b) Type of documents: articles and proceeding papers; c) Areas of interest: acoustics, architecture, business, business economics, economics, econometrics and finance, engineering, engineering industrial, environmental studies, environmental science, ergonomics, health care sciences services, health professions, industrial relation labour, management, management and accounting, physiology, planning development, psychology, psychology experimental, psychology educational, psychology clinical, psychology applied, public environmental occupational health, sociology, social sciences interdisciplinary, social issues. Moreover, only studies with first hand info were counted for a second stage, meaning that literature reviews were excluded from results. Then, the following list of keywords and search commands were used for the search:

- One search using OR and one using "": Activity-Based Office, Activity-Based Working, Activity-Based Work, Activity-Based Flexible Office, Activity-related office, Lean office, Desk sharing, Hot desking, Desk hoteling, Office hoteling, Alternative workplace arrangements, Combi office, Cocoon office, Clean desk.

- One search combining AND and "": "Activity based" ∧[1] office, "Activity based" ∧ workplace, "Work patterns" ∧ flexible, "Work patterns" ∧ office, "Activity patterns" ∧ office, "new workplace*"[2] ∧ design, "new workplace*" ∧ office, "new office" ∧ design, "new office" ∧ concept, "flexible working" ∧ design.
- One search using "": Flexible workplace, Flexible workspace, Flexible work design, Flexible office, Flexible working, Shared office, Innovative office, New workplaces, Office sharing, NWoW, NWW, New ways of working.

After the first round of search, 67 papers were identified and screened further. The papers that did not meet the inclusion criteria were discarded, e.g. literature focusing teleworking or flexible work hours. In addition, a few studies that addressed overall satisfaction, work satisfaction, satisfaction with organisation, with remote working and services were also excluded as they address aspects beyond physical boundaries of the A-FOs. As a result, 19 papers were selected for the results. A second round of search was carried out by reviewing the references of the identified 19 papers. After this iteration, 11 papers were identified that fulfilled the inclusion criteria. In total, 30 papers were reviewed for the results.

3. Results

Some of the identified papers highlight aspects regarding office employees' exploitation of workspaces in A-FOs, specifically related to (i) territoriality and (ii) switching patterns among non-assigned workstations. Other studies address employees' perceptions and experiences when relocating to an A-FO, reporting both short and long-term consequences mainly regarding (iii) health and wellbeing, (iv) productivity, communication and concentration, (v) privacy and (vi) facilities.

3.1. Territoriality

A total of nine studies were identified that report specifically on territorial behaviours at A-FO. For example, Brunia & Gosselnik (2009) present a study on the extent of personalisation in A-FOs and report on the permanency of artefacts used by the employees to personalise and mark a workspace that they returned to. De Been et al. (2015) mention that in 11 out of 20 cases studies instances of claiming workstations were identified. Elsbach (2003) reports on nesting behaviours among employees as a strategy to cope with personal and group identity threats of desk-sharing policies. Brunia et al. (2016) report on four cases in which two lacked vacant workplaces leading to claiming behaviours of employees and managers, further reducing the availability of certain workspaces –mainly the enclosed ones-. Tagliaro et al. (2016) report that 25% of the desks were permanently marked by artefacts and associate this behaviour with certain types of work functions e.g. law and procurement. Other units were associated with unmarked workstations e.g. business, sales and marketing units (ibid.). Appel-Meulenbroek et al. (2011) found that 28% of users claimed workstations with personal belongings, while 35% avoided certain workstations that were regularly used by

[1] Symbol for the operator AND.

[2] Searches with asterisk at the end of the word include the written word with other suffixes as well e.g. plurals.

another colleague. Hirst et al. (2011) report that half of the available workstations were claimed by either arriving early and/ or leaving belongings behind that denote their roles, which gave rise to socio-spatial habitualisations and the establishment of classes for settlers and mobile workers. Van der Voordt (2004) also mentions that some users arrive earlier or leave belongings behind to claim a workstation in consecutive days. Finally, in a case study by Giorgevsky et al. (2010), workstations were not claimed with belongings, because the office was fully open and any of the numerous visitors could easily steal them.

3.2. Switching patterns

A total of 12 studies present different patterns regarding the use of workspaces: from highly flexible to highly fixed. Highly flexible use patterns were described in two studies. Meijer et al. (2009) report that 86% of the users switched workstations and used several types of workstations per week. The authors argue that the extensive participatory approach in the implementation process, may explain the high rate of compliance to the new office (ibid.). Blok et al. (2009) report on a case in which the employees use on average 2.7 different workstations per day, before and after the relocation, so the A-FO had no impact besides the wider variety of settings. However, the latter study does not mention if users return to the same workstations.

Mixed results regarding use patterns are reported at five studies. Hirst et al. (2011) report on a case where the ratio was 10 employees per 6.5 desks, the office was intensively used and at least half of the desks were settled. This implies that the other half were used by users who potentially switched workstations (ibid.). Appel-Meulenbroek et al. (2011) report that 46% use 1-2 types of workstations in an average week and 68% never switch workstations during a workday. The motives behind users' choices of workstations were: personal preference, privacy, ambiance, comfort, ergonomics, social interactions and technical resources (ibid.). Giorgevsky et al. (2010), report that 45% of respondents did not switch workstations throughout the workday but present no data about the choice of workstations in consecutive days. Block et al. (2012) report that the relocation did not change significantly flexible work behaviour within the office. 40% of the working time was spent at the flexible layout, but beyond the share of hours of occupancy per workstation type, no data on switching patterns is presented (ibid.). Tagliaro et al. (2016) report that 78% of respondents use open flexible spaces, and 13% specifically reported to switch workstations. Whether the majority switch workstations in open spaces is however not mentioned.

Finally, highly fixed use patterns in A-FOs were reported in five studies. In a case study by Qu et al. (2010), 70% of the users chose the same workstations and 20% of the users who switched workstations chose the same or adjacent areas. The motives behind these patterns were to: (i) skip extra work i.e. setting, wrapping up, and moving things around, and (ii) proximity to particular colleagues or units (ibid.). Millward et al. (2007) also identified proximity to colleagues as a main reason to choose a workstation, what derived in the creation of comfort areas for regular interaction. Ekstrand et al. (2016) show that employees changed workstation for specific tasks -e.g. meet a customer- and reported great

autonomy by that, but they kept using the same desk in the back office afterwards. Similarly, Maier et al. (2010) found that users return to the same workstations if they are not scheduled to work in teams in a specific zone. Lastly, Hoendervanger et al. (2016) found that 70% of users do not or rarely switch workstations -25% never, 24% less than once a week, 21% 1-2 times a week-, although users with heterogeneous work activities were more likely to switch workstations frequently. They also found that, proximity to colleagues and teams, and difficulties with moving stuff were leading motives for not switching workstations, while finding a more suitable workspace was a main motive for those who regularly switch (ibid.). These users also reported higher satisfaction with the A-FO in the latter study.

3.3. Health & Wellbeing

A total of six papers address wellbeing and/or health-related questions in A-FOs. For example, Engelen et al. (2016) report an overall reduction of office users' sedentary time -+3% walking, +11% standing time and -14% sitting time- after the implementation of a flexible work environment. Such results are consistent with the increase in general health observed by Meijer et al. (2009) among office users with non-assigned desks. However, Kim et al. (2016) report that the most significant predictor of a negative impact on health was not the desk ownership itself, but the lack of space for breaks and the comfort of furniture. On the other hand, Vink et al. (2012) report that the office relocation barely influenced employees' health and comfort. This is aligned with the office comparison from Seddigh et al. (2014) where no significant changes on general health were found between flex offices and other types. The same study conclude that the employees at flex offices report similar levels of cognitive stress to employees at small and medium open-plan offices, and the situation worsens as more people share the same space. Lastly, Nijp et al. (2016) suggest that the implementation of AFOs may not lead to changes on health.

3.4. Productivity, Communication & Concentration

A total of 20 papers present results about productivity, communication and concentration at A-FOs. The results regarding these 3 topics are usually reported in direct connection to each other, so that the influence of each on the others is clearly established. They are therefore grouped under the same heading. For example, studies by Blok et al. (2009), De Been et al. (2015), Gorgievski et al. (2010), and Vink et al. (2012) among several others in this review, suggest that A-FOs lead to improvements in a diversity of aspects such as interaction -especially in informal contexts-, collaboration, knowledge exchange and accessibility -both physical and digital- between office users and departments. However, Brunnberg (2000) highlight that employees whose exposure exceed the real needs for communication, are led to distraction and lower effectiveness.

Seddigh et al. (2014) found cell offices -single and shared- preferable over A-FO for tasks demanding high concentration. Been & Beijer (2014) also emphasise on the value of secluded workspaces for concentration. The same study report levels of satisfaction under the expectations with communication and social interaction in A-FO. A possible explanation

is the inability to sit in sight of co-workers or the troubles to locate and/ or reach them (ibid.). In a similar way, Kim et al. (2016) report that the main predictor of a higher perceived productivity in A-FOs, was spatial factors e.g. layouts that hindered interaction, not customisable or properly adjustable workstations, and lack of storage. Brunia et al. (2016) highlight spatial factors as one of the key aspects explaining great differences in satisfaction with productivity, communication and concentration in A-FOs. Additionally, De Paoli (2013) reports on IT as another key A-FO resource to enable cohesion and a participative atmosphere, and Millward et al. (2007) found that IT was valued as a more relevant and effective communication tool among office users without assigned desks. On the other hand, Nijp et al. (2016) report a significant shift from office working to home working, but no significant effects were found on job-related outcomes after implementing new ways of working. In fact, Meijer et al. (2009) report that quality and quantity of performed work only recovered pre-intervention levels after 15 months, suggesting no significant improvements after all. Adding to these cases, Blok et al. (2012) present that, besides the increased work flexibility, business objectives remained the same and even knowledge sharing dropped significantly -presumably due to the limited impact of an incomplete A-FO implementation- . This is while Blok et al. (2009), De Been et al. (2015) and De Kok (2016), report connections between desk-sharing and a perception of time waste to find/ switch to/ clean up suitable workstations -e.g. to support concentration-.

Bodin Danielsson & Bodin (2009) and Morrison & Macky (2016) present conflicting results regarding social support and interpersonal relations at A-FOs: in the first study social interaction was positively affected by flexible workplaces, while in the latter study negative relationships, distrust and uncooperative behaviour were more recurrent. Another example of divergent results is reported by Van der Voordt (2004), showing two cases of newly flexible workers: the ones moving from cell offices registered a significant drop in their perceived productivity due to e.g. the loss of seclusion, whereas the ones moving from an open-plan office registered a notable increase due to e.g. the ability to move to quieter places. In both cases, older respondents reported poorer work conditions, which is a situation also highlighted by Pullen (2014) in a multigenerational comparison.

Finally, Petrulaitiene & Jylhä (2015) report on six new A-FOs that managed to save costs, reduce vacancy, improve business processes and increase flexibility, effectiveness, motivation and interaction between employees. However, the description of each case is extremely brief and mostly focused on the positive achievements.

3.5. Privacy

A total of 7 papers display results on visual and/ or auditory privacy in A-FOs. De Been et al. (2015), Van der Voordt (2004), Pullen (2014), Gorgievski et al. (2010) and De Been & Beijer (2014) report recurrent dissatisfactions and concerns with privacy mainly due to: (i) difficulties to converse about private/confidential matters with nearby colleagues and talk on the phone without being heard or hearing others; (ii) unwanted visual exposure due to the openness of the space. Bodin Danielsson & Bodin (2009) found privacy together with

noise as the aspect causing most dissatisfactions among office users at different office types. A-FOs were rated in between the best -cell-office- and the worst case -open-plan office-, but they particularly performed well by the possibilities to avoid been observed. The latter findings are consistent with Blok et al. (2009), who report that office users coming from an open-plan office found better privacy at the AFO -from negative score to neutral-. Therefore, the possibility to withdraw temporarily to enclosed spaces is one way of supporting privacy, but depending on the case it appears not enough to pay off the negative effects of office openness. Anyhow, individuals' opinions towards privacy in A-FO, also vary notably with the age, being the youngsters the less negative to this respect (Pullen, 2014).

3.6. Facilities

A total of 11 papers address levels of satisfaction with a large heterogeneity of factors from the indoor environment. Office layout, architecture and interior design tend to be more listed among the best aspects regarding A-FO's facilities as indicated by e.g. Ekstrand et al. (2016), Pullen (2014), De Been I. & Beijer M. (2014) or De Been et al. (2015). On the other hand, studies like Van der Voordt (2004), Bodin Danielsson & Bodin (2009) and Kim J. et al. (2016) report storage limitations and a lack of secluded spaces. Additionally, the lack of doors in an office with many external guests, is reported by Giorgevsky et al. (2010) as dissatisfaction, since personal belongings were exposed to thefts. Other aspects such as share of spaces, indoor climate and work environment in general as well as furniture and spatial openness in particular, present uneven results among the identified papers. In this sense, Brunia et al. (2016), report extreme differences -over 50-60%- in satisfaction with AFOs, that seem to be substantially influenced by the support of the physical environment, the implementation process and organisational management, among other relevant factors.

4. Discussion

This literature review shows that A-FOs are not always used as intended. The reviewed studies report diverse use patterns and territorial behaviours that contradict with A-FO's principles. For example, Qu et al. (2010), Hoendervanger et al. (2016) and Hirst et al. (2011) among others, show that proximity to immediate colleagues and team members was the most recurrent motive to choose a workstation(s) repeatedly in the same or adjacent areas. This, together with other motives e.g. own preferences or differences in job characteristics coexisting within the shared space, may enable the emergence of informal social structures over certain work areas. Thereby, what begins as territorial habits to cope with the new environment seem to become non-written agreements, e.g. people avoid to seat in "others' place" (Hirst et al., 2011). Tactics to address this issue have been employed, e.g. by adopting team-policies and zones (Millward et al., 2007), or booking programs that allocate workspaces in proximity to team members (Maier et al., 2010). This highlights a need to pay attention to employees' activities and needs when implementing A-FO. Other strategies propose to ensure rotation of staff and optimisation of space use through intelligent booking systems and predictive tools (Appel-Meulenbroek et al., 2015; Maraslis et al., 2016).

It is worth mentioning that the reviewed studies present results either from observations -e.g. regarding number and extent of desks claimed or personalised- or self-reported experiences -e.g. data regarding the switching frequency among employees in A-FOs-. One of the implications of such source imparity is shown in Tagliaro et al. (2016), where respondents reported on high occupancy and lack of workspaces, while field observations showed occupancy rates of 50%. Another issue with the reviewed studies is that they partial results regarding the switching behaviour, e.g. the extent of settled desks is provided indicating the switching behaviour, but not how the remaining desks are used. Future work about A-FO use is needed to gain a holistic understanding of use patterns.

Unintended uses of the office space could show a lack of support to specific needs – e.g. psychological, physiological and social-, that may explain the differences reported on work conditions. Several studies, e.g. Kim et al. (2016) and Brunia et al. (2016), highlight that case-specific aspects such as management, intervention approach, job profiles, IT support, spatial factors, and even prior office environments can critically influence users' appraise of A-FOs. For example, users from opposite office types -open-plan vs cell-office- report divergent reactions after relocation due to their pre-conditions (Van der Voordt, 2004).

Even when A-FOs are implemented to have efficient and fruitful offices, the extra demands to find and set up suitable workstations e.g. De Kok (2016) or unwanted exposure to openness when concentration is needed e.g. Brunnberg (2000) represent compromises for privacy and productivity in most of the cases. Additionally, identity threats such as the hindrance for spatial personalisation e.g. Elsbach (2003), and the assumption that implementing A-FOs does not naturally lead to better health and wellbeing at work e.g. Nijp et al. (2016), represent extra complexities for A-FO developments. Lastly, many studies provide partial data on pre- and post-intervention workspaces and circumstances e.g. the extent to which spatial conditions changed, leaders' roles, building's qualities and even employment conditions. For all this, further research is needed for a more detailed understanding of the interplay between organisation, office environment and individuals.

5. Conclusions

The literature review comprised of 30 papers and addressed different aspects of employees' work experience as well as workspace exploitation when implementing A-FOs. Results show that case-specific aspects can lead to disparate outcomes, suggesting that the A-FO concept is not a guarantee for organisations' success due to discrepancies found in relation to office use patterns and employees' work conditions.

Regarding office use patterns, territorial behaviour was reported e.g. personalisation of workstations or permanent demarcation with artefacts. Additionally, the overall follow-up of flexible working policies was irregular, with a minority of employees switching workstations regularly vs. a majority using persistently the same workstation(s) in consecutive days. This highlights a mismatch between A-FO use and the spaces provided to host and support their working activities. Some of the main reasons behind this mismatch are to stay in proximity to colleagues, personal preferences or the feeling of time loss

associated to search for a suitable workstation, set it and wrap it up. Nonetheless, the level of satisfaction with work conditions was higher among flexible workers –the ones using the office as intended- than in the case of people with the mentioned nesting habits.

Regarding work conditions, discrepancies were found mainly regarding satisfaction with productivity, concentration, privacy and facilities in A-FOs. The reasons behind these discrepancies were linked to both, factors in which the office type has no significant influence and factors in which the A-FO concept is a relevant predictor. In this sense, spatial qualities –e.g. indoor climate, spatial subdivision, comfort of furniture, amount of light-, organisational management and implementation approach are highlighted as critical factors and not necessarily related to the office concept. On the other hand, the lack of opportunity to personalise workspaces, visual and auditory exposure, lack of storage and a feeling of increased job demands are factors related to the particularities of A-FOs. Therefore, further research is needed to find out how A-FOs should be conceived to successfully support (i) job characteristics and tasks mutuality as well as (ii) office users' needs and case-specific circumstances, covering the mismatches highlighted in this literature review.

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Living Labs: a forum for enabling co-creation between multi-disciplinary actors in the workplace?

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Living Labs are promoted throughout the EU and beyond as being 'user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings'. This paper aims to understand what Living Labs are and how they may best be utilised within the context of digitalisation of sociotechnical work. Using a combination of literature study and field studies at two Living Labs within the freight transportation sector, it discusses the potential of Living Labs as a forum for enabling co-creation between multi-disciplinary actors directly in the workplace.

Keywords: Living Labs; co-creation; participatory ergonomics; sociotechnical work, freight transportation.

1. Background and purpose

In recent years, Living Labs have grown in number and popularity, and are being promoted throughout the EU and beyond as a novel approach to research and innovation (see e.g. Almirall & Wareham, 2011; Følstad, 2008; Leminen, 2015; Nesti, 2017). According to the European Network of Living Labs (ENoLL[1]), Living Labs are 'user-centred, open innovation ecosystems, based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings'. At the time of writing (May 2017), ENoLL listed 406 registered Livings Labs in 54 countries worldwide, mainly within the areas of ICT, mobile services and healthcare, and to a lesser extent energy, transport, housing and society at large (see also Nesti, 2017). There is a growing body of literature which aims to describe and support this development, but a common theme is the 'elusive' nature of Living Labs (Quak et al., 2016), and general lack of consensus regarding what they are and how they may best be utilised.

The work described in this paper was conducted as part of the EU Horizon 2020 research and innovation project AEOLIX (Architecture for EurOpean Logistics Information eXchange). AEOLIX has established eleven Living Labs to explore the effects of digitalisation on freight transport operations, and to develop and test a digital ecosystem to facilitate information exchange between various actors in the supply chain or network. The aim of this paper is to investigate what Living Labs actually are and to attempt to identify their potential within the context of digitalisation of sociotechnical

[1] http://www.openlivinglabs.eu/

work in general and freight transportation in particular. This will be done using a combination of literature study and field studies at two Living Labs, a multimodal freight terminal (hereinafter *'the freight terminal'*) and a consumer goods distribution centre (*'the distribution centre'*).

2. Design/methodology/approach

2.1. Literature study

Firstly, a literature study was undertaken to understand the concept Living Lab, to identify central features or characteristics, and to examine potential success factors or barriers for Living Labs. The literature study also considered how Living Labs fit in to the landscape of, and distinguish themselves from, existing participatory approaches to design. The purpose was not to perform a comprehensive literature review, but rather to try to discern the defining features of a 'best practice' Living Lab which may be applied within the context (freight transportation) described above.

Over 60 peer reviewed journal articles and papers from conference proceedings were included in the initial study, of which 15 are included in this paper (see References). These were selected as they represent: critical reviews of the state-of-the-art of Living Labs theory and/or practice (Almirall & Wareham, 2011; Ballon & Schuurman, 2015; Dell'Era & Landoni, 2014; Følstad, 2008; Leminen, 2013, 2015; Nesti, 2017); contributions to the Living Labs concept definition or methodology (Leminen et al., 2012; Nyström et al., 2014; Pallot et al., 2014; Schuurman & Tõnurist, 2017; Westerlund & Leminen, 2011, 2014), or; discussions of Living Labs specifically within the freight transportation sector (de Jong et al., 2016; Quak et al., 2016).

2.2. Field studies

In addition to the literature study, field studies were conducted in two Living Labs, the freight terminal and distribution centre introduced earlier, to reveal the extent to which their various actors share the interpretation(s) found in the literature. Using an explorative research design, field observations, semi-structured workplace interviews and discussions were conducted in order to identify: which actors are represented in the Living Labs; their understanding of the concept; their motivation for participation and anticipated results; and their expectations for how work may be improved by the introduction of new ICT.

These took place on six separate occasions with 17 participants, including a terminal supervisor and assistant supervisor, four terminal operators, three truck drivers, one export planner, one import planner, two system developers and one project manager from the freight terminal, and one transport planner, one technical support developer and one project manager from the distribution centre. Data, including sound recordings of field visits, documentation, written notes and photographs were collected and analysed using coding, categorisation and thematic analysis. The reader should note that the focus was on the 'real life setting' and user perspective of the Living Labs, and several partners and third parties were not included at this stage, namely transport operators, suppliers, customers and other researchers.

3. Results

3.1. Living Labs in theory

What are Living Labs?

As mentioned earlier, there is a general lack of consensus in the literature regarding the concept Living Lab. There are multiple views of the definition and central features of Living Labs, their aims and purposes, the methodologies which they employ and so on. Although there are many common themes (e.g. Leminen, 2015), there are also a number of controversies between the different understandings of the concept and also between theory and practice (see e.g. Følstad, 2008; Nesti, 2017). It has been argued that the elusive and diffuse nature of Living Labs is a consequence of its adoption as a buzzword in political spheres, and thus its proliferation without a sound theoretical or methodological grounding, and the tendency to fall back on old means of collaboration (Ballon & Schuurman, 2015; Leminen, 2015; Nesti, 2017; Quak et al., 2016).

For example, Living Labs claim to be a new way of *working collaboratively between multi-disciplinary actors in real-life settings*, which is different from test beds, demonstrators and so on (Følstad, 2008; Leminen, 2015; Schuurman & Tõnurist, 2017). However, in practice 'Living Labs' tends to be used as an alternative moniker for these existing forms (as noted by Almirall & Wareham (2011), Quak et al. (2016) and others), and exactly how they are different is unclear. One distinguishing feature is the *awareness of users that they are actively involved as a partner throughout a co-creation process*, rather than an informant or participant at discrete stages of the development process (according to Dell'Era & Landoni, 2014; see also Almirall & Wareham, 2011; de Jong et al., 2016; Leminen, 2013; Nesti, 2017; Pallot et al., 2014; and ENoLL). This user awareness and co-creative focus distinguishes Living Labs from similar approaches within the areas of user-/human-centred or participatory design (Dell'Era & Landoni, 2014; also Pallot et al., 2014), and from traditional research and innovation projects (Leminen, 2015; Schuurman & Tõnurist, 2017; Westerlund & Leminen, 2011). Striking resemblances may be seen to the Scandinavian tradition of cooperative design, but with emphasis on the real-life setting (Ballon & Schuurman, 2015; Dell'Era & Landoni, 2014). However, Følstad (2008) and Nesti (2017) note that, while prevalent in the Living Labs vocabulary, once again actual co-creation plays a much less significant role in their practice than might be expected (also Nyström et al., 2014).

Despite the lack of consensus, several authors maintain that Living Labs *may* successfully facilitate co-creation directly in the workplace, benefiting not only users, but also designers, developers, management, researchers and other stakeholders (Almirall & Wareham, 2011; Dell'Era & Landoni, 2014; Følstad, 2008; de Jong et al., 2016; Leminen, 2013, 2015; Nesti, 2017; Quak et al., 2016; Schuurman & Tõnurist, 2017; Westerlund & Leminen, 2014). Additionally, they suggest methodologies and tools for how this may be achieved (Leminen et al., 2012; Nesti, 2017; Nyström et al., 2014; Pallot et al., 2014; Westerlund & Leminen, 2011).

Towards a 'best practice' for Living Labs?

Nesti (2017) argues that ascertaining 'best practice' for Living Labs is problematic, not least due to their high mortality rate (2017:278-279) - only 59 of the 378 surveyed were active and displayed the 'basic characteristics' of a Living Lab, i.e. user involvement in a

co-creation process (2017:273). This may in turn be dependent on, amongst other things: the rapidly obsolete nature of ICT; political 'sponsoring' of short-term projects; the traditional bureaucratic culture of public administration, and; the lack of commitment and long-term participation by users, particularly when their participation does not lead to tangible outcomes (see also Ballon & Schuurman, 2015; Quak et al., 2016).

Leminen et al. (2012) do not define a 'best practice', but instead provide a framework for 'choosing' a Living Lab type based on the purpose and outcomes one wishes to achieve, and the typical organisational form, available actions and expected lifespan. Four main actor roles (*user, utiliser, enabler, provider*) are usually present in all Living Labs, but the type will be determined by which party is the driving force, and the coordination (top-down or bottom-up) and participation approach used (Leminen, 2013; Leminen et al., 2012). According to Leminen et al. (2012), Living Labs may thus be: *utiliser-driven* (coordinated by e.g. the developer of a product or service); *enabler-driven* (a funder or public authority); *provider-driven* (a university or consultant) or; *user-driven* (by users or communities of users). Nesti's reasons for the mortality of Living Labs (above) indicate that a *user-driven* Lab (i.e. not led by ICT service providers, politicians, public authorities, or arguably researchers) which engages the active, long-term participation of users has the greatest chance of success.

Nyström et al. (2014) further characterise the roles that users may take in Living Labs, namely as *informant, tester, contributor* or *co-creator*. (Although, as noted by Dell'Era and Landoni (2014), there are numerous existing methodologies, under the umbrella of user-centred or participatory design, where the user's role is that of informant, tester or contributor.) Westerlund & Leminen (2011) explicitly link fully-fledged co-creation to a user-driven (as opposed to user-centred) innovation process. The prevalence of co-creation in real-life settings in the Living Labs vocabulary, and the lack of an established methodology to enable this, (see above) suggests that the involvement of the *aware user as co-creator* may be an indicator of a 'best practice' Living Lab.

Living Labs in freight transportation

Freight transportation may be viewed as a complex sociotechnical system, consisting a network of multi-disciplinary actors, and involving 'vehicle technology, ICT applications, regulation, user practices and markets, several networks, such as infrastructure, supply and demand, and maintenance' (Quak et al. 2016:463; also de Jong et al., 2016:16). Quak et al. (2016) consider freight partnerships the current best practice within freight transportation: freight partnerships provide a forum for knowledge sharing, discussion and collaboration between local public and private stakeholders, but seldom lead to tangible outcomes. They argue that Living Labs may go beyond freight partnerships by enabling action and focusing on the implementation of solutions in their real environment. de Jong et al. (2016) emphasise that, due to the systemic nature of freight transportation, one should consider both its high-level strategic characteristics and lower-level tactical and operational aspects, which occur in the workplace and are often overlooked; these become visible and may thus be communicated between actors in Living Lab-style settings. Both de Jong et al. (2016) and Quak et al (2016) include the possibility to have a 'common objective' (de Jong et al., 2016:16) or 'shared ambition'

(Quak et al., 2016:470), to build trust between actors and consider both the individual actor and system level perspective as potential success factors for Living Labs.

3.2. ... and in practice

In the same way that the rhetoric of Living Labs is not necessarily reflected in their practice (Følstad 2008; Nesti, 2017), the two cases which were studied here do not neatly fit easily with the descriptions of Living Labs found in the literature. The awareness of users was noted as a central feature of successful Living Labs (Ballon & Schuurman, 2015; Dell'Era & Landoni, 2014; Leminen, 2103, 2015; Westerlund & Leminen, 2011). However, in the field, it quickly became apparent that the participants were not 'aware users' in the sense described above. With the exception of the two project managers and two system developers who are directly involved in the research and innovation project, none of the participants appeared to know that, thanks to their four colleagues, they were even 'in a Living Lab', thereby rendering redundant the authors' carefully prepared questions! They did (mostly) know that their respective companies or organisations were involved in some sort of project in which some researchers might come and do... something. (This is not necessarily a disadvantage, as will be discussed later.) They were thus content to be interviewed and observed at length, and to discuss both their current work, future plans and expected impacts of digitalisation.

To summarise, in the freight terminal, trailers with mixed goods are imported to and exported from the terminal by road and/or sea; goods are also collected and distributed on a regional and national level, usually by road. The terminal deals mainly with the loading/unloading of the trailers. They communicate primarily with import and export planning departments (which are part of the same organisation) and individual truck drivers, and to a lesser extent with the transport planning department and external logistics operators. In the distribution centre, consumer goods arrive to the warehouse mainly by rail from national/international suppliers, but also by road from local suppliers. Goods are subsequently distributed by road and rail to regional distribution centres across the country, and directly to local shops for retail. Planning of road and rail transport is mainly conducted by separate departments within the distribution centre in collaboration with external road/rail operators, who perform the transport operations.

Participants from both Living Labs identified one central issue as a barrier to successful work: that transportation of goods is inherently dependent on interaction and communication between different actors (e.g. terminal-import-export or distribution centre-train/truck operators) but that the digital tools which support their operations often focus on each part of the supply chain in isolation. For example, in both the freight terminal and distribution centre, the order management system does not adequately communicate with the transport planning system(s), and neither of these communicate directly with the terminal or warehouse where goods are loaded/unloaded or stored. While it is fashionable to talk of 'digital ecosystems', in reality a variety of internally developed Access databases, Excel workbooks, emails, phone calls, whiteboards, printed papers and handwritten notes are used to supplement their digital tools and transfer information between systems and actors (see Figure 1). In the event of delays, deviations or changes of plan, these must be updated and communicated manually, which may ultimately lead to uncertainty, confusion, frustration and lack of trust between actors.

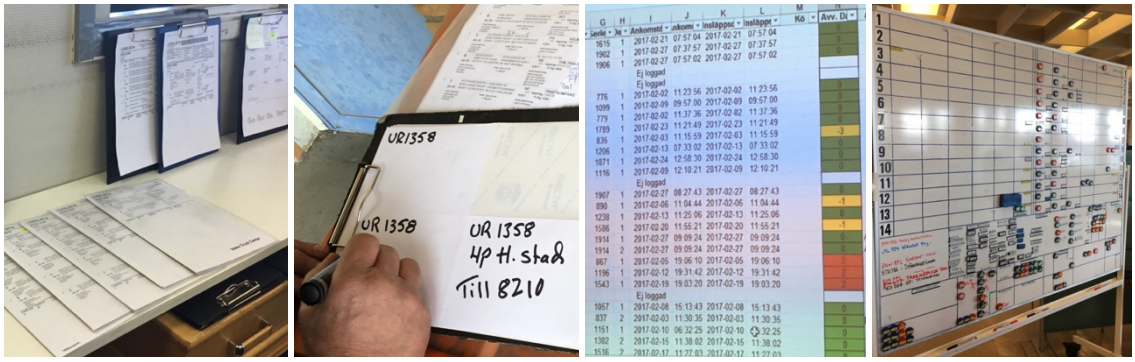


Figure 1. Some typical planning tools in the 'digital' freight transportation ecosystem.

All involved, on user and management levels, saw the need for an improved ecosystem given that the current situation is unsatisfactory and unsustainable, both in terms of efficiency and productivity, but also in terms of worker satisfaction and well-being. Indeed, the freight terminal and distribution centre had both, independent of the research project, already engaged resources to digitally bridge the gaps in the flowof information and communication. The distribution centre was utilising internal technical support and the freight terminal had partnered with a local IT developer in what may in essence be described as co-creation between users, management and developers.

The research project (whether or not one recognises it as a Living Lab) offered primarily extra resources to bolster this improvement work, but also the possibility to gain access to external data and share information with other logistics actors. For the project managers and system developers, the inclusion of researchers was seen as a condition for obtaining the extra resources, but which might potentially provide fresh insights into new ways of working, or external validation of the ongoing development work. For the terminal workers and others on the 'sharp end', the researchers' role was often unclear, but was taken as an opportunity to raise concerns about the lack of communication between actors and their respective work systems.

4. Discussion with practical implications

We proposed earlier, based on the literature, a 'best practice' for Living Labs, namely a way of working collaboratively between multi-disciplinary actors in a real-life setting, which is user-driven, and in which users are aware that they are actively involved as a partner throughout a co-creation process. However, we have seen, both in the literature and field studies, that in practice many Living Labs do not display these characteristics; our participants in the freight terminal and distribution centre are not 'aware users', nor can one say that their Living Labs are 'user-driven'. But this does not necessarily exclude them from being considered actual (or even 'good') Living Labs. Given the complications encountered when defining the concept or practice, we suggest that a static, ostensive description of what Living Labs *are* is not only elusive, but potentially unhelpful. Instead, we recommend a dynamic, performative view of what they *may be* and how they *may be utilised* in order to successfully facilitate co-creation between multi-disciplinary actors in the workplace (after all, they are *Living* Labs).

Additionally, since we a primarily concerned with Living Labs in the context of digitalisation of sociotechnical work, such as freight transportation, we emphasise the

importance of a *systems perspective*. We have seen that problems arise when partial digitalisation at a local level hinders rather than supports interaction and communication at a system or network level, necessitating ad hoc solutions to bridge the gaps. Actors who collaborate to solve their problems at a local level must also take account of the dependencies and potential impacts upon the wider system, and vice versa. Indeed, the failure of most innovations in the freight sector are 'rooted in the fact that supply chains are complex systems' (de Jong et al., 2016:16), since 'no single stakeholder has a complete image of the system, nor what the effects and rebound-effects of actions, policy measures or other interference are or will be' (Quak et al., 2016:464).

Firstly, Living Labs may be *emerging entities*. Neither their composition, activities or expected outcomes need necessarily be well-defined at the start of the collaborative process (as in the freight terminal and distribution centre, also Pallot et al., 2014; Westerlund & Leminen, 2011), provided they are grounded in a common objective or shared ambition to solve a real-world problem (de Jong et al., 2016; Quak et al., 2016). Living Labs which are initiated by a recognition of user need, or *user-need driven*, (e.g. the perceived need to reduce the manual effort required to supplement the 'digital ecosystem', Figure 1) may more successfully engage and maintain active user involvement, thus being more sustainable (also Nesti, 2017; Ballon & Schuurman, 2015).

However, users may not have the knowledge or resources to initiate or drive a Living Lab collaboration (Leminen, 2013; Leminen & Westerlund, 2012). Figure 1 illustrates how users typically utilise the available resources to solve their problems. Likewise, Section 3.2 describes how organisations which recognise the user need may utilise either internal or local resources, initiating co-creation on an organisational/local level (see also Westerlund & Leminen, 2011). Such a *top-down and bottom-up* approach may be seen as the embryo of a Living Lab, although to be successful, it may become an *open, expanding network*. While the starting arena may be users in their workplace, a sociotechnical systems perspective implies that the 'Living Lab' may expand to address the network of actors and systems which impact upon and are affected by its potential outcome (e.g. throughout the supply chain) (de Jong et al., 2016; Quak et al., 2016). Likewise, it may require augmentation by parties who enable the co-creation to materialise by providing additional knowledge and resources (e.g. designers, developers, policy makers) (Leminen, 2015; Leminen et al., 2012; Pallot et al., 2014). We also suggest that, while researchers may initially seem superfluous in this context, they (i.e. we!) have an important role to play in developing tools and methodologies to enable actors to see beyond the local to the whole system perspective.

5. Conclusions

This paper concludes that Living Labs may potentially be a valuable forum for enabling communication and co-creation between multi-disciplinary actors in the context of increasing digitalisation of sociotechnical work. One common feature, identified in both the literature and field studies, may be crucial to their success: the willingness of actors to actively engage in such a forum, combined with the expectation that participation will benefit their future work. Furthermore, the open and emerging nature of Living Labs enables them to be tailored to the needs and goals of their participants, thereby improving the chances of success.

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How do manufacturing companies acquire new knowledge? – Examples from nine Swedish companies

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Experience has shown that new research does not reach out to companies and organizations as desired. Thereby many improvement opportunities, increased profitability and competitiveness are probably missed. In order to investigate the underlying causes an interview study in Swedish companies was made. The results showed different reasons in large and smaller companies. The overall conclusion was that dissemination of academic knowledge and associated need of (external) implementation support must be better adapted to varying conditions in companies.

Keywords: Interview, Implementation, Knowledge, Manufacturing

1. Introduction

There is a tremendous competition between companies in our globalized world, which enforces development of new products and services in an ever increasing pace. The rate of new product introduction is dependent on a company´s ability to manage, maintain and create new knowledge (Drazin and Rao, 2002). Several authors (Nonaka and Takeuchi, 1995, Wong, 2005, Kevin and Awazu, 2006, Braun and Hadwiger, 2011, Durst and Edvardsson, 2012) stated that innovativeness and the creation of new knowledge is crucial for a company´s success and survival. Knowledge management (KM) has become a strategic factor and is associated with a company´s capability to achieve competitive advantage (Teece, 2001). In many small and medium sized companies (SMEs), however, there is an absence of systematic KM (McAdam and Reid, 2001, Wong and Aspinwall, 2005, Durst and Edvardsson, 2012) and if measures are implemented, they are often to be regarded as less sophisticated. Most SMEs have no explicit KM policy at strategic level and tend to treat KM on an operational level (Durst and Edvardsson, 2012). They also tend to be more oriented towards management of tacit knowledge (Edvardsson and Durst, 2013). Nunes et al. (2006) stated that unless KM is not made a strategic issue SMEs are likely to continue to focus on the traditional way of working and thereby missing the opportunity of maximizing their competitiveness and survival chances in the modern information society.

The diversity of skills and knowledge is a powerful predictor of innovation under certain circumstances and considers group tasks, knowledge and skills among team members and team integration (West, 2002). However, it takes some existing level of

knowledge to develop new knowledge, which at some point should lead to new products or services to provide value (Hargadon and Fanelli, 2002, Egbu et al, 2005). Smith et al. (2005) showed that stocks of employee knowledge, measured as education level and functional heterogeneity, are related to the process of knowledge creation. Teamwork and collective action appeared necessary for knowledge creation. A climate that supports risk taking increases that capability. Also knowledge creation capability seemed necessary for success and innovation and for constituting a key dynamic capability. A firm´s ability to access external know-how depends on having a sufficient number of qualified technical specialists, scientists and engineers. Additionally, the level of education and academic degrees of employees have been found to affect absorptive capacity (the ability to absorb) through the knowledge assimilation phase (Vinding, 2000).

Outside sources of knowledge are often critical to the innovation process according to many researchers (Westney and Sakakibara, 1986, Rosenberg and Steinmueller, 1988, Nunes et al., 2006, Braun and Hadwiger, 2011). Organizations that have a modest absorptive capacity will tend to be reactive and thus less innovative (Cohen and Levinthal, 1990).

Close relationships with both buyers and suppliers are important for innovativeness (von Hippel, 1988) and close cooperation between design and manufacturing have proven to be successful as in e.g. Japanese companies (Westney and Sakakibara, 1986).

Relationships with members of a knowledge network such as knowledge institutions including technical support, academic institutions and consultants will increase creativity and absorptive capacity (Daghfous, 2004, Debackere and Veugelers, 2005). However, only 10% of innovative firms have been found to have cooperative agreements with universities in the EU. This gap is called the "European paradox" (Debackere and Veugelers, 2005). Other forms of cooperation such as individual networks and contacts between firms and academia probably exist but is not very clear. Thus, the question is how the fruits of academic research can be better exploited for improved performance and profitability.

1.1. Costs of poor quality

10-40% of an average company´s total turnover consists of costs of poor quality (Harrington, 1987, Bank 1992, Booker et al., 2001, Özaksel, 2010, Wahlborg and Gustavsson, 2011). This means that there is a huge improvement potential in proactive (early) evaluation of the quality impact of various assembly concepts and production strategies. Studies by e.g. Falck and Rosenqvist (2012) in the automotive industry showed that assembly-related errors in manual assembly were indeed costly to fix. Errors discovered offline in the plant were 9 times more costly to fix compared to errors found and fixed immediately (online). Errors that were not found until on the market were even 12 times more costly than errors fixed on fully assembled cars (offline) in the factory. They concluded that in order to avoid unnecessary action costs and time-consuming repairs in manual assembly manufacturing conditions and production ergonomics issues should be proactively assessed and solved already in early stages of the product development process.

The objective of this interview study was to investigate how Swedish companies find and assimilate new knowledge and how dissemination and implementation of new research could be facilitated and better supported.

2. Method

Decision makers at high management level in nineteen Swedish manufacturing companies were asked to participate in an interview regarding dissemination and implementation of new research in their company. Nine companies agreed to participate representing large (L), medium sized (M) and small companies (S). One company had < 50 employees (S); four had between 50 and 250 employees (M) and four had > 1000 employees (L) in Sweden. Several had manufacturing facilities in other countries. The companies represented a manufacturer of lighting systems; an automotive company; a manufacturer of pallet trucks and forklifts; a diary company; two suppliers of the automotive industry; a telecom company; a manufacturer of oil mist separators and a manufacturer of press tools.

All interviews took place at the respondents´ work place in 2014 -2015 and normally took about two hours. All answers were recorded, transcribed and thereafter translated into English. The interview included 18 main questions besides additional sub questions (Table 1).

Table 1. Questions concerning dissemination and implementation of new research.

1. Do you have some kind of forum for coverage of new research about working- and/or manufacturing methods in your company?
2. How do you take note of new findings and methods that concern your business?
3. What kind of findings and methods are of interest?
4. Introduction of new working manners and methods in your business - how does it happen?
5. Mention some important conditions and factors that could be obstacles in implementation of new working procedures and methods.
6. To succeed (in implementation) – what is needed?
7. Have you implemented changes of working procedures and methods during the last three years?
8. What do you think is needed to achieve effective knowledge dissemination in companies?
9. How should implementation of new findings/working procedures be carried through to give prolonged effects in your company?
10. How to prevent a fall back to previous procedures?
11. Is there cooperation between production and design (in your company)?
12. If you change working procedures and methods that concern both product design and manufacturing – Who takes responsibility for a) training and information? b) impact assessment? c) implementation?
13. If assembly-related errors occur that could be referred to product development: a) who takes care of the issue? b) who is problem owner in design? c) how do you solve the problem?
14. What does the cooperation look like in your company between a) design and manufacturing engineering? b) manufacturing engineering and production? c) is cooperation missing?
15. How well do you know what assembly problems there are in your production?
16. Are there established channels to catch product-related assembly problems that are brought forward by operators?
17. How do you manage assembly ergonomics issues that are regulated by law?
18. Is there a skilled resource person with detailed knowledge of assembly-related issues and ergonomics in your project groups in design and manufacturing engineering?

3. Results

For space reasons only the most important results can be reproduced here.

1. **Q. 1 and 2:** ***"Do you have some kind of forum for coverage of new research about working methods and/or /manufacturing methods in your company?" and "How do you take note of new findings and methods that concern your business?"***

Four companies had monitoring of new research but several companies found it difficult to find research articles related to their own business. Six companies tried to keep updated through participation in conferences, benchmarking and best practice activities, exhibitions, media and via contacts, suppliers, consultants and networks. Six companies worked in clusters and had specialist functions. Seven companies utilized trade magazines.

2. **Q. 4:** ***"Introduction of new working manners and methods in your business - how does it happen?"***

The decision making on introduction of new working manners and methods varied greatly between the companies. Decisions were either taken by the upper management, by the production technology department or the responsible manager or local plant manager, by members of the management or by the executive management. One small company had received external assistance from research teams in change of the business and implementation of new methods and working manners. One large company had involved external people from various businesses who had helped adding knowledge through different outlook on things.

Evaluation was done by cost accounting, measurements of lead-time and quality output. Systematic and/or standardized training of staff and stakeholders was carried through and documented in all companies. One interviewee emphasized that *"a sufficient number of people must be trained in order to reach a critical mass of knowledge".*

3. **Q. 5:** ***"Mention some important conditions and factors that could be obstacles in implementation of new working procedures and methods?"***

An overview of conditions and factors that could be obstacles in change management are shown in Table 2.

Table 2. Conditions and factors that could be obstacles in change management.

Standardization	**Economic barriers**	**Subcontractor agreements**	**Mindset/ understanding**	**Time restrictions**	**Others**
Governing general standards were not adapted to local conditions.	Quarterly reports.	Binding and highly regulated agreements prevented change management.	Resistance or preconceptions among staff made it difficult to carry through changes.	Time limits (accessibility) decreasing options to rebuild the factory.	"*Skimp on resource persons and training".*
Standardized working methods were difficult to change. E.g. replacement of parts needing certification and approval before being replaced.	Profitability requirements were an obstacle for investing in improvement of ergonomics.	Yearly savings and tough rationalization requirements in combination with demands for salary increases were big obstacles.	Lack of understanding or acceptance from the executive board. Lack of dialogue and communication	Subcontractors: Customer expectations and demands made it necessary to focus only on the core business, leaving little time for development.	"*The union could be a stumbling block making it hard to change".*
It was said that standardization on the whole could result in a large inertia.	The entire economic system was said to prevent increased profitability	Subcontractor conditions were said to be a big problem in the whole automotive industry.	A fear of failing prevented investment in new methods or concepts in general.	Lack of time and perseverance.	Geographical distances and time zones.

4. **Q. 6:** ***"To succeed (in implementation) – what is needed?"***

Table 3 shows the most important conditions for a successful implementation. All interviewees stated it was utterly important to have a designated enthusiast and/or a change team who pushed the change work forward. Two emphasized that the right conditions/infrastructure for implementation was very important as well as own ownership of the change management. Eight wanted more cooperation with academia.

Table 3. In order to succeed in implementation of new working procedures or methods the following conditions were considered important by the companies respectively.

Company	Economic support	Sanctions from top management	Designated enthusiast and/or change team as drivers	Business case, profitability calculation	Time for innovation	Perseverance in implementation
Total:	**6**	**6**	**9**	**3**	**3**	**4**

Company	Right conditions/ infrastructure	Own ownership of change management	Info/training of staff/stakeholders	More cooperation with academia. Initial support from a research team and in training
Total:	**2**	**2**	**5**	**8**

5. **Q. 9:** ***"How should implementation of new findings/working procedures be carried through to give prolonged effects in your company?"***

Some answers about of important conditions were: "*New methods and procedures should be brought into processes and goals to make them governing; they should be systematically transferred to new groups; staff support is necessary or changes will not be possible; it is extremely important to spread success; time restriction and insufficient resources are problematic; preparatory training is necessary; a critical mass regarding skill and competence and basic conditions must be secured as well as key employees and teams pushing the issue. The ownership of the change management must be crystal clear from the start*".

6. **Q. 11:** ***"Is there cooperation between manufacturing and design in your company?" and Q. 14: "What does the cooperation look like between a) Design and Manufacturing Engineering? b) Manufacturing Engineering and Production? c) Is cooperation missing?"***

Six interviewees said they had satisfactory cooperation between the different departments but two had insufficient cooperation and one had no cooperation at all (a subcontractor). One interviewee said:*"It is difficult to make designers come out in production. Tight cooperation is necessary to succeed well"*. In another company cooperation in early project phases malfunctioned because "*the design engineers feel criticized by manufacturing and the manufacturing people feel they are too weak to stop poor concepts"*. In addition, long geographical distances was considered to hamper cooperation.

7. **Q. 12:** **"*If you change working procedures and methods that concern both product design and manufacturing – Who takes responsibility for a) training and information? b) impact assessment? c) implementation?"***

The responsibility differed much between the companies depending on what the organization looked like (Table 4).

Table 4. Distribution of responsibility in the companies.

Company	Responsible unit or person
1 M	The production technology department.
2 M	The project leader and the market department.
3 S	The executive management.
4 M	The chief project leader from R & D.
5 L	A special team.
6 L	The production technology manager.
7 L	The quality department was responsible for the design review process, thereafter the design, manufacturing and market departments for their parts respectively. The quality department had the overall responsibility.
8 L	Cross-functional teams.
9 M	No cooperation existed between Design and Manufacturing (subcontractor agreements).

8. **Q. 13*: "If assembly-related errors occur that could be referred to product development: a) who takes care of the issue? b) who is problem owner in design? c) how do you solve the problem?"***

Eight interviewees said they had appropriate procedures of taking care of assembly-related problems in various ways and mostly by involvement of design or quality departments in cooperation with other departments. One, however, complained about insufficient cooperation between design and manufacturing although 80 – 90 % of the errors were considered design-related. In one company problem solving was made in cooperation with the operators and in another it depended on the problem but ergonomics issues were always taken care of by manufacturing. A subcontractor who had no design department complained that *"we have to solve assembly-related design problems through additional controls in manufacturing"*.

9. **Q. 17: *"How do you manage assembly ergonomics issues that are regulated by law?"***

Ergonomics actions were usually taken in the factories but a couple of companies worked with proactive actions. It was obvious that legal demands were not always easy to follow but the awareness about ergonomics issues appeared to be high in general. Industry-specific rules more customized to the business was wanted. One interviewee said that "*substantially the manufacturing engineers and safety officers know the rules. The Health and Safety department is contacted when needed.*" Another said: "*we must not wear out people",* while another said: "*very heavy things are handled by lifting equipment and overhead cranes. It requires that people are on the alert and not sloppy".* An interviewee from a multinational company said: "*There are different requirements in different countries. In Tallinn, for example, there are much tougher lifting requirements than here. In our business in Asia there is much greater suspicion towards lifting devices and other things."*

10. **Q. 18: *"Is there a skilled resource person with detailed knowledge of assembly-related issues and ergonomics in your project groups in design and manufacturing engineering?"***

Overall, one appeared to consider ergonomics (mainly reactively) through existing general knowledge in production or through assistance from Health and Safety departments. In two cases the companies paid attention to ergonomics already in the

planning of new products and work places and/or did proactive risk assessments but only one company had a skilled ergonomist in Manufacturing Engineering. One had partly this skill and another did not know. Six companies did not have skilled ergonomics competence but one interviewee said they wanted an ergonomics specialist to participate in early concept phases of product and production development.

4. Discussion

This interview study of upper management resulted in increased awareness of how Swedish enterprises find and introduce new methods and working manners and what obstacles there are and further how ergonomics issues were taken care of. Many ways of searching for new knowledge emerged and benchmarking seemed to be a common way to learn from others. Only four read research articles, mainly the large companies. There were problems associated with acquisition of and exploitation of new research-related knowledge: It was perceived (very) difficult to find articles and reports of interest for the own business. Another obstacle was lack of perseverance because the implementation phase was usually much longer than anticipated and time consuming matters that were not highly prioritized could not be sufficiently considered. In some cases additional resources were probably needed in order to succeed.

Eight of nine interviewees explicitly expressed that they wanted more cooperation with universities and/or research teams initially during the implementation phase and in training of the employees. However, only one company had used this, which is a low figure. Every year significant resources are invested in new research assignments in important areas but are the efforts proportionate to the application of the outcomes? It does not appear to be the case. Similar conclusions were made by Debackere and Veugelers (2005) and Braun and Hadwiger (2011) who demonstrated that scientific research has great difficulties reaching out and being applied in businesses, especially in SMEs. Through adapted support and more efficient methods for increased spread therefore, increased innovativeness and increased profitability could be promoted because as stated by the EU Commission (2008): *"We cannot afford to let valuable inventions lie idle in laboratories or on bookshelves."*

Ergonomics problems were usually reactively taken care of by safety officers or Health & Safety delegates in current production or in late project phases when most assembly solutions were already decided. This despite the fact that early proactive ergonomics efforts could indeed prevent late costly corrective measures and increase quality and productivity (e.g. Falck et al., 2010 and Falck and Rosenqvist, 2014). The study in 2014 showed that a majority of all assembly-related errors at high and moderate physical load levels consisted of geometry-related quality errors such as loose parts and components, wrong fitting, and wrongly positioned details. A majority of these errors could be prevented by existing scientifically verified risk assessment tools.

5. Conclusions

Academic knowledge dissemination and need of implementation support have to adapt to various conditions in companies in order to reach out and be exploited. Through increased cooperation between companies and academia change management could probably be improved. Small companies often lack sufficient resources to manage major changes. In some cases probably additional (external) support is needed. Binding

subcontractor agreements counteract possible improvements of the design of products and assembly solutions developed by the clients. Ergonomics specialist involved in early development phases of new projects was unusual but this expertize was wanted by several companies.

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Enablers for improved collaboration in a remote meeting context

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In any face-to-face meeting, communication and mutual understanding is achieved through actions and enablers such as talking, gesturing, referencing (objects) and making eye contact. Many of these enablers are severely crippled when physical proximity is not possible and the meeting is held over the phone or video conferencing systems. Nevertheless, there is an undisputed value in succeeding with remote collaboration - saving money, energy and travel time while at the same time broadening the pool of potential collaborators.
In this paper, we propose two sets of factors identified throughout the Mediated Effective Remote Collaboration project (MERCO): "Communication facilitators in remote collaboration" and "Informality enablers". Communication facilitators consider the remote medium and what it could or should allow participants to communicate. Informality enablers are means to improve colloquial or relaxed rapport between colleagues or business associates that are geographically apart, using some form of remote collaboration tool or mediated communications. The factors were identified through literature studies and contextual inquiries (later explored through conceptual prototypes not presented herein). The factors presented could be used as a scorecard for an existing or proposed remote solution, or otherwise inform the development process.

Keywords: remote collaboration, informality, remote meeting, telepresence

1. Introduction

A meeting can be seen as a powerful tool to exchange information, solve problems, resolve conflicts and inspire others. The term meeting can be defined in many ways. One definition Alan Barker (2011) uses to describe a meeting is "a group of people purposefully thinking together". A sub-set of the definition – "a group of people purposefully thinking together *while geographically apart*" has implications on the meeting, as a mediating technology is needed to traverse the distance. Meeting in a remote collaboration setup using e.g. a videoconferencing system, participants perceive many "features" of a co-located meeting through what is missing in the remote context. The Mediated Effective Remote Collaboration (MERCO) research project set out to address shortcomings of current remote collaboration tools. The results presented here come from the initial research phase of the project, based on the two master theses of interaction designers Cao and Östin, and the industrial design engineers Söderbom and Parsland (see Figure 1).

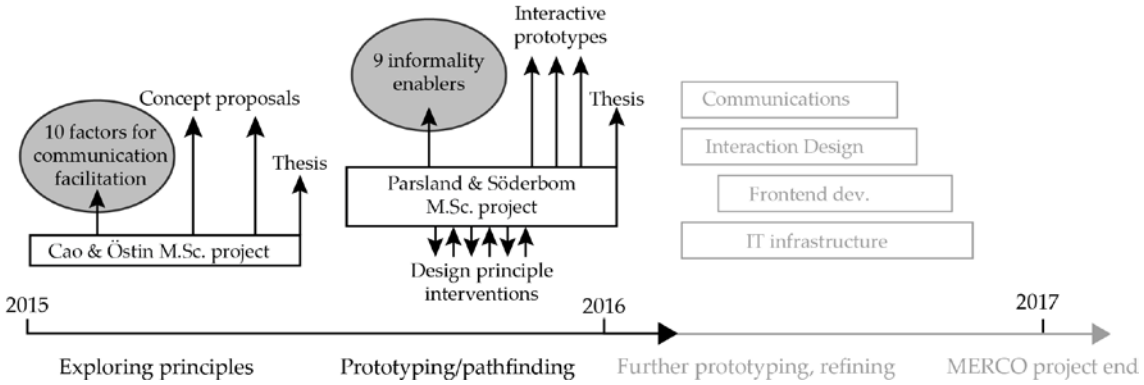


Figure 1. Part of the MERCO project process. Factors presented in this paper encircled in gray.

2. Method

The MERCO project employed an iterative and user centred approach. A series of master thesis projects, each with their own initial literature study coupled with a contextual inquiry gave input for design prototyping and testing. The prototypes ranged from specific interventions to try a certain idea in a lab environment, to prototyping a full remote collaboration client towards the end of the project. This paper presents the theoretical frameworks of remote collaboration deduced from the initial literature studies and contextual inquiries of the first two pairs of thesis students in the project, and omits the design and use test phases that followed (within the thesis projects themselves, as well as after the theses).

2.1 Literature studies

The literature reviews aimed to elicit general human factors that sources claimed to support efficient and effective remote collaboration. Moreover, they also helped position this research on the scientific map. While the contextual inquiry would produce findings related to specific companies and meeting contexts found within, the literature reviews took a wider approach investigating human behaviour during communication, current experimental concept solutions, and research on how people relate to and reference their surroundings.

Search phrases used*: Meeting and meeting structure, remote meeting, business meetings, behaviour science,communication theory, impact of body language and nonverbal cues, informality at workplaces, digitalization of workplaces, online gaming, commute environmental impact, group dynamics. User experience, mental model, designing user experience for the web, online gaming culture, theory on creativity, innovation, curiosity, interaction design, collaborative environment design, user interaction, user testing.*

2.2. Contextual inquiry

Contextual Inquiry refers to gathering data about how people work in specific contexts (Martin et al., 2012). The method places researchers on site and allows them to develop an understanding of the underlying work structure. Contextual inquiry was used to understand communication flows, task sequences and the use of artifacts and tools used to accomplish work. It also studied the influence of work culture and how the workspace itself affects the work process. The combination of immersive observation

and one-on-one interviews was a means of gathering qualitative data about people and their goals. Referred to as 'ethnographic interviews', researchers attended meetings to observe and experience the context first hand and get direct observational data and insights about problems, facts as they presented themselves (Cooper, 2014). Two researchers were present during all observed meetings. The notes from multiple researchers aided the interpretation of the findings, helped reduce bias and supported the process of writing up the results (Blessing et al., 2009).

Studied contexts. The contextual inquiries were in both cases performed at 1) an engineering consultancy and 2) an international IT company (hardware and software). The consultancy both runs projects in-house for customers and engages in sales activities with external stakeholders where no requirements can be put on the "other's" hardware or software when it comes to remote collaboration tools. The IT company has multiple sites across the world, and would benefit from increasing or improved collaboration between sites.



Figure 2. Example of a studied meeting context. Mix of local and remote participants. Laptops, shared large screens, sometimes phones. Conference calls, video calls, email, chat, presentation software with different levels of sharing and synchronicity.

Data sources. For the communication facilitation section, 10 meetings were observed and 6 follow-up interviews were conducted. For the informality enablers section, the qualitative data came from 5 live meeting observations and 5 video-recorded meetings, followed by 8 semi-structured interviews and later a number of structured conversations (see Figure 3). The reason for the latter was to gain valuable insight of the user needs and perspective in an informal and iterative way (for clarifications and validation).

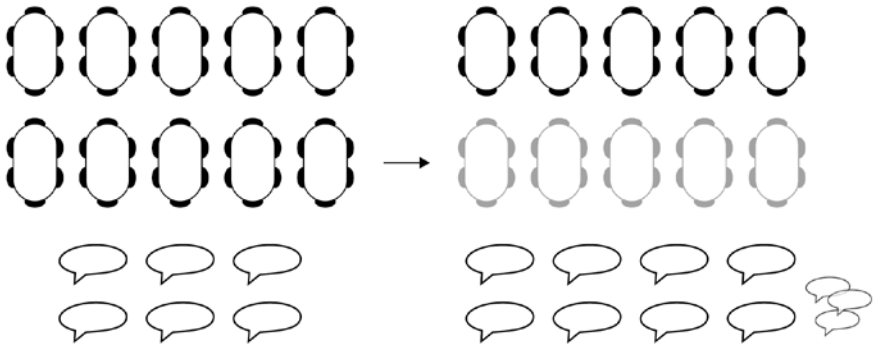


Figure 3. Cao & Östin: 10 meeting observations, 6 interviews. Parsland & Söderbom: 10 observations (5 of which were recorded instances from Cao & Östin), 8+ interviews.

3. Factors for communication facilitation

Cao and Östin's (2015) literature review and contextual inquiry resulted in a framework of important factors for efficient remote collaboration, pinpointing what a mediating technology ideally should offer its users. These factors address the properties of the tool itself, where the *informality enablers* presented later in this paper address the properties of the remote meeting's social context.

Table 1. 10 factors for communication facilitiation in (remote) meetings (in no ranked order)

	Communication facilitator	**Relevant papers**
A	**Presence, roles and relations** Design should support participants' ability to perceive others' presence, their roles and relations to each other.	Gutwin, Greenberg (2002), Tee et al. (2009), Buxton W. (1992)
B	**Accessibility and adaptation** Design should provide easy accessibility of use, and adapt to workflows found in companies and meetings.	Björn et al. (2014), Grudin J. (1994)
C	**Comprehensive view** Design should facilitate sufficient means to view the entire workspace.	Gutwin, Greenberg (2004), Nakano et al. (2003), Gauglitz et al. (2012), Rekimoto et al. (1995), Sellen A. 1992)
D	**Origin of sound** Design should facilitate sufficient means for participants to track where sounds originate from, and they should be able to perceive that they are being heard.	Sellen A. (1992), Buxton W. (1992)
E	**Verbal communication** Design should support explicit- as well as implicit verbal communication.	Gutwin, Greenberg (2002)
F	**Gesturing (non-referencing)** Design should enable watching of other participants body movements and non-verbal cues (non-referencing).	Gutwin, Greenberg (2004), Buxton W. (1992), Nakano et al. (2003)
G	**Referencing** Design should facilitate use of deictic- and representational references as well as awareness of any artifact in a workspace that is referenced.	Fussell et al. (2004), Gutwin, Greenberg (2004), Chastine (2007), Tee et al. (2009)

H	**Grounding information** All meeting participants should be able to perceive confirmation from other participants so that they know that their communication has been perceived and understood.	Gutwin, Greenberg (2004), Fussell et al. (2004), Nakano et al. (2003)
I	**Eye contact** Participants should be able to make eye contact with each other.	Sellen A. (1992)
J	**Artifacts manipulation** Design should facilitate full view and equal ability to manipulate artifacts to all meeting participants. They should also equally be able to perceive artifact manipulation by others and its effects.	Gutwin, Greenberg (2004), Edelmann et al.(2013), Buxton (1992), Tee et al. (2009)

Participants wanted to perceive confirmation that they had been understood (H), they wanted to perceive the presence of other (remote) participants (A), they wanted to know who was speaking (or which remote party) in a phone meeting to avoid confusion (D) and that the enabling technology and tools for the remote meeting were accessible, adaptable and easy to use (B). The aforementioned factors H, A, D and B were found to be highly occurring in observed co-located and remote meetings. Aside from these meeting-specific factors, a second literature study within the MERCO project found that for a team to perform, an informal rapport between meeting participants is favourable.

4.Informality enablers

In order to purposefully think effectively, i.e. have the group of people perform well in the meeting objective, it is vital that the participants of the meeting experience psychological safety together, or "team psychological safety". Team psychological safety is defined by Edmondson (1999) as a shared belief that the team is safe for interpersonal risk taking. The result from the second contextual inquiry supported this view, where meetings where participants addressed each other more informally, also addressed issues that arose during the meeting to a greater extent. An additional literature study in conjunction with the results from the contextual inquiry generated a proposed list of factors of informality enablers in remote meetings.

Table 2. The informality enablers by Söderbom and Parsland (2016)

	The informality enablers	**Relevant literature**
A	**Set degree of pre-definition** The solution should enable participants to set appropriate degree of pre-definition for the specific meeting situation.	Cao and Östin (2015), Hill et al (2014), Hoxmeier et al (2000)
B	**Balance group dynamics** The solution should encourage balanced group dynamics to occur and to create a sense of belonging to the group and task.	Adair (2007), Barker (2011), France et al (2001)
C	**Create a uniform experience** The solution should help to create a uniform experience for all participants, regardless of used technology and location.	Emmitt and Gorse (2009), France et al (2001), Kraft (2012)
D	**Including various characteristics** The solution should enable space for various individual characteristics to express themselves and to counteract low-monitoring behaviour.	Adair (2007), Harrington and Lewis (2014), Wilson (2009)

E	**Provide an intuitive use** The solution should provide intuitive use with focus on providing a consistency between the user's mental model and system ability.	Gentner and Stevens (2014), Kraft (2012), Wilson (2009)
F	**Express emotions dynamically** The solution should facilitate the user to express emotions dynamically, i.e. both negative and positive feelings are revealed in a natural manner.	Barker (2011), Emmitt and Gorse (2009), Wilson (2009)
G	**Establish an informal ground** The solution should enable the participants to establish a common, informal ground and thereby enabling information transfer in an informal way.	Cao and Östin (2015), Emmitt and Gorse (2009)
H	**Facilitate spontaneous ties** The solution should enable some degree of spontaneous interaction, both during and after the meeting situation.	Hill et al (2014), Boud (2003), Wilson (2009)
I	**Include meeting environment** The solution should facilitate the user to influence the surrounding meeting environment to create the optimal meeting room context.	Emmitt and Gorse (2009)

5. Discussion with practical implications

Scope. The MERCO project initially had a specific focus on creative workshops. As the project progressed and the contextual studies collected results, these types of meetings were found to be a) not that common in the studied context, and b) not often specifically defined as creative before the actual meeting. Meetings dynamically switched from ideating, reporting, presenting, informal bonding and decision-making. Creating a specific solution for "Creative meetings" would miss the mark. Instead, the technologies for remote collaboration must support this flowing dynamic (while including creative tools), and enable an informality to support trust among participants. The scope shift (or creep) is not be seen as a failure of the project, but rather a strength of the agile user-centred methodology.

Novelty or general applicability. To be generalizable to a wider population of the target audience than the exact context studied, one would need to make a choice on technological novelty vis-à-vis hardware accessibility. In MERCO, both paths were taken in parallel focusing on laptops, smartphones and on-hand hardware on the one hand, and a solution including a smart board (a large shared screen with touch capabilities) on the other. The latter has higher probability of fulfilling "feature demands", but a lower chance of diffusing into real-life use as the hardware is not as omnipresent as laptops.

Design context. Any list of important factors for successful remote collaboration will be incomplete or biased, based on the cultural background and technological savviness of the list's creators and studied users. In the MERCO research project, we found a comprehensive inventory of aspects of remote collaboration to be lacking, so set out to create our own foundation before progressing to prototyping. As our factors were created in Sweden and the contextual study performed at Swedish companies, the results reflect that business environment. For instance, the threshold to level out hierarchies in a meeting (Informality enabler B, *Balance group dynamics*) might be less desirable for an organization in a culture that is higher in power distance. Even so, the informality enablers are about breaking down perceived and real barriers to candid communication. One could argue, that in (or especially in) an authoritarian work

environment the affordance provided by the system to enable informality would be even more important.

Next steps. The factors presented could be applied to assess existing remote collaboration tools and meetings, and to apply as requirements in a product development process. Indeed, that is what the MERCO project did, although the results are not included in the scope of this article.

6. Conclusion

In the modern day work environment, effective remote collaboration is a holy grail that has yet to fully live up to user's needs and expectations. This paper outlines how being able to communicate better could improve creative output and bonds between remote collaborators, even after the meeting is over. It is done through properly facilitating communication and enabling an informality among participants, which lowers the threshold of being honest, candid and raising concerns in the formal goals of the meeting.

The suggested factors of communication facilitation and informality enabling lends researchers and developers of remote collaboration technologies the ability to assess an intended solution from a user's perspective, both in terms of what the technology should fulfil, but also how the social interplay of the meeting participants is prepared for and handled in a remote meeting context.

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Introduction of an activity based workplace (ABW) The effects on health/discomfort and stress/ influence using a Self-assessment tool

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Activity Based Workplace (ABW) is becoming more interesting and popular due to the digital and technical development. Costs for office-space are cut and the new environment enhances spontaneous meetings, sharing of knowledge and experience besides working in team in a flexible working space.
Repetitive strain injuries (RSI) are common among computer users. Shoulders, neck, arms and hands are especially affected. Stress is also increasing and the employer is fully responsible for both the physical and mental environment.
The purpose of this study was to evaluate if there is any change in comfort/ health/stress when working in an ABW-office compared to a traditional office with individual adjusted workplace using a digital assessment tool; Self-Assessment : Your Workplace™.
48 persons at a sales company were participating before and followed up one and eight months after introducing an ABW. Questionnaires were filled out before and after the study. After reconstruction some overall improvement was experienced by both comfort and load/discomfort by most participants. Stress was perceived as slightly increased. At follow-up, comfort felt slightly better on almost all points. The load increased especially for the shoulder/arm. The combined stressors increased while slightly more had time to complete their duties and ability to influence their situation, which is positive.

Keywords: Activity Based Workplace (ABW), Digital Self-Assessment tool, Stress, Computer ergonomics, Repetitive Strain Injury (RSI), Influence, Comfort, Health

Introduction

Activity Based Workplace (ABW) is becoming more and more interesting and popular due to the digital and technical development which enables you to work with computer, laptop, smartphone wherever you want, often with cloud support. This also enables our working outside the office.

The ABW office is cost-effective for the employer with less space per employee. Advantages for the employee is a more flexible way of working alone or with the colleagues needed for the specific task. Disadvantages for the employee are changing different workplace.

It may be an ergonomic challenge as repetitive strain injuries (RSI) are common by computer workers, (Veiersted and Westgaard, 1993). About 50% of all computer users show some physical problems, (Wahlström, 2005). Shoulders, neck, arms and hands are especially affected, (Waerstedt, Hanvold T, Veierstedt, 2010 and Wahlström et al, 2004). In the long run prolonged pain can arise, (Lindegård et al, 2012).

All different new workplaces in a ABW may not be ergonomic optical as traditional office, (Toomingas and Gavhed, 2008), (Arbetsmiljöverket, AFS 1998:5, 2014:2), which may cause an increasing problem with RSI?

Fits the ABW for all people and tasks in the organization? (L Slunga-Järvholm, 2016), (C Bodin Danielsson, 2015). Will stress increase when you lose your own workplace and have to find a new one every day? (H Jahncke et al 2011, 2012).

What is the effect of the introduction of the ABW on comfort, health/discomfort and stress/influence? Studies show a clear correlation between perceived comfort, load and the development of symptoms/complaints (RSI), (A. Lindegård Andersson, 2004), (A Lindegård et al 2012). Can these be applied also to the ABW?

There are some reports from companies, organisations and others (Addeco, 2015, Arbetsliv, 2016, Finansliv, 2016, Sunt Arbetsliv, 2014, Prevent, 2016, Veldhoen Company), about ABW, comfort, loads and stress but few studies; most are still ongoing.

Ergonomhuset AB in Goteborg, Sweden, has developed a digital assessment tool; Self-Assessment : Your Workplace™, a digital Risk Analysis with self-assessment of perceived comfort, physical complaints, stress and empowerment, It only takes 5 minutes to fill in. The Self-Assessment : Your Workplace™, can be used to map/screen the entire workplace to see how comfortable the employees are. The Self-Assessment can also be used to increase motivation to change by raising awareness of stresses and strains in the employee´s work situation, i.e. often in companies before an intervention, for example the eLearningprogram Computer ergonomics® and Stress less-Sleep better® of Ergonomhuset.

The digital questionnaire is sent out via e-mail with general questions covering:

- Perceived comfort (of your workplace)
- Perceived strain (physical complaints)
- Perceived stress levels and influence (mental strain)

The Self-Assessment is totalled and an average for each question is presented as "good–acceptable–poor comfort" and "low–medium–high strain" in a coloured graph (green–yellow–red). From this information, you can see for yourself what your current physical and mental stress loads are and thus increase your motivation to change.

The answers are confidential, and anonymised with those of others at the workplace. The anonymised answers are then returned with the work group's percentages for each question to the employer.

Objectives

Ergonomhuset AB has developed a digital Self-assessment tool called Your Workplace. The self-assessment tool contains general questions about comfort (chair, table, screen, keyboard, computer mouse/input device, noise, lightning), health/discomfort (physical complaints; back, neck/shoulder, arm, hand, eyes, head, legs/feet) and stress/influence (large workload, work fast, no break, high performance requirements, time pressure, feeling stressed, getting ready, social support, impact on job) using various rating scales.

Ratings of comfort

Perceived comfort was rated on a 9-point scale ranging from -4 (very, very poor) to +4 (very, very good).

Ratings of perceived strain/physical load

Perceived strain (physical load) during computer work was rated by using a modified Borgs RPE scale ranging from 0 (very low) to 14 (very high) for 7 body regions.

Ratings of perceived stress/influence

Perceived stress/influence in the working situation was rated on a VAS-scale, Visual Analogue scale, ranging from 1 (never) to 10 (always).

The purpose of this study was to evaluate if there is any change in comfort, health and stress when working in an ABW-office compared to a traditional office with individual adjusted workplaces.

Method

Self-assessment of perceived comfort, discomfort and stress was given to 48 persons at a company 4 months before (sept year 1), one month (march year 2) and eight months (oct year 2) after the ABW was built.

The digital Self-Assessment : Your workplace™, was given to the persons via a link via their e-mail address. It takes 5 minutes to fill in. Immediate feedback after the completion of each person who filled out the form was given in a green-yellow-red diagram.

The company studied was divided into three groups; sales, sales support and administration.

A background questionnaire was given about working situation, variability of the posture and tasks and physical problems. A follow up questionnaire extended with questions of how the respondents liked working in the ABW and how it worked to carry out the tasks in the ABW was given.

Results

Self-assessment : Your Workplace™

Results are reported for the whole group. Details could vary between the groups.

After reconstruction, some overall improvement was experienced by both comfort and load/discomfort. Stress is perceived as slightly increased.

At follow-up, comfort felt slightly better on almost all points. The load increased especially for the shoulder/arm. The combined stressors increased, they felt more stressed with shift from yellow to red, while slightly more had time to complete their duties and ability to influence their situation, which is positive.

Cognitive stress and distraction can be seen at work in open office environments. The suggestion is that the administrative and similar regular concentration tasks are performed at fixed, shielded and ergonomically designed workstations.

As the environment also was open for customer visits, planning of special visiting hours was recommended so that work could be performed undisturbed and be terminated.

Responses may be reassigned with the percent indication for each question. Please note: The summary can view over 100% due to mathematical rounding off decimals in computer application.

Table 1 Perceived comfort. Number of answers.

Sept Year 1	**46/48** (2 not answered)
March Year 2	**42/44** (3 finished, 1 on leave, 2 not answered)
Oct Year 2	**40/41** (5 finished, 2 on leave, 1 not answered)

Table 2 Perceived comfort, details.

	Sept Year 1	March Year 2	Oct Year 2
Good	**52%**	**55%**	**65%**
Acceptable	**48%**	**40%**	**30%**
Poor	**0%**	**5%**	**5%**

Specification of questions in % of the number of answers	Good			Acceptable			Poor		
	Before	After	Follow up	Before	After	Follow up	Before	After	Follow up
Chair	83%	60%	78%	17%	33%	18%	0%	7%	5%
Desk	89%	71%	88%	9%	21%	10%	2%	7%	3%
Monitor	76%	60%	70%	22%	31%	20%	2%	10%	10%
Keyboard	50%	55%	60%	37%	38%	25%	13%	7%	15%
Computermouse	54%	60%	55%	35%	29%	30%	11%	12%	15%
Lighting	28%	60%	60%	**54%**	31%	35%	17%	10%	5%
Sound level	28%	55%	65%	48%	36%	33%	24%	10%	3%

Comment: (Figures 50% or above are shown in bold in the diagram). The perceived comfort has decreased slightly for the work chair, desk, monitor, but also for keyboards in certain groups after reconstruction. On the other hand, the lighting is apparently improved. Sound levels are also experienced better. In the follow-up, note that comfort is felt slightly better on all points besides keyboard.

Table 3 Perceived strain/physical load

	Sept Year 1	March Year 2	Oct Year 2
Low strain/load	**22%**	**33%**	**35%**
Medium strain/load	**52%**	**43%**	**28%**
High strain/load	**26%**	**24%**	**38%**

Specification of questions in % of the number of answers	Low strain			Medium strain			High strain		
	Before	After	Follow up	Before	After	Follow up	Before	After	Follow up
Back	48%	36%	40%	33%	38%	38%	20%	26%	23%
Neck	33%	40%	38%	28%	24%	30%	39%	36%	33%
Shoulder/Arm	30%	29%	30%	20%	33%	20%	**50%**	38%	**50%**
Hand	54%	45%	45%	24%	33%	23%	22%	21%	33%
Eyes	26%	36%	40%	24%	21%	25%	**50%**	43%	35%
Head	39%	40%	43%	30%	31%	23%	30%	29%	35%
Legs/Feet	57%	60%	63%	30%	24%	25%	13%	17%	13%

Comment: (Figures 50% or above are shown in bold in the diagram). The load has increased slightly after the rebuilding on the back, shoulder/arm and hand concerning the medium load/strain (yellow). At the same time it also increased with respect to high load (red) for back, legs/feet. It is also noted that some displacement of the load from the red to yellow has occurred mainly in the shoulder/arm. During the follow-up, the perceived load has increased again (red) for the shoulder/arm, hand and head but declined for eyes.

Table 4 Perceived stress/mental strain

	Sept Year 1	March Year 2	Oct Year 2
Low stress	**0%**	**5%**	**3%**
Medium stress	**80%**	**83%**	**73%**
High stress	**20%**	**12%**	**25%**

Specification of questions in % of the number of answers	Low strain			Medium strain			High strain		
	Before	After	Follow up	Before	After	Follow up	Before	After	Follow up
Large amount of work	0%	5%	8%	43%	**60%**	30%	**57%**	36%	63%
Works fast	0%	0%	0%	39%	40%	30%	**61%**	**60%**	**70%**
Without a break	24%	29%	18%	43%	40%	45%	33%	31%	38%
High demands	2%	0%	0%	13%	19%	13%	**85%**	**81%**	**88%**
Time pressure	0%	5%	0%	28%	38%	25%	**72%**	**57%**	**75%**
Stressed	11%	17%	13%	43%	**57%**	38%	46%	26%	**50%**
Impact and support									
Finishes	67%	67%	53%	17%	29%	25%	15%	4%	23%
Social support	59%	67%	65%	35%	24%	25%	7%	10%	10%
Impact/Influence	41%	52%	30%	33%	33%	45%	26%	14%	25%

Comment: (Figures 50% or above are shown in bold in the diagram). Overall, the perceived stress in yellow fields has generally increased slightly after reconstruction. In the follow-up in November, the overall stressors have increased, feeling more stressed with shifting from yellow to red, while some more are done and can affect their situation.

Results of Background questionnaire

The group of 47 persons contained 31 women (age 40) and 16 men age 35 (mean).

The length varied between 1.58 cm and 1.98 cm. 41 persons worked full time (39-40 hrs), 6 part time (mean 34 hrs). At follow up only one person had changed to part time. Office work time: women 4,9 years, men 6 years.

Physical Disorders (more than one month) in the past year: 21 people (45%); 16 women and 5 men.

Sitting work/day: an average of 3.7 hours; women 3.8 hours, men 3.6 hours. Standing work/day: 34 people; 24 women, 10 men. 12 did not work in standing, of which 7 were women and 6 men.

Variation of duties during the day: 24 women (51%) and 9 men (19%).

Results of Follow up questionnaire

35 persons answered afterwards.

10 persons (29%) reported that they changed the time worked in sitting per day after reconstruction, half of which indicated fewer hours and half more hours. For 8 people (23%) the time in sitting was unchanged before and after.

Out of the 35 respondents, 29 (78%) reported that they were working standing every day; 19 women, 10 men. 8 persons (23%) did not work at all in standing; 4 women and 4 men.

Out of 35 persons, 19 (41%) had physical disabilities (more than one month) in the past year, of which 12 are women and 5 men. Several of these had trouble in several body regions. Discomfort in the neck, shoulder/arm dominated and had increased after reconstruction compared to before. 3 persons (9%) who had no inconvenience before had difficulty in several body regions; neck, shoulder/arm, hand, feet and back. Out of those who had trouble before, most were the same as had trouble afterwards.

In the follow up, most stated that they worked activity-based, some of which also worked in their own rooms.

Table 5 How respondents liked working in the ABW

What do you think of working in an ABW? Scale: VAS 1-10	**Number of persons after** (n=36, 3 on leave, 3 not answered)
1-3	1
4	1
5	0
6	2
7	4
8	4
9	12
10	12

Table 6 How it worked to carry out the tasks in the ABW

How does it work to carry out tasks in the ABW? Scale: VAS 1-10	**Number of persons after** (n=37, 3 on leave, 2 not answered)
1-3	0
4	4
5	1
6	3
7	3
8	6
9	11
10	9

Discussion

The digital Self-Assessment : Your Workplace™ is short and easy to fill out with quick and direct feedback to the responders in green, yellow and red. The company is given a summary of total (whole company) and different groups. In this way, an intervention

can be directed to certain groups, for example the eLearning program Computer ergonomics® to those who experiences less comfort than other groups and a eLearning program Stress less and Sleep better® to those who experiences high levels of Stress. The results are easy to follow up with a new Self-Assessment: Your Workplace™ .

However, the aim of this study is to see the effects of introducing an ABW. Investigation before a change with the Self-Assessment: Your Workplace™ gives a background to the introduction of the ABW that easily can be followed up over time. After the intervention/introduction of the ABW, the company gets a feedback on parts that needs to be followed up, for example light or noise due to headache as a perceived strain. Ergonomic tasks maybe needs to be taken care of due to problems with pain in neck, shoulder and/or back.

After changes are done, another quick follow up can be done again - perhaps perceived stress needs to be taken care of? The digital tool makes it possible to easy evaluate if significant changes occur in comfort, physical problems/perceived load as well as perceived stress.

The result of this study suggests a follow up to see what has happened over time, as a change in working behaviour may take longer than eight months. It would be interesting to see the effects after a couple of years working in the ABW. Is the comfort better? Has the ergonomics changed with fewer problems reported in neck and shoulders? Have the persons adjusted to the situation and found ways of not feeling stressed? The people that still are left, are those same persons who are better aimed for this flexible working style? The ones who left – did they have difficulties to adjust to ABW? New questions have arisen.

Conclusion and recommendation

- The digital tool Self-assessment : Your Workplace™ can be used before and after an intervention, for example to analyse the effects of introducing the ABW on perceived comfort, strain and stress and easy discover if changes are needed which again can be followed up with a new Self-assessment.
- Long-term work performed on laptop computers should be performed at workplaces where docking station, keyboard and computer mouse are available to reduce the load on the neck, shoulder/arm and hand.
- Computer-based education, eg web-based eLearning is proposed as a preventative measure in view of the increased perceived problems in the shoulder arm-hand.
- Cognitive stress (concentration, memory, etc.) and distraction can be experienced in work in open office environments. For this reason, it is proposed that administrative and similar regular concentration-intensive tasks are to be performed in fixed, shielded and ergonomically designed workplaces. These should be optimized ergonomically including docking station, separate monitor, keyboard, computer mouse and office light.
- Customer visits are recommended to be planned on special "visit times", such as a limited time frame, respectively, so that work tasks can be performed undisturbed and can be terminated.
- As many people have symptoms of stress in general in the groups, preventative education is proposed, for example, with a web-based education; eLearning program.

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Responsible Research and Innovation (RRI) – enhancing ethical design and engagement of stakeholders for the development of new technologies

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Green growth, sustainable development, frugal innovation and responsibility are examples of themes and terminology that have been introduced recently both to research and development as more sustainable ways to act than before. These concepts have been also introduced to citizens and consumers. The European implication, and more specifically Horizon 2020 horizontal dimension of research programs, to these themes in the context of research and development is called Responsible Research and Innovation (RRI). The empirical findings provide input into the iterative development of the RRI model that is used as a tool to help to identify debate and decide upon issues related to RRI. We have collected the main findings from our own experiences of previous and current R&D&I projects together to make a synthesis of them, and to point out tendencies and gaps in the research in relation to the theme.

Keywords: Responsible Research and Innovation (RRI), Ethics, Participatory Design, Human-Driven Design

1. Introduction

The European Commission's research and innovation framework programmes have always taken into account ethics of research and innovation in some level. During the years the emphasis on ethics and societal challenges has received more and more consideration in the form of separate actions and programs like science in society. In Horizon 2020 programme is called Science with and for society and the approach for implementation "Responsible Research and Innovation (RRI)". RRI has been described as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products in order to allow a proper embedding of scientific and technological advances in our society" (Von Schomberg, 2013).

RRI is also described in a similar way in recent official statements by the European Commission: "RRI is an inclusive approach to research and innovation (R&I), to ensure that societal actors work together during the whole research and innovation process. It aims to better align both the process and outcomes of R&I with the values, needs and expectations of European society." The Engagement, Open

Access, Gender Equality, Ethics, Science Education and Governance are presented as critical dimensions for the RRI. (European Commission 2013)

On the other hand Owen et al. (2013) define four different dimensions that Responsible Innovation as such requires to be considered effective only when next of the themes are working: Reflexive, Anticipatory, Responsive, and Deliberative. Still a little bit different conceptualisation can be found in the AREA (Anticipate, Reflect, Engage, Act) approach defined by The Engineering and Physical Sciences Research Council (EPSRC 2015) from the UK. In this definition Responsible Innovation approach should be one that continuously seeks to Anticipate, Reflect, Engage and Act – and by using these processes to influence the direction and trajectory of the research and innovation process itself. (Besides these definitions and characterisations of RRI there are quite a few others and there is not yet a common understanding to the RRI or more contextualised view to the definitions.

We have picked up and combined the main ingredients (RRI requirements, dimensions, elements or pillars) and give them a short description from practical view for implementation of these ingredients to the actual research and innovation work performed by various stakeholders.

2. RRI pillars from practical point of view

Governance/Responsiveness: The governance model of RRI has to be taken into account in the beginning of the project design. The management structure of the project defines how the RRI aspects are taken into account during the project. The management structure and the work plan of the project reflect both the more general requirements of the resource provider (i.e. funding program of company, public entity), more specific requirements of the funding call or initiative and requirements that are rising from the intentions i.e. what the researchers want to achieve with the project) of the project designers.

Anticipation: It is a vital part for any project in order to be able to abstract the future consequences in some level (both positive and negative). Anticipation can be performed in many ways for various purposes. Sort of anticipation for technological development projects is very often done nowadays with scenario-based design approach. This is usually done in order to find the main technical and user-related requirements for technologies and practises but is widely used also to examine societal issues in relation to the R&D.

Participation/engagement/inclusion is regarded generally currently as one of the main elements and tasks in R&D and there is a strong emphasis by funding organisation to increase the volume and visibility of this activity. The meaning and practise in the real world naturally varies a lot and the benefit and true impact of this activity is still not well explicitly argued. The quantity, quality and specific focus or purpose related to the methods/tools that are used in participation is not usually well justified or it is hard justify due the nature of this activity. Participation and engagement also are relevant aspects in the project internally and in close relation to the governance and structure of the project.

Reflexivity is naturally very hard for the projects as it is also for anyone. External point of view might help to establish a situation where one's (individual,

organisation or project) own framing of the context can be examined as objectively as it is possible. Naturally reflexivity already requires a certain attitude to the world when one's own framing can be revealed, discussed and even questioned. Indeed, in our opinion all other dimensions of RRI need be active also if and when authentic reflexivity can be achieved (if ever).

3. Preliminary Model/process for installing the requirements for RRI

In the following, we present preliminary thoughts how RRI must be or could be taken into account in Research and Development projects.

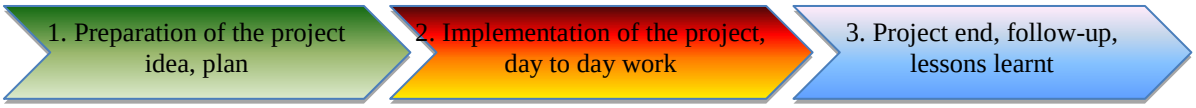


Figure 1. Project phases

1) Project design/planning -phase:

- Requirements of various funding schemes might require already RRI approach (RRI required/compulsory – no compulsory need to include RRI aspects)
- If RRI is a required element to be included to the R&I work or if it is seem to be useful even without condition then you need to think:
  a) Do you get RRI –part to the R&I in-house or outside (from your own organisation, from partner organisation or as pure consultation/contract work from third party)
  b) Resource allocation for the RRI –part of the project

All these "RRI" attributes, dimensions or requirements are in relation to the specific project and in that sense Analytical Grid (look pages from 8 to 10 in this document) could be very useful for a kind of RRI self-assessment in the beginning of the project design. Naturally each project is at least a little bit different from each other and therefore requirements of the project and on the other hand requirements of the model should be adjusted and customised for each specific case.

2) RRI governance models and implementation in the project:

- **Governance** structure and tools for RRI implementation in the project, different "models" to accomplish RRI in the project
  a) As integrated holistically all over the project (continuous interaction – check points for RRI – self-assessment etc.)
  b) Consultation towards research work in the beginning of the project and review of the results (and work) in the middle and in the end of the project.
- How governance/management structure allows the RRI to have active role in the project? Does RRI has possibility in reality to guide and orient project and even stop the project in some cases?
- Anticipation: who is performing it with what resources, tools and expertise?

- How reflexivity, mutual learning, deliberation is enabled? Who is enabling and supporting it with what resources, tools and expertise?
- Identifying and selecting the stakeholders, who are performing it with what resources, tools and expertise?

3) Project ends
- How to measure the success of RRI implementation in the project (some kind of criteria, measurements, parameters needed)
- Lessons learnt, best practises
- Follow-up and developing the approach for the next activities
- Customising the approach for the other kind research and development context

4. Anthropological theory and practice to the reflexivity dimension?

As it is clear, it is hard to fill in dimensions like anticipation, transparency, responsiveness and reflexivity, if you have not thought thoroughly the engagement and interaction with various stakeholders. Engagement and inclusion of various stakeholders are naturally dependent of the nature, content and resources of the project. Good presentations, examples and guidelines e.g. for participatory design and the user engagement are available publicly so the main task for the engagement designer/planner is to familiarise with new examples and customise the plan according to the project requirements.

However in this chapter we try to shortly introduce some suggestion from anthropological approach and based on our own experiences on project work to the issue of reflexivity and especially to the issue of establishing possibility to second-order reflexivity. As second-order reflexivity seems to require revealing both explicit and implicit structures of the society and penetration of various levels of society and even individual, we do not except here to offer a comprehensive approach to the issue as it is. But nevertheless we want to try to offer some ideas, possible new views in this context of RRI that may take us a little bit closer to start to work in projects with concept like second order reflexivity.

4.1. Thick description and Dialogical method

To Clifford Geertz (1973) concept of culture is above all semiotic: "Culture is most effectively treated, the argument goes, purely as a symbolic system (the catch phrase is, "in its own terms"), by isolating its elements, specifying the internal relationships among those elements, and then characterizing the whole system in some general way-according to the core symbols around which it is organized, the underlying structures of which it is a surface expression, or the ideological principles upon which it is based."

One of the key terms in Clifford Geertz's anthropological theory is that of "Thick Description". Geertz thinks that anthropology's task is that of explaining cultures through thick description which specifies many details, conceptual structures and meanings, and which is opposed to "thin description" which is a factual account without any interpretation. Thin description for Geertz is not only an insufficient account of an aspect of a culture; it is also a misleading one. According to Geertz an ethnographer must present a thick description which is composed not only of facts but

also of commentary, interpretation and interpretations of those comments and interpretations. His task is to extract meaning structures that make up a culture, and for this Geertz believes that a factual account will not suffice for these meaning structures are complexly layered one on top and into each other so that each fact might be subjected to intercrossing interpretations which ethnography should study.

In "Thick Description: Toward an Interpretive Theory of Culture" (1973) Geertz outlines four parameters for an adequate "thick description" and a study of culture:

1. **Interpretative study.** Since anthropology is a semiotic endeavor, cultural analysis should be an interpretative practice which traces the manner in which meaning is ascribed. The raw observational material collected by an ethnographer is not sufficient if we are to achieve a thick description of a culture.
2. **The subject of interpretation is the flow of social discourse.** Interperative ethnography according to Geertz should produce the codes required for decoding social events.
3. **Interpretation deals with extrovert expressions.** Data collection and interpretation are limited to what local informants can tell us. Therefore the thickest of descriptions can only be based on extrovert expressions of culture.
4. **Ethnographic description is microscopic.** According to Geertz ethnographic findings describe local behaviors and truths as serve as an ethnographical miniature. We always view specific and contextualized happenings, and these make up the thick description".

As making thick description possible requires very thorough understanding of the studied culture we propose for the project purpose "quick and lean" – method as a starting point in order to establish mutual learning and understanding process and to be able to start interpretation of the cultural (i.e. project related) meanings. The method is called dialogical method.

In the group of different stakeholders, we use A punctilious manuscript in order to accomplish an equal, democratic way of discussing and developing particular predefined themes and groups. The goal is to get different perspectives from the various stakeholders e.g. for the concept development in a deliberative manner. An example procedure for the dialogue/discussion is the following:

1. Short introduction to the theme (5-10 minutes)
2. First group discusses the theme (5-7 minutes) – all the others are silent
3. Next group starts first commenting about what they have heard and then continue to discuss the theme on they own view (7-10 minutes)
4. Then all the other groups are gone through in the same manner till the first one who started the dialogue will also comment about discussion.

Based on our experience the listening and interpreting the heard is the important part of the process of understanding other groups' views and on the other hand identifying some new views to the person's own thinking. The fundamental concept to open one's own thinking for "deliberative" dialogue is trust: it cannot be achieved easily so naturally "quick and lean" dialogical session can be only the first starting point in building up "thick description" for the more holistic design process. The optimal way

to start the research and development project would be to organise a series of the workshops where the trust and mutual learning process is accomplished. In multicultural and multinational project environment it is hard to arrange enough face to face meeting for continual interactions virtual co-design tools and methods of a new kind could be utilised for this purpose.

4.2. Grid and Group analysis in relation to RRI

Another interesting anthropological perspective to the reflexivity could be found in Mary Douglas' (1978) Grid and Group cultural theory. These two dimensions of sociality have been named group and grid. The exact natures of the two dimensions have been the topic of many discussions and debates, especially related to methodological consequences. The two dimensions include a series of aspects, but those are not necessarily present in each case observed.

For the grid, Mary Douglas (1978) distinguishes in four elements: insulation, autonomy, control and competition. Whereas the four elements of group strength include: frequency (of interaction), mutuality, scope (of activities) and (group) boundary. The two dimensions are generally acknowledged as such, but their presentations may vary. Aaron Wildavksy (1987) for example generally introduces the two dimensions as grasping the answer to two fundamental questions for each human being: (1) who am I? and (2) how should I behave?

The main claim of grid-group cultural theory is that culture matters. Preferences and justifications shape the world of social relations. Everything human beings do or want is culturally biased. Therefore this is a cultural theory. The second claim is that it is possible to distinguish a limited number of cultural types. That can be done by constructing a typology of cultures. This typology includes viable combinations of patterns of social relations and patterns of cultural biases (or cosmologies). These combinations are often called (sub)cultures, ways of life or rationalities, sometimes ways of organising, social orders, solidarities, political cultures, or simply types. Combinations are viable when social relations and cultural biases reinforce each other, that is: the cultural bias justifies the social relations which confirm the expectations raised by the cultural bias: i.e. when people behave rationally. The very fact that rationality is plural and that several types of rationality can be established is an important contribution of the theory to the social science where the rational choice paradigm is hegemonic. (Mamadouh 1999)

Utilising this kind of framework or model of analysis in relation to the research and innovation and especially in order to open a door slightly to the second-order reflexivity and RRI is the next step after this very short introduction to the theory. Let's embed research and development work and projects to the framework as "culturally defined activity". We can surely find various subcultures in different branches of R&D and differences between publicly and privately funded projects. In addition there are still national and international differences in these subcultures. However taken into account these limitations we still try to do a soft heuristic analysis with this framework regarding to R&I, and especially in relation to RRI.

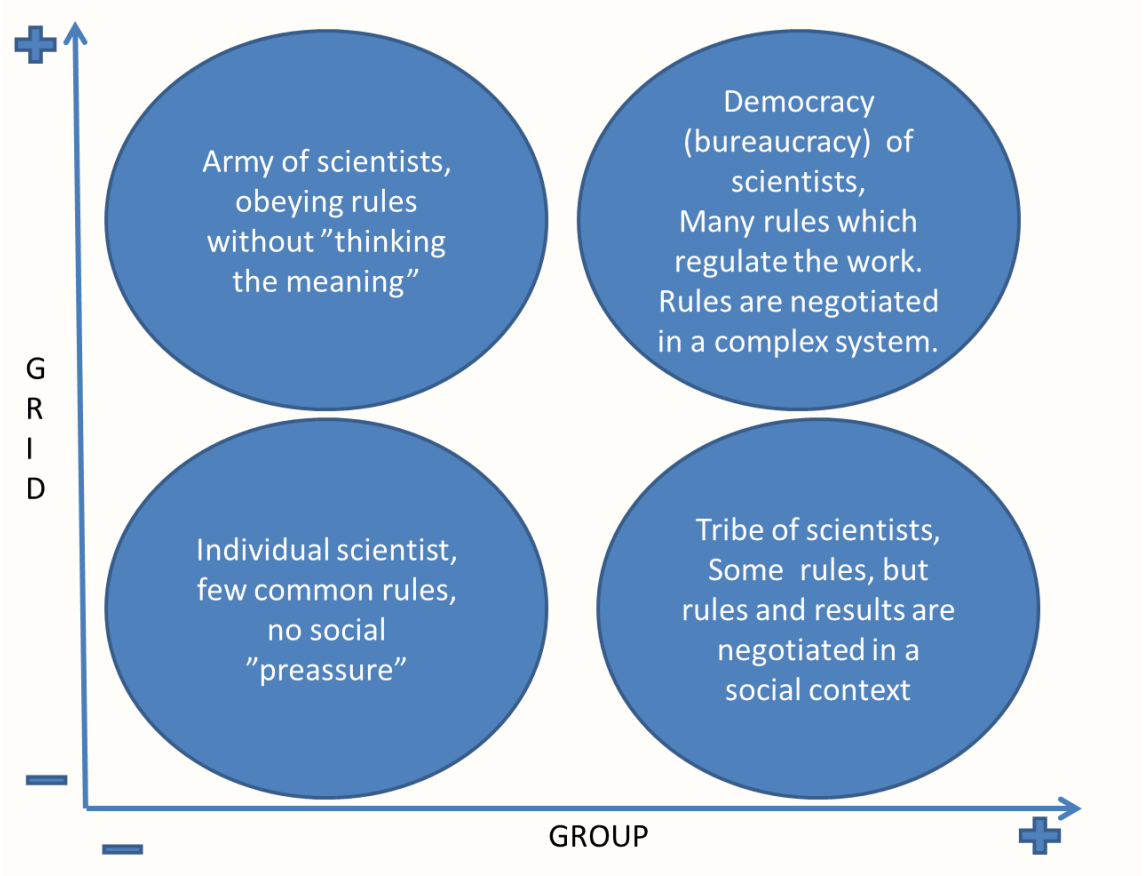


Figure 2. Group and Grid analysis of RRI approach

Basically a workable Responsible Research and Innovation approach should cover somehow at least both strong group and grid area and strong group and weaker grid area. The Grid should never be so strong that it cannot be questioned and discussed. Without authentic dialogue among various stakeholders, you will lose your capacity to achieve reflexivity and will follow the most popular, although, still jointly agreed via very complex structures and hierarchies, paradigm, model or the system. Naturally some rules have to be quite strong while some others have to be more negotiable and context-dependent. Innovation is mainly team work and RRI can strengthen the idea of collective, inclusive and even very pragmatic idea of social innovation. However, there might be sometimes even need for the "mad scientist" in some occasions to bring to the landscape something totally new ideas – as long as we could be sure that those ideas and innovation still do not cause harm to the society. One of the issues that we are leaving out here is the concept and influence of personality in these ideal types. It is obvious that it should be included in the profounder and more thorough analysis of reflexivity. Here we just can mention that personality is naturally one of the three key dimensions also both Geertz and Douglas – likewise to Habermas (1987), who defines the three spheres of the lifeworld: "culture", "society" and "personality" with like Geertz and Douglas.

5. Conclusions

If there is possibility to give evidence-based guidance and recommendations for participation it would be remarkable help for the RRI implementation. Procedures, models or even standards have been of great help in other fields of R&D (e.g. HCD – Human Centred Design or CSR – Corporate Social Responsibility) when implementing certain approaches. However standardisation of RRI might be very hard or impossible due the nature of RRI dimensions: they are not absolute or measurable yet and in many cases, contexts vary a lot and RRI integrates inside already a broad, even holistic view to the R&D.

We have presented preliminary descriptions of RRI requirements for model for guidance and governance. It is not an extensive one yet, besides we think that there must be contextual understanding of various possibilities to work (customise) with requirements in real life. We have also tried to give some insight to that how some RRI dimensions might benefit from anthropological analysis. As one of the great goals of the RRI is to make reflexivity possible in the world of R&D, we think that these views might help to grasp an idea for the further development and implementation of reflexivity (and hopefully even second-order reflexivity) enabling approaches, methods and tools.

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Expert user perspectives of the Ergo-Index model for analysis of work tasks

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The purpose of this study is to evaluate an updated beta version of Ergo-Index, a digital tool for ergonomic risk assessments. The evaluation was performed with 15 expert users who assessed type, distance, height and exposure time of certain work tasks, as well as the usability of the tool. In conclusion, the users find the present state of the Ergo-Index suitable as a first screening method. Assessments of lifting work have the greatest inter-rater reliability. Further development of the digitalized version of the tool is needed to improve accuracy assessing input regarding pushing and pulling work tasks, and to increase usability.

Keywords: ergonomics, risk assessment, physical load, exposure time, usability, recovery, inter-rater reliability

1. Introduction

This paper presents the results of a user study aiming to evaluate an updated beta version of the Ergo-Index model for risk assessment of work tasks from an ergonomic as well as a production performance perspective. To reduce the risk of musculoskeletal disorders (MSD) and work-related ill-health, it is important to understand the effects of the physical load and intensity, working posture, exposure and recovery time, and how these factors interact. Further, to secure sufficient recovery during work shifts. Using posture and force data, as well as loading time (the time the force is exerted) as input, the updated version of Ergo-Index enables assessment of load level and recovery need, allowing for different work-methods to be analysed and compared before deciding on appropriate design and performance of work procedures.

1.1. Background

MSDs are among the most commonly reported occupational injuries in Sweden and in Europe, and pose a problem for society, companies and individuals (AV, 2016; EU-OSHA, 2010). Working conditions that involve unfavourable body movements, such as heavy loads, twisting and bending or monotonous, repetitive movements are all known to increase the risk of MSDs (Bernard, 1997). In addition, high job demands with intensive and rapid pace in work performance, with insufficient time for recovery during the work shift are identified as risk factors of MSDs (Devereux et al., 2011).

Exposure time, recovery time, the relationship between exposure and recovery, and monotony versus variation, are all significant factors in the development of muscle

fatigue that in turn may lead to overloaded and damaged muscles (Ma et al., 2015; Rose et al., 2014). To minimize the risk for musculoskeletal problems and muscle fatigue, it is useful to determine the need for recovery time during statistic work and organize work tasks accordingly, for example by planning for short breaks of little or no activity (Rose et al., 2014, Ma et al., 2015, Frey-Law et al., 2012). Previous research shows that by introducing additional rest periods, development of fatigue can be reduced. Individuals who exhibit more gaps in muscle activity, for example through electromyography (EMG) measurements, have lower risk of developing musculo-skeletal disorders (Yung et al., 2012). Here, variation of work tasks, in time or in activity, may be a viable option to alternate work load exposure over time, and reduce muscle fatigue and discomfort (Luger et al., 2014: Luger at al., 2015).

Fatigue, if prolonged and without recovery, can in turn lead to pain and discomfort that restricts an individual's endurance time and prolong the time it takes to complete a work task, thus limiting work ability (Rose et al., 2000). Furthermore, unfavourable working conditions can affect system performance, both in terms of quality and productivity. Since reconstruction or adjustments of the human–machine system can be both costly and time consuming, it is preferable to consider these ergonomic risks early in a production design or development process, when improvements are more feasible and usually less costly (Jaber & Neumann, 2010).

Organizations need to carefully consider how to design work-rest schedules to maintain high performance, and at the same time keep the employees' exposure to risks for ill-health low. For this purpose, several models have been developed to estimate the physical load in different work situations and estimate work load (for an overview, see for instance Palm et al., 2014). For now, there is not consensus about one single load and exposure time based model for determining recovery time for tasks involving static muscle work (El Ahrache & Imbeau, 2009; Ma et al., 2015; Rose et al., 2014). Rather, there are significant differences between existing models, and sometimes conflicting, results in recommended recovery times for the same working conditions, depending on which model is being used.

1.2. The Ergo-Index tool for evaluation of work

The purpose of the Ergo-Index is to assess work-tasks such as pull, push or lifting and to determine the recovery-time needed, to support planning of work and deciding between alternative ways to perform a task. For example, moving windows during assembly manually, or by using a robot. In Ergo-Index, physical work load and recovery need is assessed, using four parameters as input data: type of work, height, distance and time to complete a task (the time the force is exerted). The results of an assessment are shown as recovery need, production time and physical load level. The results of an Ergo-Index assessment are presented by displaying the exposure time (in red) and recovery time (green), both in seconds and how it is distributed as a percentage of total time (Figure 1). For tasks which are assessed as exceeding maximum forces for lifting, and pushing and pulling stated in the Swedish provisions on *Ergonomics for the Prevention of Musculoskeletal Disorders* (AFS 2012:2), a warning is given.

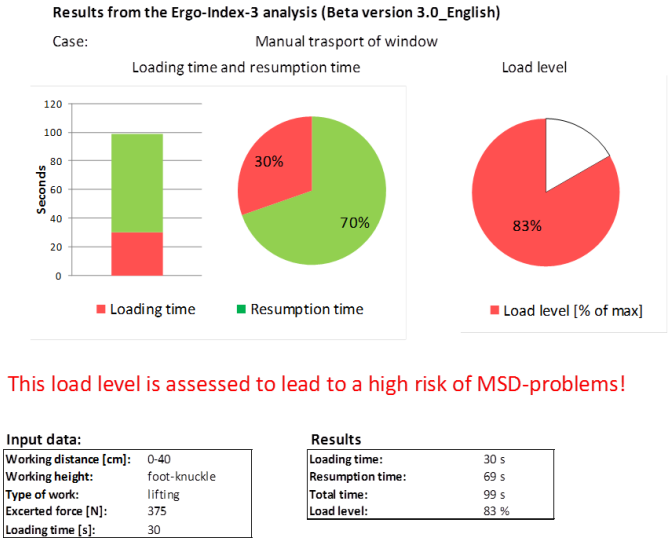


Figure 1. An example of an assessment result using the Ergo-Index program (Beta version 3.0), here assessing the task Manual transport of windows, which also displays a warning for elevated risk of MSD problems.

2. Study purpose and research questions

The purpose of the study presented in this paper is to test and evaluate an updated version of Ergo-Index, available as a beta version of a digitalized excel based tool, to receive user feedback that can be useful for the continued development process of the tool. Specifically, the aim is to evaluate:

i. face validity and inter-rater reliability of the Ergo-Index model, based on the users' evaluation data from four different work tasks.
ii. perceived usability of the beta version of the digitalized, excel based Ergo Index tool

3. Research design and procedure

The evaluation was performed with 15 expert users with a background as ergonomists or work environment engineers. The users were introduced to the beta version of Ergo-Index software and given a step-wise instruction on how to perform evaluations and assessed of four different work tasks, each with two different methods to perform the task, all illustrated in short video films.

The users were first given the task to assess type (lift, push or pull), distance, height and exposure time of the work situations, which resulted in an assessment of load level, recovery time and production time. After performing all eight assessments, the users answered a written questionnaire on how they perceived the usability of the model.

3.1. Sample

Initially, 31 participants were invited to participate in the study. 23 participants accepted the participation and finally, 15 participants completed the assessment. The main reason stated for not completing was lack of time. The participants had two

weeks of implementation, and one user received another four days because there was a problem with the platform. The invited participants are present and former students at KTH Royal Institute of Technology Master's program *Technology, Health and Work Environment Development.* It may be assumed that these participants would have adequate knowledge required to carry out this kind of assessments, although they did not receive any specific training course on the tool. They are also seen as potential future users of the Ergo Index.

3.2. Data collection and analysis

The evaluation was done entirely digitally and no physical meetings were held. Some further instructions were however given over telephone. The participants were invited to share a closed folder via Dropbox that contained eight sub-folders, each representing a step in the evaluation procedure. After reading through information about the project and instructions on how to use the program, the participants were given the task to perform risk assessments of four work tasks that each was done in two separate ways. For the risk assessments, the participants were asked to assess the type of work, working height, working distance and exposure time for each task. In four video films, the following work tasks were illustrated: 1) Lifting and transport of windows, manually and by means of a robot; 2) Installing plaster boards, manually and with a mounting rule; 3) Making beds, "traditionally" and with the 2 in 1 – technique, and 4) Transport/moving boxes, manually from mid-height and high height.

After completing the risk assessments, the participants were asked to answer a survey questionnaire on the usability of the program. Answers to the 19 questions were given on a 5 points Likert-scale (Nemoto & Beglar, 2014) and it was also possible for the participants to give free text comments. The first part of the questionnaire included questions on how easy or difficult it is to assess the physical load from different perspectives of the work tasks, where the answer options are *easy*, *fairly easy*, *neither easy nor difficult*, *rather difficult* and *difficult*. The second part contained questions on the usability of Ergo-Index that could be answered with the options *totally agree*, *partially agree*, *neutral*, *partially disagree*, and *totally disagree*.

4. Results

4.1. Ergo-Index face validity and inter-rater reliability

Physical load is assessed in Ergo-Index in terms of work type, height, distance, and exposure time.

Work type can only be exclusively categorized as either lift, push or pull. For this category, the results generally display consensus among the participants. Five out of eight assessments represent relatively uniform assessments. Of the three work type assessments that proved to be more difficult to evaluate are the movement of windows using a robot which included all three options (lift, push and pull), installation of plaster boards, manually as well as using a mounting rule

Working height is specified in relation to the workers body as: foot–knuckle, knee–shoulder, shoulder–head and above head. Here, the results varied largely depending on type of work analysed. A high degree of consistency was shown for the work that

involved moving boxes. The least degree of consistency was found in the work involving making beds.

Working distance is categorized with three different options for the distance from the worker to the object: 0–40 cm, 40–60 cm and 60–80 cm. This was the variable that was most difficult to assess and thus showed the largest variation in results. As for the other variables, moving boxes was the task that gave the greatest consistency, while lifting and transporting a window using a robot gave the least.

Exposure time for each task is freely estimated by the user, without any fixed options. Figure 2 illustrates the participants' estimation of exposure time for the different work tasks. There was generally good consistency across the assessments of work tasks, except for especially bed making, that ranged from 50 to 165 seconds, and an odd estimate for installation of plasterboards using a mounting ruler. As before, manual handling of boxes was the task that showed the greatest inter-rater reliability.

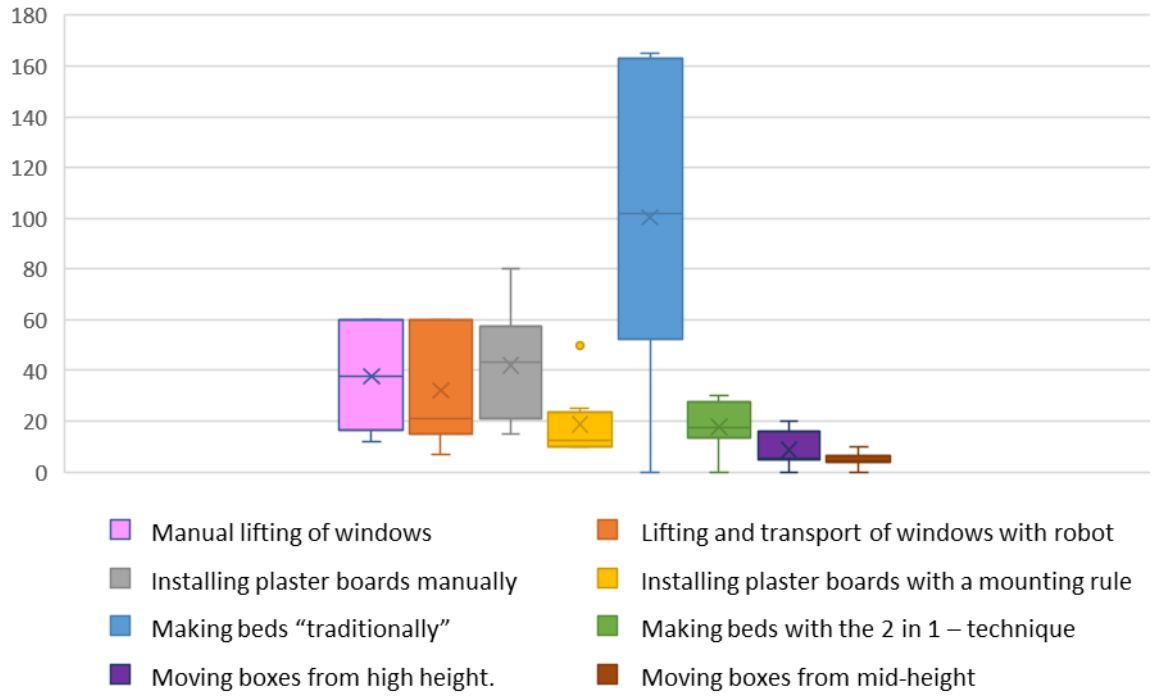


Figure 2. User evaluation of exposure times for the assessed work tasks.

4.2. Perceived usability of the Ergo-Index

Most users gave neutral answers to the survey questions on how easy or difficult they found assessing the various work tasks. Additional free-text comments do however indicate that several of the users found it difficult to use the model and requested better instructions and training opportunities.

Generally, the participants estimated that it was *neither easy nor difficult* to make assessments based on the different work moments. The participants further consider that assessment of work movements and work postures are the most difficult to determine using the Ergo-Index. Pushing and lifting work are the type of force exertions and moments that are reasonably easy to assess.

5. Discussion

5.1. Discussion on research design and methods

The greatest challenge with this study was recruiting respondents and guiding them through the evaluation process in a suitable way. According to Ejlertsson (2014), there are several components to elicit feedback from users, such as the design of the questions, the questionnaire design, informative letter of compliance and reminder to those who do not complete the data. But the most important thing is motivation to get the user to answer the questions. In principle, all participants found it difficult to understand the written instructions in the Ergo-Index beta version. On request, additional instructions and clarifications regarding the tool and its use were sent to the participants by e-mail Nevertheless, there was a large need to provide more instructions about how the program and method should be used, which caused frustration for the participants, and possibly contributed to the five rejections from those who had first accepted to participate but later opted out of the study.

The participants' completion of the use of the Ergo-Index tool might have been higher, had they received personal instruction, training and practical guidance, and, possibly, more time to get to know the method. In this study participants were solely recruited from the first author's own network, which is a limitation. Usually there are opportunities to supplement risk assessments with conversations or further observation, which was not offered in this study. This may have affected participants' assessment capabilities and their general uncertainty about the correct execution of the assessment. The information that the participants had access to in this study was recorded material, written instructions as well as the ability to contact one of the authors on uncertainties. Subsequent interviews would had given the study more dimensions, emphases and qualitative ability to capture the participants experiences and evaluations of the tool.

5.2. Discussion on results

The results of the assessments varied greatly, except for the assessment of moving boxes, as well as high and medium height. Here, the participants were almost completely consistent in all parameters; work type, height, distance and exposure time. For example, participants were completely coherent in terms of working distance when moving boxes from average height versus largely dispersed response regarding working distance when moving windows with robots. Possibly, this could be due to the videos not being filmed in the same way and that the angles of the video, light differences, which may affect the participants' perception of what they are looking at. In addition, it may be because the participants draw attention to various aspects of the videos or that experiences differ from the performance of ergonomic risk assessments. This has previously been see also in (Eliasson et al., 2017), who also discuss the importance of participants from different industries, where some may lack experience of the evaluated work tasks.

The low inter-rater reliability, and thus the validity, of the results clearly demonstrate the need for further development of the Ergo-Index. The participants themselves highlight the difficulties in making adequate assessments based on video as

compared to judging in the multi-dimensional reality, where it would also be possible to ask questions to the workers performing the evaluated tasks. However, it is important to lift the positive aspect of recorded material, i.e to be able to see the material several times and analyse step by step as well as catch any failures (as discussed by for instance Mathiassen et al., 2012). Yet, one must not rule out the other.

Participants expressed in several of the comments a desire for more information and education before using the Ergo Index. Some participants were unsure whether they used method correctly and stated that it was somewhat difficult to understand what to do and how.

5.3. Further development of the Ergo-Index

It would be interesting to supplement this study with interviews to get a deeper and broader understanding of the obtained results and elicited user comments. There is a need for development of the usability before a repeated user study. Finally, to check if the results would be different if the participants were given the opportunity to practice Ergo-Index. It is hypothesised that this would influence the results and the evaluation of the tool.

6. Conclusion

In its present state, the Ergo-Index tool is seen by the users in this study as a suitable first screening method when assessing work tasks from an ergonomics and production performance perspective. The results show that the participants experienced difficulties assessing most parameters in the work tasks and the inter-rater reliability was low.

The participants reported that they were unsure whether the Ergo Index had assessed what it intended to assess, and several sections were reported by the users to be unclear. Further development of the tool is needed to improve accuracy especially of the assessments of work tasks involving push and pull, and to increase usability and thus reduce the need for detailed instructions of how to use the Ergo-Index model before final release.

Acknowledgement

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Driving Simulator Studies - Opportunities to Elicit Important Knowledge from Experienced Truck Drivers

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Twelve experienced truck drivers participated in a driving simulator study with the overall aim to develop further knowledge on how driving postures are influenced by cab design features (e.g. head-up display and camera monitoring system (CMS). Objective data was collected on drivers' posture and subjective data on their experience of driving as well as thoughts on the new designs. The subjective data and the experience of the truck drivers brought additional value to the simulator studies in terms the pros and cons of different designs but also of suggestions how to improve the realism of the simulator; and reflections on drivers' behaviour in situations that did not exist in the simulator.

Keywords: Driving simulator, truck cab design, evaluation, CMS, rear-view mirrors

1. Background and purpose

Driving simulators are used for fundamental research as well as a tool in product and system development. A common purpose is evaluations of technical solutions and assessments of their impact on, for instance driver performance or distraction. Driving simulators allow for controllability, reproducibility, standardisation, and easy access to objective data. They also provide opportunities for systematic evaluations of new and conceptual designs, evaluations which would otherwise be difficult to accomplish. However, evaluations in driving simulators have also been questioned as unrealistic driving behaviours may be triggered and a lack of realism may affect the opinions of users. At the same time this subjective data is crucial in order to develop solutions that fulfil users' needs and requirements.

The basis for the paper is a series of driving simulator experiments performed within the project Future Layouts for Driver Positions and Visual Information in Trucks (FUDVI). The project aims to develop further knowledge on drivers' (choice of) driving postures in different traffic environments and how postures are influenced by

cab design features, such as Camera Monitoring Systems (CMS) compared to traditional rear-view mirrors and alternative locations of in-vehicle information compared to traditional instrument clusters.

The purpose of the paper is to present part of the result of these studies in order to argue the importance of collecting subjective data, more in particular the contribution of experienced (professional) drivers.

2. Methodology

In the simulator experiments (see Figure 1), the participating truck drivers drove pre-defined routes with different concepts while their choice of posture was video-recorded and head locations tracked by a sensor.



Figure 1. The simulator set up consisted of three TV-screens together with a partly physical and partly virtual truck environment.

Twelve experienced drivers (i.e. expert users) were chosen to participate in the specific study, the argument being that they could relate the different simulator scenarios to real driving scenarios, to previous experiences and to their needs as professional drivers.

The study was designed as a within-subject trial, i.e. a design where all drivers were exposed to concepts A and B (see Table 1). Six of the drivers drove a HCOE truck with semi-trailer (the FH truck type) and the remaining the six drivers drove a LCOE rigid truck (the FE truck type). HCOE, or High Cab Over Engine, refers to a truck type where the cab is positioned at a high location above the engine. Correspondingly, LCOE, or Low Cab Over Engine, refers to a truck type where the cab is positioned at a low location over the engine. The HCOE truck type is predominantly used in long-haul transport and the LCOE truck type is mainly used for city distribution.

Table 1. Description of the two compared concepts. The underlined words refer to the differences between the concepts.

	Concept A	Concept B
FH-truck	• CMS: Camera Monitor System. Main as well as wide angle rear-views as camera views, placed on the A-pillars. •IC: Instrument Cluster with speedometer, engine speed and tell-tales for chosen gear, parking brake and indicators, placed behind the steering wheel. • LCS: Lane Change Support warning lights in lower CMS display corners. • SID: Side Display placed to the right of the driver. Navigation instructions with turn-by-turn arrows. Touch interface for ignition switch, parking brake and indirect vision adjustments.	• CMS: Camera Monitor System. Main as well as wide angle rear-views as camera views, placed closer to the driver's field of view. •IC: Instrument Cluster with speedometer, engine speed and tell-tales for chosen gear, parking brake and indicators, placed behind the steering wheel. • LCS: Lane Change Support warning lights in lower CMS display corners. • SID: Side Display placed to the right of the driver. Navigation instructions with turn-by-turn arrows. Touch interface for ignition switch, parking brake and indirect vision adjustments. **Additional exercise:** • CMS: Camera Monitor System. Main as well as wide angle rear-views as camera views, placed closer to the driver's field of view. • LCS: Lane Change Support warning lights in lower CMS display corners. SID: Side Display placed to the right of the driver. Touch interface for ignition switch, parking brake and indirect vision adjustments in lower part. HUD: Head Up Display instead of an IC. Provides all information about speed and navigation (turn-by-turn arrows).
FE-truck	• Traditional mirrors: main as well as wide angle rear-view mirrors. • IC: Instrument Cluster including the main vehicle information and navigation (turn-by-turn arrows), placed behind the steering wheel. • RPS: Rear Proximity Support as warning lights on A-pillars, indicating remaining distance to object behind vehicle.	• CMS: Camera Monitor System. Main as well as wide angle rear-views as camera views, placed on the A-pillars. • IC: Instrument Cluster including the main vehicle information and navigation (turn-by-turn arrows), placed to the right of the driver. • RPS: Rear Proximity Support as warning lights on A-pillars, indicating remaining distance to object behind vehicle.

All drivers were accustomed to drive Volvo trucks, and all drove the truck model they were most accustomed to in their profession.

In all FH concepts, the drivers had access to Lane Change Support (LCS) in terms of warning lights in the lower CMS corners in order to alert the driver when

something appeared in the blind spot. In the new FE concept, the drivers had access to Rear Proximity Support (RPS) in terms of warning lights on the A-pillars to inform the driver how close he is to the warehouse door when reverse parking.

All concepts included navigation instructions consisting of turn-by-turn arrows that appeared either in the side display or the HUD.

Having completed a driving session, the drivers were interviewed in a separate room. The interview guide contained open questions covering seven main topics for each truck model with a focus on the respective design concept, allowing the interviewer (first author) asked follow-up and probing questions, and encouraging the interviewees to develop their responses to each of the questions and according to their personal experience and preferences.

For the FH (long haul truck) the topics covered were:

1. Introductory questions; questions regarding the overall simulator experience, the test setup and nausea.
2. Concept functionality; questions concerning pros and cons of each CMS concept.
3. Visibility; questions dealing with the placement of the displays.
4. Driving postures; questions regarding any difference in driving posture depending on concept.
5. Evaluating questions; questions regarding which layout that was preferred.
6. Lane Change Support (LCS); questions regarding the experience of having these types of warnings.
7. Side Display/Head Up Display (SID/HUD); questions about the experience of the different ways of showing visual information.

For the FE (distribution truck), the topics covered included:

1. Introductory questions; questions regarding the overall simulator experience, the test setup and nausea.
2. Concept functionality; questions concerning pros and cons of the mirror as well as CMS concept.
3. Visibility; questions dealing with the placement of the mirrors and displays.
4. Instrument Cluster/Side Display (IC/SID); questions about the experience of the different ways of showing visual information.
5. Driving postures; questions regarding any difference in driving posture depending on concept.
6. Evaluating questions; questions regarding which layout that was preferred.
7. Rear Proximity Support (RPS); questions regarding the experience of having warnings to inform the distance to an object behind the vehicle.

All interviews were recorded. As a basis for the analysis, the interviewer listened through the recordings and noted the essence of the answers to each question in spreadsheet. The answers were then compared across interviewees to see if there were similarities and/or differences between the drivers, and if some common themes emerged. For each topic, a conclusion was drawn and noted down.

In addition, the results obtained from the analyses of posture and head locations were compared with the answers from the semi-structured interviews. The main focus was here on responses that could be compared to findings from the video analyses in order to see if the drivers' answers and comments matched what they actually did during the test-drives.

3. Results

Analysing the interview data, the contribution of the professional drivers showed that using expert users allow valuable voices to be heard and convey a new dimension to simulator studies, acknowledging users as 'subjects' with fundamental knowledge and experience of task and use context, rather than 'measurement devices' only.

Firstly, the drivers reflected on but also suggested how to improve the realism of the driving simulator. Since the drivers had, on average, fifteen years professional driving experience, most of the drivers were confident when sharing their experiences of how a realistic truck should operate. A majority of the drivers stated that the simulator in many areas differed from a 'real truck'. Most of the drivers reacted on how slowly the truck went uphill although it was fully loaded. For example, one of the drivers stated that: "*I looked at the speedometer and realized that even with a load of 55-60 ton, I would have been able to higher the speed more than with this truck*". Also, many of the drivers discussed the override of the steering wheel, the too short braking distances, as well as the difficulty in perceiving speed as the engine noise did not correspond to reality. According to the drivers, these simulator characteristics result in a conversion that opposes the driving habit, which in turn creates a form of insecurity that the drivers are not used to experience when driving a truck.

Nevertheless, the drivers still managed to reason about the strengths and weaknesses of the evaluated design concepts. For example, when asked about the positive and negative aspects of CMS in the simulator, the drivers expressed that they did not have to make as many head movements with the CMS as when driving with mirrors. When asked how they preferred to receive visual information (e.g., speed information, navigation, LCS or RPS) in the truck, most of the drivers agreed that "*... the closer to the field of view, the better*". The majority of the FH-drivers believed that the HUD would save time as well as increase safety while driving, whereas the choice between a side display or an instrument cluster was not evident among the FE-drivers. This might be due to the placement of the IC and SID, as none of the information areas were placed in the driver's field of view why the drivers had to take their focus off the road in order to read the information. Moreover, the FH-drivers disliked the sound of the LCS warning whereas the FE-drivers thought that the RPS made parking a lot easier.

Besides being able to reason about the pros and cons of different design features in the simulator, most of the drivers took it to the next level by explaining how the new features would be perceived in a real truck. For example, the drivers did not experience any specific disadvantages with the displays in the simulator, yet most of the drivers mentioned the probability of encountering non-working components or software failure in the system that in reality would damage the displays: "*Since the mirror today is a key function in the truck, it is important to be able to replace it quickly with a*

new one, otherwise you cannot drive. A solution would be to have displays but also mirror brackets on each side of the truck to be able to place mirrors as a temporary solution when the displays are out of function".

When asked about their experience of LCS specifically, many of the drivers discussed accidents that have occurred due to design deficiencies and suggested how to work with audio information as well as visual information to make the support system more useful.

Most participating drivers discussed different displays and consequences of having the displays placed in different areas. One of the drivers suggested that centred displays would be beneficial when precision driving, for example when reverse parking. In this situation, it is helpful to have both displays placed in the field of view to avoid frequent head movements. Also, knowing that the mirrors create blind spots that affect traffic safety in a negative way, most of the drivers expressed that the A-pillars were a natural placement for the CMS displays and a substitute for mirrors that could be a future solution. Most of the drivers stated that they would prefer driving with displays on the A-pillars, a HUD and features such as LCS, which should only appear in a visual form without any sound. A majority of the drivers preferred having relevant information in the field of view rather than placed in a traditional instrument cluster. Moreover, some of the drivers also discussed the benefits of having an extra camera to be able to operate in wedge junctions and believed in modern mirrors with integrated cameras or IR. Using colour combinations to enhance the perception of the RPS was also considered beneficial according to the drivers.

Despite that the drivers in general often agreed on many design aspects in the truck, the drivers in this study mentioned that every driver has a specific driving style with individual needs and desires etc., there should therefore be room for variation.

Some of the truck drivers also pointed out solutions that have been implemented in the trucks for years and described how these could be re-designed and improved from a driver's perspective. For example, one of the drivers stated that it would be beneficial to combine the CMS and the mirrors in order to be able to use mirrors when the technical elements in the CMS is out of function.

Furthermore, a majority of the drivers in the study had the ability to discuss their driving behaviour beyond situations that appeared in the simulator. This means that they often highlighted possible scenarios that reminded of situations in the simulator or situations that related to their daily routines in the truck. For example, even though the drivers did not encounter unexpected traffic events when driving in the simulator highway environment, they could still imagine possible risks when driving with centered displays. One of the drivers stated: "*You never really know what is going to appear in front of the truck and therefore it is important to always keep the front screen clear from any blocking objects such as displays".*

4. Discussion and conclusions

Involving the actual (intended) users in the evaluation of products and systems is considered a fundamental principle of user- or human-centred design (e.g. Norman & Draper, 1986; Maguire, 2001). Nevertheless experienced truck drivers are probably more likely to be affected by the existing truck driving culture and mind-set than

would less experienced users when discussing new design concepts, such as the ones evaluated in the present study. Therefore, it has been argued, for example by Chapanis (1959), that 'naive' subjects should be chosen in order to reduce the potential bias of earlier experiences. Such a bias can however also be considered an asset. It is here argued that involving expert users, in this case experienced truck drivers, allow for valuable voices to be heard and convey a new dimension to simulator studies, acknowledging users as 'subjects' with fundamental knowledge and experience of tasks and use contexts (cf. e.g. Page 1997; Karlsson & Rosenblad 2001), rather than 'measurement devices' only. The analysis of the interviews with the experienced truck drivers demonstrated the drivers' ability to:

- reason about the pros and cons of different design aspects;
- suggest alternative design solutions (for example placement of mirrors or displays that would improve visibility and hereby traffic safety);
- imagine their own behaviour in situations that did not exist in the simulator;
- discuss how a target layout would work together with a future driver;
- suggest how to improve the realism of the simulator.

Using experienced drivers have a positive effect for the ecological validity of the simulator study. If the trucks, scenarios, tasks etc. not should reflect the real-life situation experienced drivers have a possibility to detected such discrepancies, which 'naive' subjects may not. To achieve this, it is important to interview experienced drivers about the simulation and the scenarios.

In conclusion, the experienced drivers brought added value to the simulator studies, since they could relate the simulator experience, the different scenarios, and different design solutions to their experience as a professional driver and, furthermore, they could verbalise their thoughts on the design concepts in relation, not only to the simulator study but to their experience of driving tasks and use contexts. The feedback provided by the experienced drivers have potential to contribute to developing and improving the design concepts as well as provide information on potential behavioural effects beyond the main scope of the driving simulator study. The experienced truck drivers showed the ability to ideate different scenarios and discuss improvements to the designs as well as solutions on this basis.

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Enhancing the collaborative design of safety management practices in education

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In this paper, we show how the collective view of changing work and occupational safety and health (OSH) challenges developed during a Change Workshop (CW) intervention. We examine this development in the light of the changing safety paradigms, Safety-I and Safety-II, and collective transformative agency. We show that the CW encouraged the participants to create a shared view of the OSH challenges in education and to question current OSH management practices. Although the CW did not lead to Safety-II-based solutions, it did build a view of OSH management as a collective effort and produced tools to enhance it in practice.

Keywords: Education, Safety management, Safety-I, Safety-II, Change Workshop

1. Introduction

Work demands at schools are continuously changing. Digitalization and curriculum renewals, for example, are reshaping the methods and objectives of work, and parental challenges and socio-economic problems overshadow teacher-pupil and teacher-parent interaction. From the safety perspective, this means that in addition to teaching, schools now have to be able to manage disturbances and adapt their actions to varying circumstances. Today, the central challenges of occupational safety and health (OSH) at schools are disturbances, psycho-social workload and abusive behaviour in pedagogical situations (Ervasti 2012, Fagerström et al., 2015, Koli 2014). Although the challenges to safety and well-being are currently widely recognized, the safety culture and safety management practices of schools are still in need of development (Waitinen 2011). In this study, our interest lies in proactive safety management and anticipation, and in the OSH of employees.

The challenge facing safety management in complex social environments such as schools is to create practices for managing varying situations with multiple interconnections. However, traditional safety models, most recently referred to as Safety-I thinking, are primarily designed to anticipate risky situations and eliminate risks and failures through rules, standards and routines (Hollnagel 2008, 2014). In such complex and intertwined systems as schools, risks and deviations cannot be completely avoided by standard procedures, and thus the importance of flexible actions is growing (Caroll et al., 2002). The aim of recent new safety paradigms, for example Safety-II thinking and resilience engineering, is to strengthen the resources of individuals and organizations for proactively handling safety risks in complex and changing

environments (Hollnagel 2014). These paradigms turn the focus of safety management to advancing flexible and successful actions, also in unexpected situations, and underline the importance of anticipation, learning, and understanding everyday activities.

In this study, we present an Activity Theory-based Change Workshop (CW) intervention that was conducted among the principals and OSH actors in a city organization. The intervention is part of the Safety Promotion at Education (EduSafe) project (2016–2018), which is funded by the Finnish Work Environment Fund. Its aim is to enhance the collaborative design of proactive safety management. Our particular interest lies in collective learning during the intervention, and thus we ask: How do the workings of a CW enhance the collective view of changing work and deepen the understanding of safety demands and challenges? How can the participants design proactive safety management practices and tools accordingly? This article contributes to recent safety research by offering concrete methods for improving the development of safety management.

We introduce the CW as a method for the collaborative development of safety management. We then present our data, methods of analysis and findings: how the workings of the CW enhanced the collective view and development of proactive safety management practices. Finally, we discuss our findings in the light of recent safety management literature.

2. The Change Workshop as a Method for Developing Safety Management

2.1. The Change Workshop as an Intervention Method

CW is an Activity Theory-based intervention method that aims to promote collective learning and the transformation of work activity (Virkkunen and Newnham 2013). Widely used in organizational interventions (e.g. Ala-Laurinaho et al., 2017, Ylisassi and Seppänen 2015), it helps build a shared understanding of everyday activities which, according to the Safety-II paradigm, is a prerequisite for safe work.

The central idea of CW is to engage participants in collaboratively analysing their collective activity, in this case OSH activity, and to become agentic actors in developing current way of action. This collective activity is oriented by an object (Engeström 1987) which is a motivating force that shapes and directs activity; it defines what is produced, for whom, and why. An object gives an activity a sustainable collective meaning. The way in which the object of an activity is understood also shapes other elements in the activity: tools, the division of work, and concrete forms of collaboration.

Collective activity evolves over time. Breaking away from existing patterns of activity requires transformative agency and agentic actions of participants (Engeström 2011). Collective transformative agency means that a group of people takes initiatives to transform the current frame of actions and search collaboratively for a new form of activity in which to become engaged (Virkkunen 2006, Haapasaari et al., 2014). Typical expressions of transformative agency are 1) resisting change, 2) criticizing current activity, 3) explicating, 4) envisioning future possibilities and new models of activity, 5)

committing to actions, and 6) taking consequential actions to change the activity (Haapasaari et al., 2014).

In the CW intervention, researchers (facilitators) guide participants to collect relevant data from their everyday work situations, and offer them tools and models with which to analyse the data in order to create a joint view of work and OSH activity. The aim of this collective analysis is to deepen the understanding of the problems in current activity, and to find ways in which to overcome the systemic causes behind these problems.

2.2. The Case: Change Workshop in a City Organization

The CW presented in this paper was conducted in a medium-sized Finnish city organization during 2017. Its aim was to promote the collective development of OSH management in education. In practice, OSH management in the city is implemented by different organizational actors and at different levels: by the head of the local education department, the head of school development, principles, the OSH officer and OSH representative, and the OSH agent of each school. The conceptions of safety, as well as the tools and practices in use, varied among these actors. The CW had 26 participants from different levels of safety management (11 principles and 11 OSH agents; an OSH officer and OSH representative; the head of the local education department; and the head of school development).

The aim of the CW intervention was to create a joint view of the central OSH challenges, to enhance the development of shared proactive safety management practices and to create practical tools for safety management. The CW consisted of three sessions (of 3 hours), and a fourth session will be conducted for evaluation in September 2017. The workshop was facilitated by the first and second authors. The joint development of proactive OSH practices proceeded through the analysis of changing work and OSH challenges (first session), current safety management practices (second session). These analyses created an understanding of the developmental needs of OSH management and provided material for designing the content of the future OSH management model (third session). During the third session, participants also designed developmental experiments in order to improve current OSH management. Table 1 below summarises the CW process.

Table 1. CW Process

Session	Theme	Data for reflection	Analytical tools and models
1	Changes in work activity and current OSH Challenges	Participants' notes on recent changes in work and current OSH challenges	Activity system (Engeström 1987)
2	Current tools and practices for managing OSH	Disturbance examples	Table of safety management tools and actors Proactive – situation specific – reactive practices (Teperi and Puro 2017b, Lofquist 2017)
3	Developmental needs and future model of OSH management. Developmental experiments	Participants' notes on current proactive OSH practices Summary of current OSH challenges	Concept of Proactive safety management HF Tool (Teperi et al., 2017a)

3. Data and Methods of Analysis

Our data consist of the discussions in the three CW sessions, that is, discussions on changing work activity, the safety issues of daily activities and current and potential safety management practices.

We first carefully read through the data and picked out the speaking turns concerning safety in daily work activity and safety management tools and practices. The speaking turns concerning changing work activity were excluded from the analysis, but provided an understanding about the context in which safety emerges.

The selected speaking turns were first divided into three categories according to the nature of speech. These categories were 1) descriptive (neutral); 2) criticizing or questioning; and 3) envisioning new ideas and committing to actions. This categorization is based on the idea of transformative agency and its manifestations in speech (Haapasaari et al., 2014, Ylisassi and Seppänen 2015) and helps us understand the dynamics of the collaborative development process.

Because we were interested in the development of proactive safety management practices, we then examined whether these speaking turns concerning safety challenges or safety management tools and practices manifested the Safety-I or Safety-II paradigm (Hollnagell 2014). Into the Safety-I category we classified the speech that focused on risks and failures; reactive actions; eliminating and managing risks by rules, standards and routines; and which saw humans as risk factors and sources of errors. Into the Safety-II category we classified the speech that highlighted factors that create and maintain safety, such as fluent work and well-being; human performance variation and complexity; proactive actions; and humans as resources and sources of flexibility. This categorization is presented in Table 2.

4. Findings

4.1. OSH Demands Connected to Changing Work

The aim of the first CW session was to analyse changing work and the current OSH demands and challenges (see Table 1.). Before the session, participants collected data on their changing work and current OSH challenges (data for reflection). During the session, this data was analysed using the activity system model. The speech during the session was mainly descriptive or critical, and illustrated the complexity and networked nature of teaching work and its challenges. OSH challenges were connected to complex situations in intertwined and networked work, in which teachers collaborated with several actors to support their pupils' learning. As CW highlights (1 in Table 2), the teacher is the central actor who maintains this network, and this causes mental workload for the teacher. The excerpt shows how the OSH demands were connected to challenges in complex work. The growing workload was also connected to the expanded tasks of teachers; more impatient pupils with self-control challenges; the growing expectations of parents; and the growing speed of the flow of information, which makes distant events a part of everyday school-life, e.g. through social media.

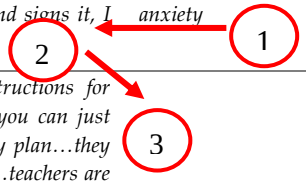
Despite the complex nature of OSH problems, safety management practices were described as quite traditional and based on instructions and routine actions. However,

the adoption of action plans was still mainly the responsibility of the individual (2 in Table 2).

The limitations of rules and standard ways of action were recognized. In particular, generic instructions were questioned, as it was felt the same instructions could not cover every situation (3 in Table 2). Rather than bringing up the developmental needs of OSH management practices, CW participants linked handling the situation to the personal, quite stable abilities of individual teachers.

Table 2. Progress of first CW session

	Safety-I		**Safety-II**	
Speaking turn	Concerns safety in work activity	Concerns safety management tools and practices	Concerns safety in work activity	Concerns safety management tools and practices
Descriptive (neutral)		*P: We do have safety plans…and instructions.* *R: Can you truly say that these plans are used in daily situations?* *P: Everyone reads and signs it, I suppose*	*More often teachers have to be dual personas with the partners, someone has to keep hold of the rains…that might sometimes cause anxiety*	
Criticizing or questioning		*You can't give instructions for these events – that you can just check from the safety plan…they are not that generic…teachers are individuals, even if we train for these events, some can manage this events, some can't …*		
Envisioning new ideas and committing to actions				



4.2. Current OSH Management Practices Questioned

The second CW session started with an analysis of the current OSH practices and tools (Table 1.). Between the first and second CW sessions, the participants collected. examples of disturbances in their work (data for reflection). To determine the concrete OSH management tools and practices used in these situations, three stories, namely a school threat, suspicion of drug possession and the violent behaviour of a pupil, were collectively analysed. The *Tool and practice* Table (as an analytical tool) revealed the flaws in current OSH management practices.

The disturbance examples prompted a discussion on complex situations and current safety OSH practices (1 & 2 in Table 3). The collective questioning of the sufficiency of the current practices started with a speaking turn in which a CW participant criticised the current forms of communication during an unexpected situation, namely the school threat (3 in Table 3). The participant pointed out a gap in the flow of information between the line organization and the OSH actors. A similar gap was also recognized between the administrative sectors. In their speaking turns, the participants emphasized the importance of communication and the central role of the OSH actors in supporting the well-being of employees.

The critical discussion on the forms of communication in unexpected situations turned from reactive actions to the potential benefits of proactive practices (4 in Table 3). In the excerpt below, a CW participant explicates the new idea of how the form of communication in critical situations can be documented and practised, which would help anticipate future flaws in communication. In addition, the two other disturbances, suspicion of drug possession and the violent behaviour of a pupil, raised a discussion on current OSH practices. This discussion centred more on describing and explicating existing tools, such as plans and instructions, than highlighting any developmental potential.

Table 3. Progress of second CW session

	Safety-I		Safety-II	
Speaking turn	Concerns safety in work activity	Concerns safety management tools and practices	Concerns safety in work activity	Concerns safety management tools and practices
Descriptive (neutral)	*So, everything was going fine and, offenders were detained, nobody had to worry about*	*As regards the flow of information, we have clear systems, and communication concentrates…*		
Criticizing or questioning		*'Our role is to take care of well-being at work… therefore it' important that at least the occupational safety officer is informed when something happens... we were in a difficult situation and it seemed that everyone else knew more than us*		
Envisioning new ideas and committing to actions				*O: I just realized that – in addition to having to clarify our ways of collaborating – we have to document the pattern; how the process works in such situations, and discuss the pattern, beforehand*

4.3. Return to Traditional Safety Management Models

The aim of the third CW session was to turn the discussion to proactive safety management practices. Between the second and third session, participants wrote down the OSH management practices of their schools and divided them into proactive, situation-specific and reactive practices. The collective analysis continued with proactive practices (data for reflection). However, even though the OSH demands and challenges were considered as arising from complex work and multiple interconnection (first CW session; summarized at the beginning of the third CW session), and although OSH management practices based on rules, standards and instructions were considered insufficient in many unexpected situations (first and second CW session), the analysis turned the discussion to traditional OSH management tools. In the speech, the developmental needs of OSH management were explicated by highlighting safety instructions and regular practices (1 in Table 4).

The idea of strengthening existing rules and instructions continued in the group work, as participants had to think up new potential safety management practices. The developmental ideas that the CW participants presented followed the idea of simple,

clear instructions, practised regularly (2 in Table 4). Interestingly, during the same speaking turn, one CW participant questioned their group's own developmental idea by highlighting the limitations of easy instructions, which might be reduced to mere fire drills (2 in Table 5). The participant continued by bringing up the complexity of the OSH demands and emphasized the fact that absence days were a growing, important daily OSH demand that is often missed in OSH activities (4 in Table 4).

The outcome of the third CW session was plans for developmental experiments. Regardless of the critical speech regarding the limitations of the predominant rule- and instruction-based OSH management practices, the developmental experiments, easy instructions, and another experiment – a safety walk – still followed traditional OSH management (5 in Table 4). However, in contrast to the discussions of the first CW session, collective practice was seen as central in implementing these instructions and practices.

Table 4. Progress of third CW session.

	Safety-I		**Safety-II**	
Speaking turn	Concerns safety in work activity	Concerns safety management tools and practices	Concerns safety in work activity	Concerns safety management tools and practices
Descriptive (neutral)				
Criticizing or questioning		3 *In the end, what is possible to cover with Easy instructions? Life is much more complicated… you can't cover whole occupational safety with fire drills*		
Envisioning new ideas and committing to actions		*What we have to highlight is the safety plan, and practise it. This should be done often enough, as the boss said, at least twice a year* 1 2 *Easy instructions that include the most important information on safety – and a regular recap. We should have an A4 sheet in each school, which we could also give to substitutes* *We go along with Easy instructions* 5		4 *We should discuss why the people of our city are absent for xx days, on average. We should discuss these serious occupational safety questions, at least sometimes. Not just falling trains with chlorine loads or things like that.*

5. Conclusions

In this study, we examined whether a CW encouraged participants to create a shared view of changing work and OSH challenges, as well as to design proactive safety management practices to respond to these challenges. Our analysis showed that during the process, the CW participants reached a joint understanding of OSH challenges, e.g. the mental workload arising from the complex work situations and multiple networks (Safety-II, see Hollnagel 2014), and illustrated the limitations of current Safety-I based OSH management practices, which mainly focused on eliminating or reducing risks in the work environment through instructions and standards (Hollnagel 2014). However, during the second session, the discussion turned to envisioning new kind of proactive collaboration patterns and their benefits, which would concretize the Safety-II paradigm in daily safety management practices. Nevertheless, the deepening of this idea of a proactive collaboration pattern did not continue during the third session, in

which discussion turned to strengthening the current Safety-I based practices. In addition, developmental experiments, easy instructions and a safety walk, followed the idea of Safety-I, even if the sufficiency of such simple models and instructions were questioned. However, the CW process did enhance the idea of the collective nature of OSH management: during the first session, maintaining safety was seen as the personal responsibility and ability of individual teachers, whereas during the third session OSH activities, instructions and practices and their use were expressed as a collective effort of the work community.

The finding that collaborative work in a CW did not lead to Safety-II solutions might stem from the prevailing tradition of OSH tools and activities, and the CW with its first three sessions might be too short a process to change the prevailing culture (see Schein 1990). In practice, decision-making in safety issues is often fragmented; and the practices and tools for maintaining OSH focus traditionally on the work environment and physical safety. During the CW process, there were a few examples of the holistic view of OSH required by Safety-II. Deepening this holistic view of safety management, and enhancing novel solutions for diverse challenging work situations requires new arenas for collaboration among OSH practitioners, HR, managers and employees (Antonsen 2009), and needs to be studied further.

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Development of an online course "Work and Technology on Human Terms"

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Prevent has collaborated with five Swedish universities of technology to produce an online course in human factors engineering, ergonomics, work science and related subjects. The online course could serve as a pedagogic tool to attract more students to the subject, not only in engineering university programs, but also in economics and human relations programs. In addition to these primary target groups, professionals with an equivalent university education can study the course. The online course is free of charge and in English comprising 14 chapters as well as four workplace cases. It is available in August 2017 at www.onhumanterms.org. The user is free to start and finish the online course independently of others and comprises totally approximately 20 hours of study. The user will get a certificate after finishing the complete course including self-correcting knowledge tests.

Keywords: MOOC, MassiveOpenOnlineCourse, Ergonomics, Work environment, Human-Technology-Organisation

1. Background and purpose

The universities of technology in Sweden offer basic courses in human factors engineering, ergonomics, work science and related subjects. The aim of the courses is for the students to acquire knowledge and skills so that in their future positions, as product developers, production engineers, human factors engineers, managers or leaders, can design products and workplaces with human abilities and limitations in mind.

Prevent has collaborated with five Swedish universities of technology to produce an online course, or what is referred to as a MOOC (Massive Open Online Course) based on the existing textbook "Work and Technology on Human Terms" (Bohgard et al., 2015)

An online course is always available, and opens up other educational opportunities compared to a traditional textbook or lecture format as well. The dual purpose of producing an online course is thus to try to enhance the interest of existing traditional university courses in the subject, while also could be a way to create new courses. The online

course could serve as a pedagogic tool to attract more students to the subject, not only in engineering university programs, but also in economics and human relations programs. The labour market partners also consider online courses to be an appropriate tool for professionals for the purpose of enhancing their skills in work science and human factors engineering.

The purpose of this paper is to describe the development process and the overall content of the online course: Work and technology on human terms.

1.1 MOOCs

For many years, universities in many countries have been offering Massive Open Online Courses (MOOCs) that are freely available over the Internet and on a variety of web portals. One of the more successful portals is www.edx.org, with over 10 million registered users from all over the world. In January 2016, UKÄ (the Swedish Higher Education Authority) presented a report (Karlroth et al., 2016) commissioned by the Swedish government detailing how it views this form of education. UKÄ's proposed to the authorities that MOOCs should be included in the Swedish University system. The motivation for their recommendation was "among other things, that the courses create new opportunities for reaching out to large groups in society with knowledge offerings, and that they can help address major societal challenges". Furthermore, UKÄ highlighted "several benefits to the technology and teaching method, particularly in conjunction with local seminars and local exams". In the report, UKÄ also suggested that the government should appropriate funds expressly for the development of MOOCs.

1.2 Target group and appeal

The developed online course is primarily aimed and adapted to university students who are pursuing degrees in engineering, economics or human relations. It is also aimed at students in the medical field (e.g. physiotherapists and occupational health professionals). In addition to these primary target groups, professionals with an equivalent university education can study the course. Also, it should be possible for universities, with the help of the online course, to more easily offer on-demand training aimed at corporate clients.

1.3 Learning objectives

The learning objectives of the online course is formulated as follows for the student:
Once you have completed the entire online course, the objective is for you:

- to be able to explain the significance of human abilities and limitations – i.e. our abilities and limitations as physically labouring, thinking and collaborating beings – when interacting with technical products, technical systems, other humans, groups of people and organisations.
- to have the ability to conduct basic assessments of how different types of influencing factors present in the work done by humans – both individual factors and complexes of factors – affect health and performance.
- to be able to explain basic principles governing the design of human-machine systems, and principles governing work organisation for the purpose of minimising risks to life and health, and in order to promote health and performance.

- to be able to explain principles governing how regulations, legislation and economic policy affect health, performance and efficiency, and the way in which good working conditions are both a part of and interact with other elements of sustainable development.
- to be able, in a given business case, to apply the above knowledge to the design of technical products, technical systems and organisations for the purpose of promoting health and performance.

2. Method and approach for development

Production of the online course was organised in the form of a development project managed by Prevent, together with a producer of online courses serving on a central project committee. The project organisation had five subprojects with approximately 30 direct members (Figure 1). Each subproject had a representative in the central project committee for the purpose of coordinating the activities across the various subprojects. In addition, four reference groups were set up for the purpose of gathering viewpoints on the content of the online course. The groups included labour market partners, lecturers from the areas of economics and human relations, students and professionals.

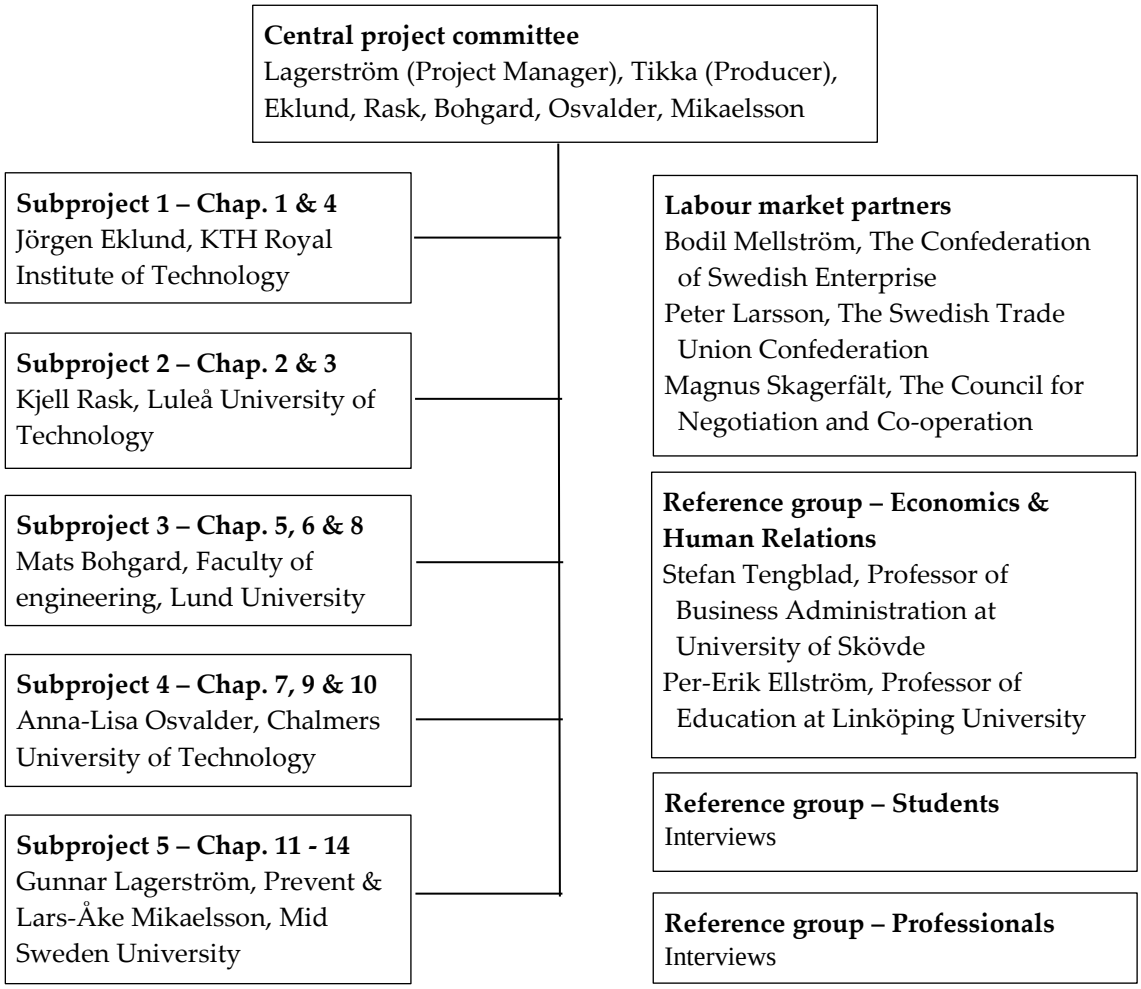


Figure 1. Organisation of the online course development

The project was implemented in four, partly parallel, phases; 1) Needs analysis and design, 2) Script, 3) Production (filming, illustration, animation and assembly), and 4) Implementation with ongoing reconciliation and continuous testing.

2.1 Pilot study

A pilot study was performed before the project started. The purpose of the pilot study was to define the target group, learning objectives, as well as the content, format and future use of the course. This was done in collaboration between participating universities and Prevent's clients. The pilot study also included work to outline a suitable project organisation. During the pilot study, a number of strategic choices also took shape with regard to the online course's design, technology and distribution.

2.2 Procurement, financing and cooperation agreement

A request for quotation was sent to three online course suppliers on the basis of the pilot study, and CleverLearning was chosen as the supplier of the online course. In parallel with the procurement process, a collaboration agreement was drawn up between Chalmers University of Technology in Göteborg, Faculty of Engineering at Lund University, KTH Royal Institute of Technology in Stockholm, Luleå University of Technology and Prevent.

A project description was formulated for the decision on financing and the project started early 2016. The direct production cost for the online course was financed by Prevent via a grant from AFA Insurance while university faculty participants contributed in the form of time spent.

2.3 Phases 1 and 2 - Needs analysis, design and script

The development project was divided into four phases (Figures 2 and 3). Phases 1 and 2 were planned out at a start-up meeting in April 2016. The design and script were elaborated by a small three-person group from CleverLearning together with the subprojects. Project groups ranging from 3 to 8 people were formed at the universities in each subproject (Figure 1).

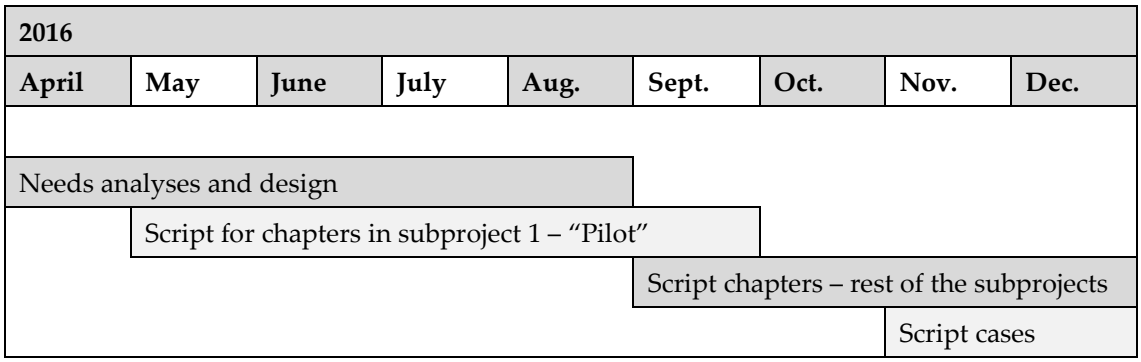


Figure 2. Time schedule phase 1 & 2

The needs analysis was conducted primarily during the pilot study, but was supplemented by a few interviews with students and professionals. Guidelines were drawn governing the online course's graphic design, as were illustration style guidelines, etc.

The chapter scripts emerged over the course of a total of six meetings in each subproject, with continuous reconciliation in the central project group for the sake of uniformity between the various subproject scripts. The case manuscripts were developed in iterations, primarily with the central project group.

2.4 Phase 3 and 4 - Implementation and continuous testing

The work by the subprojects changed in phases 3 and 4. From intense engagement with the scripts, now the work was to make contacts with researchers and companies for the interviews and documentary clips to be filmed. The contacts were handed over to CleverLearning to facilitate film shoot planning. At the start of phase 3, the universities reviewed the English translations of the scripts, and then went on to review the illustrations, animations, and final cuts of the films as they were produced, culminating with a review of the completed chapters.

CleverLearning scaled up its organisation with multiple translators, two speakers, two illustrators, four animators, one filmmaker, two film editors and programmers for the LMS (Learning Management System is a software for the administration, tracking progress and reporting of online courses.). Detailed planning was handled by a production/recording director, while the scriptwriters switched over to the role of reviewing what was being produced. There were a total of 35 recording sessions involving over 60 people (researchers, lecturers, employees, managers, project leaders, safety representatives, union representatives etc.) at around 10 different locations around Sweden.

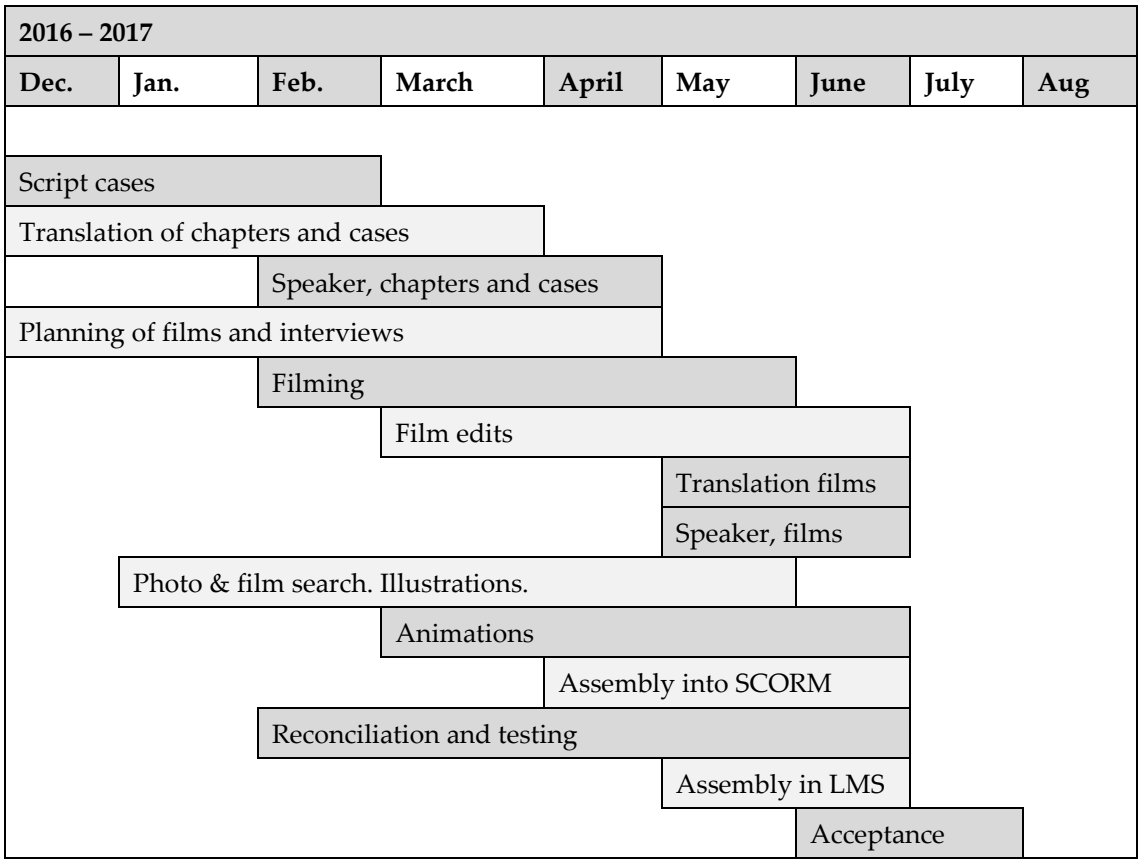


Figure 3. Time schedule phase 3 & 4

In addition, Prevent set up the operating environment with the help of its IT operations provider. In order to ensure undisturbed operation, two separate servers were installed to run the LMS and the online course. Because the online course contains a lot of film footage, good server performance is a must, with an option for continuous extensibility to handle a growing number of users.

2.5 Strategic choices in the production process

In addition to the standards governing appropriate project management, the choices outlined below were made with regard to project design.

- A traditional waterfall model was used for the implementation. It was broken up into four overlapping phases, yet with an iterative approach being used in each phase. Scripts were iterated in phase 2, while illustrations and animations were iterated in phase 3. The advantage of this approach was that the work meetings could be planned out far in advance, including the meetings in the central project, for the sake of smooth coordination, simplicity and clarity within the project. This was thought necessary in such a large-scale production project, both in terms of the number of people involved and the content itself.
- The waterfall model also created the prerequisites needed to concentrate on e.g. translations, animations and film shoots for a briefer amount of time, which led to more cost-effective production compared to project work organised on a wholly iterative basis. At the same time, the work on the scripts became quite abstract; that is to say, it was somewhat difficult, based on the text of the script, to imagine the visual appearance of the sections included in the chapters, as well as the learning flow. Because of this, a few changes were also implemented at a relatively late and costly stage of production, which required adjustments to text, speech and animations.
- The script was written in Swedish and was translated into English by a professional translator once the Swedish script was complete. This meant it was possible to speak and compose in Swedish during the work meetings; it facilitated composition and communication, as nearly everyone involved in the project was a native Swedish speaker.
- Some of the scriptwriting was carried out in the form of a pilot project (subproject 1, Figure 1) in order to gather insights and to develop the scriptwriting process for subsequent subprojects.

3. Results

The outcome of the project is an online course in English comprising 14 chapters and four workplace cases. It is available in August 2017 at www.onhumanterms.org.
The content of the course is as follows:

Introduction

Chapter 1 – Designing work and technology on human terms

Psychosocial and organisational work environment

Chapter 2 – Psychosocial work environment
Chapter 3 – The organisation of production and work

Physical work environment

Chapter 4 – Physical load
Chapter 5 – Physical factors
Chapter 6 – Chemical health risks in working life

Information and interaction in technical systems

Chapter 7 – Human-machine systems
Chapter 8 – Safety and risk

Methods and development processes

Chapter 9 – Methods
Chapter 10 – Development processes

Economic and legal conditions

Chapter 11 – Occupational injuries
Chapter 12 – Work environment and economics
Chapter 13 – Work environment legislation
Chapter 14 – Standardisation

Four workplace cases for real-world knowledge application

Case 1 – The IT company
Case 2 – The construction company
Case 3 – The home care company
Case 4 – The food company

The content consists of a mixture of photos, illustrations, animations, filmed interviews and documentary clips, along with knowledge tests (Figures 4 - 8). There is also an English speaker, and everything is subtitled in English. The textbook "Work and Technology on Human Terms" (Boghard et al., 2015) is also included as an PDF-document as additional study material. In total, it takes approximately 20 hours to study the whole online course.



Figure 4. Animation of an accident from the online course.



Figure 5. Company report (AstraZeneca) from the online course.

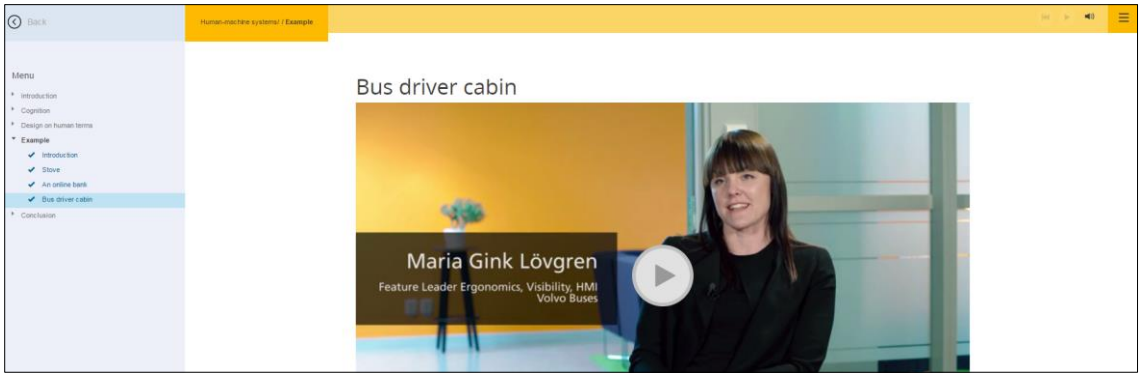


Figure 6. Interview (interaction designer at Volvo) from the online course.

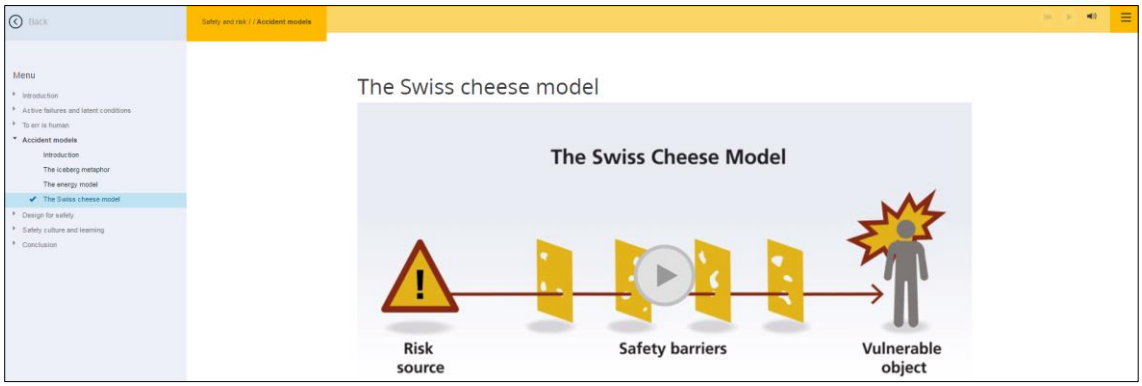


Figure 7. Animation of a theoretical model from the online course.



Figure 8. Interview (Professor and researcher) from the online course.

3.1 Strategic choices – online course design

- The online course is held in English and is based on the textbook "Work and Technology on Human Terms" (Bohgard et al., 2015).
- Theory and theoretical models are presented using animations supported by interviews with experts and researchers active in the various disciplines in order to maintain a high level of credibility.
- The content is closely linked to the situation on the ground in different types of businesses, as reflected by company reports and interviews with product developers, managers and other professionals. This was done in order to highlight the relevance of the content and to increase user comprehension of when and how the knowledge can be applied.
- In addition to the 14 theoretical chapters, the online course incorporates four workplace case studies that let the user apply the course's factual components and their new knowledge.
- The user is free to start and finish the online course independently of others.
- The online course has no chat feature or other social media component. This decision was based on a desire to avoid time-consuming manual teacher feedback and the work required to filter out inappropriate content.
- After finalizing the online course the student receives a certificate based on the knowledge tests completed.
- Universities should be able to use the entire online course or selected parts of it as a training component in their various courses. The online course can also be supplemented with e.g. additional theory, laboratory exercises, real life workplace visits, and additional examination, which together then can yield university credits.

3.2 Strategic choices - technology and distribution

- The online course was designed primarily for use on a computer, but it can also be used on tablets and mobile phones in a responsive interface. The aim is to achieve a high degree of availability on the users' various devices.
- The online course is provided via a website with its own domain name on the Internet; it was produced according to the SCORM standard (Sharable Content Object Reference Model is a collection of standards and specifications for web-based electronic educational technology), with presentation and administration in what is referred to as an LMS. A decision was taken to provide the online course this way instead of through a MOOC portal. It is likely that the online course would be more widely disseminated, had it been distributed through a well-known portal like edx.org. Yet the choice of platform secured a higher degree of freedom and pedagogical latitude in the actual design of the online course. Edx.org also charged a relatively high admission fee to its portal, and required that multiple online courses should be produced.
- The wish is for the online course to be used the world over. In Sweden this should be possible to accomplish through the Swedish universities and through Prevent's clients, i.e. the labour market parties.
- Communication initiatives to ensure widespread adoption fall outside the auspices of this project and will be organised separately.

3.3 Usage

The online course is available on line free of charge and the student can start and stop the online course independently of other students. It also includes self-correcting knowledge tests.

The universities and others are free to use the entire online course or to choose parts of it as a teaching aid in their own courses, supplemented with e.g. laboratory exercises and case studies.

The intention is for the course to be of use globally. The aim is for the course to contribute toward the development of safer and healthier workplaces as well as maintaining high organisational performance, so that people are able not only to maintain good health during their working lives, but to retire in good health as well.

4. Participants in the project

In addition to the central project group, the subproject managers and reference groups specified in Figure 1, the following people participated in the project in the different subprojects.

Subproject 1

Berglund, Martina, Linköping University; Hägg, Göran, KTH Royal Institute of Technology; Karltun, Anette, Jönköping University; Karltun, Johan. Jönköping University.

Subproject 2

Abrahamsson, Lena; Johansson, Jan. Luleå University of Technology.

Subproject 3

Akselsson, Roland; Blomé, Mikael; Borell, Jonas; Ek, Åsa; Hemphälä, Hillevi; Isaxon, Christina; Kuklane, Kalev. Faculty of Engineering, Lund University.

Subproject 4

Bligård, Lars-Ola; Simonsen, Eva. Chalmers University of Technology.

Subproject 5

Johrén, Anders, Nyckeltalsinstitutet; Mikaelsson, Lars-Åke, Mid Sweden University.

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2) Kahlroth, M et al. (2016). *Öppna nätbaserade kurser (MOOCs) i svensk högskola, Redovisning av ett regeringsuppdrag.* Stockholm: The Swedish Higher Education Authority (In Swedish).

Informal caregivers' perceptions of their physical load issues and safety

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This is a study based on survey questions about physical load and insecurity issues. The Internet-based survey consisted of nine open-ended questions on both mental and physical well-being. The survey was distributed through the channels of the Central Association of Caregivers in Finland. Altogether, 154 respondents answered the survey. The focus in this study is on the questions that concern physical load issues and safety. The answers were divided into specific themes by applying open coding by the researchers. The results show that caregivers face situations where they feel insecure and have physical vulnerabilities.

Keywords: Informal caregiver, well-being, physical health, physical load; safety; insecurity

1. Introduction

The terms *informal caregiver*, *family carer* and *caregiver* can be used synonymously; in this study the term *informal caregiver* and *caregiver* are used. In the European Union, there are an estimated 100–125 million informal caregivers. It is estimated that, in Europe, 75% of long-term care is supplied by relatives and loved ones (Eurofound 2009). In Finland, there are approximately 60,000 informal caregivers (Central Association of Carers in Finland 2017).

The International Alliance of Carer Organizations (2017) defines an informal caregiver as an unpaid individual, such as a parent or family member, who cares for, and attends to the needs of, a child or dependent adult. Caring can be defined in different ways, such as hours spent per week, types of activities performed or duration of the care period. Informal caregivers' roles differ depending on the condition of the person being cared for (Arksey and Corden 2009). Low level caring is mainly companionship, with some caring assistance. Medium level caring includes doing chores like cooking, shopping, housework and driving and some personal assistance with washing, dressing, lifting or use of the toilet. High level caring includes all of the above and the care receiver cannot be of much or any assistance to the caregiver. (Arksey and Corden 2009, Carers Association of Ireland 2009, Glendinning et al. 2009)

There are also 'sandwich' caregivers, which means those with a responsibility for both childcare and care of a disabled or older person (Eurofound 2009).

In the literature, it has been stated that informal caregivers feel their health is worse compared to that of other people. It has been noticed internationally that physical health most probably weakens after the first year of being an informal caregiver (Hirst 2004). Informal caregivers also have relatively high depression, backache and anxiety level. Being an informal caregiver subjects one to stress, to emotional tiredness and to social withdrawal. (Care Alliance Ireland 2008) In an Irish study over half of the respondents stated that they were both mentally and physically exhausted. More than half of the interviewees had physical problems and over half said that they also had mental problems, such as anxiety (Carers Association of Ireland and the Irish College of Psychiatrists 2009). Obesity, overuse of alcohol and smoking are more general to the informal caregivers than to other people (Hoffman and Mendez-Luck 2011). Many have neither the possibility nor the time for a social life or hobbies (Carers Association of Ireland 2008). The risk of poverty is greater for informal caregivers than for others (Colombo et al. 2011). This may be caused by, for example, care receiver's treatment costs, resigning from work or by the insufficiency of support (Carers UK 2011).

Half of the informal caregivers who participated in a Scottish study said that their health problems (such as the backaches and shoulder pains, stress, depression and anxiety) had begun while being a caregiver. One fourth of the ones who had health problems before becoming an informal caregiver said their health had got worse after starting to be a caregiver. On the other hand, the same study stated that those who had been caregivers more than ten years most probably had fewer health problems than those who had been informal caregivers for a short time. The informal caregivers may either adapt to the situations or they get support after having been a caregiver for a longer time. (Carers Scotland 2011) Also, an Irish study supports the thought that the health problems are not caused by being an informal caregiver as such, but rather depend on the intensity of the care, the care receiver's state of health, the caregiver's personality and the support the caregiver receives (McRae et al. 1999).

Safety means freedom of injury or danger, a state of being safe. Occupational Safety and Health Act in Finland contains the working environmental factors, such as ergonomics and physical, mental and social loading. (Ministry of Social Affairs and Health 2002) In this study the term '*safety*' covers parts of the holistic view of informal caregivers' circumstances, e.g. physical load issues and insecurities.

In this study, the aim is to further deepen the knowledge of informal caregivers' everyday life and the situations they confront. The main interest of the survey is to get information about the well-being and safety of caregivers and to get information so as to innovate good practices to improve the quality of life of informal caregivers. Specifically, the aim is to answer three research questions (RQ):

RQ1: Do caregivers feel insecure and if they do, in what situations?

RQ2: What kinds of effects does being a caregiver have on caregivers' health?

RQ3: What kinds of differences can be identified between different groups, for example, between children's and spouses' caregivers?

2. Methods and materials

2.1 Data collection methods

The survey consisted of nine open-ended questions on both mental and physical well-being. The Internet-based survey was distributed through the channels of the Central Association of Caregivers in Finland.

Due to the nature of the distribution channels of the survey, it is not possible to say for sure what the response rate was. However, as an indication, the Central Association of Caregivers in Finland has approximately 2,000 followers of their social media site and the survey was there. Altogether, 154 respondents answered the survey.

2.2 Material

Altogether, 154 respondents answered the survey. 91% (140) of the respondents were women and 9% (14) were men. Overall 84 (54.5%) of the respondents were a child's caregiver, 47 (30.5%) were a spouse's caregiver, 11 (7.1%) were a parent's caregiver and 12 (7.8%) were caregivers for others (for example, for a sibling or aunt). The respondents' age distribution is shown in Table 1. One respondent did not supply information about his age. The average age for the whole group was 50.3 years. Of the respondents, 75 (48.7%) had been caregivers for less than five years, 44 (28.6%) for five to ten years and 34 (22.1%) for over ten years. The average time as a caregiver was 8.1 years.

Table 1. Respondents' age distribution in years (with percentage of sample in brackets).

<25	25–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80
2 (1.3)	7 (4.5)	18 (11.7)	16 (10.4)	23 (15.0)	11 (7.1)	19 (12.3)	18 (11.7)	13 (8.4)	14 (9.1)	7 (4.5)	2 (1.3)	3 (1.9)

2.3 Data analysis

This study is based on open-ended answers; therefore, its nature is qualitative and interpretative. Nonetheless, the researchers were able to categorise answers into specific themes during the analysis phase, which provided a basis for quantitative analyses.

The analysis of the open answers was conducted by applying open coding in order to categorize identified development needs (Järvinen 2004). During the analysis, the researchers first read through the answers and sketched different themes from the answers. Prior to the second analysis round, the researchers formed final themes from the sketches. Each respondent may have described one or more situations in their answers. The chain analysis method was applied in order to demonstrate the answers (see Klen and Väyrynen, 1983, 1984).

A Chi square test with IBM SPSS 24 was used to test whether there were significant differences between groups. In the analysis the answers that did not contain background information were ignored. The level of statistical significance was defined as $p < 0.05$ (see Yates, Moore and McGabe, 1999).

3. Results

Each open-ended answer was analysed separately and a certain theme or themes were identified to fit the answer. For example, the answer "My back is painful, my hands are snapping, occasionally my knee gives way and once or twice my glasses have flown from my head" for the question "Have you hurt yourself physically while acting as a caregiver? How?" fits for the themes *back issues*, *upper limb issues* and *others*.

3.1 Caregivers' feelings of insecurity (RQ1)

The caregivers answered the question "Tell us about a situation in which you had a feeling of insecurity". Five situations were identified from the answers. 71.4% (N = 110) of the respondents had felt insecurity and 26.0% (N = 40) described two or more situations in their answers. Only 17.5% (N = 27) had not felt insecurity and 11.0% (N = 17) did not answer. Figure 1 shows the situations in which respondents felt insecurity and what combined situations caregivers faced. The leftmost column shows the number of occurrences of the situation and the lines to the columns to the right show how many caregivers had more than one situations in their answers. The combined situations are counted only once. For example, "Threatened by care receiver" in the leftmost column does not have lines to the columns to the right because the combined situations are already shown.

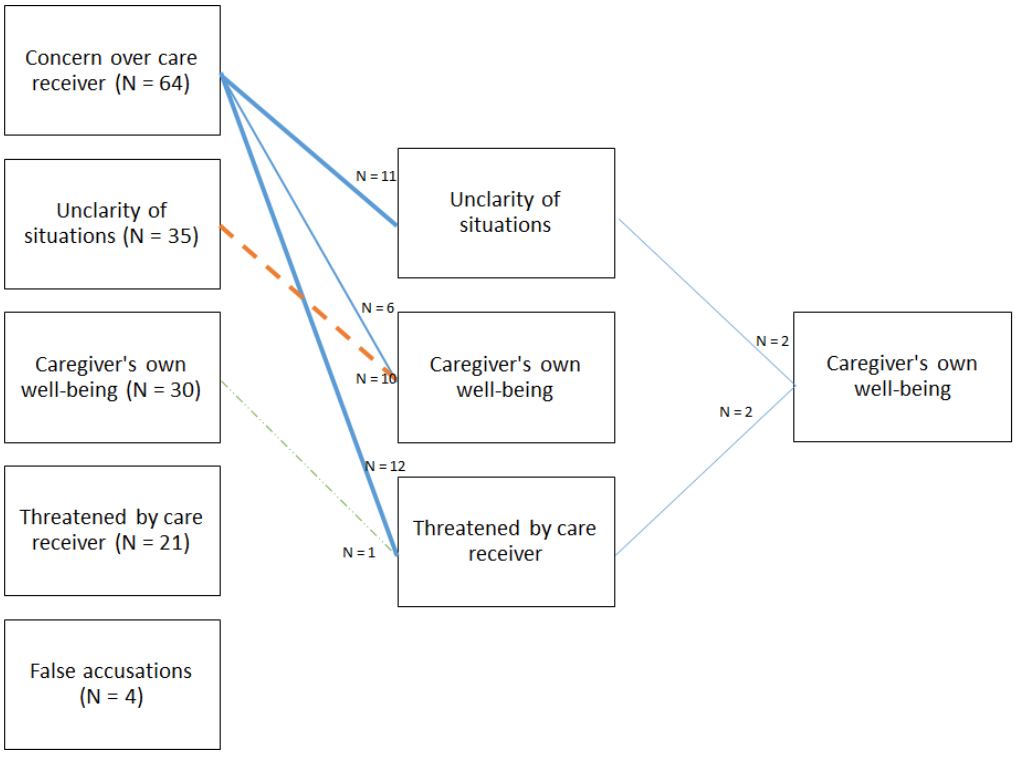


Figure 1. The situations in which respondents felt insecurity and what combined situations they faced

3.2 What kinds of effects being a caregiver had on caregivers' health (RQ2)

The caregivers answered the questions "Have you hurt yourself physically while acting as a caregiver? How?" and "Has your health worsened while being a caregiver? How?" For the first question, five issue types were identified from the answers. Overall, 51.9% (N = 80) had not hurt themselves physically, but 42.2% (N = 65) had indeed hurt themselves and 10.4% (N = 16) described two or more issues in their answers. Figure 2 shows how the respondents had hurt themselves and what combined situations caregivers faced. The leftmost column shows the number of occurrences of the issue and the lines to the columns to the right show how many caregivers had more than one issue in their answers. The combined situations were counted only once. For example, "Others" in the leftmost column does not have lines to the columns to the right because the combined situations are already shown.

For the question "Has your health worsened while being a caregiver? How?", six themes were identified from the answers. As seen in Figure 3, most of the caregivers, 76.0% (N = 117), felt that their physical health had worsened while being a caregiver. In total, 22.1% (N = 34) felt that their health had not worsened.

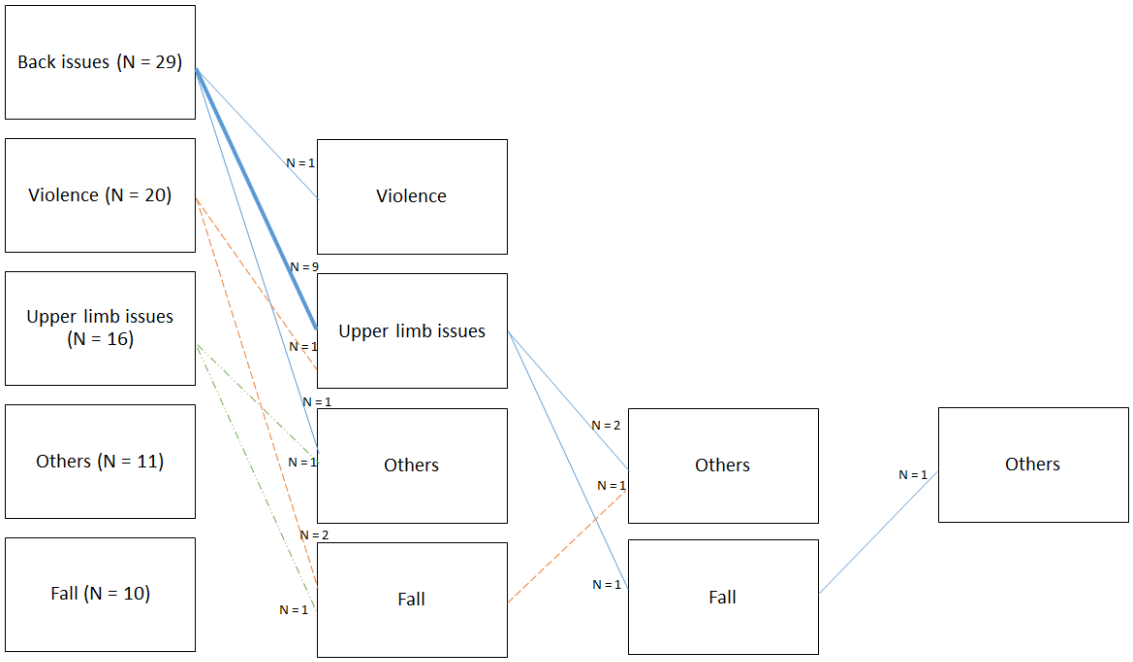


Figure 2. How respondents hurt themselves and what combined situations they faced

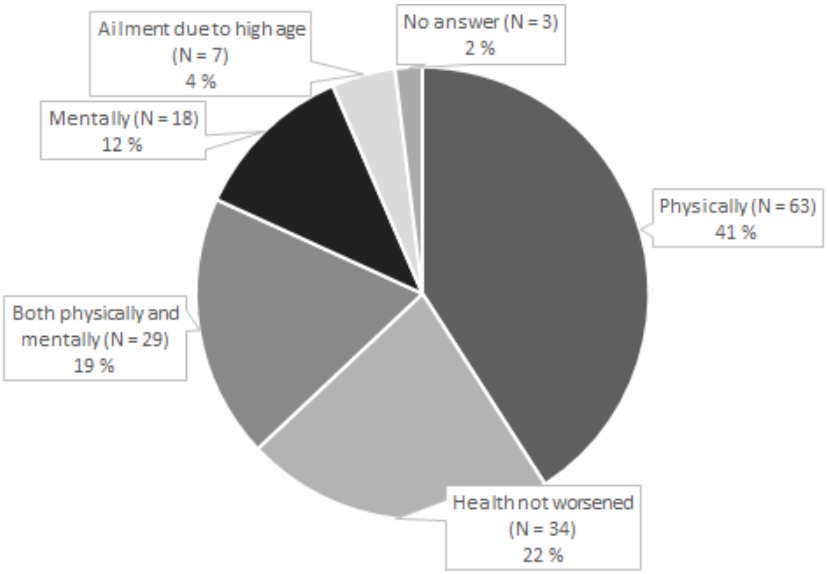


Figure 3. Answer distribution as a percentage to the question "Has your health worsened while being a caregiver? How?" (N = 154)

3.3 Differences identified between different groups (RQ3)

The researchers studied differences between children's caregivers (N = 84) and spouses' caregivers (N = 47) and differences between those who had been caregivers for less than five years (N = 75), for five to ten years (N = 44) and for over ten years (N = 34). It was not meaningful to study differences between age groups because the number of answers with certain ages was too low.

After performing Chi square tests for every question, the researchers found only one statistically significance difference between the groups. The significant difference is between children's and spouses' caregivers' answers for the question "Have you hurt yourself physically while acting as a caregiver?", $X^2(1, N = 124) = 3.591$, $p = 0.047$. It seems that children's caregivers have hurt themselves more often. The answer distribution is shown in Figure 4.

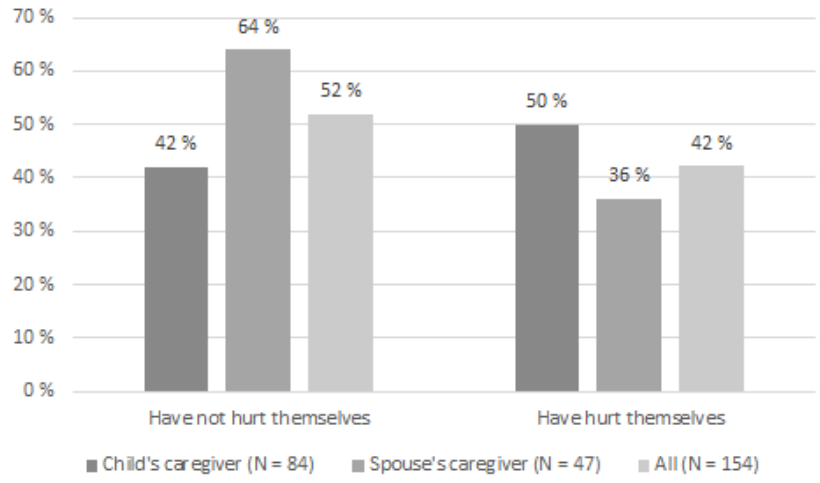


Figure 4. Answer distribution of children's caregivers (N = 84) and spouses' caregivers (N = 47) for the question "Have you hurt yourself physically while acting as a caregiver?"

4. Limitations

As emphasised by Sinclair (1991), there are certain problems related to questionnaires. An open-ended question provides an opportunity for various kinds of answers and the interpretation of the answers can be challenging.

The benefits of using a questionnaire are its effectiveness, the manageability of the answers and the consistency of the questions—they are the same for everybody. On the other hand, it is unknown how seriously the respondents took the questions, or if the respondents misunderstood something; slight variations in the words used in a questionnaire or the context of a question can affect the results (Järvinen 2004; Strauss and Corbin 1998). The same principles apply when a researcher is analysing the answers; they can misunderstand the answers or variations in words used in the answers and that can affect the analysis and the results.

5. Discussion and conclusions

Although the number of respondents to the survey was rather low, the results support earlier international findings (see e.g. Hirst 2004, Care Alliance Ireland 2008, Carers Association of Ireland and the Irish College of Psychiatrists 2009, Carers Scotland 2011). In this survey, it has been demonstrated that caregivers' safety is not guaranteed; they are in situations in which they feel insecure and have physical vulnerabilities. From the answers can be seen that 71.4% (N = 110) of the respondents had felt insecurity, 42.2% (N = 65) have hurt themselves physically in some way, and 76.0% (N = 117) felt that their health had worsened while being an informal caregiver.

Further research could study whether caregivers' negative feelings, physical insecurities and issues are correlated. Furthermore, the kinds of issues caregivers face have been widely studied internationally, but support tools and methods to improve caregivers' personal health and coping are not as well-known and have not been studied as deeply as their issues. This study's follow-up research will focus on constructing those support tools and methods.

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How to not run into a wall: A comparative experiment of Movement in Virtual Reality

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Recent technical developments have resulted in the increased use of Virtual Reality and Head Mounted Displays (HMDs) for entertainment and industrial purposes (Bengtson, Borsos, & Krupenia, 2017). A persistent problem associated with the use of HMDs for VR is that when moving within a virtual environment, the user can experience motion sickness and disorientation resulting in reduced ease of use or efficiency. The purpose of the current research was to establish which movement-based design principle(s) is/are best suited for a virtual environment. Three movement techniques were implemented and tested; a fading teleport, a drag/floating movement, and a hybrid concept. Of interest were motion sickness, disorientation, ease of use, and efficiency. Results indicated that the fading teleport technique best supported ease of use and also reduced disorientation. Further investigation into the teleportation technique and how it can be further improved is suggested.

Keywords: Virtual reality, interaction, movement, teleportation, computer- and systems science, disorientation

1. Introduction

Over the last few years, Virtual Reality (VR) has increased in popularity and usability. According to (Statista, n.d.) a 3000 percent increase from VR software revenue is expected in the coming four years. Despite this increasing popularity, numerous studies suggests that head-mounted VR displays can induce motion sickness and disorientation (Akiduki et al., 2003; Bakker et al., 2003; Hironori et al., 2005; Regan, 1995). Motion sickness and disorientation are especially prominent when moving inside a virtual environment (Bowman et al., 1997). The physical world space limitation when moving over larger areas in a virtual environment adds complexity to the issue, and therefore, almost all VR applications need some sort of movement/teleportation function. Moving through space at a quicker pace then what can be achieved in the physical world can induce motion sickness (So et al., 2001), while teleporting can cause disorientation (Bakker et al., 2003). This study was conducted in collaboration with Scania CV AB, an Original Equipment Manufacturer of premium trucks and busses who were seeking to extend the VR capability to support product development. In the current manuscript, we describe, compare and evaluate three movement techniques on their effect on motion sickness, disorientation, ease of use, and efficiency.

2. Background

Virtual Reality technology and its applications has rapidly evolved. Due to the flexibility and (relative) low cost of VR technology (compared to using the actual system of interest), it was originally developed for educational purposes in specific domains, for example, flight simulators, space simulators, and simulated medical environments. More recently, the technology was adopted for the entertainment, and industrial product development.

Despite the cost and flexibility advantages of VR, too often there is insufficient consideration for how people interact in virtual environments. Specifically, with VR technology, despite high levels of visual and auditory realism, the ability to naturally move in the virtual environment is significantly impaired. Although early VR systems afforded little-to-no opportunities for movement, today it is possible to walk while wearing a VR headset. There is however, a physical space constraint, users will eventually collide with a physical object (or move outside the tracking range). Therefore, to support more naturalistic movement in VR new ways of manoeuvring were required. If the movement technique has been poorly implemented, then the user can experience significant motion sickness and disorientation.

Motion sickness is a broad term used to define symptoms shared by many applications (car sickness, sea sickness, and simulator sickness). Motion sickness is triggered by the vestibular system when there exists a mismatch between what is felt and seen. Physical symptoms include one or more of the following: paleness of the skin, nausea, vomiting, cold sweating and headaches (Oman, 1990; Treisman, 1977).

Disorientation refers to the inability to correctly locate oneself in space. Several studies suggest that HMDs can cause disorientation. Sharples and colleagues (2008) reported that participants experienced an elevated sensation of disorientation after interacting in VR. Similarly, Darken and Siberts (1996) concluded that test participants, when exposed to a large virtual environment, were unable to complete their tasks and were easily disoriented. This research suggests that disorientation can emerge through the mere presence of a virtual environment. Although no movement was required in these experiments Bowman and colleagues (1997) identified teleportation in VR as a source of disorientation. Bowman and colleagues also reported that a difference in velocity in relation to the teleportation did not create any significant difference in the user's experience of disorientation. However, at very high velocities, participants reported increased disorientation. Riecke and colleagues (2002) attempted to reduce disorientation by providing participants with a longer, more gentle, VR familiarization period. This appeared an effective way of introducing participants to VR, and ensuring sufficient time to become comfortable with VR.

3. Methodology

Prior to the user study, existing VR movement techniques were benchmarked. A summary of these results were presented at a workshop involving Scania's Interaction Design group. An example result from this workshop was that the concept technique should consist of two techniques, inviting the user to choose which ever technique she saw fitted best. The information gathered from these two events guided the development of three movement techniques. The techniques were evaluated by twenty-four Scania employees (average age = 30.36 years, range = 25-48, SD=5.61).

3.1. Apparatus

This study was conducted using Unreal Engine 4 as the simulation platform. The scenarios were build using the UE4 development environment. The simulation was driven by an Intel core i5 processor and a NVidia GTX 1080 graphics card. Participants interacted in the VR using an HTC Vive.

3.2. Design

The user study was a 3x2 within-between design. As mention, three Movement Techniques were used (Drag, Teleport, Concept). To reduce the amount of time each participant was exposed to VR (and thus reduce the probability of motion sickness), a between subjects design was selected for Movement Technique, such that each participant completed the scenarios using one of the three techniques. However, because the effect of movement technique on disorientation and motion sickness may be influenced by task complexity, two Scenarios were created (Short, Long). Scenario was a within subject factor such that each participant completed both the Short and Long scenario. Of interest were four dependent variables: subjective motion sickness, objective disorientation, objective efficiency, and the subjective and objective ease of use of the three concepts.

3.3. Movement Techniques

For all three techniques, effort was made to reduce the effect of motion sickness.

Drag/Floating technique (Drag).

The drag/floating technique was based on the idea that the user shall be present at all times. With this technique, the user mimics "flying" through the world while standing still in the physical world. The user is thus aware of their surroundings and disorientated should be limited. The user is, however, susceptible to motion sickness. This technique may not always be the most suitable technique, especially when covering larger areas, since a faster movement speed results in a higher chance of motion sickness (So et al., 2001). As suggested by Lin et al. (2002), a larger field of view increases susceptibility to motion sickness, therefore the drag/floating technique narrows the vision, creating a tunnel-like view, reducing peripheral visual movement. Kolasinski (1995) argued that altitude is one of the greatest factors for simulator sickness. The further up the user is the less the movement will be felt. Consequently, for Drag, the user was elevated compared to Teleport and Concept. The reasoning behind this is that Drag is the only technique where the user truly experiences the movement. Despite making effort to reduce motion sickness for Drag, it is important to note that this is the only concept for which the participant stands still during VR movement (a potentially motion-sickness inducing factor).

Fading teleportation technique (Teleport).

Teleport was based on the idea that the user teleports, or "jumps", to the destination. By not having to experience moving through the world the user avoids being exposed to motion sickness. However, this jumping could increase the likelihood disorientation because it may be difficult to predict the visual features at the movement destination. Teleporting could yield more efficient results when traveling longer distances but may not always be the easiest to use, especially when precision is required.

Concept technique (Concept).
The concept technique builds on a combination of previous studies and considers previous successful VR movement techniques. The goal of the concept was to try and combine different techniques and to create a more versatile and practical technique. Concept consisted of a blinking teleport function and a swimming/zooming function. The blinking teleport function pushes the user forward so that they can experience the movement. O'Luanaigh (2015) argued that if a movement is done in under 100ms, the motion will not be recognized by the user, thus not resulting in any motion sickness. Therefore, the blinking teleport is always performed at under 100ms. The swimming/zooming function is intended to support navigation around smaller spaces. The way the function works is that the user moves both hands apart from each other and by doing so creating a gap in between. The wider the gap the faster the user moves. To reduce motion sickness, the maximum speed a user can travel is set to a fast walking pace. With this function the user can control how fast they want to go as well as experience the movement so that no disorientation can occur. The function also implements the tunnel-vision used in the drag/floating technique.

3.4. Scenarios

Movement Techniques were tested in two different scenarios, Short and Long that were counterbalanced across participants.
Short scenario.
In this scenario, participants were equipped with a laser beam on the left-hand controller. The scenario consisted of a circular area with two large pillars, one red and one green. When starting the simulation, a smaller pillar appeared somewhere in the area on which was a large hole. The participant was required to move to the pillar (via their movement technique), and insert the laser beam into the hole. When completed, that pillar disappeared and a new pillar appeared in a new location. This is repeated for a total of five pillars. The participant then transported themselves to end location.
Long scenario.
This scenario consists of a maze, with one red pillar located at the start and one green pillar located at the end. The participant moved (via their movement technique) through the maze. They continued to move until a message appeared on the screen saying "Movement is locked". The participant was required to aim their right-hand controller at the position that they believe the red pillar was located. Neither the red pillar nor the green pillar was visible inside the maze. This was completed three times at three different maze locations.

3.5. Dependent measures

To assess susceptibility to motion sickness, the Motion Sickness Susceptibility Questionnaire (MSSQ; Golding, 1998) was used. To assess motion sickness experienced during the study, the Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Bermaum, & Lilienthal, 1993) was used. To assess ease of use, the System Usability Scale (SUS) was used. Disorientation was only measured in the Long scenario via the angular displacement between the participants assumed position of the red pillar compared to the actual position. To assess Efficiency, the time to complete scenarios was recorded together with the total distance travelled.

3.6. Procedure

The participant was greeted and provided with an information and consent sheet. When signed, participants were given a demographics questionnaire and the MSSQ. Next, information about their specific movement technique was given. Finally, information about the scenarios and the tasks were provided. When ready, participants was equipped with the head-mounted display (HMD) and given the hand controllers. Participants then entered a generic virtual environment and were encouraged practice the movement technique. When participant were comfortable moving around, they were placed in the chosen scenario. The information about the task was then repeated, and when the participant was ready, the test started. Following completion of the first scenario, SSQ was answered. The second scenario was then completed followed by the second SSQ and the SUS. Finally, participants were thanked for their participation and encouraged to ask questions about the experience.

4. Results

A summary of the results is shown in Table 1.

	Motion Sickness	*Disorientation*	*Ease of use*	*Efficiency - Time*	*Efficiency - Distance*
Drag	1,5 (M) 3,1(SD)	36,2(M) 13,2(SD)	79,0(M) 9,7(SD)	97,6(M) 13,8(SD)	200,7(M) 13,6(SD)
Teleport	-1,1(M) 1,7(SD)	16,2(M) 14,1(SD)	82,5(M) 8,0(SD)	103,9(M) 24,3(SD)	182,7(M) 9,7(SD)
Concept	-,6(M) 2,1(SD)	23,6(M) 16,8(SD)	68,4(M) 13,4(SD)	102,6(M) 29,5(SD)	191,5(M) 22,1(SD)

Table 1 – Mean (M) and Standard Deviation (SD) results for Drag, Teleport, Concept Technique conditions on Motion Sickness (SSQ raw score), Disorientation (Degrees), Ease of use (System Usability Score raw score), Efficiency (seconds, meters).

4.1. Motion Sickness

Motion sickness was assessed using the difference scores between the two SSQs responses. If the participant felt that symptoms of simulator sickness had increased between the two times the questionnaire was answered, then the mean score [*see (M) in Table 1]* would increase, and vice versa. There was a marginally significant effect of Technique on Motion Sickness, $F(2, 21) = 2.616$, $p < 0.097$. No significant follow up comparisons were observed, however, the marginally significant value is likely influenced primarily by the difference between Drag and Teleport ($p = 0.103$), where Drag appeared to be more motion sickness inducing than Teleport. Participants who used Drag, answered on the SSQ, that the motion sickness had increased compared to the other techniques between the first and second SSQs.

4.2. Disorientation

The mean average angle measured from the three attempts from all participants was between 0 – 180 degrees [*see (M) in Table 1]*. Overall, there was a significant effect of Technique on the angles measured, $F(2, 21) = 3.713$, $p < 0.042$. Specifically, it was

observed that Teleport had the best precision, and was significantly more precise than Drag ($p < .035$) but was no different to Concept ($p = 0.585$). There was no significance between the Drag and the Concept technique ($p = 0.230$). The average angle for the Teleport was 16° while the Drag had 36°, suggesting that participants using Drag were more than double the amount of degrees off from the red pillar compared to the participants using Teleport.

4.3. Ease of use

Ease of use was measured using the SUS. The mean average of the total sum of the score can fall between 0 – 100 [*see (M) in Table 1]*. Overall, there was a significant effect of Technique on SUS score, $F(2, 21) = 3.784$, $p < .039$. Specifically, it was observed that Teleport received a significantly higher score than Concept ($p < .039$) but not than Drag ($p = 0.797$). There was no significance between the Drag and Concept ($p = 0.138$).

4.4. Efficiency

These results are based on the time for completion and distance travelled. The time for completion was measured in seconds. The mean average is the combined time for completion in both the short and long scenario for all participants. There was no effect of Technique on time completion $F(2, 21) = 0.158$, $p = 0.855$. The distance travelled was measured in meters. The mean average is the combined distance for all participants for each technique in the short scenario [*see (M) in Table 1]*. There was no significant effect of Technique on distance travelled $F(2, 21) = 2.525$, $p = 0.104$.

5. Discussion

Out of the four dependent variables measured, significant differences were observed for two; Disorientation and Ease of Use.

5.1. Motion Sickness

Consistent with the expectations only a marginally significant effect of Technique on Motion Sickness was observed. Even if the result for motion sickness, and more specifically for Drag, was not significant, it could be argued that Drag may be the more motion sickness inducing techniques. The reason for this trend is that the Drag was the only one where movement was experienced. The Drag technique was implemented with an attempt to reduce motion sickness susceptibility resulting in certain movement types being removed. During the benchmarking it was noted that the movements that felt worst in relation to motion sickness were when the user moved left and right in relation to where they were pointing. This feature was removed for Drag due to this reason, a movement technique was not allowed to induce motion sickness. This could be viewed as the drag/floating technique as not a viable movement technique, since it already has been stripped of most of it features, and to add more flexibility could cause more motion sickness, which was not acceptable.

5.2. Disorientation

Data from the Disorientation measures suggested that Teleport was the least disorientating technique. However, Teleport was only significantly less disorientating compared to Drag with no difference existing between Teleport and Concept. One possible reason for why (at least) Teleport had a significantly less disorienting impact

on the participant compared to Drag could be due to the complexity of the technique itself. Given that Teleport scored highest on the SUS, it could be considered that Teleport was the easiest to use. Furthermore, it was observed that Teleport required less effort and less steps to perform the tasks compared to Drag. For Drag more arm movements were required to move forward, which also had to be repeated more times compared to Teleport for equal distance gained. All of this adds complexity, when at the same time faced with a task that needed to be completed for a successful scenario there is a possibility that it overwhelmed the user, thus increasing disorientation.

5.3. Ease of Use

The results suggested that Teleport was the most appreciated movement technique. Score from the SUS reveal that Teleport received a score of 82 out of 100, significantly higher than Concept (68). This result might derive from the fact that Concept involves two types of movement. Participant were required to learn two different ways of moving. Compared to Teleport, where the participant only had to learn one way of moving, with Concept, there are more features for the participant to consider. This might be account for the ease of use results; the more details and factors to consider the more difficult the technique is to use. This, in extension, can be discussed in regards to VR experience. Most participants in this experiment had little previous experience of VR (less than 1 hour). Therefore, participants needed time to feel comfortable using the VR equipment and to learn how to manoeuvre using the movement technique. If participants had more VR experience they may have performed better with the seemingly more difficult movement technique. When experiencing virtual reality for the first time, most users concentrate on getting to know the environment, and getting used to the hand controllers. Of course, when using Concept, there are more buttons to use and, therefore, more things to consider. If the user is already familiar with VR and the HTC controllers, this would arguably help participants understand the movement technique faster.

5.4. Efficiency

The data resulting from time to complete and distance travelled were not significant and no conclusions can made from this data.

5.5. Limitations

During the experiment, it was clear that some participants using Teleport, were expressing an increased feeling disorientation compared to participants in other conditions. This contradicted the actual result. Two of the eight participants who used Teleport even went in the wrong direction at one point during the long scenario. This data was never captured or stored, no observations were made and no interviews afterwards were carried out. This would have been beneficial to prove that some participants' subjective opinion contradicted their actual results.

Another limitation could be that all participants were Scania employees (engineers or designers) having some form of higher education and fitting within a rather narrow age range. This of course narrows the sampling group, and in turn could have influenced the results. For example, we have not tested the movement techniques on younger persons or children, where the difference in physique and/or brain development between children and adults could have altered the results.

Finally, the movement techniques were both evaluated and tested on users where the mind-set was focused on work efficiency. This means that the results could be different for applications aimed towards entertainment purposes.

6. Conclusion

From this study, we observed that of the three movement techniques, Teleport is the movement technique that excels in comparison to the other two techniques. Even though there was no significant data in regards to motion sickness and efficiency, there is a clear indication that fading teleportation is the most successful movement technique of the three techniques tested. Both the discomfort aspect as well as the overall usability aspect pointed in favour of this technique.

An assumption can be made that the fading teleport technique is the best technique simply due to it being the easiest to use and the most basic technique. Information gathered from the participants showed that their experience with VR was little or close to none indicating that the fading teleport technique suits people with little experience of VR better and that other techniques may suit people with more experience better.

6.1. Future research

Data obtained in the current study suggests that further investigation into the teleport movement technique is warranted. There are many ways a teleport can be performed, in this study, for example, a fading teleport and a blinking teleport were used. Comparing the different ways a teleport can be implemented could potentially yield valuable results.

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Innovative Training Networks for Interactive E-Learning and Application of Ergonomics of the Remote Evaluation of the Grafts in Organ Transplantation

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Innovative Networks for Computer Assisted Collaborative E-Learning technology, method, clinical and training standards analysis referring to specialists in Organ Transplantation (OT) for training in the ergonomics of the remote evaluation of the grafts and in the pre- and post- grafting and pre-transplant decision making and planning with a prospect to integrate Big Data analytics and computing to reduce the damaged organs and optimize quality in OT.

Keywords: Transplantation, Remote Evaluation of Grafts, Collaborative Learning

1.Introduction

Traditionally, the provided training in Organ Transplantation (OT) focuses on the technical knowledge, skills and abilities to complete specific tasks as they relate to specialty responsibilities (Forshythe 2009). However there has been a shift in this traditional pattern of training as the need emerged to focus also on the holistic development of the professional. In fact the professional development has been a reflection of the overall change in educational distribution throughout the workforce (Schwarz and Asterhan 2011, Martorell et.al.,2014).

Over the past seven years the major data that have contributed to the growth of this participative, on-line training and collaborative work sharing in OT are related to the emergence of the new type of OT that of Uterus Transplant (UT) (Brännström et.al.2015) and mainly to the Professor's P. Friend lecture according to which the 8% of the liver (LG), the 14% of the pancreas (PG), the 11% of the renal (RG), and the 10% of the lung grafts (LnG) (the same percentage is expected for the Heart (HG)) arrived at the recipient hospitals in the UK in 2010 and after benching considered damaged, improper for transplantation or needed an intervention (Friend 2010).

The percentages considered high and with tremendous healthcare, socio-economic, working and social consequences which are expected to multiply in other countries. Also, based on the fact that surgical damage during retrieval or bench preparation is a potentially avoidable event, which can often be salvaged by high technology combining tele-communication (TC), improved imaging, tele-visualization, tele-conference, tele-consultation and tele-mentoring among coordinators, surgeons, radiologists, pathologists, cytologists, microbiologists, specialist physicians, immunologists, biologists (Mammas et.al.,2001,Krupinski 2014). All can be implemented in the Innovative Networks for Computer Assisted

Collaborative E-Learning and E-Training (INFCACE-L,E-T) which are the most advanced versions of computer assisted learning systems (Schwarz and Asterhan 2011, Mammas et.al.,2011) .

2.Objectives

The project analyzes the technology, the clinical and training standards and the evaluation of (INFCACE-L,E-T) for the remote, specialized, multidisciplinary and personalized evaluation of the Grafts using Prometheus(pn 2003016) (Mammas et.al. 2011, Mammas 2012, Mammas 2013) technology, method and standards, as applied in the clinical trial between the Aretaieion University Hospital of Athens and the Hippocrateion University Hospital of Thessaloniki on 28.06.2016 (IKY Excellence - SIEMENS program).

In this trial the team members and individuals registered in the following site www.prbite.wordpress.com and actively implemented the best practices, high technology and geographic and timing strategies for pre- and post-grafting remote evaluation of the grafts and decision support and making, to reduce the damaged and diseased organs and improve outcomes in Liver (LT), Pancreas(PT), Renal (RT), Heart (HT), Lung (LnT) and UT transplant by pre-transplant operative planning.

3.Design/Method

The experimental (INFCACE-L,E-T) technology, process, service and standards processed in a procurement phase based transplant scenario in the experimental trial applying TC in the Coordination Process (CP), Tele-radiology (TRE),Tele-pathology (TPE), Tele-cytology(TCE), Tele-microbiology(TME),Tele-genetic biology TGBE) for the remote evaluation of the grafts between the donor hospital (DH) and the Recipient Hospital (RH) on 28.06.2016.

Experimentation included a:The development of an Experimental type of Prometheus (pn 2003016), the Exp.-TS (Table 1.) (Karavatselou et al. 2001, Mammas et.al.2001), b: TC among DH, National Transplant Organization (NTO) and RH based coordinators and completion and transference of the medical record of the deceased donor on the electronic space of Prometheus(pn 2003016), c: Prometheus (pn 2003016) based retrospective and Real Time Projection (RTP) and TC, TRE and TPE (including TCE and TME) of the grafts in the DH from specialists based in the RH or else, assessing the diagnostic accuracy of injury-trauma, infection or cancer of the grafts (Morgan 2001, Fonyard et.al.2012, Allen 2014, Coiera 2015, Mammas 2012, Mammas 2016, Mammas 2017).

According to the didactic transplant scenario the potential donor was a young woman of 20 years old who was the victim of a severe accident three days ago. Her brain death had been confirmed by a neurologist and her family has consented for multi-organ donation. As far as the experimental process is concerned seven participants (n=7 specialists: n1=Surgeon of the Grafting Team, n2=Transplant Surgeon, n3=Radiologist, n4=Pathologist, n5=Cytologist, n6=Microbiologist, n7=Cardiologist) allocated in different points which connected remotely in the internet and participated in a clinical simulating process (Hubert and Bergin 2008, Mammas 2012,2013,2015,2016,2017). The (INFCACE-L,E-T) using Prometheus technology, method and architecture in the procurement phase of OT, can be seen as

a triangle (including the donor, the coordinator and the surgeon) as the didactic base for remote evaluation of the donor and the abdominal and thoracic grafts for pre-grafting and pre-transplant instant decision making and preoperative planning from the part of the participants located in the DH and in the RH who continuously interact to implement the clinical and training standards (Schwarz and Asterhan 2011,Mammas 2012,2013,2015,2016,2017).

The experimentation started from the department of Pathology of Aretaieion University Hospital which simulated the DH and the Hippocrateion University Hospital which simulated the RH on 28.06.2016 (13.00-14.30) on the innovative networks (Cloud) and realized the (INFCACE-L,E-T) simulating the CP of OT and the remote macro- and micro- evaluation (TRE, TPE,TCE and TME) of LG,RG,PG,UG,HG,LnG among departments (Figure 1.).

Table 1: Comparison of Modules between OTE-TS and the PROMETHEUS based Exp.-TS

MODULES	OTE-TS	PROMETHEUS based Exp.-TS
Medical record process	+	+
Examinations results	+	+
Capture/ imaging.	+	+
DICOM and PACS	+	+
Real-time tele-conference	+	+
Chat and whiteboard	+	+
Tele-secretary facilities	+	+
Tele-Mentoring facilities	+	+
Telecommunication net	ISDN based	Internet based
Virtual Slide integration	-	+
Cloud	-	+
Big Data Analytics	-	+

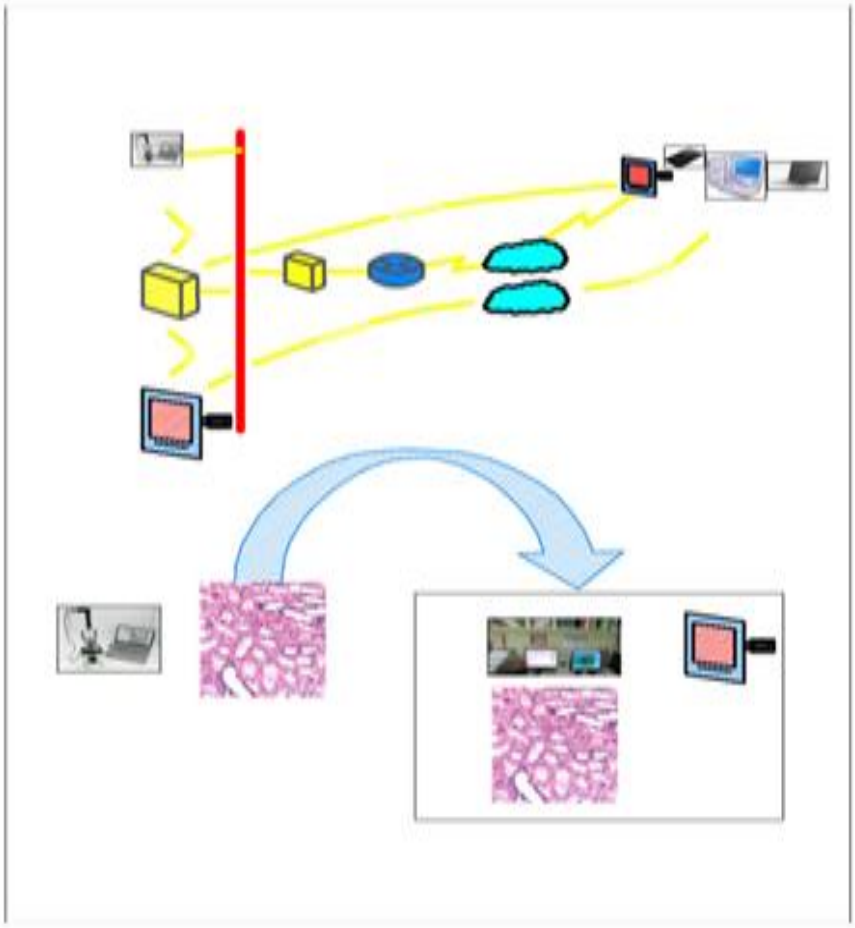


Figure 1: The pre-grafting TC and TRE of the grafts before grafting projected directly from the DH PACS (yellow box behind the red wall) to the RH radiologist for remote diagnosis of the Grafts' lesions (inflammation, infection, neoplasms) and for anatomic variation classification. The pre-grafting TCE and TME and the post-grafting TPE for microscopic diagnosis on the Exp.-TS (blue and red box behind the red wall) of the UG between the Grafting Team in the Donor Hospital (DH-in the beginning of the blue arrow) and the Transplant Team in the Recipient Hospital (RH-in the end of the blue arrow) on the Exp.-TS dynamically (RTP) and for TPE of the Renal and Liver Biopsies of the donor also as DH RTP to the RH.

3.1.DH-NTO: Donation referral and donor management, NTO-RH:Selection of a possible recipient from the recipient list, DH-RH:Coordination about donation and donor-recipient matching

Multi-visceral organ donors require a greater degree of scrutiny than isolated kidney, liver or heart donors. As such, specific criteria associated with the donor case may affect the ultimate outcome of the intervention. Coordinators in the RH were announced the donation and they communicated with coordinators in the NTO. Applying the standard criteria the NTO coordinator suggested a list of possible recipient or recipients in the RH. The donor-recipient matching of the ABO grouping and tissue typing for HLA match with T- and B-cell cross-matches-defined compatibility (Forsythe 2009, Mammas 2011)(figure 2.).

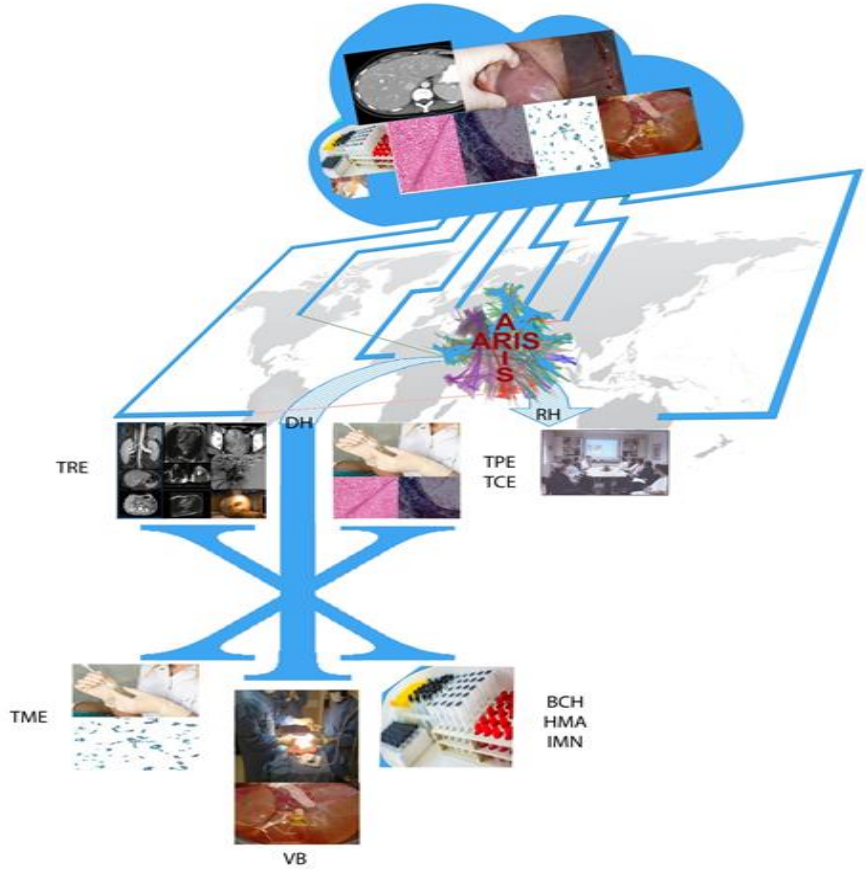


Figure 2. According to the experimental protocol the transplant coordinators, the grafting and transplant surgeons and the specialists doctors divided in two main experimental groups allocated in the DH (Aretaieion University Hospital of Athens) and the RH (Hippocrateion University Hospital of Thessaloniki) while five additional points referred to the cooperated departments where specialists cooperated prospectively or retrospectively for remote diagnostics and consultation (**Point 1**=Aretaieion University Hospital of Athens, Department of Pathology as DH, **Point 2**=Hippocrateion University Hospital of Thessaloniki as RH, Department of Immunology for CP on HMA,BCH,IMN, **Point 3**=Medical School of Athens, Department of Pathology for TPE, **Point 4**=Eugenideion University Hospital of Athens, Department of Radiology for TRE, **Point 5**=Hippocrateion University Hospital of Thessaloniki, Department of Microbiology for TME, **Point 6=**A Department of Cardiology in the RH, **Point 7**=A Department of Cytology simulated the department of cytology in the RH for TCE. The tests and consultations completed as part of the medical record for the remote donor evaluation before donation. The donor-recipient matching of the ABO grouping and tissue typing for HLA match with T- and B-cell cross-matches-which were negative- defined compatibility. Finally coordinators found the possible recipients in the list who undergo a thorough evaluation in order to determine their candidacy for organ. The donor-recipient matching of the ABO grouping and tissue typing for HLA match with T- and B-cell cross-matches-which were negative- defined compatibility and the coordinator's reports about each graft projected for the DH to the RH is as follows**: *Heart Donation:***The routine examinations in the evaluation of the cardiac donor included an ECG and an echocardiogram. Also the CPK iso-enzymes are depicted. Cardiac catheterization with coronary angiography is not included because the donor is under 45 years. Instead we performed CT Angiography. The hemodynamic monitoring profile of the heart donor for the monitoring of cardiac output is included..***Lung Donation:***The potential donor didn't suffer from any chronic pulmonary disease such as chronic obstructive pulmonary disease or asthma requiring multiple medications. On the other hand he was routinely examined with arterial blood gases, a chest X-ray film, Chest CT angiography and O2 challenge. In regards to O2, we used a cutoff of PO2>100mmHg on 40% inspired O2. We didn't notice any pulmonary contusion by chest film neither pulmonary edema which didn't clear with the volume restriction and diuresis. Among the respiratory parameters were the peak ventilator pressures were acceptable, as we didn't find any high peak pulmonary pressures, neither poor response to O2 challenge. **Liver Donation:***For the evaluation of the possible Liver donor our biochemical examination included Hepatic enzymes, including AST and ALT, as well as GGT, alkaline phosphatase, bilirubin and prothrombin time. The enzymes were not elevated. The coagulation time showed an elevated prothrombin time, however, this considered as a result of his brain injury.**Renal Donation:***The Renal evaluation*

included serum creatinine and urea and measurement of urine output. Also included an one hour creatinine clearance which is normal. An elevated creatinine declined during resuscitation and didn't preclude renal recovery. However, CT scan showed and anatomic mal-position and ischemia of the left kidney which was confirmed with the angiography. The latter showed a restriction in the left renal artery. That is why the left kidney is precluded from recovery and grafting. Given the abnormality in the left renal artery the renal biopsy of the left kidney is indicated. The CT scan showed that there is no doubt about the donor's right kidney suitability given that a portal mass is probably cystic. However right renal biopsy is also indicated. ***Pancreas Donation:****According to the preoperative hematologic, biochemical and radiological evaluation of the pancreas graft of the young and healthy non-diabetic donor have to be intact for donation.****Uterus Donation:****Cusco's speculum was introduced intra vaginally and then vaginal material was obtained from the posterior fornix with a sterile swab stick for 1) Wet mount-with normal saline and 10% of KOH 2) Whiff test 3) Gram stain. The donor's possible pathology is expected to be classified into four categories on the basis of vaginal macroscopic and microscopic discharge characteristics upon remote gross pathology with Prometheus pn:20130100325 digital camera and microscopic diagnosis using a gram stained anatomic section.* According to experimentation coordinators had completed all questionnaires and forms referring to the deceased donor medical record on the electronic space of Prometheus(pn 2003016) for the CP: **a.** Consenting the deceased donor family: **b.** Management of the donor, **c.** Organ distribution, **d.** Organ retrieval and about **e.**Notification and maintenance of medical records for intermediation between: i. cooperated specialists and the surgical teams, ii. the grafting team in the DH and the transplant team in the RH. 4.7.**The Coordinator's report based on immunologic (IMN), biochemical (BCH) and hematologic (HMA) analysis of the donor from the DH is as follows:** *There is no evidence of malignancy, HIV, hepatitis B or C, No history of intravenous drug abuse or other high-risk behavior, neither significant severe medical problem. With regard to the* ***kidneys and the pancreas*** *there is no history of renal disease, long-standing hypertension, or diabetes the serum creatinine within normal limits on admission and the cold ischemia time < 40 hours. As far as the* ***liver donation*** *is concerned, there is no history of liver diseases or major alcohol abuse, the Serum sodium < 160 and the Cold ischemia time < 16 hours, although there was a Mild steatosis depicted by the abdominal ultrasound and the liver function tests are normal. Regarding* ***the heart*** *there is no history of coronary artery or valvular disease, neither prolonged cardiac arrest, no ECG changes and no conduction abnormalities, the Inotropic requirements dopamine < 15μgkg-1min-1 the Mean arterial pressure > 60mmHg, the CVP & PCWP < 12mmHg. As far as the* ***lung donation*** *is concerned there is no contradiction about the donation according to the aforementioned criteria. In the same context the donor evaluated with Pap-test for health assessment of her uterus for the prospect of* ***Uterus donation*** *and transplant. A vaginal smear collected and two anatomic sections prepared for microscopic examination of Pap-test and Gram stain remote microbiologic examination and consultation about the donor and decision making in the uterus transplant.* Also, activated and intermediated: **f.** TRE of the organs (kidney, liver, pancreas, heart, lung, uterus) from the DH, between radiologists and the grafting team before grafting, and **g.**TRE, TPE, TCE and TME of the grafts between the grafting team and the transplant team, after grafting. Additionally and based on TRE, TPE, TCE and TME, coordinators facilitated the **h.** Final decision making about sending the retrieved and evaluated organs to the RH or not, elaborating mutually by the grafting and the transplant team and the **j.** Final pre-transplant implantation planning elaborated remotely by the transplant team.All data can be projected in the Cloud for static or RTP management by the Aris IBM Hyper-computer for Big Data analytics and computing.

4.Results

4.1.The pre-grafting TRE of donor's grafts between DH and grafting team in RH

Pre-grafting RTP TRE of the donor between DH and RH initiated with an evaluation of the remote examiner's satisfaction level for TRE . The cooperated radiologist in the RH assessed remotely the projected series of the upper abdomen and thoracic CT scan and the lower abdomen MRI scan images of the donor commenting as follows (Mammas 2016): ***CT abdomen:*** *As a possible stenosis of the left kidney noticed in the CT scan, the donor examined by a CT Angiography. The CT Renal Angiography of the donor showed that she had two kidneys and they are normal in size. There are two arteries coming from one root in the left kidney and an auxiliary renal artery sourced from the aorta as well. No double ureters neither horeshoe, nor hypoplastic, nor aplastic disease of any of the two kidneys are noticed. However the left kidney needs to be biopsied as the left renal artery seems to be stenosed with a stricture in the renal portal area.* ***CT Thorax:*** *No pulmonary contusion was noticed in the chest CT except from a pulmonary edema (collection of fluids) of 3cm length at maximum in the left hemi-thorax. Normal depiction of the great vessels. No lymph-*

nodes were noticed either. ***MRI of upper abdomen:*** *Anatomic mal-position and ischemia of the left kidney. The latter showed a restriction in the left renal artery. Given the abnormality in the left renal artery CT angiography and renal biopsy of the left kidney is indicated. A cyst of maximum diameter is located in the lower lobe of the left kidney of a maximum diameter of 7cm. A mass of maximum diameter of 3.5cm noticed in the right renal portal. A hepatic cyst of 5cm diameter located on the left lobe of the liver. No abnormalities noticed in the examination of pancreas. No lymph-nodes in the retroperitoneal space neither ascetic liquid in the abdomen. No anatomic variations of the vessels noticed either.****MRI of lower abdomen:*** *There are no abnormalities in the examined uterus. A benign cyst in the left ovary of a maximum diameter of 2cm identified.*

4.2.The Macro- and Microscopic pre-grafting TPE of the donor's grafts

Pre-grafting RTP TRE of the donor between DH and RH drove the grafting team from the recipient hospital to exclude the left kidney from recovery and grafting and to concentrate on a left and right renal biopsy and plan a direct right renal excision as well as a hepatic cyst biopsy, hepatectomy and pancreatectomy.

The pathologist's report of the donor's biopsies in the RH -prepared and projected from the DH to the RH- is as follows (Mammas 2016): ***Right renal biopsy:****We can see the cortex of a normal kidney. We can see the various types of tubules- proximal tubules and distal tubules. There is absolutely no fibrosis and the epithelial line of the tubule has no damage at all. Furthermore there is absence of any lymphocytic infiltrate. The mass is a cystic mass non malignant.* ***Left renal biopsy:****There is evident fibrosis in the inters tissue, there is ischemic damage to the glomeruli whereas there is also some damage in the urinal tubules. We can see them being cystically dilated.* ***Liver biopsy:****This is liver parenchyma, we can see some degree of fibrosis in the form of a septum with a number of lymphocytes which separate the liver sinusoids and the liver parenchyma. This degree of fibrosis is not a contradiction for transplantation. It may be considered as approvable.*

4.3.The pre-grafting TCE of donor's grafts

The pre-grafting retrospective RTP TCE for microscopic diagnosis of inflammatory or neoplastic lesions of the vagina of the uterus graft between the DH and the RH over the Electronic Space of Prometheus in the context of clinical experimentation on 28.06.2016 applied retrospectively using the data and the results of the clinical experimentation with RTP that took place between Aretaieion University Hospital and the Agios Savvas Anticancer Hospital on 22.10.2015 (Mammas 2015). The cytologist's report is as follows: *The vagina of the uterus graft of the donor is free of pre-cancerous lessions.*

4.4.The pre-grafting TME of the donor's grafts

The process of the remote evaluation of the uterus graft for TCE of the PAP test of the vagina included pre-grafting RTP TME of the collected vaginal smear stained with gram stain. The remote multidisciplinary, specialized and personalized microbiological diagnosis performed prospectively by a specialist Microbiologist located from the RH at the time of experimentation on 28.06.2016 (Mammas 2012, 2013, 2016). The microbiologist's report is as follows: *The vaginal smear stained with*

gram stain showed:Vaginitis (12-15 neutrophils). Further examinations of the examined vaginal smear of the donor (Chlamydia special test, Transaminase test, Cultivation of the vaginal smear) are indicated.

4.5.Post-grafting macro- and micro- TPE of the grafts between DH and RH

The grafting team performed left nephrectomy, hepatectomy, pancreatectomy and hysterectomy in the DH and prepared the grafts (Benching). According to the tele-pathology protocol the decision about sending the organs to the RH has to be a consensus after their mutual remote examination using Prometheus(pn 2003016) (Virtual Benching) (Mammas 2012).

In case of our experimentation the grafted left RG and the PG found to be transplantable by the transplant surgeon according to the conclusion of the ''virtual benching'' between Aretaieion University Hospital and Hippocrateion University Hospital of Thessaloniki on a Prometheus experimental prototype on 28.06.16 (Mammas 2016). *However the grafted liver found to suffer from a long (L=6cm) and deep (D=2cm) trauma parenchymal trauma on the lower surface of the right lobe (section V) probably attributed to the grafting operation which had been escaped inspection by the grafting team. The virtual benching between grafting and transplant team not only indicated the lesion of the liver graft but drove transplant surgeon to a significant preoperative decision about accepting the liver graft. The transplant surgeon in the RH finally decided to receive the liver graft because of the youth of the donor and under the prerequisite that he would manage the trauma using a biologic glue, as he underlined.*

According to the collected data the PG, LG, right RG and UG and HG, LnG of the donor harvested by the grafting team. However the virtual benching between the DH and RH on 28.06.2016, limited to the abdominal solid organs that the cooperating transplant surgeon was enough experienced (Abdominal OT). As abovementioned he was positive to receive the abdominal grafts for transplantation and only gave general guidance about HT, LnT and UT. For this reason another clinical, quantitative retrospective and prospective trial in (INFCACE-L,E-T) focused on thoracic grafts (HG and LnG) of the same transplant scenario two months later i.e. on 08.09.2016 and from 14.30 to 16.00p.m.

A consultant cardiologist participated remotely and simulated the specialist cardiologist in the RH on line and completing the heart and lung pre-grafting and post-grafting evaluation, decision support and making based on remote RTP US Cardiac and CT Thorax evaluation (Mammas 2016).

4.6.Heart and Lung pre-grafting and post-grafting TRE on 08.09.2016

The cooperated cardiologist assessed remotely the medical record and the results of the pre-grafting hematologic, biochemical and ECG examinations and mainly the dynamic US and the thoracic CT scan of the donor as projected from Prometheus (pn 2003016) from the DH with the following results (Mammas 2016): ***CT Thorax:*** *Collection of fluid on the left hemithorax on the CT.* ***US Cardiac:****The Echocardiography showed a LVEF > 50% and no wall motion abnormalities. Thus both the Heart and the Lungs of the donor considered as transplantable.* In the simulation of the post-grafting macro-TPE evaluation, the cardiologist projected the macroscopic images of the HG and LnG: *An injury on the pericardium of the Heart for which he consulted that it was repairable.*

When he was projected the LnG also consulted that they were transplantable. Regarding the impact of the fluid accumulation in the left hemithorax he said that it wouldn't have significant impact and that there was no contradiction for LT (figure 2.).

5.Discussion/Conclusion

Integrated TC, CP, TRE, TPE, TCE, TME and TGBE of solid abdominal and thoracic organs i.e. PG, LG, RG, HG, LnG and UG for minimization of their damage in OT and for pre- grafting and/or pre-transplant planning has shown high sensitivity, specificity and accuracy (ranging from 90% to 98%) in the remote diagnosis of infectious, inflammatory, neoplastic lesions which is the basis for (INFCACE-L,E-T) (Mammas 2016).Considering the abovementioned data and the results of experimentation on 28.06.16, the cooperated transplant surgeon confirmed the high feasibility, accuracy and dynamics of the analyzed (INFCACE-L,E-T) for training in the remote evaluation of the grafts (Mammas 2017).

Also attested its clinical usability and possible contribution in organ safety in OT. Commenting on the impact of the abovementioned training technology, method and standards on the rate of transplantations he added that probably it will increase the rate of transplantations. He underlined the significance of the clinical experience of the transplantation center to benefit from the (INFCACE-L,E-T) and optimize quality in OT (Mammas 2016). According to principles of systematic approach to training evaluation the objectives of training for quality should be derived from the hospitals involved in OT only through strategic quality planning. Also it should be conducted only after the hospitals involved in OT receiving it have deployed quality measurement system.

It worth underlying that (INFCACE-L,E-T) should be delivered on a prioritized basis such as that those hospitals involved in OT with direct effect on transplantation should receive training first (Schwarz and Asterhan 2011, Mammas 2016). Also, the cooperating microbiologist commented that both the applied TME and (INFCACE-L,E-T) were innovative and crucial in OT, found them very useful in Microbiology (Mammas 2016). The cooperator cardiologist underlined that the abovementioned technology, and process is useful for clinical micro-TPE and TCE, TME in HT and LnT. Among the limitations is the implementation of retrospective diagnosis for micro-TPE and TCE which doesn't coincide with reality in procurement phase of OT (Friend 2010). Also, it is the cardiologist's complementary evaluation in HT and LnT in a second trial.

Integration with ARIS-IBM Hyper-computer elaborates Big-Data analytics and computing in the (INFCACE-L,E-T) to: a.Minimize damaged or diseased grafts, b.Teach semantic technologies, c.Reduce time, cost and maximize outcome and enhance personalization in OT (Panahiazar et.al. 2014, Mammas 2016).

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Reliability of Applied Ergonomics of a New Mobile Clinical Unit for Remote, Specialized, Multidisciplinary and Personalized Service for Cancer and for Diabetes Related Complications Integrated Prevention, in Developing Countries

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Reliability analysis of applied ergonomics of the clinical operations with a new mobile clinical unit, tele-medicine and cloud based technology and method for remote, specialized, multidisciplinary, holistic and personalized process and service for general for cervical and breast cancer for women and prostate cancer for men and for special for diabetes related complications primary, secondary and tertiary prevention with an emphasis on diabetic foot and amputations in developing countries, are analysed on three dimensions: 1.Medical outcome (effectiveness), 2.Cost-benefit analysis of resources and 3.Fulfilment of the personalization issue.

Keywords: Mobile Clinical Unit, Tele-medicine, Prevention, Diabetic Foot

1.Introduction

In healthcare technologies, analytics and computations have the potential to create significant value by improving outcomes while lowering costs for each individual patient. In addition, preventing errors pre-emptively in machine assembly and field installation as well as in remote high volume information systems management seem to be the right ways to deal with such ergonomic complexities (Martorell et al., 2014 Human factors (HF) engineering is a discipline concerned with the design of tools, machines, and systems that take into account human capabilities, limitations, and characteristics (Krupinski, 2014). The impact of HF in terms of reliability analysis of the clinical operations of a new Mobile Clinical Unit (MCU) integrated for remote primary, secondary and tertiary general for cancer and diabetes related complications primary, secondary and tertiary prevention is the topic of our high technology operational and high demanding quality massive service for Greece and developing countries (DC).

2.Objectives

Reliability analysis of applied ergonomics of the clinical operations of a new MCU, tele-medicine and cloud based technology and method for remote, specialized, multidisciplinary, holistic and personalized technology, process and service integrated with Big Data analytics for remote mass health education and for general for cervical

and breast cancer for women and for prostate cancer for male population and for special for diabetes related complications with an emphasis on diabetic foot primary, secondary and tertiary prevention with an emphasis on diabetic foot and amputations in Greece.

3.Design/Method

A Hellenic epidemiological study that published by Laikon University Hospital of Athens (Tentolouris et al., 2012) showed that Type 2 diabetes mellitus is associated with obesity, smoking and low socioeconomic status in large and representative samples of rural, urban, and suburban adult Hellenic populations: Among the participants, 4269 (49%) were men and 4471 (51%) were women, while 31% were residents in urban, 34% in suburban, and 35% in rural areas. On the other hand it is well known that Breast Cancer (BC) is the first cancer in the female population and Cervical cancer (CC) is the second most common cancer world-wide and the leading cause of cancer related deaths among women in developing countries (DC) (Stewart and Wild, 2014). Prostate Cancer (PC) is one of the leading diseases in the male population.

Among aetiologies is the law percentage of women undertaking mammography and Pap-test respectively (Pap-test ranges from 5-10% of women and the lack of cytologists in DC). Also PC is increasing in male population because of the lack of life-long prevention. Thus, the problem for high quality primary, secondary and tertiary preventive services for both general diseases with an emphasis on cancer and special for diabetes related complications with an emphasis on diabetic foot and major amputations prevention, obesity and quit of smoking seems to be resolvable if analysed for reliability, maintainability and availability of remote, specialized, holistic, multidisciplinary and personalized technology, process and service perspective (Mammas et al., 2001, Pickwell et al., 2013).

Thus a novel mobile transportation unit (MTU) or mobile clinical unit (MCU) completed Prometheus I pn 1008239 digital medical device technology and method since 2013 (Kainotomeis.gr, 2014). Currently, the aforementioned solution has been empowered with Big Data analytics and computing for mass health education and screening for decision making from the centre to the periphery and if indicated for remote secondary and tertiary massive prevention from the periphery to connected tertiary hospitals in the centre not only for Greece but for DC as well (Mammas et al., 2016). The experimental process based on two partners (a non-specialist doctor or a nurse in the MCU in four places in the periphery of Hellas and a specialist doctor in the diabetic foot clinic (DFC).

The partners were linked with each other via an experimental private Cloud based tele-medicine network. Applying the aforementioned technology and method prospectively and retrospectively, specialists from the diabetic foot clinic examined the digital medical record enriched with digital photos of the diabetic foot and ulcers of the examined diabetics from August to September 2015. There were 50 participants (n=50), seven (n1=7) remote interventions -out of the 29 (n2=29) local clinical examinations- while four (n3=4) of the examined diabetics were in high risk for amputation or death.

3.1.Designing for Human factors: The remote, multidisciplinary, specialized and personalized primary, secondary and tertiary general and special for diabetes related complications prevention

By experimental simulation, the ergonomic impact of the electronic space (ES) for remote macro and micro examinations evaluated on a digital medical device PROMETHEUS I pn 1008239 (http://www.livemedia.gr/video/171480) as the experimentation material in terms of the ergonomics of Digital Macroscopy and Microscopy (DM) in Tele-medicine and Tele-pathology (TPE), in Tele-cytology (TCE) and Tele-microbiology (TME), for macroscopic and microscopic inflammatory, infectious and/or neoplastic lesions. Simulating experimentation included: a. The Development of an OTE-TS similar digital device (PROMETHEUS I pn 1008239) (Mammas et al., 2001, Karavatselou et al.,2001, Mammas, 2013) (Table 1.), b. Integration of the Exp.-TS with the VS for digitalization for TPE or TCE applying DM. (Table 1.), c. Simulation of static or dynamic TPE and TCE for microscopic diagnosis of inflammatory or neoplastic lesions (Coiera, 2015, Allen ,2014, Fónyad† et al.,2012) (Figure 1.).

Table 1: Comparison of the Modules between the OTE-TS and PROMETHEUS I

MODULES	OTE-TS	PROMETHEUS I
Medical record process	+	+
Examinations results.	+	+
Capture/ imaging.	+	+
DICOM and PACS	+	+
Real-time tele-conference	+	+
Chat and whiteboard	+	+
Application sharing.	+	+
Tele-secretary facilities.	+	+
Tele-Mentoring facilities	+	+
Telecommunication net	ISDN based	Internet based
Virtual Slide integration	-	+
Cloud	-	+
Big Data Analytics	-	+

3.2.Designing for Human factors: Applied ergonomics of the MCU based Specialized, Multidisciplinary, Holistic and Personalized Prevention Operation for diabetes related complications and for CC, BC and PC in Volos City, in Lafkos and in Milina Villages of Mountain Pelion in central Greece

The method of using an MCU to visit neglected populations for Specialized, Multidisciplinary, Holistic and Personalized mass Health Education and general primary, secondary and tertiary remote prevention with an emphasis on CC, BC and PC in the general population and for diabetes related complications education, primary, secondary and tertiary remote prevention processed, patented, presented, and published in 2013, in 2014, in 2015 (Mammas, 2013, Mammas, 2014, Mammas, 2015) and in 2016 (Mammas C.S. and Mamma A.S., 2016), while integration with Big Data analytics and computing published in 2016 (Mammas et al., 2016). Following the

aforementioned principles the personnel of the MCU travelled from Athens to the municipality of Magnesia in the Periphery of Thessalia, initially in the neighbourhood of Agioi Anargyroi in the City of Volos on 12.08.2015, then into Lafkos village on 14.08.2015 and into Milina village on 04.09.2015 both located in the southeast part of the mountain Pelion. Fifty (n=50) participants -who were located in four different rural places in Hellas-who, during the session, first under-took general related to their gender prevention guidance for cervical, breast and prostate cancer and then special for diabetes related complication primary prevention (diabetic foot, obesity, quit smoking, cardio-circulatory, ocular, neurologic, psychiatric) (Mammas C.S. and Mamma A.S., 2016).

Then only diabetics examined clinically and in case there was a high risk patient a telemedicine approach, applied. The majority of patients were pensioners (n4=23). The 60.0% of the participants were females. Only, 6.9% of women had ever undertaken Pap-test or mammography and only 22.0% had ever been subject of massive prevention. All participated in the general prevention session and about n2=29 were finally examined. Almost 50.0% of the participants were diabetics and the 65.5% of them were females. The mean age of the patients was 65.9y. Ergonomics analysed on three dimensions: 1.the medical outcome, 2. The cost-benefit analysis and 3.The fulfilment of the personalization issue. Reliability testing analysed (Siersma, et. al., 2014, Mammas, 2013, Mammas C.S. and Mamma A.S., 2016). In technological terms, to achieve the abovementioned prevention operation a new architecture based on MCU, integrated with PROMETHEUS I pn 1008239 and Big Data analytics infrastructure based on ARIS IBM Hyper-computer (Figure 1.) (Panahiazar†, et.al., 2014, Mammas, C.S. and Mamma, A.S., 2016, Mammas, et al., 2016).

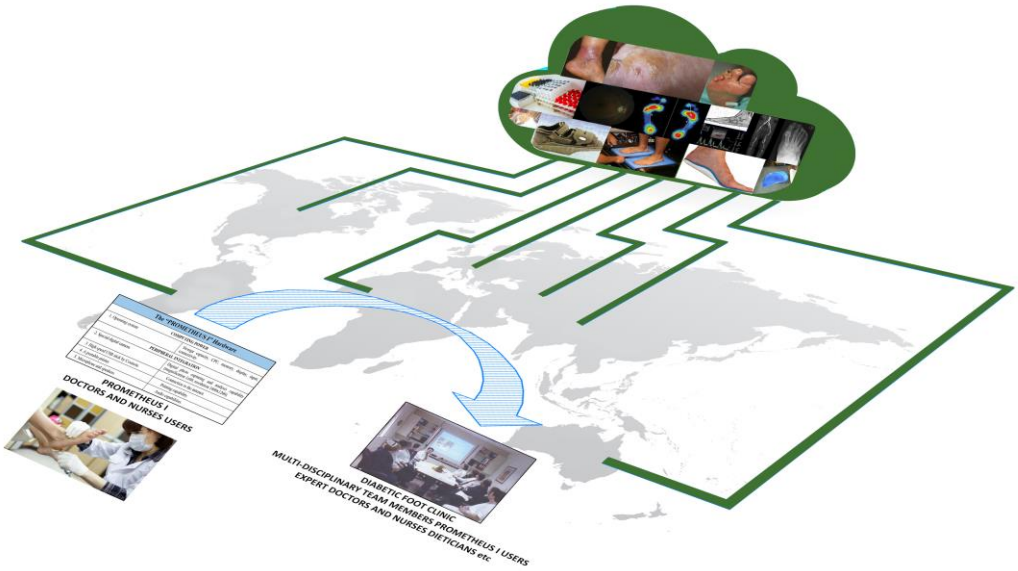


Figure 1: The foot examination of the patient (left part of the arrow) between the personnel of the MCU in the periphery (left part) and the team of experts in the tertiary healthcare centre on the Electronic Spaces (on the Cloud on the top at right) (http://www.livemedia.gr/video/171480).

3.3.Designing for Human factors: applied ergonomics of the MCU operations, integrated with Big Data analytics, for Specialized, Multidisciplinary, Holistic and Personalized mass Health Education and General Diseases, Cancer and Diabetes related complications remote primary prevention

With regard to general health education and prevention with an emphasis on Cancer Prevention our technology and method consisted of the so called Week of Panhellenic Health Education and Prevention which addressed to almost a 1.000.000 public workers in N=500 central administrative points of all types of public working or national administrative divisions in Hellas: Peripheries, Municipalities, Chambers, Ecclesiastical Dioceses, Great Hellenic Public Organizations (ΔΕΗ,ΟΤΕ,ΕΥΔΑΠ and their public workers associations), Centres of Education of the Ministry of Education in Hellas from 20.02.2017 to 26.02.2017. The abovementioned public sectors received a digital leaflet from PROMETHEUS I pn 1008239 with a link for information and usage of two algorithms for self-computation of annual preventive examinations according to age and sex (National Documentation Centre *http://www.ekt.gr/el/events/all/20671)*.

4.Results

4.1.Reliability testing of applied Ergonomics in the remote primary, secondary and tertiary remote general and special for diabetes prevention: The medical outcome parameter

Today of about N1=438 central administrative points of the public sector (87.6%) have viewed or downloaded remotely the material for further spread to their workers and at the same time to the population. Regarding the diaspora of the material to the rural areas this is currently analysed and the optimum result will be the abovementioned 1.000.000 public workers and the related general population. Big Data analytics and computing by ARIS Hyper-computer will refer to the cost-effect analysis in relation to the resources and the final outcome (http://www.ekt.gr/el/events/all/20671), Mammas, 2017).

However, at the time of the MCU operation in 2015 a 17.2% of the examined diabetic patients suffered from diabetic foot complication. Also, a 41.4% showed foot deformities and only 10.3% a deep ulcer. Among the latter a 66.7% showed an ulcer larger than 5cm^2 and all of them suffered for more than 3 months. Moreover, a 17.2% of the patients diagnosed with soft tissue infection and a 3.4% with osteomyelitis (Siersma, et. al.,2014, Mammas C.S. and Mamma A.S., 2016), (Table 1.).

Table 1: Signs after diabetic foot examination locally (7/29)

Disease	Parameter	N	%
Diabetic Foot	Yes	5	17.2
	No	24	82.8
Foot deformities	Yes	12	41.4
	No	17	58.6
Deep ulcer, n (%)	Yes	3	10.3
	No	26	89.7

Size of ulcer (cm2)	<1	0	0.0
	1-5	1	33.3
	>5	2	66.7
Duration of ulcer	<1 week	0	0.0
	1 week - 3 months	0	0.0
	>3 months	3	100.0
Location of ulcer	Toes	1	33.3
	Midfoot, Heel	1	33.3
	Elsewhere	1	33.3
Soft tissue infection	Yes	5	17.2
	No	24	82.8
Osteomyelitis	Yes	1	3.4
	No	28	96.6

If a tertiary prevention examination indicated, that would proceed remotely by instant tele-medicine based connection with the tertiary health care centre. In this context the medical data of the examined diabetics could be shared in a static or dynamic way. There were seven (n3=7) remote interventions -out of the 29 local clinical examinations- while four (n4=4) of the examined diabetics were in high risk for amputation or severe complications including death (A=Diabetic male patient suffering from a chronic diabetic ulcer, B=Diabetic female patient suffering from renal insufficiency and undiagnosed diabetic foot complicated with erysipelas at the time of examination, C=Obese diabetic patient suffering from diabetic foot and D=Diabetic patient suffering from severe pain walking 50 meters because of vascular impairment of the lower extremities. All seven remote interventions prevented complications while four (n2=4) very possible amputations or death if neglected were finally prevented- (amputation prevention rate 100% in a period of one year and half follow-up) (Mammas, 2013, Siersma, et. al.,2014, Mammas C.S. and Mamma A.S., 2016, Mammas, 2017), (Tables 2,3).

Table 2: Types of e-intervention after indication for remote assessment (7/29)

	N	%
e-Follow up and orders	6	20.7
e-Therapy for ulcer infection	1	3.4
Personalized e-prescription of blood examinations	7	24.1
Personalized e-prescription of radiologic examinations	7	24.1
Personalized e-Pelmatography	5	17.2
Personalized e-prescription for bone deformities	6	20.7
Personalized prescription of socks	5	17.2
Personalized e-Microscopic Examination of pus	0	0.0
Personalized e-prescription and/or construction of pair or change of shoes	2	6.9
Personalized e-Prescription for quitting passive/active smoking	4	13.8
Personalized e-Prescription of a diet	7	24.1.

None of the examined patients died (mortality 0%). A 13.8% had finally reduction of pain level and a 10.3% finally experienced extension of walking distance and reduction of foot oedema redness, warmness as significant outcomes Siersma, et. al.,2014, Mammas C.S. and Mamma A.S., 2016, Mammas, 2017), (Table 3.).

Table 3: Outcome after e-examination and decision making in 7 patients (7/29)

	N	%
e-Follow up and orders	6	20.7
Extension of walking distance	3	10.3
Reduction of foot edema redness, warmness	3	10.3
Reduction or relief of foot oedema	2	6.9
Quit of smoking*	1	33.3
Quit of passive smoking	2	6.9
Reduction of pain level	6	20.7
Loss of weight	1	3.4
Healed ulcer**	2	66.7
Enrolment to Hospital	3	10.3
Hopital Management of sever foot infection	2	6.9
Hospital Management and Hyperbaric O2	1	3.4

*referring only in smokers (N=3) **referring only in those with ulcer (N=3)

4.2.Reliability testing of applied Ergonomics in the remote primary, secondary a tertiary remote general and special for diabetes prevention: The Cost and Benefit analysis parameter

For the seven tele-medicine based medical interventions analysis showed a cost-effective impact compared to the mean costs of the current method. In fact the comparison of the cost between the current practice and the abovementioned technology process and service based on PROMETHEUS I pn 1008239 showed a significant difference favouring the second (p=0.048). Considering the outcomes the cost for patients underwent e-intervention was significantly lower than the current method demands (benefit of 40.78euros vs -182.48 euros expenses; p=0.008) (Siersma, et. al.,2014, Mammas C.S. and Mamma A.S., 2016, Mammas, 2017), (Figure 2.).

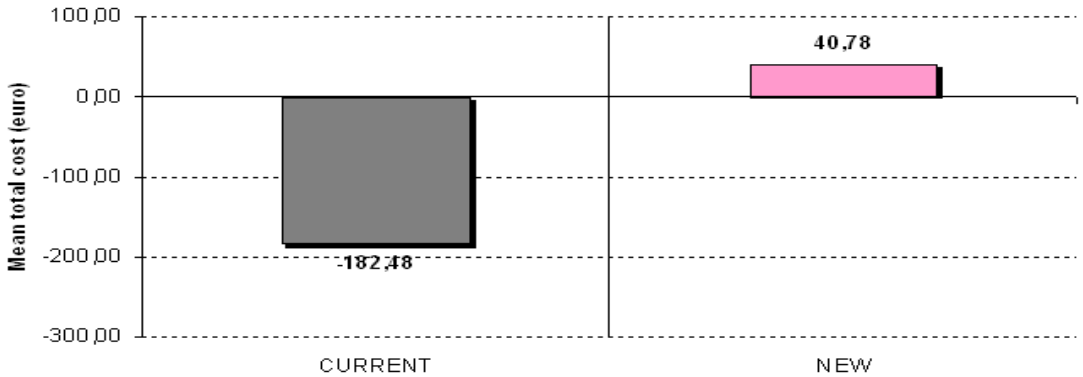


Figure 2. The total amount demanded for e-interventions in the context of MCU and Prometheus I for remote examination and decision making is significantly decreased and an amount of 40.78 euros is returned to each patient (pink) than what currently has to be paid (grey).

4.3.Reliability testing of applied Ergonomics in the remote primary, secondary a tertiary remote general and special for diabetes prevention: The Personalization parameter

To distinguish from the sense in which medicine has always been inherently "personal" to each patient, the personalization parameter commonly denotes the use of some kind of technology or discovery enabling a level of personalization not previously feasible or practical (Mammas, 2013, Panahiazar† et.al., 2014).

Regarding Health Education this is in the context of MCU and PROMETHEUS I pn 1008239 operations by Cloud-based remote, specialized, multidisciplinary, holistic and personalized self-computation of the annual preventive examinations (Health Check-up) individually according to the age and the sex of each one in the assessed population (for example computation of the annual preventive examinations -Pap-test and Mammography for the prevention of Cervical and Breast Cancer for women respectively and PSA examination for the prevention of Prostate Cancer for men etc.- in the e-address www.pribite.wordpress.com (Mammas, 2017). On the other hand the personalization parameter is absolutely fulfilled in the remote evaluation of the stained anatomic section after Pap-smear sampling, or of the mammography applied in the periphery or brought in a digital form from the part of the examined individual for cancer prevention and in the remote evaluation of diabetic extremities and ulcers in the secondary and tertiary diabetes related complications prevention from the periphery- where the MCU is located- to the connected tertiary hospitals in the centre (Tables 1,2).

5.Discussion/Conclusion

Reliability analysis of applied ergonomics of the clinical operations of a new MCU, PROMETHEUS I pn 1008239 technology, method and standards showed high feasibility, clinical reliability and cost-effectiveness (Siersma, et. al.,2014, Mammas C.S. and Mamma A.S., 2016, Mammas, 2017). The latter is attributed to its capacity to recoup expenses and increase the local capital by preventing amputations, by the low cost for its resources and mainly by saving expenses for disability pensions if tertiary interventions after e-intervention and decision making are successful. Integration with ARIS Hyper-computer empowers MCU for development in DC on a global level for Big Data analytics and computing (Mammas, 2017).

Among the limitations of the study is that analysis is based on both prospective and retrospective assessment and decision making and that the remote Health education followed the local examinations program (Mammas C.S. and Mamma A.S., 2016, Mammas, 2017). Regarding the first limitation this is attributed to technical infrastructure which was limited in the villages visited. On the other hand the target populations should first receive Health Education remotely and then local secondary and tertiary general and special for diabetes complication prevention enriched with e-interventions in the field if indicated. However, only after experimentation for the best ergonomic design for reliability, maintainability and availability of the assessed MCU technology, process and services in the field became obvious that the Health Education of the Hellenic population is un-expectantly very basic (Mammas C.S. and Mamma A.S., 2016, Mammas, 2017). That is why massive Health Education followed the local prevention program. Taking into consideration the abovementioned results and facts,

new clinical, experimental and innovative networks for computer assisted collaborative training models including MCU are being prospectively designed, structured and processed to integrate Big Data analytics and computing services nationally for Greece and internationally for DC (Panahiazar†,2014, Stewart, 2014, Mammas, 2017).

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Could the use of unstable, shock absorbent work shoes reduce musculoskeletal discomfort?

A pilot study among employees in a large supermarket

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Work related musculoskeletal symptoms, particularly in the lower back and lower extremities, are common in professions that involve a lot of walking and/or standing.The purpose of the study was to investigate whether the use of an unstable and shock absorbent shoe, MBT (Massai Barefoot Technology), could decrease self-rated discomfort in the lower back and lower extremities among workers in a large shopping mall in Sweden. The result showed statistically significant reduction in self-rated discomfort as well as in perceived tension and fatigue in feet, lower extremities and lower back while, using unstable and chock absorbent work shoes.

Keywords: Work shoes, musculoskeletal, pain, discomfort, foot, knee, hip, lower extremities, spine, low back pain, walking, standing

1. Background

Work related musculoskeletal symptoms, particularly in the lower back and lower extremities, are common in professions that involve a lot of walking and/or standing. Foot related issues are particularly noticeable. In an Australian study with industrial workers, 91% claimed to have problems with their feet, whereof almost half, 49%, claimed to have painful feet (Marr and Quine 1993). The aspect of time in relation to the problems is important. Among female shop assistants in Thailand it turned out that the longer the shifts were for the workers, the more common were hip, feet and ankle problems (Pensri et al, 2010). A Canadian study carried out in Quebec showed that lower back problems can be connected to working standing up long-term (Riddle et al., 2003) and this was also confirmed in a Norweigan study (Sterud 2013).

Lin et al. have proven in a study that a soft surface reduces musculoskeletal symptoms in the lower extremities. A reduction was proven when the person wore trainers rather than being barefoot, and an even greater reduction was obtained when an absorbent work mat was used (Lin et al, 2012). In their summary of several studies, Mark S. Redfern and Rakié Cham have established that a soft floor surface is preferable to a hard one, when it comes to reducing fatigue and discomfort when standing for long periods of time (Redfern and Cham 2000). Industries with hard floors often have absorbent work mats by machines where people spend most of their time standing, but the relief is limited by the location and shape of the mat. As soon as the worker steps off the mat the relief is lost. There are also many jobs where mats cannot be used since the worker moves over large areas, e.g. people who work in healthcare, shops, or certain types of industries. The mats can also be a hindrance for forklift trucks.

Another way of addressing the issue of hard floors is by using shoes like Masai Barefoot Technology, referred to in this study and generally as MBT shoes, (imported by MBT Sverige, Fysiologiska Skor, Tjörnarp), which provide shock absorbance and instability. The idea of the shoes is that they mimic walking barefoot on a soft, uneven surface, the way our forefathers walked. There are two strong signifiers of the MBT shoes, one is the rounded sole that simulates the uneven surface and the other is the soft, absorbent core of the sole that gives you a feeling of walking on e.g. moss. The high level of absorbency in the sole reduces the impact caused when you put your heel down (Taniguchi et al, 2012). The rounded sole promotes a more upright posture when balancing your body. This makes it easier to find a favourable posture, since wearing these shoes makes it difficult to e.g. overstretch your knees, something that is otherwise commonly done when standing. When you overstretch your knees the strain is put on your heels, but the rounded sole means that you will fall backwards if you overstretch your knees while wearing these shoes. By moving your centre of gravity further forward on your foot, the overstretching of your knees is prevented, which in turn makes it easier to find a posture that is more beneficial for both knees and spine. Walking and standing in this new posture, requires activation of the postural muscles, and consequently for many people these muscles will get a workout. The shoes thereby have several effects: they cushion your step on a hard surface, they promote a more upright position which provides joint relief, and finally, they also activate your postural muscles.

The aim of this intervention was to see if the use of an unstable, absorbent shoe – MBT – could reduce the perceived musculoskeletal discomfort in primarily the lower back and lower extremities in people who do a lot of walking and standing on hard floors. Since the author has picked up signals of reduced discomfort also in the neck and shoulders in people who have used MBT shoes, the participants were asked to rate their discomfort in these areas as well.

2. Methods

The aim of this intervention study was to see if MBT shoes could be a suitable alternative as work shoes for jobs that require a lot of walking and/or standing on hard surfaces. The study was designed as a pilot study conducted in a large supermarket, consisting of one intervention group, (the MTB group) and one control group, with a follow-up after 5 months.

2.1. Participants/sample

The rehab manager at the large supermarket was responsible for recruiting respondents to the study. The workplace has around 1,000 employees whereof the majority works in the shop and the warehouse. The inclusion criteria specified that the employee had to walk and/or stand for a minimum of 4 hours/day, and that they were experiencing discomfort in their neck/shoulders, back or lower extremities as a result of having to walk and/or stand a lot. There were 35 pairs of MBT shoes available for the study, which dictated the size of the intervention group. 70 people signed up as interested in participating and fulfilled the inclusion criteria. Out of these, 35 were randomly selected to be in the MBT group, leaving an equivalent number for the control group. All participants didn't complete the test.

2.2. Research method

The questionnaires used in this study were designed by the author, based on her clinical experience, and were tested in practice before being used in the study. There were questions about frequency and intensity of fatigue/tension in three different parts of the body, and an estimate of the discomfort in 13 specific areas of the body. The participants were asked to estimate their level of discomfort in 13 different parts of the body by using a Number Rating Scale ranging from 0 to 10 (NRS-11). In order to see if the respondents' most pronounced discomforts were affected, we dichotomised the high scores (5-10) and the low/medium scores (0-4).

The control group completed the same questionnaire, both initially and at the follow-up. In addition to the questions on frequency and level of discomfort, the MBT group also received some follow-up questions about their use of the MBT shoes.

2.3. Data processing and analyses

Since the groups were so uneven, with 25 respondents in the MBT group and 10 respondents in the control group, all statistical analyses have been run per group only. Data processing has been done using IBM SPSS Statistics 22, applying the Wilcoxon signed-rank test, which is a non-parametric statistical hypothesis test. McNemar's test has been applied to calculate statistical significance for dichotomous variables (2 samples). The bar charts used to present data have been created using Microsoft Excel. The significance level has been set at $p<0.05$.

3. Results

25 respondents completed both questionnaires in the MBT group and 10 in the control group. The majority (16/25) required 2-4 weeks to get used to the shoes. Once they had got used to wearing the shoes, the majority (20/25) of the respondents (walking or standing) used the shoes during most of their work day, i.e. 6-8 hours. The remaining (5/25) respondents used their shoes for half days, i.e. 3-4 hours.

3.1. Sore muscles and other initial discomfort

Around half of the respondents (13/25) claimed to have experienced sore muscles or other discomfort when they started wearing the MBT shoes. This discomfort was mainly present in the feet, legs and lower back.

3.2. Estimating frequency and degree of perceived tension and fatigue

When estimating the frequency of perceived tension and fatigue in the neck/shoulders, back and feet, several respondents in both groups claimed to experience such symptoms every week or every day. When presenting the results in the charts, and when calculating the statistical significance, the response options were dichotomised into "no" and "sometimes" versus "every week" and "every day". See figure 1.

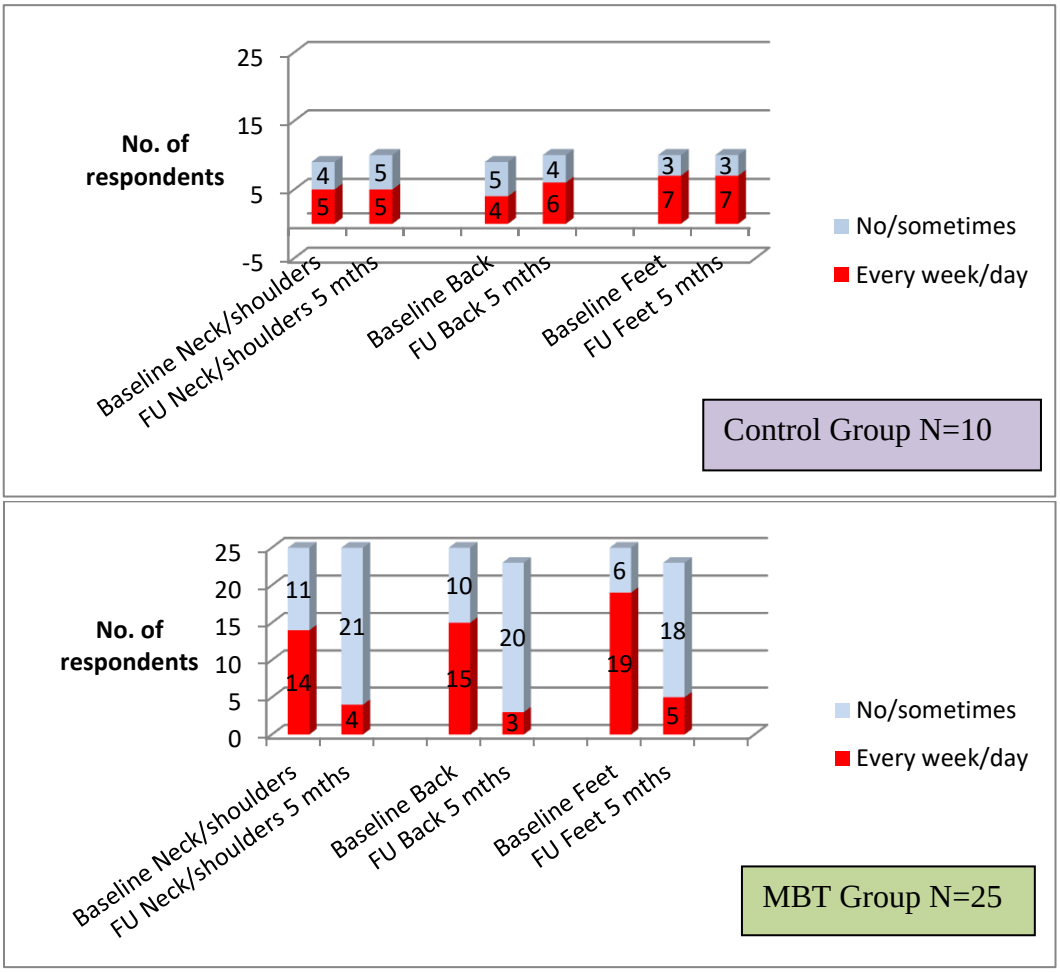


Figure 1. The upper chart illustrates the control group's estimates of frequency of tension/fatigue in the neck/shoulders, back and feet, at baseline and follow-up. The lower chart illustrates the equivalent figures for the MBT group.

The majority in the Control Group estimated the frequency to remain unchanged. In the MBT group, the majority of the respondents showed a reduced frequency in tension/fatigue in all areas: neck/shoulders, back and feet, with a statistical significance of $p<0.001$ in all three areas. See figure 1.

When asked to estimate the frequency of symptoms the respondents were also asked to rate their degree of discomfort on four levels, from none to considerable. There was no one at the baseline study in either group who was completely free of tension/fatigue in their feet. At the follow-up of the MBT group, there were a number of respondents who were completely symptom free and an increased number of respondents with only negligible tension/fatigue. This shows a significant change between baseline and follow-up at $p<0.0001$. In the control group, there was still no one at the follow-up stage that was completely free from tension or fatigue in their feet. See figure 2.

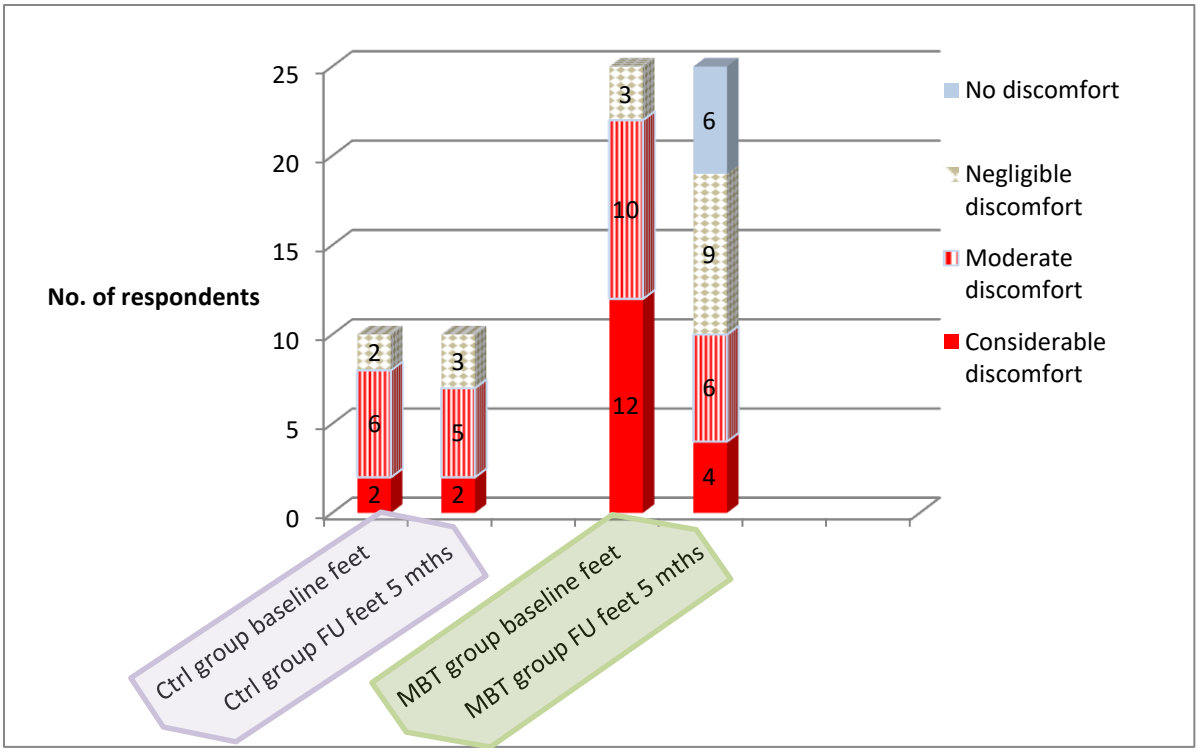


Figure 2. Estimates of the intensity of tension/fatigue in the neck/shoulders, back and feet, at baseline and follow-up, for the MTB and control groups respectively.

3.3. Estimating the level of discomfort by using a Number Rating Scale (NRS-11)

The participants were asked to estimate their level of discomfort in 13 different parts of the body by using a Number Rating Scale ranging from 0 to 10 (NRS-11). There was a statistically significant improvement in the MBT group, where $p < 0.01$ for 12 out of the 13 estimated areas, and for the right hip/thigh, $p<0.02$. In the control group, there was no significant change in discomfort in any of the 13 areas.

3.4. Estimating discomfort in the high range of 5-10

In order to see if the respondents' most pronounced discomforts were affected, we dichotomised the high scores (5-10) and the low/medium scores (0-4). The number of respondents with high scores for the different areas at both baseline and follow-up in the respective groups can be seen in figure 3.

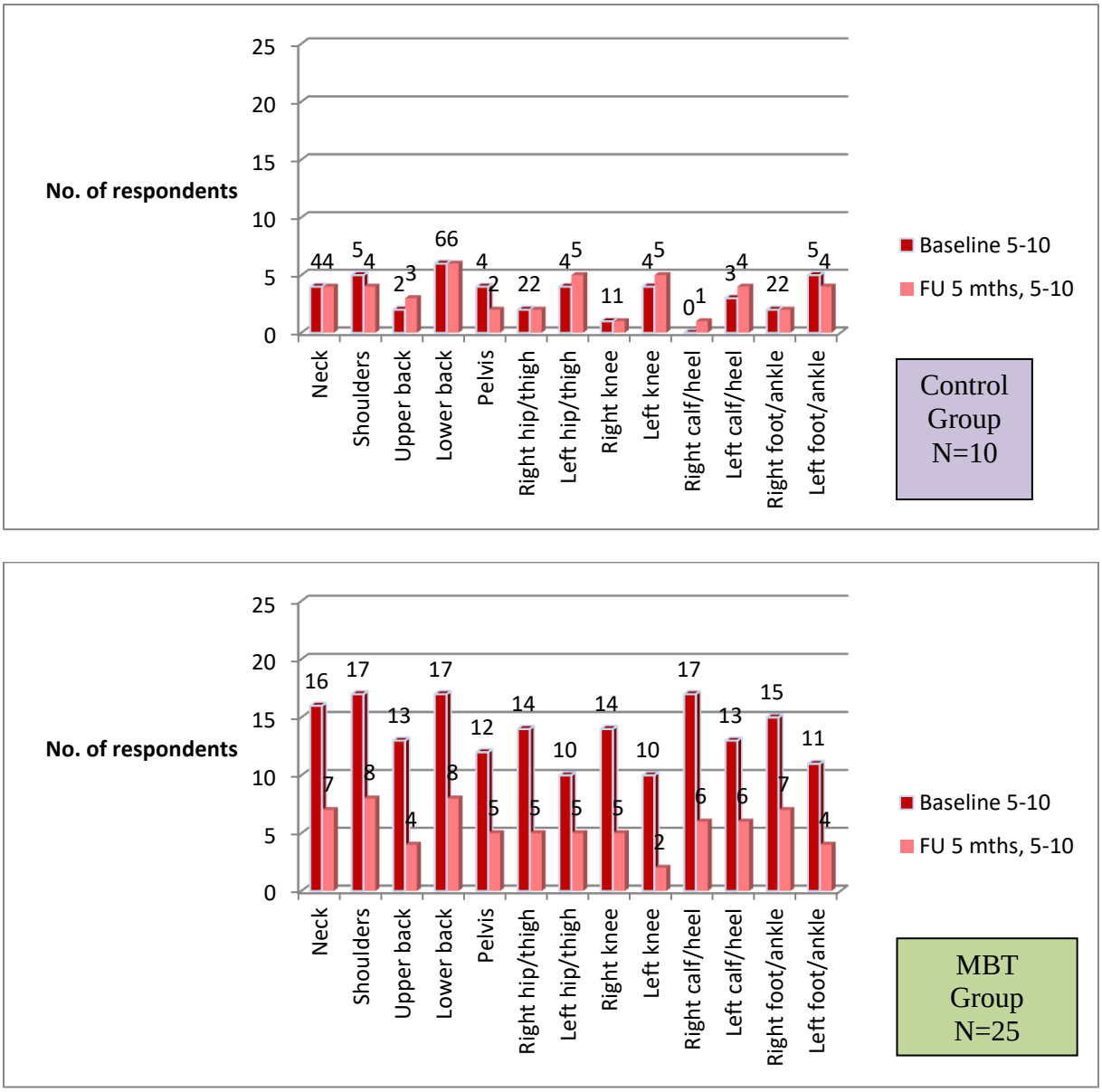


Figure 3. Number of respondents who have estimated their discomfort in the high range, 5-10, at baseline and follow-up respectively. The upper chart shows the control group's estimates and the lower chart show the MBT group's estimates.

In the MBT group, there was a statistically significant reduction in the number of respondents who estimated great discomfort in 11 out of the 13 areas ($p < 0.01$), as well as for the remaining two areas ($p < 0.02$). There was no statistical significance shown in the control group for respondents with high scores.

Discussion

The results show that for the respondents in the MBT group, who used MBT shoes at work, when standing or walking for 4-8 hours/day during a 5-month period, both the frequency (originally every week or every day) and the intensity of tension/fatigue in the neck/shoulders, back and feet were reduced. The level of estimated intensity of discomfort was significantly reduced in all 13 areas, from the neck to the feet.

A statistically significant improvement was obtained for the most pronounced discomforts, scores 5-10 on the NRS-11 scale. In the control group, there was no statistically significant change in discomfort on the NRS-11 scale or in the frequency of tension/fatigue. Since the difference in size between the groups was so great, 25 and 10 respondents respectively, no direct comparisons have been made and all analyses are per group.

The rounded sole with a soft core could be the reason behind the great reduction in estimates of tension/fatigue and discomfort in the MBT group. The soft core absorbs the impact of the heel hitting the ground when walking (Taniguci et al. 2012), which can provide relief for all joints from the feet to the spine. There are studies that show a reduction in knee joint strain when wearing MBT shoes (Buchecker et al., 2012 and Kutzner et al., 2013). The rounded sole promotes more well-balanced standing and walking, which in turn can stimulate the wearer to find and keep a more straight and beneficial posture. A straighter posture combined with increased muscle strength (Laundry et al., 2010, Romkes et al., 2006, Nigg et al., 2006, Stöggl et al., 2010, Buchecker et al., 2013) in the postural muscles, and the absorption that eases the joint strain, (Buchecker et al., 2012, Kutzner et al., 2013) could be the reason for reduced discomfort.

Conclusion

As opposed to the control group, the MBT group experienced a reduction in perceived musculoskeletal discomfort in 13 areas from neck to feet, and a reduction of the frequency of tension/fatigue in neck/shoulder, lower back and feet. The results indicate that ergonomically speaking, MBT shoes can be successfully used in professions that require a lot of standing and/or walking in order to reduce both the musculoskeletal discomfort and the frequency of tension/fatigue in the neck/shoulders, back and feet.

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Are well-being and joy at work related to age?

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According to the Slovenian legislation, workers above 58 are protected from being fired. We tried to identify the most important gripping points for retaining workers' joy and well-being for the whole senior working period. Questionnaire of actual availability (QAA) composed from 47 items with 5-point scale was implemented on 1884 service workers. The perceived level of well-being and joy was lower in the middle-age group (50-57) than in the older one (above 58). According to our results, the main gripping points for keeping long-lasting joy at work are education, keeping of flexibility and adaptation and supportive organization for all age groups.

Keywords: Well-being, Service work, Flexibility, Middle age workers, Older workers

1. Introduction

Older workers, according to the Slovenian legislation, are above 58 years old. They have to work until the age of 63 to 65 and they have to have 40 years of working ages. In the time of restructuring and in the period of economic crisis, the content of a work has been changed. New technologies and new work place demands become a reality for working places. According to general public prejudices, older workers are perceived as less competitive and less effective, than their younger colleagues. Consequently, they are fired as an expensive and less flexible part of work force. With this approach, employers reduce costs and keep profit of their companies also in the time of worse economic conditions.

According to meta-analyses of connections between performance at work and ages, there are no statistical significant correlations between performance decrease and ages (Sturman M. C., 2003). Older workers have the same declines of abilities, so older workers have problems in visual perception abilities. There is on age related decline in colour perception, difficulties to focus on object up close because of presbyopia (Ishishara K, Ishishara S, Nagamachi M, Hiramatsu S, Osaki H., 2001). Human reaction

abilities are stable with a slight decline in the period between 30 and 63, after that period decline is more evident (Cronin A, Mandich M. B., 2015).

Performance at work is slightly related to perception and reaction abilities. The most important is cognition. Cognition abilities, adaptation and decision making shape the performance at work in the majority of the today working environments (Powell D. H., 2014). Ergonomic adaptation of working environment and new technologies have reduced importance of the perception and reaction abilities of workers. With a recovery of economy and with a new economic growth, there will be a deficiency of the available competent workers also in the modern ergonomically adequate working environments (Demography, growth and inequality, 2014).

Human performance at work depends on the actual availability which is shaped with human health, personality and motivation. Availability for work is an individual self-esteem of his/her abilities and well-being (Molan, G., Molan, M., 2002). A real workers performance depends on the abilities, competences and well-being. Well-being at work is an external manifestation of workers' perception of the work load. According to the results of Waldman's meta-analysis, there is a statistical significant connection between ages and well-being (Waldman D., Bruce J. A., 1986).

Well-being at work is influenced also by the psychosocial relations at work. Non supportive psychosocial working environment with a lot of competition, time pressure, poor defined work and conflicts between different age groups creates a poor psychosocial atmosphere (Thomas W. H. Ng, Daniel C. F., 200). It is manifested in a low level of well-being. An external manifestation is a passive behaviour and depressed mood of workers.

2. Research goal

We tried to evaluate workers' well-being in the service sector in two groups of workers, all above 50 years old. On the basis of the evaluated well-being, we tried to identify gripping points for keeping joy at work until retirement between older workers, to keep them in the world of work.

3. Method

Sample: 1884 service workers (1400 female; 400 male)

- Service workers: 1884 (1400 female, 484 male)
- Age: all above 50
- Origin: 3 financial institutions
- Education: secondary education (majority of them)
- Younger workers: age between 50 and 57 (1646 workers)
- Older workers: age above 58 (238 workers)

3.1 Procedure

Data were collected during a periodical medical evaluation of estimation of well-being during an average work day. All questionnaires were validated and the data were collected in the data base. Data were analysed with the statistical package R from Jupiter environment. To individuals with a low level of well-being, a psychological

intervention was offered. On the basis of this individual interventions, the root causes of a low level of well-being were identified. Identified root causes of a low well-being have been defined as gripping points for implementation of humanization measures to keep a well-being at work.

3.2 Technique

For the data collection Questionnaire of actual availability (QAA) from AH model was implemented. The questionnaire is composed of 47 items describing a well-being with 5 point scale:

- 1 – means excellent well being
- 5 – means total exhaustion extremely low level of well-being.

With a cluster analysis, all items were composed in 7 subscales of well – being (physical fatigue, psychical fatigue, general exhaustion, decrease of motivation, decrease of vigilance, depressed mood and perceived stress). There is also a self-estimation of performance.

The QAA is based on the AH model and connects relations between work load and human performance and well-being. The model serves as a basis for humanisation interventions implementation at the work place. The QAA has been used on 20,000 Slovenian workers. From this validation, the limits for individual and organization intervention were defined.

4. Results

According to the AH-model, workers with a low level of well-being (self-esteems above 2.5 on average scales of QAA) are identified as tired and over-loaded. These workers need additional evaluation and support. On the group level, the proportion of the exhausted and tired workers is important (Molan, G., Molan, M., 2002).

From the previous researches, a proportion below 10% is normal. It is related to the workers individual, social, psychical or health problems. The proportion of tired between 10 to 20% reflect influence of external economic problems. Proportion above 20 to 30% reflects organizational problems in the company. The proportion of over-loaded above 30% reflects joined impacts of organizational problems in the working environment and perception of workers health and availability. For all those workers, individual psychosocial and, sometimes, also medical interventions have to be implemented. Almost always interventions at the work place are necessary.

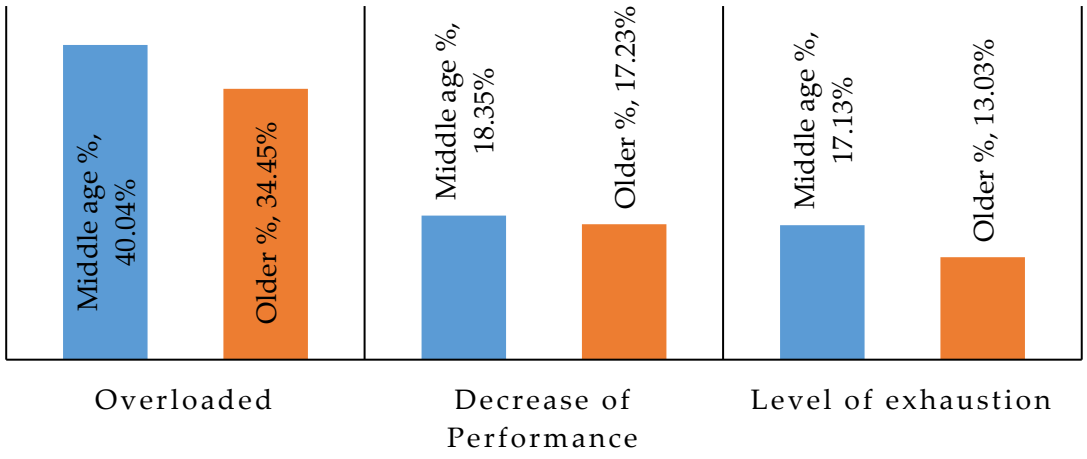


Figure 1 Comparison between meddle age and older workers

In the Figure 1 is presented the comparison of proportions in both groups. According to our results the proportion of overloaded in the middle age group is higher than in the older group. In the middle age group, the proportion of overloaded is 40.04% and in the older group, the proportion of overloaded is 34.35%. The proportion of overloaded is high in both groups and it reflects negative impacts of psychosocial environment.

The general exhaustion is manifested in the level of exhaustion, as a consequence of the perceived fatigue, decrease of motivation and mood, and perceived stress. The proportion of exhausted workers is in the middle age group is 17.14% and in the group of older workers it is 13.03%.

Table 1 Distribution of well-being in middle age and older worker group

	Middle age				Older			
	count	mean	STD	max	count	mean	STD	max
Physical fatigue	1646	1.92	0.67	4.60	238	1.76	0.55	3.60
Psychical fatigue	1646	1.93	0.67	4.85	238	1.83	0.62	4.71
General fatigue	1646	2.09	0.75	5.00	238	2.02	0.68	3.87
Decrease of motivation	1646	1.77	0.68	4.60	238	1.71	0.63	3.60
Decrease of vigilance	1646	1.68	0.87	5.00	238	1.63	0.75	4.00
Decrease of mood	1646	1.86	0.72	4.80	238	1.82	0.67	4.20
Perceived stress	1646	1.91	0.66	4.44	238	1.85	0.60	3.44
Level of exhaustion	1646	1.88	0.63	4.48	238	1.80	0.55	3.51
Decrease of performance	1646	1.91	0.73	5.00	238	1.89	0.69	4.00

On the Table 1 is presented an average level of well-being in both groups which is the interval of an adequate well-being, but in the youngest group the variation is higher and the values are slightly higher than in the older group.

Average middle age workers (50-57) report more fatigue, less joy and a lower well-being. A difference in perception of well-being includes more parameters; the most important difference is in perception of the psychical fatigue. In this group, variability is also bigger due to more differences between workers.

In individual interviews, we identified root causes of the lower well-being among workers. Identified root causes are the potential gripping points for interventions in creation of work that is pleasant and attractive for all age groups.

The most important root causes for the lack of joy at work are education, position, fear of losing a job, menopausal problems, motivation, lack of flexibility and poor adaptation.

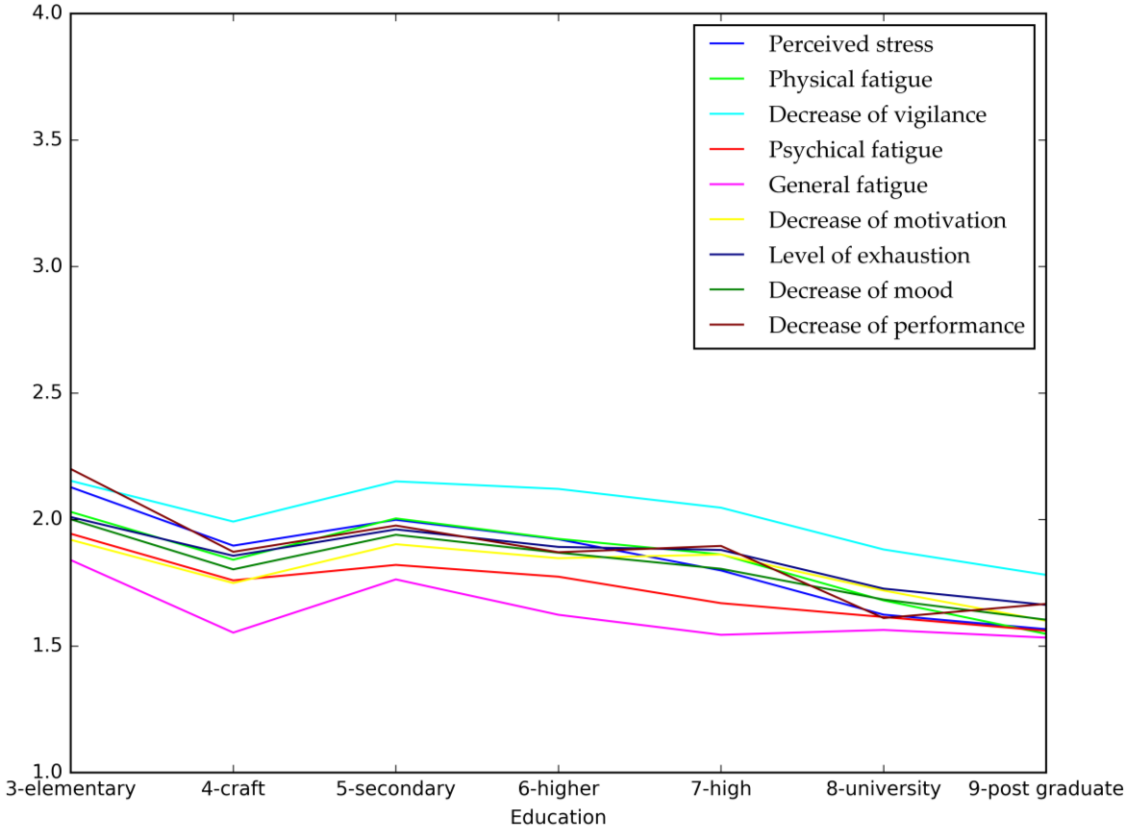


Figure 2 Middle age workers' well-being decrease according to education

The education level assures a basis to get the workplace position. As is presented in the Figure 2, in the middle age group there are less workers with lower educational position and less competent workers have lost jobs.

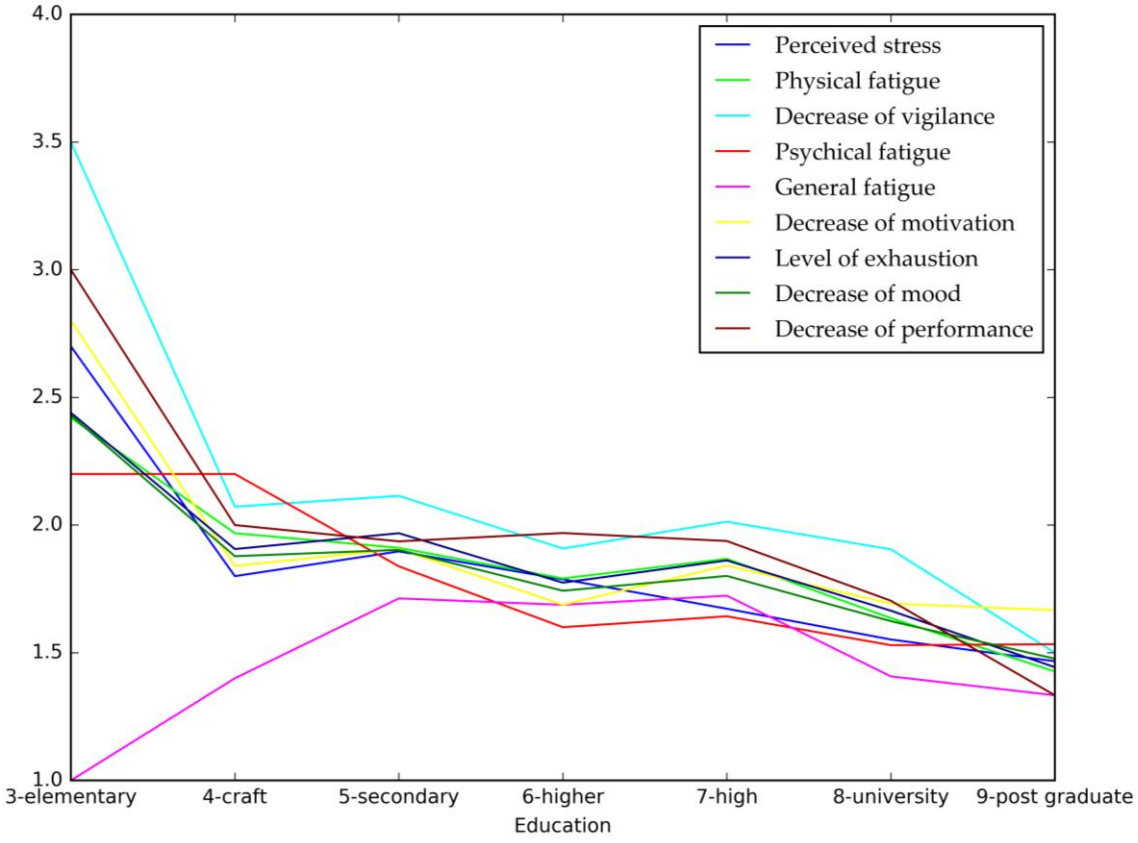


Figure 3 Older workers' well-being decrease according to education

In the Figure 3 connection between education and a well-being of older workers is presented. In the older group, there are still some workers with lower education on the support back-office position.

According to our research the influence of education level is important. Workers with a higher level of education report less fatigue and depression than those with a lower level of education. Workers with a university degree have better job position, they are on decision making positions or they have influential consulting position. Those workers were forced to keep an adequate level of competences and availability due to more demanding workplaces.

5. Conclusion

The reality of the future working environments, due to the demographic changes, is older work force. Meta-analysis of older workers' abilities does not identify an important decrease of abilities before middle of 60. In the working environments, the conflicts between older and younger workers are very frequent. Younger workers perceive older workers as competitive for working positions. Older workers have to keep their availability and performance on the adequate level until old age.

Middle age workers (50-57) are the most vulnerable group – they are not protected, they have to work for additional 10 to 17 years, they have to adapt to new technologies, procedures and new a working reality. To keep such position, they have to be flexible and they have to stay in touch with novelties. They have menopausal

problems, some of them have poor health, and they are not as familiar with new technologies as their younger colleagues. This is the group which needs special concern and support.

To increase their competitiveness, they need a special concern in training procedures, because they have to learn new tasks. Despite some disadvantages of middle age workers, employers have to be aware of the fact that these workers still have some competitive advantages.

Older group above 58 is the protected one. On average, they have a better job position, they enjoy their job because perceive themselves as competent and able to meet work place demand. According to our results, in the group above 58 only competent and flexible workers remain. This is the group with a high level of well-being and work for them is joy.

Behaviour patterns competences and attitudes of this group should be a model for keeping long-lasting performance, well-being and joy at work.

Joy at work depends on the age and employer have to be aware of this fact. They have to invest in keeping of reliability and competence of workers until retiring age. Middle age and older workers need enough training and education to meet new workplace demands. They have experiences but they need a training in novelties.

For the future working environment, a long lasting adaptation and retention of adequate flexibility is crucial. Workers in services have to get an adequate support in creation of their competence on the job market. They have to be aware of their advantages and benefits of their experience. But they also have to be aware that their flexibility depends only on them. Different age groups at work need adoption of a new work organization. More skilled tasks should belong to older service workers; tasks demanding fast adaptation are more tailored for middle age workers.

A special concern has to be given to the creation of working teams where each worker has a possibility to realize his/her competences to the maximum. The consequence is the work offering a long-lasting adequate well-being and joy.

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Is the Importance of "fun at work place" underestimated? – A cross-cultural perspective on work environment factors for creativity performance

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The new economy driven by fast changes creates need for new ideas and innovative solutions. Companies' creativity potentials are among the top interest of strategic goals. Although creative personality is very important it is not the only factor which influences creative performances. There is increasing trend of importance of creativity supporting work environment. This exploratory research studies how different elements of work environment: "Socio-organization work environment", "Physical work environment" and "Fun at work place" are implemented on sample of ten countries. Furthermore it gives an overview of needed changes to facilitate differences between current and "ideal" creativity supporting work environment.

Keywords: Fun at work place, Creative work performance, Work environment, Cross-cultural perspective

1. Background and purpose

Work environment is a complex blend of different factors which jointly affect the creativity performance of employees. Traditional focus of creative work performance is related to creative personality. However the personality itself is only a part of the whole picture of creativity (McCoy & Evans, 2002). Work environment as blend of physical environment, social interaction, organizational structure and different activities plays important role in employees' abilities to generate creative content. As creative personality itself is not the only drive of creativity, importance of socio-organizational work environment was introduced. Recently, increasing number of researches is talking about the role of physical work environment. As the new economy is driven by fast changes, the need for new ideas and innovative solutions is recognized as an important challenge and opportunity at same time. To be able to answer to this fast changing business world, increasing number of world leading companies are considering the importance of "fun at work place" for creative

performance. This concept introduces work space that is full of fun supporting activities which create atmosphere for employees to feel free in expressing themselves, but not blocked or constrained to think, innovate and generate new creative solutions.

This approach started in Silicon Valley during the dot-com era when increasing number of start-up companies appeared on the market and turned their offices in fun places where employees even play roller hockey (van Meel & Vos, 2001). The trend suggests that "fun at work place" concept has started in USA where is well recognized and accepted. This raises the questions "is the importance of fun at work place underestimated and differently accepted in different cultures?"

This research aims to understand the differences in current level of application of factors from physical work environment (PWE), socio-organizational work environment (SWE) and fun at work place (FWP) on sample of ten countries. Furthermore, the research supports understanding of participant's perception of "ideal" work environment for support of creative performance. Result applications are very pragmatic and applicable in terms of managerial practices. Results can be used as basic platform for improvement of current work environment toward achievement of ideal environment for creativity support. Furthermore, results can serve to researches and practitioners for better understanding of position of "fun at work place" element of work environment in the perception of employees. Based on the research results, it is expected that further action toward spreading the importance of creativity supporting work environment can be taken.

2. Research methodology

2.1. Sample and procedures

Primary data is collected using a survey distributed to a convenience sample of MBA (Master of Business Administration) students from ten countries. Given the exploratory nature of the research, which can be extended to more extensive survey study in the future, it is considered that the best matched sample which we could find and afford to collect data from were university students. Taking into account that this research focuses on work environment, selecting MBA students were seen as a good sampling strategy, as pre-requirement for joining MBA program is several years of working experience. Furthermore, MBA students are the new generation which is about to lead the market place soon, thus understanding their ideas and vision about work place as contributor to creative performance would allow to interpret results in terms of managerial implication to meet needs of new generation of workers. In addition, this research sample allowed us to overcome very crucial and significant pitfalls in cross-cultural researches such as poor matching of samples and limited number of countries (Hofstede, 2003). Choosing MBA students allowed us to collect data from samples which differ in nationality but are alike in many other aspects which resulted with well-matched samples. According to Hofstede (2003) even sample representatives do not fully represent the population of countries in cross-cultural researches, well-selected matched sample is expected to accurately estimate the differences among countries included in the research. Convenience sample of university students allowed this exploratory research to cover large number of

countries, in this case, ten, which satisfied requirement of cross-cultural researches and overcame a very usual pitfall of limited number of countries (Hofstede, 2003).

Countries included in the research are: Bosnia, Bulgaria, Egypt, Croatia, Germany, India, Indonesia, Taiwan, USA and Vietnam. The total number of questionnaires issued to each country was 40. The average (AVG) return rate per country was 70%. Among the returned questionnaires there were non-correctly answered which were omitted for incompleteness. The usable questionnaires among the distributed were 66% or numbered 265 (Bosnia – 22, Bulgaria – 34, Croatia – 35, Egypt – 20, Germany – 22, India – 24, Indonesia – 32, Taiwan – 30, USA – 24, Vietnam – 22). Total numbers of usable questionnaires per country are aligned with cross-cultural research requirements of 20 – 50 representatives per country (Hofstede, 2003).

2.2. Questionnaire design

The questionnaire consists of two parts. In the first part participants were asked questions about their current work environment (WE). Respondents were asked to rank each of the given elements of physical work environment (PWE), socio-organizational work environment (SWE) and fun at work place (FWP), based on their presence in the WE which they have experienced. PWE was presented with twelve elements which were measured using a seven-point scale from "very little" to "very much". SWE was presented with nine elements which were measured in the same way as PWE. Elements of PWE and SWE were adopted from CDQS (Creativity Development Quick Scan) elements of work environment which contributed to creativity (Dul & Ceylan, 2011). FWP was presented with ten elements and measured on five-point scale from "very little" to "very much". They were adopted from Ford et al. (2003).

In the second part of the questionnaire, participants were asked to rank the same elements of the PWE, SWE and FWP; however, based on their *"ideal"* work environment without taking into account any work environment they have faced previously. While the purpose of the first part of the questionnaire was to understand current level of adoption of creativity supporting elements of work environment, the second part of the questionnaire aimed to clarify respondents' preferences toward those elements. Research design allows this exploratory study not only to understand the current level of implementation of elements which are seen to contribute to creativity supporting work environment, but as well to propose needed actions to facilitate changes for better creativity supporting work environment.

2.3. Research goals

The research observes two main variables: current work environment and "ideal" work environment on research sample of ten countries. The goal of this exploratory research consists of three main parts:

- Understanding the current level of implementation of creativity supporting WE in each of the sample countries and to understand the differences in implementation of current WE between sample countries;

- Understanding the preferred or "ideal" level of implementation of creativity supporting WE in each of the sample countries and differences in preferred or "ideal" levels of creativity supporting WE between sample countries;
- Understanding the differences between implemented current and "ideal" WE in each of sample countries as well between sample countries.

3. Research results

The following section presents the results of this exploratory study. The first part covers analysis of data related to the current level of implementation of creativity supporting work environment. The second part reports the result of data related to the preferred or "ideal" creativity supporting work environment. The third part overview similarities and differences between current and "ideal" creativity supporting work environment.

3.1. Exploratory study on current levels of implantation of creativity supporting work environment

Ten countries have been researched in terms of three components of work environment – including PWE, SWE and FWP. Each part of this section will present one type of current WE.

3.1.1. Current PWE (Physical Work Environment).

Collected data were transformed on scale from "0" (minimum) to "100" (maximum). Where "0" represents that given element of creativity supporting work environment is "not at all" present in the respondent's current WE and "100" indicates "highest level" of presence of given element of WE.

The average (AVG) presence of creativity supporting PWE based on all ten countries was 45. There were no significant differences between levels of implementation of PWE among researched countries. They were all very close to the average. Thus it can be concluded that differences in implementation of PWE elements are expected to be driven by individual companies and not on country base. When it comes to individual elements of PWE two groups of elements have been highlighted based on the oscillations from the average. The lowest presences on average of all countries have "Inspiriting colors" with average score of 36, "Calming colors" with 38, and "Indoor plants/flowers" with 38. In the second group are elements with the highest presence: "Quality of lights" with 55, "Day lights" with 53, "Any window view" with 52, and "Indoor climate" with 51. The first elements to which companies worldwide pay the most attention among the PWE elements are those related to lights and climate.

3.1.2. Current SWE (Social Work Environment).

The average presence of creativity supporting SWE based on all ten countries was 48. There were no significant differences between levels of implementation of SWE among researched countries. Similarly to PWE when it comes to SWE there is no one country which is more advanced compared to other countries in implementation of SWE elements. Differences in its utilization are expected to be driven by individual companies rather than on country base. Presence of majority of elements of SWE is

similar and close to the average, however the lowest presence on average of all countries has "Task rotation" which is about 19% less present compared to the average of other SWE elements.

3.1.3. Current FWP (Fun at Work Place).

The average presence of creativity supporting FWP based on all ten countries was 43. FWP is very similarly emphasized in each of sample countries and there are not big oscillations. This is aligned with the situation recorded in implementation of PWE and SWE. There is no specific country which emphasizes FWP more than others. Differences in implementation should be sought on company not country base. When it comes to individual elements of FWP there are two groups based on their oscillations from the avarage. The lowest presences on average of all countries have "Entertainment" (34), "Games" (35) and "Stress related activities". In the second group with the highest presence are: "Opportunity for personal development" (53) and "Recognition of personal milestones".

3.1.4. Comparison of Current PWE, SWE, FWP

On the average of ten countries SWE is the most present and recognized as contributor to WE for creative performance. It is 5% more present than PWE and 10% more present than FWP. FWP is the less present element of creativity supporting WE which indicates its underestimation and low level of understanding of its implementation and influences. However, the average presence of each three components of WE is scored less than 50, on scale from 0 to 100, which suggests low level of recognition of influence of WE on creativity and low level of implementation in real work environments worldwide.

3.2. Exploratory study on "ideal" levels of creativity supporting work environment

Respondents were asked to score each element of PWE, SWE and FWP based on how each of the elements should be present in their "ideal" work environment.

3.2.1. "Ideal" PWE (Physical Work Environment).

The average (AVG) preferred presence of PWE in "ideal" WE based on ten countries was 62. Majority of countries scored similarly, however the highest numbered Bosnia and Egypt (about 12% above the AVG), and lowest Germany and India (about 20% below the AVG). Lower levels of understanding the contribution of PWE for creative performance in "ideal" WE indicates need for promotion and explanation of main characteristics of PWE and its potential contribution to creative performance. On level of individual elements in PWE there were no significant oscillations form the avarage. Participants equally value the contribution of each of the elements of PWE which confirmed the importance of each of the creativity supporting PWE elements. Each of the elements should equally be taken into account when creating "ideal" PWE.

3.2.2. "Ideal" SWE (Social Work Environment).

The average presence of SWE in "ideal" WE based on all ten countries was 66. Majority of countries scored similarly, with exception of India, which scored about 20% below the AVG. However Croatia scored 20% above the AVG. It can serve as a good example for future researches for understanding the ways of promoting SWE for creative performance. On the base of individual elements participants relatively equally value the contribution of each of the elements of SWE which confirmed the importance of

each of creativity supporting SWE elements. In planning "ideal" SWE no one of its elements should be ignored or underestimated.

3.2.3. "Ideal" FWP.

The average presence of FWP in "ideal" WE based on all ten countries was 64. All of the countries scored relatively similar with exception of India which scored 18% below the AVG. On the level of individual items there are not significant differences in the preferences toward FWP elements in "ideal" WE. The exception is "Opportunities for personal development" which were scored 25% above the average and is considered the most important FWP element.

3.2.4. Comparison of "Ideal" PEW, SWE, FWP

On the average of all ten countries there are no huge differences in respondents' preferences toward PWE, SWE and FWP. All of three components of WE scored relatively similarly. The highest score was recorded in SWE, which was scored 5% higher than PWE and 3% higher than FWP. On AVG all three factors in "ideal" WE should be present about 64% of their maximum presence. This indicates low level of abilities of participants to understand and imagine the influence of WE on creativity. This could be influenced by current WE, experiences and available information. It indicates need for further presentation and education about WE for creative performance. This result could be also related to abilities of participants to immerse in WE they have never seen and experienced, which further confirm the need for introduction of WE for creativity

3.3. Exploratory study on differences between levels of implemented and "ideal" creativity supporting work environment

Considering differences between current and "ideal" WE it can be concluded that each of PWE, SWE and FWP are less present in respondents' current WE compared to "ideal" WE they are picturing. Data are shown in Figure 1. On average the need for improvement from current to "ideal" stage is 41%. Which leads to the conclusion that there is huge gap for improvement on each of three components of WE. The highest need for change is recorded in FWP (48%) which is result of lowest presence of FWP elements in current environment but as well the desire of employees for higher presence in "ideal" WE.

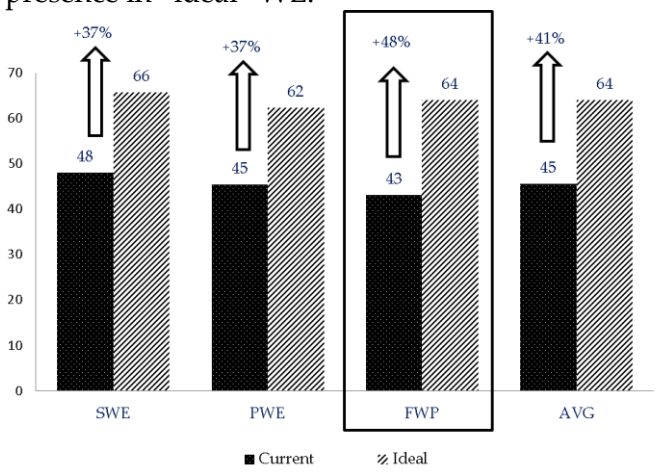


Figure 1. Differences between current and "ideal" support from different WEs on AVG of ten countrie

On the base of individual elements of PWE, SWE and FWP, each of the elements should be improved to answer the needed transition from current to "ideal" WE. However, taking into account that in real business environment actions cannot be taken all at once, research results suggests which corrective actions are to be taken the first. Conclusion is based on the largest difference between "ideal" and current stages. In PWE the first to be changed in terms of increase of their presence are: "Inspiring colors", "Privacy" and "Window view on nature". In SWE: "Recognition of creative ideas" and "Incentives for creative results". In FWP: "Stress release activities" and "Entertainment".

On country base all of countries have requirement for changes from current to "ideal" stage as shown in Figure 2. There are two specific countries where required change is significantly below the AVG. Specifically, in Germany the required change in PWE is only 16%, SWE only 13% and FWP 13%. While in India, the required change in PWE is 17%, SWE 12% and FWP 4%. Future researches should facilitate the need for further understanding and reasoning behind these results. Due to importance of WE for creative performance there is need for promotion of influence of WE on creativity worldwide, with special accent to India and Germany.

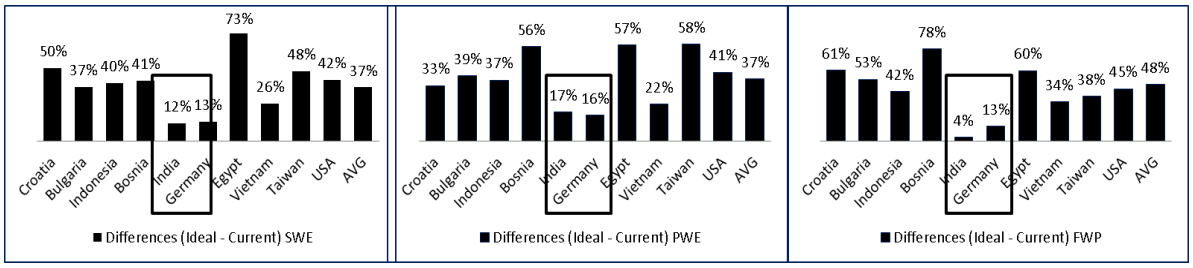


Figure 3. Differences between current and "ideal" WEs in each of the research sample countries

4. Conclusion, discussion and managerial implications

The research has a number of important implications for understanding the current level of implementation of creativity supporting work environment which is the beginning stage for taking actions toward achieving "ideal" work environment. This exploratory research gives a clear overview of current support from PWE, SWE and FWP perceived by participants but as well it introduces the desired support from these elements in "ideal" WE. Furthermore, this study takes multi-national approach which allows understanding of current and "ideal" WE from the perspective of different countries which significantly influence the application level of research results.

In current stage implementation of PWE, SWE and FWP is lower than 50% of its maximum, which emphasized the need for quick change. SWE is currently the most emphasized and present element of WE which is in accordance with expectations as SWE has longest history of promotion among employees as well implementation among companies. There are no significant differences among countries in the current level of implementation of WE elements for creativity, thus this can be observed as

universal problem. Differences in implementation are expected to be driven by individual companies but not on country base.

The results clearly demonstrates that on average bases no one of creativity supporting work environments, including PWE, SWE and FWP are enough present in current WE. There is significantly large gap between implemented and "ideal". Thus universally worldwide companies should start engaging more in creating better WE in terms of its creativity potentials. Even there is a significant gap between current and ideal stage of WE implementation, the presence of elements of WE in "ideal" case are scored with AVG 64% of its maximum. This indicates need for promotion and explanation of the influence of WE on creativity performance as results could be influenced by current experiences and abilities to immerse in "ideal" environment which participants have never experienced before. Research results are applicable worldwide due to low oscillations between countries. However still there are some country specific cases due to individual characteristics and uniqueness.

The research results should be interpreted within the bounds of its limitation. First, when it comes to "ideal" WE it has not been visibly illustrated to participants thus they might be unable based on information they have to picture that environment. This could potentially influence the results of desired level of each of elements of WE. This limitation to the certain degree is acceptable, as elements of SWE and FWP cannot be visible presented to participants if they are not placed in controlled environment as a part of experimental research. Secondly, the number of respondents was limited and they were from similar backgrounds. Future researches should enlarge number of respondents and their background (such as from different industries) to gain broader insights across more diverse range of participants from a given country.

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Assessing the Digital Work Environment: a Case Study of Digital Transformation in Higher Education

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This paper discusses the trajectory in an organisation of survey tools for examining ICT in the workplace. The tools used were the UsersAward survey, a survey tool from Prevent, and the well known System Usability Scale (SUS). Against the background of an action research project, it has been possible to trace some of the effects of the results in practice and discuss their actionability. Preliminary results indicate that on a strategic level assessing the digital work environment provide valuable input. Yet, on a more direct level the results from the survey tools are harder to convert into action.

Keywords: digital work environment, digital workplace, survey, actionability

1. Introduction

The ongoing digital transformation provides many opportunities but there are also risks of negative effects on the workplace. A successful digital transformation requires insight into the status of the digital workplace. While other aspects of healthy workplaces are rather well understood, research relating to digital transformation and organizational ergonomics is still limited.

There are numerous survey tools for assessing usability aspects of ICT (Kavathatzopoulos, 2012), yet not so many tools for assessing the digital work environment exist (Thorner, 2012). In Sweden two tools for analyzing this has attracted attention lately. The first is the UsersAwards tool, with is distributed by TCO. The other is the online tool provided by Prevent. There are some important differences to these tools. The UsersAwards is the result of a research project and it is also closely related to the Scandinavian tradition of workplace research. The other tool is declared as not being a scientific tool but rather based on best practices. As its focus is ”ICT related stress” it also draws on a different tradition than the first, and it is more based in psychology and concepts such as technostress and work life balance. The latter tool is the more readily available as it is provided as an online tool for self testing or as an input for work place discussions. The former is well known in Sweden as it has been the base for a number of well cited reports from the union Unionen, on the state of ICT in the workplace.

There is nevertheless a gap in how such tools function in real life settings, in particular how they impact the organisation that use them. While new tools can–and should–be developed for examining the digital workplace, this study has the overarching purpose of analyzing existing tools in order to shed light on current best

practices. This has been done as part of an action research project focusing on a large scale implementation on an administrative system for student affairs in higher education. (see Nauwerck et al., in press for more details on the project). This setting provided an opportunity to trace the trajectory of surveys and survey results relating to the digital work environment through an organisation. On the organizational level, the study contributed to a deeper understanding of the current situation to aid the design of the implementation project, as well as to allow a follow up and possible even continuous monitoring of the effects of the new system. The aim of this paper is instead to discuss the trajectory of said study through the organisation. Thus, the main contribution of this paper is related to the *application* of tools for assessing the digital workplace.

2. Method

The study was designed in three stages. In the first stage the survey tools to be studied were selected. In the second the actual surveys were conducted. In the third stage the reception in the organisation was observed. Before the survey study the researcher conducted six interviews with future respondents. The selection was done with help of the internal project team and the main criteria for inclusion was that the interview respondents should come from different divisions within the organisations. These interviews were documented in writing and summarized by the researcher within a day of the actual interview. It should be noted that the surveys should be seen as the first step in a longitudinal study. As such, they provide a snapshot of the current situation before the anticipate change.

On the whole, the study can be said to have aimed at ecological validity, that is to emulate how such a study could have been conducted and received in a real life setting. The selection of survey tools were based on three criteria: (1) they should be relevant to the study of the 'digital work environment', (2) the tools had to be freely available and (3) the tools had to be established outside of academia. The third criteria excluded survey tools only developed and/or used for research. In the end two tools remained, namely the UsersAwards survey and a survey tool for IT-stress designed by Prevent. A third tool, the UDIPA (Thorner, 2012), was a possible candidate but as it was deemed to have comparatively low visibility it was excluded. It was deemed that the population was large enough to be split in two groups, each receiving one of the survey tools. The idea behind this was to allow a comparison between how the two tools worked in practice. Had the population been larger it might have been possible to include the UDIPA as well but in this case a split into three groups would have resulted in to small sub populations. In order to compare the two groups both surveys were extended with the System Usability Scale (SUS). This had the additional advantage of including an internationally well known tool that to some extent also fulfills the three criteria above. A limited number of background variables were included as well. (See Nauwerck, in press, for an overview of all survey questions.)

A few items were removed either as a result of the test round or to keep the two equal in length. As far as possible they were left in their original form.

The surveys were distributed as online surveys using the commercial Kurios web survey tool (property of Paloma). The the survey was advertised in presentations, on the organisation's intranet and via e-mail sent from within the organisation. The actual invitation and the following reminders were also sent by the organisation's internal project leader. There was also a small test run of the survey before it was distributed to the target population. In the end the survey was sent to (all) 322 administrators within the organisation (with a response rate of 54%).

When the survey was closed, data was downloaded and analyzed via the JMP Statistical Software. The control-demand-support model was then used as an interpretative framework (Karasek & Theorell, 1990).

As the study was part of an action research project, the researcher had an active part in the presentations (McKay & Marshall, 2001). The trajectory of the surveys and the survey results through the organisation were documented in the project group's minutes as well as on the organisation's intranet. The two hour seminar also included some direct feedback via group discussion, mentometers and questions. While the approach was that of action research the method for this part of the study is best labeled as organizational ethnography (Boll, & Rhodes, 2015).

3. Results

The results from this study are on two levels. On a direct level there are the specific results from the specific surveys which give an insight into an ongoing digital transformation. On a meta level the study also contributes towards an understanding of how these surveys are received in actual practice. As most of the latter is inductive in nature it will mainly be part of the discussion in the next section, here the focus is on the direct survey results.

The System Usability Score questionnaire has 10 items but is used to build a single index value. In contrast, the two main surveys had about 40 items each more or less loosely grouped under a number of headings.

In the feedback to the organisation there was no point in making a distinction between the different surveys used, Also, this level of granularity was not suitable for presentation. Instead, the material was interpreted using the control-demand-support framework. The concrete results indicated high demands on administrative staff, driven by a high service level as well as technology gaps. Control also varies and here results indicate that job experience is really important. This can be a challenge as a number of administrators will retire over the next few years and will be replaced with new staff that might lack similar experience. While the support organisation was rated high, what was lacking was the higher level support from management. Some possible strategies for improving organizational ergonomics and resilience during digital transformation were also noted. The first is to acknowledge the changing role of the workers, in this case the administrators. The second is to develop networks that allow for support and development of best practices between departments. The third is to provide high quality support. These overarching results were the basis of what was reported back to the organisation. For a bit more detail on this, see Nauwerck et al. (in press).

Based on the analysis above a presentation was developed. This presentation was then given to the organisation's project group, in a two hour seminar aimed at the respondents and–as part of a larger information effort–in a number of 5 minute presentations. The material was also distributed on the organisation's intranet. Judging from the feedback from the above mentioned seminar, the results resonated well with the respondents. That is, as far as data collection goes, the surveys did what they were supposed to do.

Despite of this, the effect of the survey did seem to fade out quite rapidly over time, as other matters pushed to the forefront and the news value declined. So far, the results do not seem to have reached senior management, with the exception of the project owner.

4. Discussion

The major limitation of this study is that is only a snapshot in time. This is a limitation as it means that most survey items are hard to interpret, as they cannot be compared with anything. If and when a follow up survey is done, it will be more interesting to look at individual items to see if they have changed.

Something of a remedy to this was intra-organizational comparisons. Yet, we had to tread very carefully in doing this as it was politically sensitive. Actually we elected not to have that much granularity in the background variables to avoid ethical issues. It was still possible to note that there probably were organizational variations and that these could be relevant to address.

Again, on a high level there were no discernible differences between the three survey tools. Of course, as can be seen just by reading the respective questions, they have slightly different focus. Still this variation in focus is not an important problem.

What does seem as a weakness–and this is known from discussions on employee satisfaction surveys–is the level of abstraction which is a consequence of intra organizational evaluations. That is, in trying to create tools that can be used to compare different organizational settings, the tools lose relevance to the specific organisations. In particular they do not seem to lend themselves to action. For this, they probably have to be much more specific to the specific organisation, which reduces possibility for benchmarking (Hartebrodt & Chtioui, 2016). Also, as indicators aimed at putting the spotlight on ICT, they leave other aspects in the dark. Going back to the interviews it seems that it is hard to understand ICT without including organizational aspects in general and management in particular.

A minor note is that in the open question quite a few noted that they found it hard to comment on ICT rather than one one particular system. Most respondents did not comment on this, but it might be that this is indeed a problem and if so it is a real challenge to the study of the "digital work environment".

Existing tools for mapping the work environment do indeed provide insight into the digital workplace but there are also blind spots that need to be addressed. Further research is needed and a next step will be a closer examination of the tools used and possible alternatives or extensions to these.

Acknowledgements

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From conflict to operational efficiency: an exploratory study on conflict management guidelines

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Conflicts at work is one of the biggest source of corporate inefficiency : their ineffective management constitute one of the most important psychosocial stressors for the quality of work life and the organizational productivity. In fact, most of the organizations lack knowledge on the tools they could integrate into the conflict resolution process. In this context, we conducted a survey among 56 professionals of various ages, professional experiences and business sectors. We describe the major impact of conflicts on well-being and work efficiency and we show the participants felt abandoned from the companies functions in half of the situations described and that no tools were implemented for solving these issues. Taking examples of conflicts described by the participants, we demonstrate the potential for digital applications in supporting firms function preventing or anticipating such situations. At this stage, we support mainly the development of communication tools to identify the origins of the situations and improve their description by employees.

Keywords: Workplace conflict management, sustainable working life, upcoming technologies

1. Introduction

Even if managers can devote up to 42% of their working time dealing conflicts (Dana, 2001; Katz & Flynn, 2013; Thomas & Schmidt, 1976), conflicts at work and their ineffective management constitute one of the most important psychosocial stressors for the quality of work life and the organizational productivity (Roberts, 2005). This is partially due to the lack of conflict management systems or their formalism (i.e grievance systems with standard processes of completing a grievance form) which in many cases creates more conflicts than solves them (Katz & Flynn, 2013). Moreover, researches have shown that conflicts at work remain largely unrecognize as one of the most significant costs in many business (Dana, 2001). These researches revealed that conflicts are a decisive factor in at least 90% of terminations, including voluntary resignations.

Yet, there are also “stimulating conflicts” that can be source of creativity (Hackman, 2002) and "good conflict" encourages constructive debates and creates effective solutions (Toegel & Barsoux, 2016). Knowing successful teams are likely to be proactive in anticipating the need for conflict resolution and develop conflict resolution strategies (Behfar, Peterson, Mannix, & Trochim, 2008), it seems necessary to empower managers and employees to benefit from conflict resolution. For instance, mediation methodologies and techniques to improve interpersonal communication such as Non Violent Communication (NVC) (Rosenberg, 1983, 2003) have been studied in a variety of settings like schools, hospitals, or prisons (Juncadella, 2013). In the field of work

organization and management we find a growing literature on the design of protocols to support discussions about conflicts in the workplace (Detchessahar, 2013; Falzon, 2014). Nevertheless, such techniques require prior training and coaching so they are rarely implemented in a sustainable way in companies.
Our project aims to develop technologies to improve conflict management processes, considering the complexity of conflicts and the process of their development. Moreover, news solutions integrate artificial intelligence models to help professionals (managers, human resources, etc.) anticipating the creation of conflicts from the analysis of everyday work situations. This paper presents the results of an exploratory research designed to study the processes involved in conflicts in organizations. Also, we sought to identify the existing conflict management systems and methods in the corporate environment.

2. Background and purpose

Conflict is an inherent part of organizations (Boz, Martínez, & Munduate, 2009; Nussbaum, Susa, Castillo, Flies, & Moreno, 2011). Not only they are inevitable but they can serve a positive function in the workplace (Afzalur Rahim, 2002; Gil, Rico, & Sánchez-Manzanares, 2008). In this perspective, conflict management processes are critical elements in determining if conflicts have a negative or positive effect on the workplace environment (Katz & Flynn, 2013). It seems important to define the conflict and the processes involved in its development to adapt the conflict management strategies.

2.1. How to define conflicts in the organization?

Managers can define conflict very succinctly as a dispute between employees or between employees and managers, others distinguish the conflict which is a serious problem and disputes which are considered a minor problem (Katz & Flynn, 2013). The literature provides various definition of conflict that focus on the conditions of appearance and on the process of development. (Rodriguez, 1991) defines three conditions which favor the appearance of conflict: 1) The existence of two simultaneous behavioral tendencies which are incompatible or contradictory; 2) The existence of pressure to decide; 3) Significant needs are impacted. For (Thomas, 1992) "*conflict is the process which begins when one party perceives that the other has frustrated, or is about to frustrate, some concern of his*" (Thomas, op.cit, p.891).
These definitions highlight the process dimension of conflict which interest us in two ways. First, it allows to understand conflicts not only as a result but also as a series of determinants leading to the choice consisting on managing a situation in the form of a conflict. Secondly it suggests the possibility of intervening in the stages preceding the choice (intended or endured) of conflict.

2.2. Personal and situational determinants of conflicts

The conditions for the onset of conflicts can be linked both to persons and to the tasks or the organizational structure to which they belong (Jehn, 1995). Personal conditions include the values and beliefs of individuals and groups, as well as the characteristics of the personality responsible for certain attitudes and behaviours (Rahim, 1989; Robbins, 1987).

Conditions related to organizational structures or situations may concern: the type and structure of tasks, the characteristics of groups, ambiguities in responsibilities, reward systems, leadership and management styles, communications problems and incompatibilities between the capacities of a person and the tasks or positions assigned to her (Nussbaum et al., 1995).
Finally, conflicts can also originate from the difficult economical context encountered by firms, which often results in overwork, insecurity and stressful work situations (Katz & Flynn, 2013).

2.3. Consequences of conflicts and conflict management processes

Several authors have shown the negative impact of conflict on the working environment, on groups and individuals. Conflicts can influence the psychological well-being of employees affecting, for example, their motivation at work but also the cohesion of the group (Peiró, Prieto, Zornoza, & Ripoll, 1999). However, conflict can also have positive effects on the employee and on the organization. By integrating and comparing the diversity of viewpoints, conflict can increase the capacity for innovation and divergent thinking. Also, it can increase the quality of problem-solving and decision-making processes (Nussbaum et al., 2011; Peiró et al., 1999). Nevertheless, to draw positive consequences from the conflict, several conditions are necessary, one of them being the capacity of recognising the existence of a conflict.
(Clot, 1999; Litim, 2006) emphasise on the importance of the revelation of conflicts of activity and the organization of the controversies on problematic work situations to empower individuals. Yes, many studies show the growing difficulties of front line managers to establish local discussions on work (Detchessahar, 2013).
Employees also show relatively low levels of satisfaction with the way their organization manages conflict (Katz & Flynn, 2013). According to the authors, organizations that have formal conflict management systems in place often choose to resolve most of conflicts informally to avoid a long formal process. Moreover, other "traditional" ways of dealing with conflicts are the denial of conflicts, litigations or threats. Also, firms are more likely to call outside expertise to manage conflicts rather than develop their own capacity to manage them. In fact, most of the organizations lack knowledge (or means) on the tools they could integrate into the conflict resolution process. Above all, companies lack benchmarks about the cost of unmanaged conflicts.

2.4. Innovative tools for conflict management

Our project aims to develop technologies to improve conflict management considering the complexity of conflicts and the process of their development and resolution. These technologies are addressed to managers, human resources professionals and all members of staff. They do not intend to replace professionals or existing practices such as the ones presented above. Instead the aim is to facilitate the formalization and the rise of the determinants leading to conflicts so they could be anticipated and managed in a constructive way. Therefore, through this tool, we seek to analyze the forms of expression of conflicts to provide a feedback to the user and to present a non-nominative cartography of the conflicting situations in the team for employees, managers or human resources.

This paper presents the results of a prior exploratory research designed to study the processes involved in conflicts in different French organizations. Also, we sought to identify the existing conflict management systems and methods in the corporate environment including technological and more traditional tools.

3. Design and methodology approach

We conducted an exploratory study mixing qualitative and quantitative data gathering methods. The team conducted eleven semi-structured interviews with executives, high level managers and employees using a series of open-ended questions based on the following subject areas: The conflicts encountered in their work environment; The main causes of these conflicts; Their impact on performance, and the means of solving them.

The data collected during the interviews as well allowed us to build a survey aimed at collecting systematic data from a wider population. The survey consisted of 4 parts based on the following subject areas: 1) General information about the respondent, their company, their position in the company. 2) The description of a conflict situation experienced in the actual workplace followed by a series of questions about its determinants, its management and its impact on the person's well-being and on their work performance. 3) The importance and the determinants of well-being in the work environment and the current practices in the company to develop these dimensions. 4) The use and perceived utility of developing digital tools to improve workplace well-being and to manage conflicts.

Participants were selected among the professional network of the team project. They were contacted by email presenting the aim of the project, the content of the survey following and the link to respond to the survey online.

4. Results

In this section, we present a general synthesis of the data collected with the interviews and the survey.

4.1. Participants

Overall, 56 persons contributed to our study among which 31 women and 25 men. Most participants are between 30 and 39 years old among which more than a half has less than 5 years of seniority in their current company (*Table* 1) with an average 12 years of professional experiences. Even if the 30 to 40 years are more likely to change several times of company during their career, more than a third of the 30-39 have between 6 and 12 years of seniority in their company. We didn't analyze the links between workplace conflicts and seniority; this may be an interesting data for the next steps in the project.

	Seniority in the company					
Age	0-5	6-12	13-20	>20	NC	Total
18-29	5				2	7
30-39	20	14	2		2	37
40-49	3	3	2	1		9
50-59			1	1		2
	28	17	5	2	4	56

Table 1- Age of the participants and seniority in their current company (NC= non-communicated)

Participants belong to diverse activity sectors such as: Arts and media, justice, marketing, human resources, health, telecommunications, tourism, finance and insurance, etc. The latter is the most represented among the participants (N=16) and its fallowed by consultancy (N=8).
As we are interested in the conflict management strategies of collaborators and specially of manager's, we looked to characterize the profile of managers among the participants. Among the 56 participants, 44 have management functions among of an average 15 collaborators what can be defined as large team managed. This is particularly interesting because the literature on conflict management strategies often focuses on proximity management and their time invested in the day-to day management of conflicts.

4.2. Conflict situations

Based on the definition of the conflict as a process, we asked the participants about a situation they encountered in the professional area that created a feeling of: frustration (based on an impression of injustice), tension (characterized by a state of lasting exasperation), or conflict (characterized by a state of established opposition and disagreement). This classification is subjective but it allows participants to describe situations that are not yet conflicts (all participants may not have experienced conflicts in their workplace) and it allows us to identify and understand precursory or underlying events of a conflict. Participants described 63 situations (each participant could describe several situations) among which 25 situations of conflict, 21 situations of frustration and 17 of tension. At the same time in our survey these workplace situations were classified and defined as (1) Horizontal situations (H) between employees or managers at the same hierarchical levels or Vertical (V) interactions when different hierarchical levels were involved; (2) Situation linked to task to be executed (T) or based on interpersonal relationship (R)

	RH	RV	TH	TV	Total
Conflict	**9**	11	3	2	25
Not solved	**8**	7	1	1	17
Solved	1	4	2	1	8
Frustration	1	**7**	3	**10**	21
Not solved		6	2	8	16
Solved	1	1	1	2	5
Tension	4	4	2	7	17
Not solved	**3**	4	1	5	13
Solved	1		1	2	4
	14	22	8	19	63

Table 2- Participants feeling of situations resolutions depending on situations type

Results in *Table 2* suggest that conflicts are mainly related to interpersonal situation (N=21) and frustration to work organization (N=17) (distribution of tasks and goals definition). Conflicts described have been solved without satisfaction (with 68% of unsolved conflicts feeling from participants and 76% of unsolved frustrations and tensions). For example, in 3 cases, the resolution involved a resignation.
Frustrations are commonly related to work organization. This can imply a lack of communication about the distribution of tasks "who does what" involving for example situations in which one colleague executes the tasks that were originally assigned to another one. But it can also be related to the pressure employed by managers on teams

to achieve results set by the organization. Finally, frustrations can emerge from a lack of resources: time, human resources, clear procedures, etc.

Tensions are more likely to be related to the type of management, that is all the strategies mobilized by the manager to manage their team. Participants describe situations in which they faced difficulties directly linked to their manager's strategies (or lack of strategy). For example, the manager may underestimate the work done by the collaborator because he lacks knowledge about the content of the collaborator's missions. Moreover, tensions may also arise from a lack of communication of the company's objectives from the manager to the team, creating a blur in the objectives to be achieve.

Finally, among the conflicts we identify situations in which a team member or a manager lies or hides information for his own benefit. Other situations describe conflicts with the hierarchy on the strategies of awarding bonuses creating a feeling of inequity between employees.

Results suggest that, contrary to our initial expectations, most of the situations experienced by the participants are linked to relational (N=36) determinants (type of management, trust, personal relationships) rather than to task or work content (N=27) determinants (work organization). However, these data need to be further investigated to determine the extent to which conflict of tasks are intimately linked to interpersonal conflicts. In fact, for some participants, relational conflicts originate from a different perception of teamwork.

4.3. Impact of conflicts on employee's well-being

As specified before, conflicts can influence the psychological well-being of employees affecting, for example, their motivation at work but also the cohesion of the group. Practically all the situations experienced by the participants had a negative impact on their well-being whatever the determinant of this situation and to a lesser extend their work efficiency (*Table 3*). Among the 56 participants:

- 81% of the 42 answering this question (or 61% of the overall participants) considered conflicts impact negatively their well-being. To be noted these 42 also considered harmony and well-being at work as important or very important
- 48% of the 40 answering this question (or 34% of overall participants) considered conflicts impact negatively their work efficiency.

This results in a loss of interest in work, in a loss of efficiency in the work team and in some cases in a psychological burn out.

4.4. Conflict management and resolution

Conflict management strategies seem unsatisfactory among most participants. A large majority is unsatisfied with the conflict management resolution (*Table 3*). That is in several situations conflicts are not really resolved, instead they are ignored or teams are restructured to dilute the conflicts. In extreme cases, the resolution the resolution implies the resignation of one of the employees or his temporary departure. Participants state that even when conflict has been resolved, interpersonal relationships have deteriorated. Moreover, conflict management deploy short-term solutions and frequently the root causes are not worked out.

(Well-being - Work efficiency)	RH	RV	TH	TV	Total
Impact	10 - 7	21 - 9	6 - 5	15 - 8	52 - 29
Not solved	8 - 5	16 - 7	4 - 3	11 - 6	**39 - 21**
Solved	2 - 2	5 - 2	2 - 2	4 - 2	13 - 8
Didn't impact	3 - 6	**1 - 9**	2 - 3	**4 - 10**	10 - 28
Not solved	2 - 5	1 - 6	0 - 1	3 - 7	**6 - 19**
Solved	1 - 1	0 - 3	2 - 2	1 - 3	4 - 9
	13 - 13	22 - 18	8 - 8	19 - 18	62 - 57

Table 3- Participants feeling of situations impact on their well-being and work efficiency depending on situation type and resolution

When asked about the conflict management or resolution process:

- 100% of the 31 answering this question (or 55% of the overall participants) admitted no tools nor specific methodology was used in their companies
- 49% of the 39 answering this question (or 34% of the overall participants) considered no third party was involved in the resolution. Proximity management was involved for 13% (9% of overall participants) and Human resources function for 10% (7% of overall participants)

We thus asked participants (N=36) what would be their ranking of the most important components of well-being and efficiency at work and if some digital tools could improve their current state of development in their companies (*Table 4*).

	μ	σ	App compatible	#
Team spirit, climate of trust and harmony	2,4	1,8	36%	35
Recognition of your work and skills	3,7	2,1	47%	32
Work/life balance	4,0	2,1	47%	32
Salary	4,5	2,0	31%	32
Career opportunities	4,8	1,6	63%	32
Efficient management with clear organisation of goals and their priority	5,0	2,3	68%	31
Freedom of expression of ideas and emotions	5,5	2,2	59%	32
Image of your function or of your company	6,1	1,7	41%	32

Table 4- Average ranking for components of well-being at workplace (from 1 to 8, 1 being the most important) and potential digital tool adhesion for a future development of these components

The highest ranked components seem more difficult to improve via digital tools among participants than carrier opportunities management or organization/priority of task. Nevertheless, vertical concealed/underlying conflicts or horizontal task related frustration often seen as damaging climate of trust and harmony for a team seems to be more avoidable now with new communication tool protecting privacy to face the conflict origin or improving expression of team members *(Table 5)*. Open and confident communication between management and team members is described as the primary means for conflict management. External consultants can also intervene to help better define the missions of each collaborator to solve organizational conflicts. Concerning more personal methods, participants recommend adopting a reflexive posture on situations and to choose simple and-aggressive words to deal with the conflict.

	Conflict RH	Frustration TV	Total
Fear of having to face the conflict's origin	4	4	8
Difficulties to express	5	3	8
Not all conflicts should be discussed		2	2
It is a normal thing in companies	1	2	3

Table 5- Reasons of concealed or underlying conflicts or frustrations according to the participants for 2 examples of situations: horizontal interpersonal conflicts and vertical task related frustrations

5. Discussion

After defining and describing 3 types of professional problematic situations (conflicts, tension and frustration) and 4 associated different contexts or determinants (THRV), we evidence through a survey analysis of 63 problematic situations that most of the counterproductive situations described by the participants are based on a state of established opposition and disagreement arising from personal interaction at work or impression of injustice at the same hierarchical levels. These situations largely impacting the well-being (84%) and work efficiency (51%) of employees represent an overall risk for companies facing aging of population and hiring needs. Knowing the participants reported they felt accompanied only 50% of times that they faced these situations and every time with no defined methodologies or tools, we identified some space for improvement.

Crossing the main components of participant's well-being with conflict management processes only a few companies use with coaches, our study showed that the development of digital tools integrated in the employee's workspace could improve some of the main components of well-being. Moreover, some other task management tools are seen by participants of our survey to be more easily integrated in their current workplace and would reduce impression of injustice from frustration they felt.

To already offer a first solution in the current economical context, we started implementing some conflict management methodologies in digital applications to help the responsible functions to mitigate more efficiently these operational human risks. These relatively simple tools aim at improving communication and description skills when the situation faced by employees have an underlying risk of developing. It also gives to the company organization metrics of overall wellbeing, and feedback more efficiently when the situations are solved by the responsible functions.

At this stage, our survey is focusing mainly in French speaking countries but is already planned to be enlarged to English and German speaking countries. Moreover, the frequencies and quantitative impact of the described situations would be interesting to analyze in the future for an operational risk full overview.

6. Conclusion

This exploratory study on conflict management describes a sample of diverse work situations where both human and economic goals of companies were not met according to the participants of various hierarchical levels. About well-being components, we also described some new approaches that could be integrated in the current workplaces already widely digitalized.

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Industrial Designers' activities and Ergonomics application in SMEs

Analysis of the footwear manufacturing companies at neighborhood Restrepo in the city of Bogotá

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Small and medium-sized companies (SMEs) constitute the highest percentage of industrial organizations worldwide, in that sense, for the industrial design community it is very important to know which the role of industrial designers in SMEs is. The main objective of this research project is to characterize the participation of industrial designers at SMEs, and to establish if that participation contributes to improve the performance of organizations with the application of Ergonomics practices. This document presents the main aspects found in the documental review as an introductory step of an on-going study and some partial conclusions.

Keywords: Design, Ergonomics, SMEs, footwear manufacturing companies

1. Introduction

In recent times, the small and medium-sized enterprises (SMEs) constitute the highest percentage of industrial organizations in many places of the world, always being one of the most important production forces anywhere. In Colombia, SMEs constitute a percentage above the 90% of the total of productive organizations, however, these kind of companies have a short life cycle, which does not overcome more than two or three years (Santana Viloria, 2017).

This might be caused by a series of difficulties that SMEs commonly suffer, such as the limited resource management, low management skills, low market penetration, excessive bureaucracies, management informality, high quantity of competitors, weak associativity, low productivity, etc. (Krause & Schutte, 2015; Ministerio de Comercio Industria y Turismo (MINCIT) & Universidad Nacional de Colombia UNAL, 2010). According to this, it could be implied that these difficulties, specially the limited resource management and the excessive bureaucracies, make the life cycle of these organizations shorter than what entrepreneurs would expect. A study made in SMEs in the city of Bogotá proved that three main determinants for the survival of this

organizations are the number of employees (a higher number of employees means a higher probability of failure), cost effectiveness in the initial asset, and the financial indebtedness (Santana Viloria, 2017).

Understanding the impact of the SMEs in the productive development of any region, it is very important for the industrial design community to know and understand which the role of industrial designers in SMEs is, and to evaluate if designers are being appropriately prepared to perform it. The difficulties named above not only unshorten the life cycle of the SMEs, but they also could be hindering the potential activities performed by designers who work in these organizations.

It is important to consider that Industrial Design is a relatively new profession in the Colombian context. Particularly at the context of an economic activity like footwear manufacturing, designers probably are the newest professionals. The professional designers have been working in this kind of companies for less than ten years. So, it is an opportunity and a challenge to improve industrial designers' competences and abilities to apply a more robust development of new products and other needs of these companies.

In that sense, the main purpose of this investigation project was to characterize the participation of industrial designers at SMEs, and to establish if that participation contributes to improve the performance of organizations thanks to the application of ergonomics. Also, in this study it is considered important to compare what is being taught in the Colombian industrial design academy related to the ergonomics discipline with the reality about the activities related to that discipline performed by industrial designers at their place of work, across the case of the footwear manufacturing SMEs.

However, starting the field work some impediments arose, some of them related to the ways to communicate with the companies, like

- Shortage of databases of companies in the sector, making difficult to find current and accurate information about the business owners and leaders.
- Low formalization of organizational structure of the SMEs.
- Scant organization among designers and ergonomists, which does not make it easy to find companies where industrial designers and ergonomists can be found.

In despite of that, the previous experience of the researchers at this project has shown that, in footwear manufacturing SMES, as well as companies from other sectors, design is mostly dedicated to aesthetic activities related to product and services design, but it is not included in other tasks. Also, SMEs where the researchers have been working in do not have R&D departments in order to develop knowledge about ergonomics to apply in product design or production systems. A good example of this in the footwear manufacturing SMEs, is the vamps and out soles of the shoes, many companies already have some predetermined models that are being used in most of their products, but there are no real intentions of designing new shapes or developing another ergonomic attributes for those parts.

This document presents the methodology applied in the documental review prior to the field work, some partial conclusions and aspects to consider in the following phases of this research project.

2. Methodology

As it has been said before, this study is being carried out in the footwear manufacturing companies from the neighbourhood Restrepo at Bogotá city(Colombia). The reason to do that is because in these companies there are a great variety of processes in whose Design and Ergonomics can be applied at different levels, such as product, production and management design. Also, in these companies it is common to find industrial designers among the hired personal, and that offers the opportunity to evaluate their activities, the application of their ergonomics knowledge, and their influence in the company development.

However, the mere presence of industrial designers in the SMEs is not enough to improve their dynamics. For this, it is also necessary a transcendental change in the management of the different levels of the organization. There is now a great variety of organizational management tools and models, created from disciplines as diverse as engineering and administration, which purpose is to help SMEs to overcome their difficulties in order to improve their general conditions, increase their productivity and promote their growing and development. This research project is focused particularly on tools and concepts provided by Ergonomics, because this discipline has, since its fundamentals, a close bonding with Industrial Design.

In that sense, a documental review has been made, analysing documents about the inclusion of design and ergonomics in SMEs in different places of the world. The documents analysed were found in different data bases, being EbscoHost, Academic Search Complete, Business Source Complete and Jstore the most important ones.

This review started with an analysis of papers about design applied in any kind of productive organizations, with a special emphasis in those related to SMEs. The main purpose of this first analysis was to evaluate the relations of Design and productive organizations (SMEs) among four main dimensions as shown in Figure 1. : Design as a discipline, design research, designers' activities, and trends in product design and development. Some relevant concepts and practices were found, such as Design Management, User Centred Design and Participatory Design.

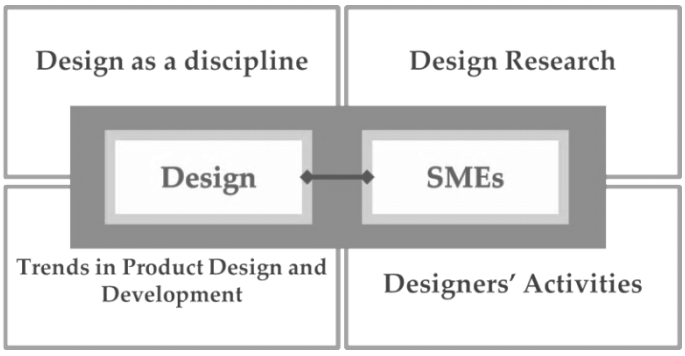


Figure 1. Analysis of the relations between Design and SMEs among four main dimensions of Design

The following step was to make a similar analysis of papers related to Ergonomics in SMEs. Just like the previous analysis, this analysis was made among four main dimensions too, shown in Figure 2. , those were: definitions of the Ergonomics discipline, its domains of specialization, history and trends, and its relations with product design. Some relevant concepts that resulted from this analysis

were Organizational and Physical Ergonomics, Organizational Safe and Health (OSH), physical adjustment, cognitive adjustment, and Organization Design.

From this two analysis', some fundamental aspects about the activities potentially performed by the industrial designers in productive organizations were found, and the way those are currently being applied in Colombian SMEs are presented in the next two sections of this document.

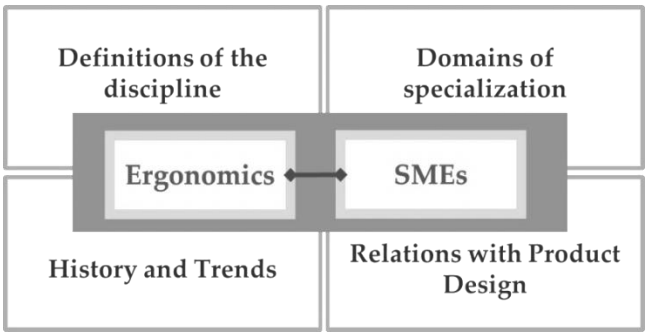


Figure 2. Analysis of the relations between Ergonomics and SMEs among four main dimensions of the Ergonomics discipline

3. Relations found: Design at SMEs

From the first analysis, about relations of Design and SMEs, there were found three main aspects, which are listed next.

Design Research. Beyond the implementation of design inside SMEs, it is mandatory to establish how design should investigate this kind of organizations. Three main approaches of design research have been analysed. The first one, proposed by Bruce Archer, is concerned with the understanding of the things and systems made by human beings (Archer, 1981). On the other hand, Richard Buchanan proposes a design research focused on product development, introducing product attributes like utility, usability, and desirability, which are the result of a conscious and disciplined interdisciplinary work of designers with other professionals (Buchanan, 2001). And last but not least, Nigel Cross established three main categories of design research: Epistemology, Methodology, and Morphology (Cross, 2013).

Despite the fact that these three approaches might seem distant, they have common elements that can be useful to understand the nature of design research, which studies:

- Objects –or products – created by human beings
  - Form
  - Composition
  - Structure
- Creation processes
  - Development and applications of tools
  - Human ability of design
- Relations between objects and people
  - Value – Desirability
  - Meaning
  - Purpose – Utility

- Usability

Thus, if the object of study of design research is SMEs, the man-made object would be the productive organization per-se, processes would be all those performed at the different management levels of the company, and the relations to study would be how all those processes affect the people in the organization and vice-versa.

Design Management. Concerning this aspect, it has been found that independently of their location, SMEs are characterized for a low hiring of designers, low investment in design departments, management improvisation, and silent design (Cawood, Lewis, & Raulik, 2010; Iduarte & Zarza, 2010; MINCIT & UNAL, 2010). This is also witnessed by the investigators of this project, who had worked several times as designers at SMEs in different sectors, including footwear manufacturing.

Design Trends: Participatory Design. It is based on the participation of different stakeholders in a product (or service) design process. This can happen among different stakeholders of one organization, professionals from different disciplines, between companies from a determined union, etc. (García-Acosta, Lagos-Puentes, & Lange-Morales, 2012). This specific trend is the one that is being applied currently (and in the best cases) in Colombian SMEs according to the previous experience of investigators in this research project. Some others use the concepts from Usability. However, this is not the case in most of this kind of companies, where processes are in some way very unstructured and improvised.

4. Relations between Ergonomics and SMEs

In what respects to ergonomics, most of the studies are concerned about occupational health and safety, but not too many of them study ergonomics' relation with design inside productive organizations, especially SMEs. In most of the data bases consulted the results for search equations such as "Ergonomics AND Design", "Ergonomics AND SMEs" did not overcome 30 documents listed, and after a revision of the abstracts only one or two documents were chosen to be entirely read.

Even so, there is a great variety of studies about ergonomics interventions in productive organizations (not necessarily SMEs) that go beyond physical ergonomics. Analysing some documents of those studies, some important aspects about the relations of Ergonomics in productive organizations were found, such as:

Definition of Ergonomics. Along its history, the discipline of Ergonomics had multiple approaches, and so, it also had multiple definitions. However, the most accepted and acknowledged definition is proposed by the International Ergonomics Association (IEA), which contemplates the main aspects of the interactions of humans with the elements of the systems where they perform their activities (International Ergonomics Association (IEA), 2000). For this project, an alternative definition of ergonomics is proposed:

Ergonomics is the study of the relations among human beings and all the elements of a productive or a socio-technical system, in order to improve human wellbeing - including physical, cognitive and social factors - and the performance of the system itself.

This definition incorporates the main elements from ergonomics' previous definitions, such as the interactions between people in socio-technical systems, human

wellbeing, and the performance improvement of systems (Hendrick, 1991; Koningsveld, Settels, & Pikaar, 2007; Wilson, 2000). Likewise, this definition results appropriate to work with SMEs, where the system is the productive organization, and people, like employees, managers, clients and other stakeholders interact with internal elements of the system, such as physic space, tools, organizational structure, as well as with external elements, such as markets, and cultural, social, and economic aspects, among others.

Trends in Ergonomics. Along its history, the interests that moved ergonomics have changed and evolved to subjects much more advanced than the original concerns about OHS, exploiting knowledge from several disciplines like biotechnology or genetic medicine. According to this, four main moments (or generations) in ergonomics' history have been identified: Physical adjustment, Cognitive adjustment, Neural Adjustment and Biological adjustment (Boff, 2006).

However, at determining in which of these generations are Colombian SMEs developing in current times, it must be said that many of them do not overcome the goals proposed in the second generation of ergonomics, most of them hardly reach First Generation. This is said according to this project researchers experience in SMEs from different sectors, such as furniture, advertising products and footwear manufacture. It must be said that companies that incorporate design at their early stages of development, are the ones that get closer to the approaches of the Second Generation.

This could result concerning, because the state of progress and development of the Colombian industry, getting into mind that SMEs constitute more than the 90% of active enterprises, reveals a poor state of progress and development of the whole country.

Domains of Ergonomics. When investigating the relation of Ergonomics and SMEs, many efforts should be driven to the Organizational Ergonomics domain, where socio-technical systems to improve are precisely SMEs, studying aspects related to design, internal communications, human resource management, quality management, etc. Organizational Design, that makes part of Organizational Ergonomics studies, brings useful tools to characterize the internal functioning of productive organizations, allowing also to study possible ways to optimize the relations between the human and the technological sub-systems.

Nevertheless, since the investigation is intending to analyze Ergonomics application in the different management levels of the company, factors related to Physic Ergonomics should be studied too, and in a minor scale, some aspects related to cognitive ergonomics. This is because Cognitive Ergonomics' subjects as well as its methods might seem too advanced for the current state of Colombian SMEs, that still struggle with other aspects to solve related to the other two domains of Ergonomics.

5. Conclusions and Discussion

At analysing the main aspects of implementing Design and Ergonomics in SMEs, it becomes evident that including one of them properly, the other will be implicitly applied. If Design is included as a main process inside the company, Ergonomics will be included too, even if the stakeholders do not have knowledge of it.

This means that Design must be understood as much more than an aesthetical component in product design. As shown in **Figure 3.**, an ideal collaboration of industrial designers with all the other departments inside (and outside) the company, intervening in the seven main management levels –human resources, marketing, logistics, exports, environment, communications and finance (Zapata, 2004), will result in a complete Ergonomics application that will represent a performance improvement for the productive organization.

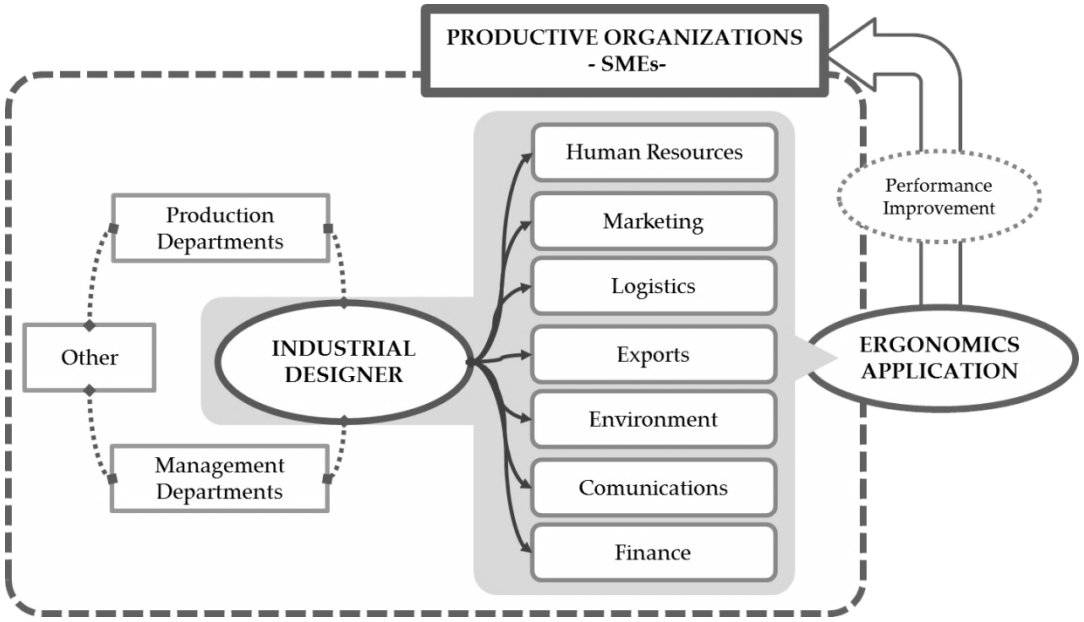


Figure 3. Industrial Designer's activities and Ergonomics application in productive organizations

This would be really useful in order to help SMEs to overcome their natural difficulties. However, in this kind of organizations, Design and Ergonomics are not understood in depth. This in the case of SMEs that already have design departments, because, in many cases, this department has not even been started (Cawood et al., 2010; Iduarte & Zarza, 2010).

By the year 2012, the Industrial Design National Program (PNDI, acronym in Spanish) made an important campaign among twenty SMEs proving how design can improve the general organizational system performance (MINCIT, UNAL, Programa Nacional de Diseño Industrial [PNDI], & Dirección de MiPymes, 2012). Nevertheless, it is important to consider that Design in those companies was present since their very beginnings, and it was considered a fundamental tool for their development.

Apparently design and ergonomics are not very well known in many Colombian SMEs, and from this situation a new concern arises. It is possible that there is a lack of communication of the benefits of the application of Design in productive organizations from the Industrial Design community. Also, it could be implied that there is also a responsibility of Industrial Designers to perform activities beyond the knowledge of their superiors, and beyond of what they are being told to do.

It is true that many SMEs have survived for several years without applying Design or Ergonomics, but the fact is that they barely survive in their respective

context. For that reason, if an organization not only wants to survive, but it also wants to grow and to be acknowledged for the quality in their products and processes, then the proper practices of Design and Ergonomics become, more than optional, mandatory.

One final consideration that is very important is the fact that most of the current models of organization improvement, from Design as well as from Ergonomics, have been created in and for European or North American companies or institutions, where very important factors about society and general culture are very different from the conditions found in Latin American, or other third world countries. Thus, it would be necessary to validate if all those models are applicable in the social and cultural conditions of countries like Colombia, or some other third world countries. Maybe, there is a necessity to improve our educational system in order to apply and to develop knowledge for the particular conditions of our culture and historical moment.

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A comparison of human factors evaluation approaches for nuclear power plant control room assessment and their relation to levels of design decision specificity

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Many design decisions must be made and repeatedly evaluated during the development process to form a nuclear power plant control room system that supports safe operation. The purpose of this paper is to compare utilised approaches to evaluate nuclear power plant control room systems and explore how they relate to design decisions at different levels of specificity. The method used was a review of academic literature. The result showed that evaluation of more specific design decisions is largely addressed. However, there is a need to further develop methodologies and methods for formative evaluation of more general design decisions to support assessment earlier in the development process.

Keywords: Nuclear power, control room, human factors, evaluation method, development process, design decision, early evaluation

1. Introduction

Nuclear power is a high-risk industry where safe operation is crucial. The purpose of a nuclear power plant is to produce electricity, but this process involves risks. The International Atomic Energy Agency (2007) defines nuclear safety as "*the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards*" (ibid, pp.133). Widening the definition to include hazards other than radiation, safe operation of a nuclear power plant is thus the production of electricity without exposing workers, the public or the environment to undue hazards.

A nuclear power plant is operated from a central control room: the plant's core functional entity with associated physical structure, where operators are stationed to carry out centralised control, monitoring and administrative responsibilities (International Standard Organisation, 2000). The physical structure of the control room, together with the operators and organisational structures such as work routines, can be viewed as a socio-technical system (for example using the definition by Hendrick and Kleiner, 2001), a control room *system*.

According to the IAEA International Nuclear Safety Advisory Group (1999), human factors is one of the underlying principles of nuclear safety. The discipline of human factors as a profession is concerned with optimising human well-being and overall system performance through the application of theory, principles, data and methods to design (International Ergonomics Association, 2016). Applying a human factors perspective when designing a control room system is thus a necessary approach to achieve safe operation.

Nuclear power plants do not remain unchanged during their lifetime, components must be upgraded when spare parts are no longer available and new technology allows

modernisations that enhance efficiency. This is true for equipment in the control room as well. In addition, since the control room must maintain the ability to control the process, changes in the plant's process systems will consequently require changes in the control room. Due to its central function in the operation of the plant, all changes to the control room system have the potential to impact safety (Norros and Nuutinen, 2005).

According to Ullman (1997), design is the successive development and application of constraints to reduce the number of potential solutions to a problem, until only one unique product remains. Developing and applying constraints is another way of saying that the possible values of design variables are constrained, in other words it is the making of design decisions (Bligård et al., 2016). When successively narrowing the solution space through the application of constraints, the design variables considered are more and more specific. Constricting the value of a design variable will in turn limit the possible underlying and dependent design variables that can be considered. A design decision is when a design variable is given a specific value. For example, the design variable "colour" can be given the value "red" – making "red" a design decision. A further specification of the variable would be to decide on a specific colour code. The natural order in a development process is to gradually move from more general to more specific design decisions, and phases in development processes are often differentiated based on the specificity of design decisions considered in that phase.

The need to address safety issues during the design process is supported by reviews of accident and incident data, which suggests that 20-50% of accidents and incidents have their root causes in design (Kinnersley and Roelen, 2007; Taylor, 2007). A multitude of design variables must be decided to form a control room system, and identifying and specifying them to create a control room system design that supports safe operation is not a trivial task.

Evaluation is an activity that can be used to navigate among this multitude of design decisions in the development process. A report from a Nuclear Energy Agency committee (OECD/NEA Committee on Safety of Nuclear Installations, 2005), stated that the process for modification of nuclear power plants should include actions to verify the fulfilment of requirements and validate the appropriateness of the modification. Hale et al. (2007), when comparing development processes for complex technical systems involving major accident hazards, noted that one similarity between the processes was "*the idea of waypoints at which the safety of the design is checked, before moving on to the next phase*" (ibid, pp. 312). According to Hale et al. (2007), this iteration of safety checks ensures that safety issues are kept in focus as the design process progresses.

In a development process, the ideal is to evaluate constraints on design variables as soon as they are set, in order to avoid having to reconsider the constraints on underlying design variables. Because of this, during the development process constant evaluation is not only important for safety issues (as stated by Hale et al., 2007), but for all constraints on design variables that form the solution, to ensure that the design achieves the desired effect. For this to be possible the evaluation approach used must be able to assess design decisions at different levels of specificity.

Design decisions must be represented in some way for evaluation to be possible. This representation can take many forms (see for instance Nielsen, 1993; Broberg et al., 2011), for example a description in text form or a wooden mock-up with paper printouts representing the operator interface. Because of the gradual specification of design variables in the development process, it is possible to use a representation of more specific design decisions to evaluate the more general design decisions preceding them, but not the other way round. The

representation of design decisions used in an evaluation is thus a determining factor for the level of design decisions the evaluation activity is able to assess.

The purpose of this paper is to compare utilised approaches to evaluate control room systems in the nuclear power industry and to explore how they relate to design decisions at different levels of specificity. The assumption behind this purpose is that identified gaps shown by this comparison and mapping of evaluation approaches to design decision levels should indicate needs for further development of evaluation approaches.

2. Evaluation, Verification, and Validation

The dictionary definition of "evaluate" is to "*determine the value or condition of usually by careful study*" (Britannica Online, 2017). Nielsen (1993) differentiates between two kinds of evaluation activities depending on their purpose: *formative* and *summative* evaluation. Formative evaluations are done to improve the design as part of an iterative development process. Summative evaluations are done to assess the overall quality of the design. Both formative and summative evaluations may be performed during the course of the development process, and an evaluation activity may fulfil both formative and summative purposes at the same time. There is little use, however, in performing a formative evaluation at the end of the development process because of the limitations in available time and resources to actually improve the design.

The terms 'verification and validation' (V&V) are commonly used in literature dealing with control room evaluation. In an ergonomics standard for the ergonomic design of control centres (International Standard Organisation, 2006, p.1) the evaluation process is defined as the "*combined effort of all verification and validation (V&V) activities in a project using selected methods and the recording of the results*". Evaluation here is an overall concept, and verification and validation are specific activity types. Verification is defined as "*confirmation, through the provision of objective evidence, that specified requirements have been fulfilled*" (International Standard Organisation, 2006, p. 2) and validation as "*confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled*" (ibid). These definitions propose that verification focuses on details whereas validation is a more holistic assessment. The purpose of verification and validation activities is to assess and provide proof of the quality of the design, thus making them summative according to the definition given by Nielsen (1993).

3. Method

The method used in this paper was a literature review of academic literature on the subject. More specifically, the comparison of utilised approaches to evaluate control room systems in the nuclear power industry and the exploration of how they relate to design decisions at different levels of specificity was executed in two steps.

In the first step, approaches were utilised to evaluate control room systems in the nuclear power industry sought through a search in a scientific database. The Scopus database was searched using the search string "*("nuclear power plant" AND "control room") AND ("evaluation" OR "validation" OR "verification" OR "assessment")*", limiting the search to texts from the last ten years (2007-2017). From 241 papers in the list of search results, 35 papers concerning evaluations proposed or performed in industry were identified based on the contents of titles and abstracts. Papers describing more research-oriented control room design and evaluation method studies were omitted to focus the review on approaches better adapted to conditions in industry projects. Papers not in English or unrelated to the topic of the study were omitted

too. The review of the 35 papers focused on determining if the proposed or performed evaluation activities were formative or summative, and on comparing the methodology used, especially the system representation used for the assessment.

The second step of the methodology explored how the identified evaluation approaches related to design decisions at different levels of specificity. A common reference for different design decision levels was needed to allow comparison between different evaluation approaches. The design levels of the ACD³-framework (a product development mapping tool visualising design decisions) and development process phases derived from them was chosen to serve as this reference (Bligård et al., 2016). In the present paper, the design levels are viewed as "falling", with design decisions being more general at the top (higher levels) and more specific at the bottom (lower levels). The ACD³-framework defines the different design levels in the following way:

- *Effect* (*Needfinding* phase): The effect that the machine is intended to achieve in the context (the term 'machine' is defined as the artefact the end users will be interacting with, i.e. the product being developed)
- *Usage* (*Design of use* phase): The use of the machine by humans
- *Architecture* (*Overall design* phase): The technical architecture of the machine
- *Interaction* (*Detailed design* phase): The interaction between human/context and the machine in detail
- *Element* (*Structural design* phase): The technical elements of the machine

Each of the 35 papers in the review was mapped to the design levels the assessed design was in when it was evaluated. In many of the papers the descriptions of the specificity of the evaluated designs were not very elaborate. For these cases the specificity of the evaluated design was assumed to be the same as the representation used for the assessment. For example, if a mock-up containing detailed operator interfaces was used, the design decisions to be evaluated were assumed to be on the interaction level. In the review, a distinction was made between clear mappings (where the level of specificity of the evaluated design was clearly specified in the reviewed paper) and estimated mappings (where the level of specificity of the evaluated design was difficult to determine and had to be estimated).

4. Results

This section describes similarities and differences between the stated purpose of the reviewed evaluation approaches and other aspects of the methodology used (such as the system representation used). The mapping of the design levels the assessed design was in when it was evaluated for the different papers is also presented.

4.1. Evaluation of Nuclear Power Plant Control Rooms in Industry

The review revealed that the papers by De La Garza et al. (2012) and Labarthe and De La Garza (2011) were based on the same project; so too were the papers by Hwang et al. (2009) and Yang et al. (2009); as were the papers by Rivere (2015) and Rivere et al. (2015); as also Gunnarsson and Eliasson (2010) and Hill et al. (2009); and Jia et al. (2014) and Jia and Zhang (2014).

Of the reviewed papers, some focused on verification and validation, and described these as summative activities (Ha et al., 2007; Lin et al., 2009; Lee and Chung, 2012; Suh et al., 2013; Jia et al., 2014; Jia and Zhang, 2014; Sun et al., 2016). Others described evaluation activities, sometimes called V&V, that fulfilled both summative and formative purposes (Alonso et al., 2008; Dobos et al., 2010; Zhang et al., 2010; Labarthe and De La Garza, 2011; De

La Garza et al., 2012; Liu et al., 2012; Eisner et al., 2015; Rivere, 2015; Rivere et al., 2015). Some of the papers described approaches where formative and summative evaluations were separate activities (Carvalho et al., 2008; Chuang and Chou, 2008; Manrique and Valdivia, 2008; Gray and Basu, 2009; Hill et al., 2009; Gunnarsson and Eliasson, 2010; Rejas, 2010; Roth et al., 2010; Song and Zhang, 2010; Pfledderer, 2012; Boring, 2014). Five papers described approaches where the main purpose was formative, to provide input to design (Huang et al., 2007; Hwang et al., 2009; Yang et al., 2009; Liang and Chen, 2010; Hanes et al., 2015). In the remaining papers the purpose of the evaluations was not clearly stated (Anokhin and Marshall, 2007; Jones et al., 2007; Anokhin and Marshall, 2009).

In the reviewed papers simulators of some sort, often full-scale, were used when performing validation activities. The accounts of summative activities (especially validation) were also more detailed in terms of describing the methodology used than the accounts of formative evaluations. Overall, the reviewed papers focused more on the overall structure of the evaluation process and the system representation used, than on the detailed methodology used in the different evaluation activities.

4.2 Relation to levels of design decisions

The specificity of the design assessed in evaluation activities in the reviewed papers is presented in Table 1. To denote the difference in certainty in the mappings, clear mappings are indicated with dark grey and estimated mappings with light grey.

Table 1: The specificity of the design assessed in evaluation activities in the reviewed papers (dark grey indicates a clear mapping, light grey indicates an estimated mapping). Each evaluation approach is mapped against the design levels of Bligård et al. (2016).

Reviewed papers	*Effect (Needfinding)*	*Usage (Design of use)*	*Architecture (Overall design)*	*Interaction (Detailed design)*	*Element (Structural design)*
Rejas (2010), Labarthe and De La Garza (2011), De La Garza et al. (2012), Rivere et al. (2015), Rivere (2015)	3	3	3	3	3
Manrique and Valdivia (2008); Song and Zhang (2010)	2	2	2	2	2
Chuang and Chou (2008), Dobos et al. (2010), Liu et al. (2012), Pfledderer (2012), Hanes et al. (2015)			5	5	5
Hill et al. (2009), Gunnarsson and Eliasson (2010), Zhang et al. (2010), Boring (2014), Eisner et al. (2015)			4	4	4
Anokhin and Marshall (2007), Huang et al. (2007), Jones et al. (2007), Alonso et al. (2008), Carvalho et al. (2008), Anokhin and Marshall (2009), Gray and Basu (2009), Hwang et al. (2009), Lin et al. (2009), Yang et al. (2009), Liang and Chen (2010), Roth et al. (2010), Lee and Chung (2012), Suh et al. (2013), Jia et al. (2014), Jia and Zhang (2014), Sun et al. (2016)				15	15
Ha et al. (2007)				1	1
Sum of evaluation approaches mapped to the level	**5**	**5**	**14**	**30**	**30**

Counting papers based on the same project as one, the papers reviewed showed that five evaluation approaches could be mapped to the Effect and Usage levels, 14 to the Architecture level, and 30 to the Interaction and Structure levels respectively. Also, the mappings for the higher levels were not as clear as for the lower levels. For example none of the papers clearly described an approach that assessed a design at the Effect and Usage levels.

5. Discussion

The purpose of this paper was to compare utilised approaches to evaluate control room systems in the nuclear power industry and to explore how they relate to design decisions at different levels of specificity. However, not all control room evaluations executed at nuclear power plants are reported in academic literature. Consequently, this search does not provide a comprehensive account of all control room evaluations in practice, but it does shed some light on the experiences that are shared for others to learn from and build upon.

The 35 reviewed evaluation approaches could to a greater degree be mapped to lower levels of design decision specificity. Mapping to higher levels was also more uncertain due to less detail in the descriptions. For many of the reviewed control room evaluations in practice, the descriptions focused on the need for evaluation and the system representations used, and did not reveal much detail on the exact method used. This was especially true for evaluation of design decisions at higher levels.

Even though lower level design decisions may be *considered* before the higher level decisions, the higher level design decisions must be *finalised* before the lower level decisions. This explains the connection between the design levels and the process phases of the ACD^3-framework (Bligård et al., 2016). The possibility to make changes in a design decreases with its finalisation, which makes formative evaluation more worthwhile earlier in a development process. There is thus a connection between higher level design decisions, formative evaluation, and earlier process phases. Consequently, the lack of details on methodology for assessing higher level design decisions is a lack of detail in methodology for early evaluations, especially formative ones. The most detailed evaluation approach descriptions were given for the activity Integrated System Validation, a final summative assessment of the control room. The same observation was made in one of the reviewed papers, where Eisner et al. (2015) note that there is less guidance from codes and standards to be found for verification and validation activities that are not Integrated System Validation.

Some researchers have focused specifically on early evaluation of control room systems. Two such examples are Boring and Lau (2017) and Boring (2017), who argued for evaluation approaches that relieve the Integrated System Validation activity of some of its burden in providing evidence of acceptability, promoting complementary evaluation activities earlier in the development process. In the paper by Boring (2017) some suggestions for suitable methods are given, but the focus is on the overall evaluation process structure and general advice for this rather than detailed description of methods and methodology.

Another group of researchers who have addressed the issue of early evaluation are Laarni et al. (2011), who conducted a series of small-scale usability tests preceding the final validation. More specifically, the methods used were usability test, expert evaluation, cognitive walkthrough, focus group, and usability questionnaires. Simulator testing was seen as a central task, but human-system interface-oriented walkthroughs using screen/paper mock-ups were also mentioned. The approach presented in Laarni et al. (2011) was set in the context of the verification and validation process in Laarni et al. (2014). Here, the authors

described a stepwise validation approach where sub-systems were validated successively before the final validation. The paper focused on how this stepwise approach builds evidence for the final assessment of design acceptability, but also acknowledged the evaluation activities' contribution to improving the design.

Simulator testing was seen as a central task in the evaluation approach proposed by Laarni et al. (2011). Validation activities in the reviewed control room evaluations were also reliant on simulators of some sort, often full-scale. This is a trait shared by other research on nuclear power plant control room evaluation which describes methods or methodology that require the use of a physical simulator of some sort, often a full-scale simulator (for example Le Blanc et al., 2010; Jang et al., 2011; Braarud et al., 2015; Gibson, 2015). Other approaches rely on 3D models and virtual simulators (for example Tran et al., 2007; Luquetti dos Santos et al., 2009; Gatto et al., 2013; Chen et al., 2014; Yan et al., 2014).

A simulator for a proposed design is typically not developed or upgraded until later in the development project, making these types of approaches unsuitable for evaluating design decisions at higher levels of specificity. 3D models or virtual simulators, since they are cheaper to develop and change, can be created and used earlier than physical simulators. Evaluation approaches using this kind of representation can thus be used for design decisions at higher levels. Still, if the virtual simulator includes operator interfaces it cannot be used until the design is at the Interaction level, thus limiting the possibility to assess design decisions at higher levels when they are taken (often earlier in the development process).

Human reliability analysis (HRA) methods are a group of methods typically used to identify sources of errors in use (typically called human errors) and quantify how likely it is for such errors to occur. In the nuclear industry, it is typically a part of the probabilistic safety assessment and not a part of the development process (Boring and Bye, 2008). Some have however argued that HRA should be done as part of the design process (see for example United States Nuclear Regulatory Commission (2012) and (Boring and Bye, 2008)). Boring and Bye (2008) propose that "*a thorough HRA at the design phase can help ensure that an unbuilt system is safe*" and that "*such an analysis may also allow effective comparisons between competing designs or prioritization of design issues*" (ibid, pp 736). One of the evaluation approaches reviewed in this paper, by Manrique and Valdivia (2008), utilised HRA in a manner similar to this, to evaluate the risk of use errors early on. Another reviewed approach, by De La Garza et al. (2012), proposed better integration of HRA and other human factors activities. Other reviewed approaches mentioned HRA as a source for input to V&V (Song and Zhang, 2010; Zhang et al., 2010; Lee and Chung, 2012; Li et al., 2012; Rivere, 2015), or merely that it is a part of the human factors engineering process (Rejas, 2010; Roth et al., 2010; Pfledderer, 2012; Rivere et al., 2015). The rest of the reviewed articles do not mention HRA at all.

Many decisions must be made when planning an evaluation activity, and they must be made consciously in order not to risk skewing the evaluation result. More detailed information on how to implement methods for evaluating design decisions at higher levels in control room designs would benefit evaluation planning and execution. HRA methods are one topic that is interesting to explore further, together with the reviewed evaluation approaches mapped to higher design decision levels found in this paper. Further work should also endeavour to develop or identify methods that do not require the use of system representations developed later in the development process (such as simulators), to allow formative evaluations earlier and thus reduce the risk of late and expensive changes.

6. Conclusions

The literature review presented in this paper showed that formative evaluation approaches for design decisions of higher levels of specificity are less common and not described in as much detail as summative evaluations for lower level design decisions. This gap has to some extent been addressed by academia, but guidance can be further detailed and improved, for example by further investigating evaluation approaches utilising system representations available in earlier project phases (when more general design decisions are normally made).

Much can be gained from assessing control room system design decisions at higher levels, since this means design concepts can be evaluated earlier in the development process, making changes easier and cheaper to implement. There is a need to further develop methodologies and methods suitable for formative evaluation of design decisions at higher levels, and to assess their applicability for control room system evaluation.

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Joy in creating improvement of the psychosocial environment through workflow analysis

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This paper presents and discuss a method developed to improve psychosocial working environment using lean inspired methods. A pilot and five ward intervention programs were completed in a university hospital. Participants across professions pinpointed problematic work processes in each ward and through three workshops analysed the work flow, developed solutions and evaluated the outcome. Between the workshops the wards produced data about the work processes through observations and registrations of daily work. The paper presents the design of the method using a programme theory and discuss the effects of the method.

Keywords: Healthcare, cross-professions, lean, psychosocial working environment, relational co-ordination, value stream mapping, workflow analysis

1. Introduction

Danish hospitals are under severe economic pressure. This is a consequence of both budget cuts and the demands for continuous increase in productivity. The challenge increases as patients are hospitalized for even shorter periods and require treatment that is still more specialized. The staff experience constant pressure to deliver more, while at the same time make more and faster decisions and coordinate with an increasing number of other professions and units, both inside and outside the hospital. This development may have adverse consequences for the staff. The increasing demands may result in work overload, stress and burn out, as they feel hampered in delivering the required quality of care to the patients (Westgard & Winkel 2011).

Lean is one of the most important tools for hospital management in the effort to meet the requirements for productivity increases. The productivity results of lean are mixed

with positive examples from the logistic and more standardized part of hospitals, whereas the results are not very convincing in the more complex areas of direct treatment and patient care (D'Andreamatteo, Ianni, Lega, & Sargiacomo, 2015; Radnor, Holweg, & Waring, 2012). From an employee's perspective, the effect of lean is debatable. Lean originates from the manufacturing industry and has in this context been named 'lean and mean' (Harrison 1994; Landsbergis, Cahill, & Schnall 1999). However, recent research indicates that the effects of lean depend on the context as well as the implementation approach (Hasle, Bojesen, Jensen, & Bramming, 2012; Hasle, 2014) and research from the healthcare sector indicates that lean tends to have had a positive effect (Holden, Eriksson, Andreasson, Williamsson, & Dellve 2015; Ulhassan, Westerlund, Thor, Sandahl, & Schwarz 2014), although this is not always so (Hasle 2010; Stanton et al. 2014).

It is common in lean to emphasize the need for employee participation (Hasle 2014; Womack, 1996) and this participation also seems to have positive effects for the employees (Bamber, Stanton, Bartram, & Ballardie 2014; Cullinane, Bosak, Flood, & Demerouti 2014). As the work pressure on staff originates largely from productivity demands, the question remains unanswered as to whether lean can be used not only to improve productivity but also to ease pressure on the staff. An answer to this question is pursued in this study.

Our starting point is Value Stream Mapping (VSM) which is a key tool in lean (Rother & Shook 2009). VSM is a participatory tool for mapping work flow and the identification of value adding and non-value adding activities, which subsequently can be used for improvement of the processes (Rother & Shook 2009). Insights into the process can potentially also be used to identify work environment problems and possibilities for improvements (Jarebrant, Winkel, Hanse, Mathiassen, & Öjmertz, 2015). We developed a methodology for improvement of the psychosocial work environment based on VSM and with the participation of the local staff. The methodology is tested in a qualitative case study in a large university hospital in Denmark. We present the development and testing of the methodology, called P-Lean, in the following text, discuss how the professionals may overcome the challenges in using the method, and we end with further implications for research and practice.

2. Methodology

The project was developed and implemented in a collaboration of researchers, management and staff at a large university hospital in Denmark. The University hospital has 690 beds and covers both emergency and elective treatments. It has 4400 employees divided into 25 departments. The hospital implements workplace assessment (the Danish version of risk assessment) every three years. For the psychosocial work environment, the hospital has used a questionnaire survey following the general guidelines from COPSOQ (Kristensen, Hannerz, Høgh, & Borg 2005). The idea is to use the result from the survey to make action plans for improvements. However, the experience from this activity has been at best mixed. Many departments have found it difficult to transform the survey results into practical changes. Therefore, the hospital has been looking for alternative possibilities for improvement of the psychosocial work environment.

2.1 The intervention design

The design of the intervention is based on the following sources:

a)The literature on lean and VSM (Jarebrant et al., 2015; Rother & Shook 2009) and participation (DeJoy et al. 2010; Nielsen, 2013; Van Eerd et al.,2010). The context of the hospitals regarding the general organisational development as well as the particular experience with lean and workplace assessment.

b) The experience of the consultants and researchers from a large number of former intervention activities, primarily the concept of relational coordination. In relational coordination, the goal is to gain shared goals, knowledge and mutual respect through improving communication (Gittel 2009).

c) Realistic evaluation (Pawson and Tilly 1997) theory has been used for design of intervention programmes (P Hasle, Kvorning, Rasmussen, Smith, & Flyvholm 2012), and we used it in a similar fashion. We built a programme theory based on the desired outcome, followed by the mechanisms that could initiate this outcome, and subsequently the activities, which could activate these mechanisms.

Intervention	Activity	Change Mechanism	Outcome
Decision about project start in the ward	Consultant presents a meaningful and implementable programme theory	Visible problem Confidence in intervention programme	Ward committed to participation in the project
Project establishment	Management of the ward forms a local intervention group with one management rep and 1-2 employee reps. The group met with consultant 8 – 10 times throughout the project The group identifies project focus and measures	Competencies to implement organizational changes available Relevant knowledge and tools to implement change	A project group with the capability to implement the project Mutual goals identified
Identification of priority problems	Value stream mapping (VSM) workshop with a focus on problematic work processes and consequences	New insights in flow, relations with colleagues and problem causes	A list of relevant priority problems Shared knowledge
Problem analysis	Observations of daily work routines related to problematic work process 2nd VSM workshop	Comprehension of the causes to priority problems based on facts	Shared knowledge of problem causes disintegrated from personalities

	focussing on problem causes		Shared platform for development of solutions
Solutions development	3rd VSM workshop focussing on development of solutions Creation of indicators for measurement of achievements	Realistic and beneficial solutions	Relevant solutions for pinpointed problems Reflections on how to make solutions possible
Action plans	Action plan including goals and indicators for impact Allocation of resources for the implementation of activities	A transparent implementation process A manageable and realistic process with the necessary resources	An implementable action plan Commitment to implementation
Implementation and follow up	Implementation of improved work processes Collection and publishing of data on indicators	Enthusiasm that this will actually work!	Improved work processes Improved well-being and job satisfaction

Table 1: The programme theory for the intervention

As Table 1 shows, the key mechanisms are generally described as creating motivational resources by providing concrete and transparent data about workplaces, which on one hand provides the platform for the development of relevant improvements and on the other create confidence in the improvement project.
Six wards volunteered for the project and five interventions programs were started and implemented after a visiting meeting in each ward with the hospital internal consultant. In the meeting the consultant presented the selection criteria, as 1) the ward should not experience severe internal conflict, bullying or harassment. 2) Nor should the ward be involved in overly organisational changes and as a third selection criterion, 3) the ward should engage in the project and provide the resources in terms of time and representatives for all relevant profession.

2.2 Evaluation methodology

In the evaluation of the method we used data collection included the following elements.

- Shadowing the consultant's activities in the wards
- Collection of written information including results from VSMs workshops, written plans, information materials etc.
- Follow up interviews with members of project group, workshop group and other employees three months after the last VSM workshop.

3. Results from the intervention

We give an overview of the results for all five wards in Table 2 below.

	The work process selected for VSM	**Project activities**	**Improvements**
Ward Z	The good registration of patients	Three VSM workshops Descriptions of morning situations Observations Registrations Patient questionnaires	A redesign of the receiving process (including a new position as team coordinator) Disturbance of each other during morning planning stopped Cooperation and climate improved considerable between receptionist and coordinators. Time for four extra examinations daily
Ward B	Information in shifts to make delegation of job tasks in accordance to qualifications	One whole day WSM workshop Consultant observed morning procedures	Clear morning procedure for reading patients information Delegation through qualifications made transparent in the morning dialogue
Ward O	Avoiding disruptions in medicine dispensing room	Registration of interruptions in three dispensing rooms	The importance of informal communication recognized and moved outside the dispensing room Film produced by the employees, showing disturbances in the dispensing room
Ward G	A good balanced workday in the scanning section	Three VSM workshops Interview with patients Registrations of time used for the scanning methodology	Small solutions regarding towels, PC's, parking, letters to patients, information signs Action plan for different scenarios for reorganising the whole scan procedure, including the demand for resources and competences
Ward E	Well-structured workdays with well-structured meetings	Three VSM workshop situations Consultant observed and evaluated morning meetings	Well-structured and well prepared morning meetings Reorganizing teams Time outs to coordinate Small solutions such as moving the coffee table, local medical supply depots etc.

Table 2: Overview of the intervention programs foci, activities and improvements

4. Discussion of the results of constraints and enablers

The results of the interventions showed that all five wards carried out thorough VSM analysis, and evaluated the process and the results from the VSM workshops as a valuable method to improve work processes across professions. The VSM workshops were used as the basis for discussing solutions, which were subsequently agreed upon as the wards adjusted their implementation continuously.

The VSM workshops, the observations and registration of work processes methods were quickly adopted by the participants. Shortly after the start of the VSM workshops, an engaged and often loud discussion began about each step of the work processes. Sharing the different professional's information about how they performed their tasks and the reasoning behind the choices they made, was respectfully received by the listeners and created an interesting and informative atmosphere. The observation and registrations between the workshops also revealed in detail why some of the problems were persistent and not easily solved. Instead of pointing the finger at other people or at the overall structure and lack of resources, it was a relief for those involved that by focussing on the very small micro processes, the workflow became transparent and it became much easier to find possible solutions.

The point of departure for the VSM workshops was the need of the patients which was the natural way to start thinking of improvements for the staff involved – even when, as in this case, the aim of the workshop was to the improve the psychosocial work environment. This point of departure also provided central criteria for the analysis of the internal communication and coordination processes, which was an issue of priority in all five wards. The VSM tool proved to be an effective tool to understand the communication processes, which paved the way to a change of focus from personal or interpersonal issues to task oriented communication.

5. Discussion

Hospitals are often described as a typical example of a professional bureaucracy with reference to the conceptual frame developed by Glouberman and Mintzberg (2001). In hospitals, there are many groups of professionals with high autonomy when performing their tasks. As a tendency, this has led to development of an organisation often characterised as a silo-organisation where professionals only have limited inter-silo communication concerning the performance of tasks even though they share the task of treating patients.

It is therefore well in accordance with professional silos that communication and coordination proved to be the focus points for all the intervention wards. The staff in their different professional groups tend to lose the overall view of the workflow. When constraints for their work appear, they are inclined to attribute the problems to persons and personalities rather than the organization of the work. It is therefore a key to understand and solve the problems to secure social relations in communication and coordination. The process which Gittell and colleagues call relation coordination (Gittell, Weinberg, Bennett, & Miller 2008;

The involvement of employees through the intervention methodology P-lean seems to be VSM and the subsequent follow up seems to be a feasible way to work with the problems related to both the psychosocial work environment and the inefficiencies related to constrained communication.
The results indicate that outside assistance is needed for successful achievements. While the ambitions of the design were to create a self-implementable methodology, the wards lacked sufficient competence and outsider were needed to help create the momentum necessary for progress.
One of the constraints for the test of P-lean methodology presented in this paper is the lack of experience with cross-departmental issues such as the way wards transfer patients from one ward to another. All the wards chose to work with their internal problems first although the cross-department problems were addressed and discussed. The employees apparently do not believe that they have sufficient power within the hospital to open for action even though they can describe the structural problems in the hospital.

6. Conclusion

Our results indicate that lean, and in particular VSM, can serve as a valuable tool for improvement of the psychosocial work environment of the hospital. In this context, there is no indication of the 'lean and mean' argument often emphasized when the consequences of lean are discussed. The intervention methodology P-lean can therefore provide a possibility for improvement of problems related to communication and coordination across professionals, and it secures the participation of the employees as a necessary resource for implementation. It is necessary to utilise outside assistance to assist the wards in implementing P-Lean, and it probably needs further development to work with problems related to communication and coordination across different wards.

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Essential non-technical skills for adult intensive care staff in managing unplanned extubations

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Unplanned extubations (UE) present a unique challenge to intensive care unit (ICU) staff due to varied staff skill mix and ICU experience. This study undertook a human factors work analysis and qualitative evaluation of ICU staff in one NHS Trust. Both nurses and doctors reported a reliance on staff skill mix and teamwork to coordinate response in UE situations. Leadership of senior nurses and doctors was essential, including clear communication for junior staff. Situation awareness and unspoken tacit knowledge of roles and responsibilities also informed UE response. The non-technical skills highlighted by these ICU staff are essential to address when designing UE management training and learning programmes.

Keywords. Unplanned extubation; Non-technical skills; Task analysis; Critical care

1. Background and Purpose

In the adult intensive care environment, many patients remain connected to mechanical ventilation to support their respiration. A complication which may occur in the intensive care unit (ICU) is an unplanned extubation (UE), or the accidental or purposeful removal of an endotracheal tube (ETT) of a ventilated patient (Richmond, et al., 2004). Sometimes referred to as accidental extubation, this pre-mature removal of the endotracheal tube may be partial or complete, and may be self-induced (by the patient) or may accidentally occur due to patient care activities. The occurrence of UE events ranges from between 0.7% and 15% (Maguire, et al., 1994; Christie, et al., 1996; Chevron, et al., 1998; Carrión, et al., 2000). Although not all unplanned extubations result in failure, patients who do not tolerate an UE event may be at risk for prolonged mechanical ventilation, and longer stays in the intensive care unit and hospital (Krinsley and Barone 2005; Epstein et al., 2000).

Unplanned extubation is an infrequent occurrence; however, the critical care team must be capable of responding to the potentially life threatening event as a matter of emergency and successfully rescue the compromised airway. Staffing within ICUs operate on a 24 hours basis, but the capabilities of the individual nursing and medical team members may depend on level of experience and medical speciality. In 2012, UK standards for critical care specialisation changed to permit doctors to focus solely in Intensive Care Medicine or in combination with a second specialty such as Acute

Medicine, Anaesthetics, Emergency Medicine, Renal Medicine, and Respiratory Medicine (RCoA 2017). Although British anaesthetic trainees are required to train in intensive care for nine months, others will aim to work as a consultant lead in ICU. These anaesthetists have increased experience in airway management, which differs from doctors of other specialties.

Researchers at the University of Nottingham Human Factors Research Group collaborated with clinicians from both the Trent Simulation and Clinical Skills Centre and the Nottingham University Hospitals (NUH) NHS Trust Intensive Care Units to implement human factors within the NHS. The project aimed to investigate the clinical practices associated with the management of UEs in the ICU and develop a training toolkit of best practice by way of a mastery learning programme, which was designed to upskill the diverse mix of both nurses and doctors working in the ICU. This paper will discusses the exploration of current practice in patient airway rescue in response to UE, recommended practice and how deviations may occur, and the sociotechnical factors that influence response to UE and decision-making for its management.

2. Methodology

This study aimed to provide a human factors systems work analysis and qualitative evaluation of ICU staff in the NUH NHS Trust, a tertiary teaching Trust with three ICU units and 58 ICU beds. The study protocol included the development of a hierarchical task analysis which was used as a framework for qualitative interviews conducted with critical care staff members.

2.1. Hierarchical Task Analysis

A hierarchical task analysis (HTA) is "a broad approach to task analysis, which prompts the analyst to establish the conditions when various subtasks should be carried out in order to meet a system's goals" (p.104, Kirwan and Ainsworth 1992). The system goal in the context of this project was the safe response to an UE event and successfully rescuing the patient airway.

Based on clinical input and observation of the NUH ICU, the human factors team iteratively co-created an initial HTA of all required steps in the management of an UE in to help supplement discussions with critical care staff members. All interview participants were provided with a copy of the UE management HTA to discuss key decision points and deviations from the theoretical process as outlined in the HTA.

2.2. Qualitative Interviews

Semi-structured interviews were conducted with twenty-one participants, eleven nurses and ten doctors from both NUH NHS Trust adult ICU units. Staff members were invited based on level of experience in critical care. Both junior (less than 3 years of ICU experience) and senior (3 or more years of ICU experience) nurses were represented in the sample. Doctors were separated by airway training, where 5 were non-airway trained and 5 had airway training (anaesthetic background), although all levels of training were included.

The UE management HTA was used in conjunction with a brief question guide, to ensure discussion of past experiences with UE events (if applicable) and the training

received related to airway rescue. Utilising a human factors systems approach to the enquiry, participants were provided four prompts: Tasks, People, Information, Equipment and Environment. The prompts were consistent with the layers of the human factors 'onion model' from Wilson and Sharples (2015) and were included to ensure participants considered the whole context of work and full range of potential contributory factors to tasks and decision making associated with airway rescue. The aim of this interview strategy was to facilitate the sharing of experience on key areas which might benefit the development of the mastery learning programme.

Interviews were conducted face-to-face and took between 18 to 68 minutes. All interviews were digitally recorded, transcribed verbatim, and analysed using NVivo® software for thematic analysis of key concepts and themes.

3. Results

Themes emerged from the interview results relating to safe and timely management of UE events, these were considered in relation to the non-technical skills of the clinicians, such as - teamwork, leadership, communication, and situation awareness. Participants were designated as airway or non-airway trained doctors (DA, DN), and junior or senior nurses (NJ, NS).

3.1. Teamwork

Many of the tasks described in UE management required fluid roles and responsibilities. Although tasks were accomplished as a team, there was a focus on the skill mix of the team composition -a balance of junior and senior staff was valued by participants, ensuring junior members could rely on the skills and experiences of senior team members whilst also being informed enough to offer practical input as required. One junior nurse mentioned the support provided to less experienced nurses, saying: "*I'd always just grab someone just anyway, but you tend to have a senior member in your team, like top member that will come and help support you.*" (NJ-12).

An important factor in ensuring the appropriate support for more junior staff members was the planning of the unit's staffing to provide the skill mix of junior and senior staff. A senior nurse described the staffing rota, saying: "*The rota is planned in advance by our band 7s and then on the day they sort out the individual allocation depending on the skill required and of the patients, but there will always be band 7s, band 6s and band 5s on duty*" (NS-11). Although an airway trained doctor was always staffed on the ICU, the consultant hours do not always cover the entire shift. In the absence of an airway trained doctor on the ICU, an on-call anaesthetist or crash team was called to respond to UE events during out-of-hours to fill that skills gap.

3.2. Leadership

Participant experiences of UE events highlighted the required leadership and coordination of the ICU team, which most often referred to the doctor leading the situation. Interviews showed a tendency of the doctor to allocate tasks to the team, whilst nursing staff assumed practical roles in the UE procedure. The team leadership was described as being flexible and changing, as one doctor explained how nurses respond to an UE: "*And they're kind of taking charge and when I get there, I assume*

responsibility or the responsibility's assumed to come from me, so that everyone sort of looks to the doctor. And then when the consultant comes, he assumes responsibility… the hierarchy based on knowledge and experience… and that's the role. That's how it works" (DN-7).

Whilst the leadership role was generally taken by the airway trained doctor, leadership was also exhibited by nurses, as a senior nurse stated: "*If a doctor or a consultant comes along, again it would depend on who they are, but usually if it's one of the consultants they will take the lead. It's a bit of a joint effort really, because they will be looking after the airway, so it might be you, as the senior nurse, saying to someone, 'Go and get some sedation,' to kind of guide the team*" (NS-1). Another senior nurse reiterated this by stating: "*… in your team and you have nurse in charge and in the team we are four, there are various levels of experience so, if… you are inexperienced... your team leader, in that crisis situation, someone will take responsibility*" (NS-3).

A common theme in several responses regarding team coordination was that of a seniority based leadership, where more experienced team members may not need instruction. One senior nurse described: "*So most of the time the person who is there normally goes for the oxygen. That's the first thing to do and then when the seniors come they take over that, and then there is allocation of tasks. This person does that. This person takes that...But because it's something we do for a long time so we tend to do it unconsciously*" (NS-3). However, more leadership and specific direction was deemed necessary for more inexperienced nurses, as one junior nurse said: "*… the nurses are very, they know what to do, what equipment to get, what drugs to get before the doctor tells them, so I think it'd, just like for new people like myself who don't really know cause of lack of experience"* (NJ-19).

3.3. Communication

The verbalisation of tasks during UE procedures, was valued by participants, to make clear the priorities and decision making that was taking place. Upon reflection of a past UE event which was managed efficiently, one doctor stated: "*… communication wise was pretty crystal clear. He was vocalising it very well. Close knit communications and task prioritisation was good because we knew the gravity of the situation... overall it was very well lead, it was very well coordinated and the outcome was good*." (DN-10).

Handover, as a component of safe UE management, was discussed in relation to passing of information from the ICU team and any airway trained doctor responding from outside of the unit, such as an on-call anaesthetist from theatres or an emergency crash team. The difference in communicating with an airway doctor from outside of the unit was noted by one junior nurse who explained what should be done when the crash team responds: *"… when it's the crash team there's always a bit more nurse input, because they don't know the patient so you're very much advocating for your patient and sort of saying, 'Right, this is what we've been doing, and this is what I think you should do.' Whereas if it's the doctor that knows the patient, then that stage is cut out and they know what's best in more detail*" (NJ-6). The extent of information provided by the nurse may depend on the knowledge of the attending doctor, who might already be familiar with the specific patient including previous medical history and intubation grade.

3.4. Situation Awareness

Some participants reported experiences where individual leadership and direct communication were not the dominant factors in smooth UE management, but that a general situational awareness and ability to respond accordingly were more important.

It was suggested that in teams composed of more experienced nurses and doctors, certain tasks that would otherwise need to be directed explicitly might happen naturally. For example, one junior nurse referred to the airway trolley as something that would be gathered immediately and pre-emptively, stating: "*Straight away, if there is an emergency like that the arrest trolley will be at the bedside*" (NJ-13). However, this may be dependent on experience of the nurse, as one doctor stated: "*It depends on the experience of the nurse 'cause some nurses would know immediately what to get, how to get it, what to do, but some don't really know*" (DA-9).

The unspoken aspects of UE management, including reliance on tacit knowledge regarding the correct course of action, were reported by both doctors and nurses. When asked how nurses know when they are no longer needed in an UE, participants said that it was very natural and generally understood, as one junior nurse stated: "*Nothing really needed to be said, people sort of started drifting off and before everyone went they just said to the nurse and the doctor, 'Is there anything else you need in here?'*" (NJ-6).

An important aspect of situation awareness also related to knowing the team and their ability to respond appropriately to an UE. Participants stated that this understanding is learned through shared experiences, as one senior nurse said: "*Maybe with the more junior doctors, again you don't know their experience. They don't know you… It might be their first shift on here. How things work. Where things are. Because they're the doctor everyone's looking to them and it might be really stressful for them, so I think it's probably easier with people you know, which is always the case isn't it? And it's difficult not knowing what peoples' experiences are*" (NS-1).

4. Discussion

The qualitative interviews with ICU nurses and doctors provided insight into staff experiences with unplanned extubations and managing the safe airway rescue of endangered patients. A wide breadth of ICU experience was explored and issues relating to established non-technical skills that are used as ways of coping with ICU staff of mixed experience and skills, teamwork, leadership, communication, and situation awareness, were identified. The non-technical components of the system have been identified as essential for any future guidelines or training programmes developed for UE management in the ICU. Whilst the human factors evaluation also assessed the specific tasks, equipment, environment, and required information for safe and efficient UE management, the findings of which are reported elsewhere (Velzen et al. 2017).

Reader et al. (2006) conducted a review of critical incident studies in the ICU and found the Anaesthetists' Non-technical Skills (ANTS) taxonomy (Fletcher, et al., 2003) to be relevant to the categorisation of contributory factors of ICU critical incidents. The ANTS categorised skills under task management, teamwork, situation awareness, and decision making. This study similarly highlights the importance of teamwork and situation awareness, whilst also emphasising the roles of clear leadership and

communication to bridge gaps in experience within the team. Although the ANTS taxonomy includes leadership within the teamworking category, it does so because it is designed specifically for anaesthetists working within theatres (Flin, et al., 2010), leadership was separated in this study's categorisation, because clear identification of a leader is necessary for the ICU team.

The experiences of Nottingham ICU staff revealed the essential nature of non-technical skills that are employed to cope with uncertainty in experience level and technical knowledge of team members who will respond to an UE. Skill gaps were identified in some participants due to lack of familiarity with UEs and reintubation procedures.

4. Conclusion

A human factors approach to exploring UEs and incorporating the essential non-technical skills affecting safe UE response in future training programmes will help ensure ICU teams can respond to UE emergencies promptly, efficiently, and safely. On a local level this new knowledge will contribute to the development of a mastery learning programme for adult ICU staff for UE management. Whilst on a broader scale, this understanding may help supplement critical care policies, training, and guidance of non-technical skills for both ICU nurses and doctors in UE management.

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Scientific evidence suggests a changed approach in ergonomic intervention research

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Ergonomic interventions have generally been unsuccessful in improving workers' health, with concurrent rationalization efforts negating potentially successful intervention initiatives. We propose the two aims are considered simultaneously, aiming at the joint consideration of competitive performance and work environment in a long-term perspective ("organizational sustainability"). A prerequisite is a high level of dialogue between the different groups of stakeholders, and we argue that the Nordic countries, through high levels of trust and justice (social capital), have unique opportunity to carry out such research. The present authors bring forth the vision of "a Nordic Model for development of more sustainable production systems".

Keywords: Organizational sustainability, social capital, organisational redesign, implementation

1. Background and purpose

The ergonomic pitfall: The systematic review by Westgaard and Winkel (2011) concludes that ergonomic interventions have limited musculoskeletal and mental health effects in a long-range perspective while rationalization has predominant negative health effects. The negative impact of rationalization on ergonomics seems to be due to reduction of non-Value Added Work (non-VAW), which generally offers less risky exposures compared to VAW (e.g. Kazmierczak et al., 2005; Jonker et al., 2011; Jonker et al., 2013; Östensvik et al., 2008; Palmerud et al., 2012). The reduction or elimination of potential risk-reducing effects of ergonomics due to simultaneous rationalization initiatives has

been called "the ergonomic pitfall" (Winkel 1989; Winkel and Westgaard 1996). Ergonomic interventions are introduced by one group of stakeholders, the ergonomists, while another group of stakeholders focuses on rationalization. Both groups seem to have a "tunnel vision" focusing on immediate benefits excluding potential side effects and their implications in the long run.

The innovation pitfall: Rationalization processes may also become counteracting. Thus, the participatory ("horizontal") rationalization processes Value Stream Mapping (VSM, a Lean tool) aim at time savings and may therefore increase exposure porosity for the employees (improved work environment). This may offer extra allowance for the employees. But in fact, the saved time is often used to perform extra tasks as a result of "vertical" processes for cost reductions demanding more work to be performed by fewer people, i.e. causing a work intensification (Winkel et al., 2015). Such interactions between the horizontal and vertical processes create an "innovation pitfall" (cf. Neumann et al., conditionally accepted).

Organizational sustainability: We therefore need more research on tools and methodologies that allow concurrent tuning of performance and wellbeing in a rationalization process. The aim should be to increase organizational sustainability; i.e. the joint consideration of competitive performance and working conditions in a long term perspective (Westgaard and Winkel 2011).

2. New tools integrating health ergonomics and performance

On this background, participatory approaches and tools have been developed for simultaneous consideration of ergonomics and health promotive conditions in rationalization processes. Examples are the process tools Ergonomic Value Stream Mapping (ErgoVSM) (Jarebrant et al., 2016a; Jarebrant et al., 2016b), integration of workplace health protection, health promotion, and continuous improvement (i.e., Kaizen) (Ikuma et al 2011; von Thiele Schwartz, et al. 2015), and increased participation, autonomy, and ability to influence the work for cleaners (Öhrling 2014). The need for new forms of collaboration and coordination between workers, management, designers, and ergonomists with different work practices and organizational positions has been discussed by Broberg et al. (2011).

3. Need for dialogues between key stakeholders

A key issue in the improvement of organizational sustainability seems to be the extent to which dialogue between key stakeholders takes a more holistic systems perspective. According to Abrahamsson (2002, 2014) this may be facilitated by increasing gender equality. Dialogue is needed to support engagement and keep balance between resources and demands; i.e. horizontal dialogs at floor level and vertical dialogues between top management and floor level. This kind of governance through dialogue, based on trust, has been named "practice-servant governance" and is associated with increased engagement among professionals and teams (Dellve et al., 2016).

4. Conflicts and opportunities at society level

Unfortunately, the benefits of a long-term focus on organizational sustainability seem difficult to understand and realize for many key stakeholders. In 2012 this was clearly expressed by the British Prime Minister David Cameron: "So one of the Coalition's New Year resolutions is this: kill off the health and safety culture for good," saying that it "has become an albatross around the neck of British businesses" (cited from "the London Evening Standard", January 5, 2012). But a raising awareness of the significance of organizational sustainability seems to occur within the business world: A paper by Spreitzer and Porath (2012) in Harvard Business Review, concluded that "… Across industries and job types, we found that people who fit our description of thriving demonstrated 16% better overall performance". Further, a leader in periodical The Economist (2nd February, 2013) states: "Politicians from both right and left could learn from the Nordic countries" aiming at "the Nordic model".

5. "The Nordic Model"

The Nordic model has been the subject of extensive discussions and studies (e.g. Schiller et al., 1993). The broader concept of "The Nordic model" is somewhat more difficult to define, but includes "mutual recognition" and trust between the parties. Dialogue-based change processes may be more common in the Nordic countries compared to other parts of the world. The key point in the present context is the collaborative actions of stakeholders with different primary objectives (work environment, efficient production systems, economic success, customer needs) to ensure sustainable work systems in a long-term perspective. It is argued that the Nordic countries have unique opportunities in this respect, with a proven successful outcome in terms of macroeconomic indicators (The Economist, February 2, 2013). This status is supported by a high level of trust at all levels of the society and is backed by a flexible legal framework that recognize the need for a competitive work life together with the need to ensure workers' health and welfare.

Recent studies show that the Nordic countries occupy worldwide leading positions regarding social capital (Tinggaard Svendsen and Haase Svendsen 2006) and this may have played a key role as a fuel for organizational engagement among workers (reviewed by Olesen et al., 2008). High level of social capital in the Nordic countries may, in turn, have contributed significantly to the impressive economic growth in these countries (discussed by Olesen et al., 2008).

The unique circumstances of the Nordic countries may find its origin hundreds of years ago. These countries developed a weak feudal system compared to the rest of Europe. The power struggles between the Crown and the nobility allowed peasants personal freedom and the right to the land they worked on. When later, an industrial workforce was recruited from the countryside, employers, in the unique spread of collective agreements, more easily confirmed their freedom and rights. During the Great Depression political alliances between farmers and workers laid the foundations of welfare policies in all the Nordic countries. This political truce made the pacification of the turbulent labour markets urgent and the problem was solved through negotiations between the major workers' and employers' organizations (Schiller, forthcoming). This collaboration was extended in the 1960-ties by cooperation

at the factory floor, with studies of technical and organizational renewal of the production line, based on sociotechnical theories. Well-known examples are experiments with self-governed groups in Norway (Thorsrud and Emery, 1969) and the Volvo experiments with new factory layout (e.g. Kadefors et al, 1996). This culture of cooperation between stakeholders at different organizational levels of the work life and within companies and public enterprises in the Nordic countries has generally survived till today, in face of threats such as declining trade union membership and globalization. Although surely, companies without strong collaborative culture will exist in the Nordic countries and vice versa for European and American companies, we posit that company culture aimed at collaboration and negotiated settlement is a dominant trait in Nordic working life, more so than in other industrialized countries. Hence, our labelling of the proposed intervention research model as "the Nordic model".

6. Implications of a new research agenda

The previous section argues that specific opportunities exist within the Nordic countries for projects actively including more stakeholders and with project aims that in traditional intervention research are not jointly considered. Our hypothesis assumes an ingrained Nordic culture that facilitates collaboration between these stakeholders with different primary aims. This, in contrast to other countries, where the same stakeholders find themselves unable to establish the necessary dialogue to resolve conflict issues. A corollary is that the type of intervention project we argue for is more readily established in Nordic countries and we hope to see a Nordic research tradition developing that is generally recognized within the research community.

We see the need to substantiate or render probable this hypothesis and to understand mechanisms that take place at company level. In particular, we need to understand aspects of the dialogue process: what are critical prerequisites for a positive environment for dialogues, and how can such insight be measured and made available to a wider audience in a meaningful (applicable) way? Furthermore, are the Nordic countries really distinguished from other industrialized countries in this respect? This would be important insight to facilitate similar comprehensive intervention projects worldwide, and help minimize barriers to establish intervention projects in the Nordic countries (as surely there will be mixed experiences also here). In practical terms, this necessitates an expanded research protocol that includes recording of experiences when establishing intervention projects, such as company culture including dialogue between stakeholders with conflicting primary aims. In established intervention projects, it is important to include intermediate variables or actions that offer the prospect of improved work environment, even though the hoped for final outcome is better workers' health. In general, many aspects of project evaluation should take place.

6. Conclusions

- So far ergonomic interventions have had a predominant "tunnel vision" focusing on immediate benefits excluding potential side effects and implications in the long run.
- Scientific evidence suggests a broader approach considering both health and production in order to increase organizational sustainability; e.g. by development of tools and methodologies that allow concurrent tuning of performance and wellbeing considerations in a rationalization process.
- Different stakeholders are responsible for the development of increased health and production system performance respectively. Prerequisites for proper dialogues between these stakeholders need to be investigated.
- The Nordic countries seem to offer unique opportunities carrying out case studies investigating the above research issues (cf. the Nordic Model).
- The present authors bring forth the vision of "a Nordic Model for development of more sustainable systems" in order to highlight our unique opportunities within ergonomic intervention research.

We are at present preparing for a Nordic multicentre study along these lines.

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Visual communication for improved safety learning and safety culture in mining industry

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Work related accidents do occur in heavy industry even though written safety instructions and routines exist. In order to improve work safety, the impact of different artefacts for visually communicating safety aspects was explored. The artefacts: silent boards, silent movies, a documentary movie, posters, and game-like interactive training environment prototype were explored with interviews and questionnaires. The documentary movie showed the best effect for increasing risk awareness and motivation for applying safety routines. Results also revealed a discrepancy between knowing the safety routines and actually applying them. A conclusion was that visual communication improves learning and increases motivation to follow safety routines.

Keywords: Visual communication, gamification, safety at work, work related accidents, safety culture

1. Background and purpose

This paper reports the results from a study named AIM4S (Attitudes, Insights and Motivation for Safety), which was a collaboration between Luleå University of Technology, the mining company LKAB, and the game developer Zordix. The purpose of the study was to increase the knowledge of aspects that can contribute to learning and motivation among workers in high-risk industries in order to decrease the number of work related accidents.

'Safety first' is a strong motto at the mining company LKAB in Sweden. However, accidents do still occur and the company is continuously searching for new ways of improving safety. An assumption in line with the conclusions of Andersson (2012) is that many work related accidents occur due to a 'culture' or 'attitudes' among workers that contribute to an increased risk taking. Andersson (2012) found that some mining workers want to maintain the general, but out-dated, perception of mining industry as something dangerous and physically challenging. These factors are often associated with masculine work culture and status and are often strived for in order to maintain an occupational identity when the industry changes towards higher safety with the help of automation and improved safety equipment (Andersson 2012, Aurell 2001).

Time constraints are also an issue that contribute to risk taking. Workers who perceive time pressure or perceive demands on increased productivity are more likely

to engage in risky actions if this is believed to reduce the time of the work task (Öhrling, 2014). The physical environment also plays a great role in how tools and safety equipment are used and occasionally, the physical environment prevents proper use of such artefacts (Öhrling et al., 2012). Safety culture is to some extent built upon how well safety is demonstrated by the management; they should communicate a positive attitude towards safety (Wiegmann et al., 2004). Somerville and Abrahamsson (2003) investigated means of learning safety and found that, in excess of learning through practice, incidental learning from accidents and a focus on body care was important.

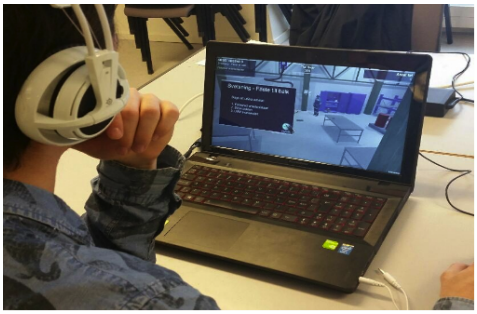
Many companies only use written documents to communicate safety policies and routines. A problem with written material is that it may not reach all employees; especially not employees with reading disabilities or a lack of language skills. Therefore, LKAB has developed alternative ways to communicate safety with purpose to (1) increase learning of safety routines (2) remind about the safety routines and (3) create an attitude and habit to follow safety routines at all times. There was a need to explore if visual communication can contribute to a safer work environment and the reasons why employees do not always follow safety procedures. The focus of the study was to investigate how employees and subcontractors at LKAB perceive safety at work in general and specifically how they perceive the alternative ways of communicating safety. The study investigated four different types of visual communicating artefacts and a gamification based interactive training environment. The question was if and how the artefacts can mediate safety routines in a way that contribute to workplace safety.

1.1 The visual communication artefacts

By using new artefacts for safety communication, LKAB was hoping the safety routines would reach employees and subcontractors to a higher degree than before. It was also hypothesized that visual communication would strengthen the building of a healthy safety culture. Visual artefacts can be used to evoke emotions (i.a. Baumgartner et al., 2006), which, in this study, was believed to create a motivation to follow safety procedures. Gamification was another approach, believed to create motivation for learning and training. With gamification we mean using game mechanisms in an area where games are not normally used (Deterding et al., 2011), in this case as an interactive safety training game.

The newly introduced artefacts of visual communication at LKAB are in this paper called: *Silent boards*, *Silent movies*, *Documentary movie* and *Posters* (Figure 1). In addition, Zordix developed an *Interactive training environment* (Figure 1) for evaluation purposes during the project. The silent boards and silent movies demonstrated safe work procedures using pictures and animations without text and sound. The silent boards were placed at the worksites. Hence, workers could view the safety instructions and routines while performing the task that were addressed in the artefacts, as an instruction or a reminder. Monitors with silent movies were placed next to elevators, inside internal buses, and at bus stops within the LKAB industrial area, i.e. at places where employees and subcontractors were awaiting and had time to watch them. The posters portrayed workers and management personnel performing high-risk leisure

time activities, dressed with proper safety equipment. They included text with the message to keep safe at all time, also when not at work. The posters were placed in connection to offices and in corridors. The purpose with the posters was to remind the employees to apply safety routines and to use safety equipment all the time, not only at work. The posters could also be interpreted as a reminder that you need to be safe at work in order to keep living an active life outside work. As some of the posters portrayed managers, LKAB also wanted to signal that safety thinking concern all employees, from the floor up to the highest levels. The documentary movie depicted a real and severe workplace accident where the employees involved in the accident describe the situation, how it affected them and they reflect upon how the accident could have been avoided. The documentary movie has been used as workshop material with all LKAB employees where they have watched the documentary and discussed it in small groups. The interactive training environment, developed as a prototype by Zordix, was a new concept never tried before at LKAB. The employees had not seen it before this study.



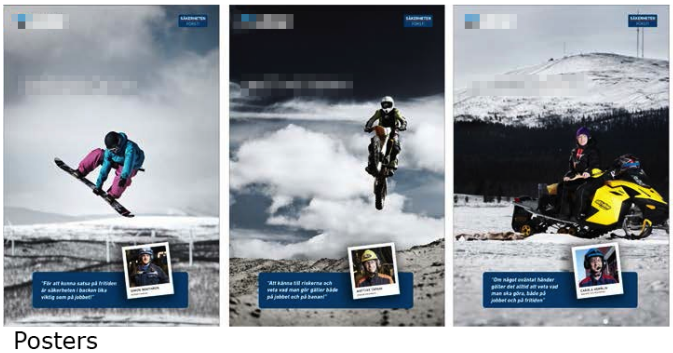
Interactive game prototype



Silent movie



Documentary



Posters



Silent board

Figure 1. The visual communicating artefacts investigated in the study.

2. Methodology

Data was collected at LKAB through qualitative interviews and questionnaires. These methods are described below.

2.1 Participants

Twelve employees (process operators, control room operators, mechanics, and production managers, men and women, young and older, novices and more experienced) and two subcontractor electricians participated in the investigation. All participants had seen the visual artefacts investigated in the study. The exception was the interactive training environment, which were developed during the project. This was not seen by the participants prior to the study.

2.2 Material

During the study, pictures describing the visual artefacts and the interactive training environment were used as support in discussions and during evaluations (Figure 1). The short silent movies were shown in full length to the participants during the study. However, the documentary was too long to show in full length. Instead, a short passage (1 minute) of the documentary movie was shown. In addition, the main parts of the documentary movie were printed as a series of images (Figure 1). The interactive training environment was also shown as a series of images.

2.3 Interviews

The interviews were semi-structured and all respondents, except for the subcontractors, were interviewed individually. The interviews lasted for 30-45 minutes. The purpose with the interviews was to investigate how the participants perceive the artefacts (including the interactive training environment prototype), used for visual communication of safety. In addition, the employees and subcontractors were asked questions regarding safety at work in general, i.e. their possibilities to control their own work, perceived workload and perceived safety culture. Another purpose of the interview was to investigate how the 'safety first' motto was respected in relation to demands of production rate. The interviews were transcribed verbatim and the responses were categorized and summarized. In order to keep objectivity, three researchers read, coded and summarized all interview material in collaboration.

2.4 Questionnaires

All of the interviewed participants filled in a questionnaire with purpose to complement the interviews by quantifying their opinions regarding the visual communication artefacts. The questionnaires were also used as a basis for discussion during the interviews. The first part of the questionnaire was based on the technology acceptance scale developed by Van Der Laan, Heino, and De Waards (1997). The assessment method consists of nine 5-point rating scale items in form of word pairs, translated to Swedish. One of the original item (Nice-Annoying) was excluded. The word pairs used in the study were: *Useful - Useless, Pleasant - Unpleasant, Bad - Good, Effective - Superfluous, Irritating - Likeable, Assisting - Worthless, Undesirable - Desirable,*

and Raising alertness - Sleep-inducing. The results were analysed with nonparametric analyses in SPSS with a significance level of .05. In addition, the questionnaire included a matrix with all artefacts and the categories: *Learning, Reminding, Increase risk awareness*, and *Motivate safe behaviour.* The respondents were asked to tick the categories that best described the purpose of the different artefacts. The respondents were allowed to tick more than one category for each artefact.

2.5 Procedure

All interviews began with general questions regarding the participants work tasks and how they perceive their control, workload and safety at work. Thereafter, the different artefacts were shown, discussed and rated, successive, i.e. one artefact was discussed and rated before the next artefact was introduced. The interviews ended with the categorization of all artefacts.

3. Results

Both the result of the interviews and the questionnaires show that the silent boards and silent movies were primary perceived and rated as good reminders of already familiar safety routines, and not primary as learning material (Table 1). However, a majority of the respondents said they believed that the effect of the boards would decrease with time. The silent movies were believed to be more effective; however, they are less suited within the working area because they demand some viewing time and, hence, cannot replace the boards as reminders during specific work tasks.

The perception of the posters varied. Some respondents thought that the mediated message was to remain safe also in spare time. Others thought that the message was to bring safety awareness at home to work. Further, some interpreted the posters as a message saying that it is important to stay well and healthy at work in order to maintain the leisure activities you like. However, a majority of respondents were doubtful that the posters would increase the safety awareness at work. They were more seen as posters building closeness between management and operational employees, showing that all were alike at leisure time, sharing the same interests.

All of the respondents were familiar with the documentary movie and stated that it was the most effective artefact for preventing risk taking. The documentary movie caused emotional responses and was described as good at giving insights of how easily accidents can occur and what the consequences could be. The respondents also stated that the documentary movie would be useful for education of newly employed and subcontractors but also as a reminder for all employees. They thought it was well suited at workshops since documentaries takes time and is good to discuss together. They did not think a documentary would be suitable to show during work, as the silent boards are.

None of the respondents had previous experience with the interactive training environment prototype. The majority were vaguely positive and thought that it could be useful for educating purposes. Most respondents agreed that the interactive training environment should offer some challenge, as a game, and not be too easy to complete. They also believed that the more text could be replaced with images, video, or audio, the better it would be for learning. Many thought that if the interactive training

environment would become a recurring element in their work, some kind of incentive in the form of prices or rewards would motivate use. The categorization of the artefacts according to learning, reminding, increase risk awareness, and motivate safe behaviour are summarized in Table 1.

Table 1. Perceived purpose of different media types. The percentage represents the amount of respondents that indicated the artefact as a tool for learning, reminding, increase risk awareness or motivate safe behaviour. For example, the upper right score, 7 %, means 1 of 14 thought silent boards were effective for learning.

Purpose	Silent boards	Silent movies	Documentary movie	Posters	Interactive training environment
Learning	7%	43%	86%	0%	71%
Reminding	86%	86%	57%	43%	43%
Increase risk awareness	36%	57%	93%	36%	29%
Motivate safe behaviour	36%	50%	93%	21%	29%

The questionnaire results considering word pairs showed that the Documentary movie were rated more positive than the Poster (p =.007) and the Interactive training environment (p=.023) in general. The Documentary movie was rated higher than the other artefacts regarding the adjectives Useful, Good, Effective, Assisting, Desirable, and Raising alertness.

3.1 The need of reminders and learning

None of the respondents stated that they felt unsure about how they were supposed to follow the safety routines. Instead they said that they know how to work in a safe manner but thought that the silent movies and the silent board still could work as reminders or injunctions in the working areas. They mentioned that safety routines sometimes were neglected due to different reasons (see part 3.2). Some of the respondents also stated that the silent boards and movies could be useful before a safety inspection.

When introduction of safety to new colleagues were discussed several employees expressed a need of standardised routines. More experienced employees should educate the new employees of the safety routines and many perceived a burdensome responsibility for ensuring no details in the safety routines were missed. This was something that most of the respondents felt uncomfortable with and one suggested some form of checklist as support. The majority of the respondents also reflected upon the fact that "bad habits" easily could be transmitted from them to new employees, unintentionally.

The two subcontracted electricians stated that LKAB felt as one of the safer work sites that they had been working at. Even so, they wished for better information about safety routines and did not feel that they knew enough about the routines to feel safe during work. This was described as a general problem for subcontractors and not as a specific LKAB problem. The subcontractors thought the visual artefacts could help in

this aspect and suggested that information should be displayed in the waiting room at the guard at the entrance. The visual information at the guard could also be adjusted to show more general subcontractor tasks.

3.2 The need to motivate the 'safety first'-motto

The respondents were all familiar with the 'safety first'-motto but the perceptions of how well it was followed varied. Some of the respondents said that the motto was followed without exceptions while others (mainly employees with a long employment) admitted that the safety instructions were not always followed. The most critical factor, when it came to neglecting safety routines, was a perception of non-easy accessible safety equipment. Some respondents mentioned they considered the effort and time it would take to find or fetch the safety equipment in relation to their apprehension of risk. One of the respondents gave an example of a ladder, which seldom was close by when needed. So instead of fetching the ladder the employee climbed and balanced on the safety railing even though the respondent was well aware of the risks and that this type of climbing was against regulations. Some employees also described that they degraded the safety routines if the routines were perceived to be in conflict with personal comfort and with a more desirable method of conducting the work. The respondents also mentioned situations when the safety routines actually could not be followed, e.g. the use protection glasses in warm environments due to problems with mist.

4. Discussion and conclusion

According to this study, visual communication of safety routines was positive and promising, at least as a complement. No artefact could meet all criteria, being both a learning material and a reminder. However, a more ordinary introduction course or a text material would not fulfil all criteria either. A combination of several means of communication, including both verbal and visual messages and discussions are probably a good way. The study did not find any opponents to an increased communication of safety, rather the opposite. The respondents did not see the communication as reprimands but as a confirmation that safety matters and should be considered at all times. Among the artefacts discussed in the study, the documentary movie appeared to be the most effective means to motivate safer behaviour at work. It was believed to give an increased understanding of how easily accidents can occur and what the consequences could be. The documentary movie was emotional, perhaps because it described a real accident told by the affected employees with their own words. This made it more real and close to reality. The close to reality format created a true feeling of "this could actually happen to me," employees explained, and this was a key factor to increase motivation to mind safety.

The documentary was found effective in creating risk-awareness and to motivate safety behaviour, but it was clear it could not replace other types of visual communication. Documentaries demand time for viewing, contemplation and discussions in order to be fully effective. Other means of conveying messages were better for reminders during work. Silent movies, and to some extent silent boards appeared to work well for that purpose. Silent movies could advantageously even be

placed at more locations, for example at the guard office at the entrance, in toilets or in lunch rooms, i.e. places where employees and subcontractors gather and spend waiting time.

The posters with colleagues conducting leisure time activities were liked by the employees and described to mediate a kind of family feeling. The posters were not perceived as a reminder of safety at work though. Complementary posters, viewing the effects of how a work related injury would affect life outside of work may work better as a motivator. Posters could mediate the importance of getting home safe to one's family and not only communicate that rules must be obeyed.

The respondents were slightly positive to the interactive training environment prototype. The reason that the responses were not more positive or negative is probably due to the fact that no one had actually tried out the artefact. Thus, it was hard to draw conclusions regarding the usefulness of gamification as a tool for learning safety. A complementing study with a fully functioning game is needed.

When safety was discussed in general, the respondents expressed a need for additional visual material when introducing and supervising newly employed. This material could support them in their role as teachers. Also, the more experienced employees seemed to have a higher tendency to take shortcuts in safety procedures, and these shortcuts risk to be inherited by new employees. Visual reminders, an accessible interactive training environment or a checklist might counteract this.

Some workers expressed worries that the 'safety first' motto will be challenged by cut downs and increased demands on efficiency and production rates. These worries indicate a good result in creating a well-functioning safety culture among employees. One employee explained that, previously, safety needed to be forced and taught top down, but now the employees want to feel safe at work.

This study also revealed a discrepancy between what employees say and what their closest management says. The middle management claims safety is never compromised. However, technicians and operators sometimes experience an indirect pressure from the management to take shortcuts. There exist situations when the 'safety first' motto comes in conflict with the production demands. When all focus lies on solving a production problem as quickly as possible, safety is sometimes omitted in the communication. Production may never be put above safety, explicitly, but sometimes problems became difficult to solve in a safe way. The existing visual artefacts, together with an interactive training environment, could build a support to lean on and as a reference if, or when, contradictions occur on how specific safety routines should be followed. A documentary movie could also be effective to watch in small groups with both workers and management in order to discuss and elucidate the priority conflict between safety and production demands.

Based on the findings in this study, visual communication could be recommended as means to decrease work related accidents in mining industry. Pictures and movies can be recommended as learning tools and as a reminder of safety routines. However, in order to change attitudes towards safety and create a motivation to follow safety routines it appeared to be important to create emotions and use close to reality examples with severe effects. Further, the results suggest that an interactive training environment may be a useful tool for learning and to validate knowledge.

However, further studies on interactive training environments are needed. The results of this study also elucidates the conflict between different goals, i.e. production and safety, and the problem with subcontractors not being equal the 'in house employees' when it comes to risk and safety education.

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Exposure and risk quantification for improved relationship assessment in occupational investigations

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Data gathered in occupational workplace investigations can be used as a source to improve the statistics. The aim of this paper is to start a discussion on how this can be done. Some suggestions for this are given: e.g. that there should be an increased use of quantitative data in occupational investigations. The number of variables used in exposure quantification should be limited and agreed upon. The variation in terminology should be reduced by improving the definitions of the terms used and also by developing a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms. There are many influencing factors which affect the possibility to make comparisons over time, but increased use of precise concepts and standardized methods can result in much better statistics.

Keywords: Exposure, occupational risk assessment, dose-response, standardisation

1. Introduction

From numerous studies of occupational work load and disorders in professional groups there is general agreement that there is a relationship. For a Swedish compilation and evaluation, see Report 210 by SBU, the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU 2012). Too high work load results in bodily disorder after enough strong exposure. Despite the number of studies the relationship between cause and effect is not very well determined. There are several reasons for this.

In many occupational investigations the aim is to identify the risk for harmful conditions, and then through different measures reduce the risk to an acceptable level, or preferably to zero as the aim is that nobody should get hurt in the job. However, it is not the risk that is assessed, even if it is said so, but rather the exposure, usually determined as load level and rarely as load dose

Ideally then the exposure assessed should be related to injury outcome through dose-response relationships and a risk measure obtained. This means that dose-response relationships play a very important role. Unfortunately, established dose-

response relationships are seldom available. A reason for this is that the relationships are quite tedious to determine, they must be based on relatively large materials and they require precise definitions and assessments of both load and response. Instead agreed classification of exposure is used as a risk indicator for action (e.g. Hansson et al. 2016).

In the practical investigations made at company level the origin is that a person has started to complain about ache or pain from a body part and reports this to the occupational health service in order to get some help. The OHS is then required to do an investigation. Such an investigation has two parts: the first concerns characterisation of the symptoms the person has, and the other is an exploration of exposure factors that can have caused the symptoms, both should be in quantitative terms. A third part that should also be considered in the investigation is to determine possibilities to improve the work situation. This means that both response related and dose related factors are gathered even if they are not carefully recorded. With little extra effort, these findings can be used to continuously improve the statistics. The aim of the present paper is to start a discussion of how actions for such improvements can be done as part of the OHS routine and result in much better statistics.

2. Exposure assessment

The aim of exposure assessment is to grade the degree of loading a job or work moment entails. The assessment involves two entities, viz. (1) grading of the load level and (2) estimating the time duration of the loading. Many of the methods for work load assessment are handling grading of load level quite well while time duration assessment is quite difficult since peoples work is varying a lot concerning both type and duration.

There are a large number of more or less reliable methods available to identify and assess exposure, many of which are qualitative and based on judgement of observations. The methods are commonly categorized under three main headings: subjective judgments, systematic observational methods, and direct (or technical) measurement methods (e.g. Kuorinka et al., 1995).

One of the first methods for assessing awkward or strenuous postures by observation is the OWAS method presented by Kahru et al. in 1977. The method was very welcomed as it led to an ordered structure of observations that could be used at the workplace. It rated observed postures of the whole body and classified them in four classes according to the urgency for action. This method was later followed by the also very often applied Rula method (McAtamney and Corlett 1993) providing a quick assessment of the postures of the neck, trunk and upper limb. Both these methods gave a structure to the observations made by an experienced investigator directly at the workplace. They also presented a way of grading the severeness of the assessed exposure based on reports available at the time and the authors' experiences from own work place investigations.

These two methods and similar methods that have been developed over the years (see e.g. Takala et al., 2010) became very popular among investigators as they were considered very easy to carry out and did not require any instrumentation. Also the recommended structure for classification of the observations simplified the

evaluation of the work load and conclusions on what should be done. Despite appearing simple to carry out, the observations require a certain experience and skill by the investigator. That this is a problem in the practical use of observational methods is shown by the rather low accuracy of the methods (e.g. Palm, 2016). Another problem with the methods is that they are based on direct observations and after a session only the observer's notes remain meaning that the work studied cannot be rechecked. By video recording of the observed work this drawback can be remedied and is often done, but then some of the simplicity of the method is lost.

3. A comment on scaling

The aim of work load assessment is to make observations at a work place and evaluate the load assessed to determine whether it is harmful or not. This is basically a dichotomous decision. But since there is always a degree of uncertainty about borderline cases, the need for a borderline class arose, a need that lead to the establishment of the *traffic light scale* with its three levels. Green means that the job or work moment is without risk for harm or injury and therefore acceptable. Red means that the job involves an unacceptable risk for harm or injury and that the job must be improved as soon as possible. Yellow means basically that no clear decision can be made and that the work situation needs to be investigated further. However, it did not last long until the traffic light method became established as a scale of three levels often even numerically quantified as 1 for green, 2 for yellow and 3 for red. This should be looked upon as an ordinal type scale, but the numerical values have invited treatment (incorrectly) as an interval scale. Since the borderline uncertainties still are inherent, this has led to the introduction of half-steps between the colours leading to a scale with five steps. Despite the number of steps or grades this does not result in very precise characterisation of exposure since it depends on the structure and accuracy of the underlying assessments.

4. Transducer based measurements

To improve the workload assessment quantitative methods should be used. For the load level, new possibilities for more precise assessments have become available in recent years. Through development of transducer technology (for movements, acceleration, forces and moments), signal conditioning and recording equipment as well as computer based analysis software, more occupational investigations can be based on direct measurements with reliable and precise assessment of exposure. Good examples of what can be achieved have been given by Hanson et al. (2016). However, despite these achievements in measurement techniques, the measurements may still be too difficult to carry out for use in everyday occupational health work.

5. Computer manikin simulations

Another very promising possibility is to use the simulations of work that are done more or less routinely in early phases of production preparations in technically advanced companies using computer manikin software. When the structure of the computer manikins involved is detailed enough, the modelled movements of the body

parts can be recorded and used for kinematic assessment of postures and movements, statically as well as dynamically as both snapshots and the time variations of the exposure variable can be recorded (e.g. Keyvani et al., 2013), and, with suitable biomechanical models, even kinetic assessments can be made so that postures, movements, gravitational loads and acceleration forces can be determined.

Thus, the biomechanical modelling introduced in manikin software permits also kinetic assessments, i.e. assessment of the forces acting on, in and between the body parts in addition to the kinematic assessments of postures and movements. The IMMA manikin software developed jointly by Chalmers and Fraunhofer Institute is an example intended for industrial applications (IMMA 2014). This means that exerted forces, gravitational loads and acceleration forces can be determined and used as exposure variables. Even if the biomechanical models used in the software are advanced and based on sophisticated considerations, the use of the software can be quite straightforward and easy to manage. Thus a number of questions concerning internal forces and moments in the body during work can be answered. Unfortunately the usefulness of kinetic quantities in risk assessment is limited at the present time since connected response data are not available. This situation can be expected to be improved in the future as the results from kinetic analyses become available together with concomitant injury statistics.

6. Time and load dose

Even if quantitative methods for assessing the load magnitude are used, it is still problematic to determine the time extent of the exposure. The harmful effect of an exposure depends on both the magnitude and the time extent; the load dose being calculated as the summed or integral of the product of the magnitude and the time. Here some new questions arise, namely whether the load dose is additive in the meaning that if the load dose is doubled, does the response also double. A variant of this is whether a certain load dose is equivalent to another in which the load is halved and the time extent doubled.

The time aspects of the exposure should be recognised better when acquiring dose-response data for epidemiological considerations. This not so easy, however, as time records of the load history for individuals are hard to obtain due to the variability of the employment situation in many companies. In companies where the mobility is less it should be possible to get data on which jobs a person has had and for how long since such data are recorded. If these data are put together with work load data from computer simulations of the work, it would be possible to obtain very useful statistics on dose-response in such jobs.

7. Quantification of symptoms

On the effect side the classification of symptoms need to be improved as the symptoms are denoted verbally and not easy to quantify. Descriptive words like pain, trouble, distress and even fatigue are common. A further trouble is the wide spread of work-load assessment methods in use. Even if the different methods have much in common they do not give simply comparable results. A consequence of this is that despite all the information that is available, it is hard to systematise this information and use it to

establish precise relationships between cause and effect or to perform deeper analyses aiming at for example better understanding of injury mechanisms.

8. Need for quantitative data and a methods standard

In order to remedy the situation there should be an increased use of quantitative data in occupational investigations both concerning exposure and symptoms. Another issue is to try to reduce the variation in terminology by improving the definitions of the terms used and also to develop a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms. On the exposure side there are several possibilities for improved quantification of exposure, level as well as duration. Also the variables to be used in exposure quantification must be agreed upon. This is not an easy task, however, as workload can be characterised by so many variables.

9. Load dose and risk

When interpreting the load dose relationship, it must be remembered that it is a statistical concept. This means that if individuals in a population are subject to a given load dose, only a certain percent of them will develop symptoms of harm or injury. What is then a safe dose level? A level which causes problems in one percent of the population, or should five percent be acceptable? To bring order in the reasoning about dose-response issues of this kind must be clarified.

Casually the word risk is used with several meanings to indicate how possible it is that an unfavourable event will lead to harm under certain circumstances. In occupational contexts risk is used to indicate the likelihood that an injury or accident will occur. The likelihood or probability that a single event (injury or accident) will occur is perhaps not so meaningful in a certain situation as the event will either occur or not. The meaning becomes clearer if the conditions are repeated under the same circumstances. Then the likelihood signifies the relative frequency of occurrence of the event. Here both likelihood and relative frequency can be expressed in percent.

The risk concept has also a different meaning, however. In risk science it is defined as the probability of an event times the consequence of the event. The risk can then be expressed as the cost a single event amounts to, or as a yearly cost for the events that takes place during a year.

Both these risk concepts are important in occupational health work and there should be a definite strive to put figures to the risks by putting together available data. This can very well be done locally in a company, and by having such compilations, it is possible to follow the development of harmful conditions over time and also the effect of measures undertaken. Of course there are many influencing factors which affects the possibility to make comparisons over time, but by increased use of precise concepts and standardized methods these can be overcome resulting in much better statistics.

10. Conclusions

There should be an increased use of quantitative data in occupational investigations. The variables to be used in exposure quantification should be agreed upon. This is not

an easy task, as workload can be characterised by so many variables. Another issue is to try to reduce the variation in terminology by improving the definitions of the terms used and also develop a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms.

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Work environment challenges and participatory workplace interventions on passenger ships

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This study is part of a larger research project investigating working conditions for employees in the service department on board passenger ships. A mixed methods approach was adopted, and this paper focuses on the findings related to the physical work environment. The main findings show the physical factors to be largely related to high physical load and time pressure. The design of workplaces and equipment is a cornerstone for a sustainable work environment. Participatory design practices open the opportunity to foster employee engagement in workplace design, contributing towards increased employee health and well-being.

Keywords: Ergonomics, physical load, employee participation, participatory design.

1. Introduction

Work place conditions are known to affect employee health, safety, well-being, and job motivation. In what can be labelled the *cycle of success*, the working environment for service personnel may also affect service quality, customer satisfaction, and in the end, have an impact on a company's financial performance (Gazzoli et al., 2010). For operations of passenger vessels, the manning represents a two-fold challenge. On the one hand, it concerns recruiting, selecting and ensuring the mandatory safety training of all personnel before they can join the vessel. On the other hand, it concerns retaining of personnel, to make them want to return to the vessel and to keep the personnel healthy, fit for duty and motivated.

Despite significant changes in work tasks on board modern merchant vessels, seafaring remains one of the most hazardous occupations (e.g. Ellis et al., 2011). However, the symptoms and origins of seafarer morbidity have changed with the times. Along with fast work place developments and changes in work tasks comes a greater risk of psychosomatic disorders (Oldenburg et al., 2010; 2009). Previous research (Österman & Hult, 2016) shows that personnel in the service department (working in the hotel, cleaning, restaurant and shop departments) display a greater degree of perceived exhaustion, job stress and fatigue than do other positions on board. Catering crew also report lower sense of identification with the seafaring occupation (Hult, 2012).

The high incidence of occupational ill-health in the service department does not only mean that many individuals suffer from pains and sometimes lifelong disability and relegation from the labour market. It may also affect service quality and disrupt the organisation of work, and come with heavy expense to businesses and community.

Research that specifically addresses the work environment in the service department is scarce. There are some studies that focus on working on board international cruise ships, but primarily from a business-oriented perspective, e.g. the impact of job satisfaction on customer satisfaction (e.g. Larsen et al., 2012; Sehkaran & Sevcikova, 2011). In addition, some sociological studies have investigated, for instance, occupational communities (Lee-Ross, 2006), work perceptions (Dennett et al., 2014), and working and living conditions onboard (Gibson, 2008). Due to major differences in employment and working conditions between the international cruise industry and Scandinavian ferries, it is, however, not always possible to compare these two.

2. Study purpose and aim

The study presented in this paper is part of a larger research project investigating physical, organisational and social working conditions, job motivation, and sick-leave for employees working in the service department on board Swedish flagged passenger ships (Hult et al., 2017). The research project was conducted during January 2015 to January 2017 as a cooperation between researchers at Kalmar Maritime Academy and the Swedish Social Insurance Agency for Seafarers (Försäkringskassan Sjöfart).

This paper focuses on the findings related to the physical work environment. The aim is to identify physical factors of special importance for the occupational health and safety, and if it is possible to discern health-promoting factors to counterbalance the risk for accidents and ill-health.

3. Research design

The project adopted a *mixed methods approach* and the findings are based on interviews, observations, survey data and social insurance statistics concerning sick leave longer than 60 days. The data collection was based on three main research activities:

- Analysis of statistics on sick leave longer than 60 days reported during 2011–2014 to the Swedish Social Insurance Agency, the special branch for seafarers (Försäkringskassan Sjöfart).

- Field studies on board Swedish flagged passenger vessels during 2015–2016, where direct and participating observations were made of various work tasks. In-depth individual and group interviews with managers and crew working on board in the catering department, and HR managers working at passenger ship companies, allowing for rich, detailed information on the service crew's working conditions. In all, the respondents represent ten passenger ships from six shipping companies. Interviews have also been held with trade union representatives and case workers at the Social Insurance Agency.

- Survey questionnaire conducted in 2015 that in part could be compared with results from a corresponding survey conducted in 2010. The questionnaires were largely based on the International Social Survey Programme, Work Orientations III study, and the material contains detailed information on a wide range of

relevant aspects, as well as data for index construction of several types of motivation, job satisfaction and perceived health and stress.

In the final phase of the project, a workshop was organized where preliminary results from the project were presented and discussed with a total of 27 representatives from the Swedish passenger ship sector. The purpose of the workshop was to get feedback on the results and to some extent validate them (Praetorius et al., 2017). A detailed description of the research activities and how qualitative and quantitative data was collected and analysed, can be found in the project report (Hult et al., 2017).

3. Results

This section presents and discusses the findings related to the physical work environment on board; here categorized as physical load, workplace design, and employee participation in design.

3.1. Physical workload

The service crew generally experience high physical workload. Many tasks are performed standing and walking, often with strenuous working positions with bent and twisted postures or over-reaching. Part from the more visible work that is performed by the service department personnel in shops and restaurants, the work behind the scene include taking onboard supplies, transport goods to the shops, bars and restaurants, handle garbage, bedding and linen to the cabins, making the dishes in cafeterias and restaurants, and so forth.

For example, when serving tables at à la carte restaurants, waiting staff may be forced to carry up to 5–6 kg of food and drinks per table, which overall gives a high and repetitive load during a workday. In the hotel department, cleaning public and crew spaces and cabins, handle linen and making beds imply a high physical load. This work must often be performed under time pressure, with the crew having low control over their own work.

Furthermore, working on a ship involves continuous exposure to noise and whole-body vibrations. Even when the noise is not harmful for the hearing, disturbing noise can induce stress and make it difficult to hear work instructions, questions or guest requests. Whole-body vibrations and ship movements represent an increased risk of musculoskeletal disorders (MSD), especially in the lumbar spine, neck and shoulders. Noise and vibrations may also have negative effect on sleep quality.

Above all, the respondents emphasize heavy lifting and having to stand and walk for prolonged periods of time during a workday. One respondent working as a waiter, logged over 20 km with a pedometer during a busy day with à la carte dining. The crew working in restaurants describe how long distances between the kitchen and the restaurant tables often make them carry too much instead of going twice. During a group interview with serving staff, two respondents discusses this:

> *One should really listen to the body and not carry 20 plates at a time, but you don't. With the long distances, you have to walk all the time.*

Someone takes two plates. And when I am capable of carrying four or five plates, sometimes six and seven plates, then I take all those plates, because I'm in such a hurry the whole damn time, the clock is ticking. And then I get sored joints, thumbs, shoulders, back ...the whole body.

In some restaurants, it is not encouraged to use a serving cart, since it is said to be a less exclusive guest experience than serving the plates by hand. In other cases, the respondents say that there is not enough space to use serving carts.

If you have to run and drag so many carts.., we have no place to store those carts and there is no room to take the carts to the counter either, to unload the dirthy dishes. It would take even longer time.

The respondents mention some measures that could be taken to reduce the physical load, but these measures are either not perceived as sufficient, or they must be paid for by the crew themselves. Examples are the possibility of having a massage at work, and using appropriate shoes during work.

Many of us have shoulder problems. We have a staff massage therapist that comes in every week, but she should be here a little more often, all the time.

Although work and safety shoes are funded by the employer in some departments, this is not the case for all personnel in the service department.

Everyone does not buy ergonomic shoes either. Everybody can't afford it. So here is something that ... there are many who have wrong shoes.

Just because the kitchen and the dish washers work with chemicals, they get safety shoes, but we who walk for twelve hours a day, we have to buy our own shoes and do not even get a refund.

3.2. Workplace design

The risk for MSDs is not only related to heavy load during work, but can also be associated to workspace design and the ability to adjust the workplace and working conditions according to various individual needs. The results from the interviews and observations reveal several aspects of the physical work environment that can be derived from how workplace and work equipment are designed. There are examples of how sub-optimal design of restaurant kitchens leads to unnecessary strenuous movements, and that the kitchen staff runs into each other during hectic situations with a high workload. During the interviews, countless examples of heavy, impeccable porcelain that does not always fit in the counter were given. During a group interview with restaurant personnel, the respondents discuss how poorly designed dish counter forces the crew to regularly work with their arms above shoulder level and below knee level:

- We have damn heavy dinnerware in our restaurant.

- Yes, and then it's the dish counter. It is so un-ergonomic, both for the people washing the dishes and for us.

- The dish washers have to bend like this to take the plates [Shows by folding the upper body].

An important aspect is the employee involvement and the ability to influence the workplace design. Many of the interviewed employees in the kitchen, bar, restaurant and hotel departments show that they are aware of the challenges and shortcomings of their own work environment, as there are many specific suggestions for solutions, especially from respondents with long work experience. Yet, many changes in the physical work environment seem to have been conducted without the crew being involved in the planning and evaluation of the change. Decisions that is perceived by the respondents as creating unnecessary costs and causing frustration, when these changes have led to increased workload rather than to improvements. An example mentioned during the interviews is a shock-absorbing carpet in a bar. The purpose of the carpet is to alleviate whole-body vibrations during standing work, and reduce the risk of ill-health. Unfortunately, the carpet was not adapted to the workspace or working conditions. The carpet is big and heavy, making it so difficult to move that it takes more people to clean the bar. Although the respondents stress that they do appreciate the initiative with the carpet, there is reason to believe that it would have yielded better outcome had the personnel been involved before deciding on dimensions and materials.

Why dont they just ask the bar crew? Because it was great for us who stand a lot, but why not take three pieces at two meters then? I mean, when they do something, why not listen to the people working with it instead of deciding over our heads? And now it's not possible to cut the carpets, because you know, it is some foam filling and it is pressed together.

In addition to contributing contextual knowledge on work tasks and working conditions, employee participation has other positive effects, related to job satisfaction and the sense of coherence, or as it was expressed by a local union representative:
The importance of feeling involved and being able to influence your work situation; that you are allowed to play the whole game.

3.3 Employee participation in design

Despite many negative aspects of the physical work environment and workplace design mentioned, the respondents in this study also emphasized the importance of participatory design activities through examples of good practice in relation to changes in the physical work environment.

One good example of participation was the building of a cabin prototype before renovating a number of passenger cabins. Here, the employee safety delegates in the hotel department initiated a test cleaning of the cabin prototype that was documented and photographed. The test revealed that the cabin design made it very difficult to clean and required the use of unnecessarily strenuous work postures, while sharp furniture corners increased the risk of accidents in the small space. After presenting the test cleaning results for the managers in charge of the cabin renovation, necessary adjustments were made to the cabin's interior. A smaller bed was chosen, corners were rounded off, and a thinner TV was mounted on the wall to increase the space as much as possible.

Another good example is the change of drinking glasses in a cafeteria. The topic of heavy glassware and dinnerware was raised repeatedly during the interviews by many respondents. In this case, crate with glasses weighed 13 kg when lifting it to and from the dishwashing station. The cafeteria crew argued that the many lifts caused pain and problems in the neck and shoulder and initiated a test with new kind of glasses. The result was to exchange the type of glasses used in the cafeteria to new glasses that cost one third of the old ones in purchase, and weigh 6 kg per back. According to a respondent:

It became so much easier. It is mostly short and slender girls who work in there. And to stand and lift those damn crates ...

Since each crate is lifted and manually handled several times between the cafeteria and the dishwashing station, the change of drinking glasses is likely to reduce the risk of MSDs.

4. Discussion

This study aimed to identify physical factors of special importance for the occupational health and safety, as well as promotive factors to reduce the risk for accidents and ill-health. First, it must be stated that the results of the entire research project show that perceived health and job motivation is influenced by myriad of complex and inter-related factors (Hult et al., 2017). Clearly, the physical, organisational and social work environment factors are closely linked. Hence, it is necessary to adopt a wide perspective that takes more than one aspect into account when designing and organising work tasks, workplaces and equipment. Single efforts may counteract each other, conflict with other interests and lead to sub-optimisations, if decisions are made and measures are taken unilaterally.

Nevertheless, this study on physical work environment factors shows some distinct areas for improvement that can be categorized into three different types: workplace design and processes for planning and designing workspaces; organisation of work tasks and work techniques; as well as health promotive measures.

A good physical work environment is created early in the design stage and it is important that the crew is given the time and opportunity to participate in the design of workplaces and working methods. Several recent publications stress the need for end-user involvement throughout the design process (eg. Kataria et al., Cervai & Polo, 2017; 2015; Rasmussen et al., 2017). The involvement also regards the design of workplaces and work organization, not only technology. The employees' knowledge of needs and requirements related to how the work is performed, and under which conditions is a vital input in the design process. Employee participation in change and development processes will also increases the staff's experience of influence and contribute towards a higher acceptance for the final solution, given a better understanding of the compromises that have been required. Participation in all types of changes relevant to the work environment is also a requirement in Swedish occupational health and safety legislation (AML ch 2 1§). Further, participation might also communicate increased decision latitude for the employees. High work demands and perceived low decision latitude is one of the well-known factors that contributes to stress-related ill-health

(Karasek & Theorell, 1990). Hence, employee participation can create a more favourable, and possible more efficient, physical work environment, as well as create a positive organizational climate, enabling employees to influence their own working conditions.

Another important measure is the implementation of risk assessments when purchasing work equipment. The results include several examples of how uninformed decisions regarding design and equipment have resulted not only in frustration and increased risk of physical and mental ill-health, but also in negative effects on work performance and service quality.

Most occupational categories within the service department are physical and effective MSD prevention require a systematic approach to identify and control all causal factors. Several publications examining the effectiveness of interventions consistently report that multifactorial approaches are needed which take a range of relevant factors into account (e.g. Silverstein & Clark, 2004; Westgaard & Winkel, 2011). Measures mentioned during the interviews were largely targeting the individual, such as proper work shoes, massage, and individual health promotion activities. These are all good suggestions that most likely will have some positive effect, but it is not enough. A more holistic, macro-ergonomic approach should be encouraged, as suggested for example by (Westgaard & Winkel, 2011). Work must be planned and organised to avoid health-endangering or unnecessarily fatiguing work postures and working movements and consider both workloads duration, frequency and intensity. To minimise the risk for MSDs, both supervisors and employees need knowledge on appropriate work techniques, and allocate time for adequate introduction to duties and use of equipment. Individual health promoting measures may indeed increase well-being in the work environment. Access to healthcare and the opportunity to participate in physical activities during the free time on board is clearly an appreciated feature, but here the employer can only create the preconditions. It is up to the individual to make use of it. It is important that time is allocated for these activities, especially when the job is both physically and mentally exhaustive.

Overall, the results of this study illustrate how knowledge of ergonomics and systematic work environment management can be used as a tool for employee and management collaboration, and for achieving benefits in terms of reduced sick leave and improved employee health, well-being and job satisfaction.

5. Conclusions

The main findings of this study show that physical work environment factors important for the occupational health and well-being of the crew working in the service department are largely related to the high physical load and time pressure experienced by the employees. The design of workplaces and equipment is one of the cornerstones for a sustainable work environment. It can either be a factor that increases the risk for ill-health, stress and frustration, or it can become a precondition for a work environment characterised by a good fit between worker, environment and organization. As shown in this paper, participatory design practices open the opportunity to foster employee engagement in workplace design and can be used to transfer control to the workforce, enabling employees to influence and improve their own work environment significantly.

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Preventing workplace violence and threats among professional cleaners – how not to be in the 'wrong place at the wrong time'

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Professional cleaners work in a complex work environment, subjected to various physical and mental loads. This paper focuses on work related violence and threats and practical suggestions for its prevention and mitigation. By organizing and designing cleaning work in time and space it is possible to reduce the risk of cleaners being in the 'wrong place at the wrong time'. Cleaners need to have sufficient knowledge of how their work can be carried out as safely as possible; how to act when threatening or precarious situations occur, and feel confident in managerial support if they need to interrupt work in a threatening situation.

Keywords. Work related violence, work environment, cleaning, work organization.

1. Introduction

Professional cleaners work in a complex work environment, subjected to various physical and mental loads. The study presented in this paper is a part of a larger project aiming to further the knowledge about cleaners working conditions, and to develop and disseminate methods and practical measures for an improved work environment (Antonsson et al., 2016). Specifically, this paper presents an analysis of the risks associated with work related threats and violence, and suggest preventive measures.

1.1. Background

Cleaning companies operate in a highly competitive market, placing high demands on cost efficiency. In practice, this implies that the time allowed for completing a task is very limited. Since it is also a service industry, customer requirements are instrumental for the content and organization of the cleaning work that is usually performed on premises owned and controlled by other actors. The work is often done as solitary work, or in small groups, and the contact with other occupational communities that might be present at the premises is often limited.

The cleaning industry in Sweden is an expansive industry. In the wake of the introduction of the *RUT* tax deduction for domestic services in 2007, the industry saw a rapid expansion of new establishments. According to the Swedish Work Environment Authority (SWEA), many of the newly started small cleaning companies lack basic knowledge about work environment management, and the number of accidents and

incidents reported to the SWEA from the cleaning industry increased by more than 200 per cent between 2005 and 2010. Long-term sick leave is twice as common among cleaners compared to the average for workers in Sweden. The most common causes for long-term sick-leave are musculoskeletal disorders, but statistics has also seen an increase in cleaners being subjected to occupational threats and violence.

There is no generally agreed definition of occupational threats and violence. The term has been defined in diverse ways depending on context and area of activity (Wikman, 2016). For the purpose of this study, the point of departure is the definition used in the SWEA provisions on Violence and Menaces in the Working Environment, that defines violence as the full range of aggressive acts, including homicide, assaults, threats, sexual harassment and verbal abuse (AFS 1993:2, p.5).

Previous research show an increase in work-related violence in Sweden and the Nordic countries, and especially among women (Wikman, 2016). The violence in general has however remained at a relatively constant level, making the working life the single largest arena for threats and violence. In the 2013 Work Environment Survey, about 14 per cent of the survey respondents (18 per cent of the women and 11 per cent of the men), representing all professions, reported that they were subjected to work-related threats and violence sometime during the last 12 months (Arbetsmiljöverket, 2014). Contemporary workplace violence is more than the stereotypical image of robberies and assaults in the retail business, and violence aimed at first responders. Certain groups of professionals, such as health care and social workers account for an increasing proportion of incidents, both as perpetrators and victims of violence (Wikman, 2008). In the typology of Bowie (2002), workplace violence can be categorized in four types: *intrusive* (intentional criminal action performed by a stranger), *consumer-related* (customer, client, patient to employee, or vice versa), *relationship* and *organizational* (organizational violence against employees or costumers, clients, patients).

In Sweden, bullying and sexual harassment is significant of the incidents classified as *relationship violence* , where the aggressor is a colleague or in other ways is familiar with the victim (Wikman, 2008). Sexual harassments at the workplace is particularly common in sectors, traditionally dominated by women workers (LO, 2015). Harassments range from physical acts, such as unwanted hugs or groping, to body-shaming, comments or gestures. In a survey conducted by Novus on behalf of LO (The Swedish Trade Union Confederation), 11 per cent of employees in the hotel and restaurant industry, including cleaners, report to have been subjected to harassment by other persons (LO, 2015, p. 33). In addition, the survey shows that relationship violence is more common at hotels and restaurants than other workplaces, and that the risk is further increased for employees on fixed-term employment contracts. That the risk of being subjected to workplace harassment varies with gender and class has been described also in international research (see, for instance the systematic literature review by McDonald, 2012).

1.2. Study purpose and aim

The purpose of this study is to identify the most common types of threats, violence and sexual harassment directed at cleaning professionals in Sweden, and in which context

these incidents occur. The overall aim is that with increased knowledge of underlying causes and contributing factors, it is possible to suggest preventive measures to eliminate, minimize, and mitigate effects of occupational threats and violence.

2. Methods and materials

To provide a sufficiently elaborated understanding of the problem domain, a *mixed methods* approach was adopted (Johnson et al., 2007), combining quantitative and qualitative data collection and analysis techniques. The study is based on the following research activities:

- *Analysis of statistics*. Analysis of occupational accidents and injuries related to threats and violence of cleaners, as reported to:
  - The Swedish Work Environment Authority[1] (SWEA) during 2005–2010
  - AFA Insurance[2] during 2005–2011.
- *Research interviews* with relevant stakeholders (Table 1), primarily focusing on frequency and type of events, causes and possible actions. Observations and interviews with professional cleaners during workplace visits to a hotel, a school and a pre-school.
- *Stakeholder workshop*. In the final phase of the project, a workshop was held with invited representatives of cleaning companies (manager, safety delegate, work environment specialist, and HR manager), a representative from a cleaning equipment supplier, as from the social partners. The workshop aimed for a critical and reflective discussion of the identified risks and suggest appropriate measures to eliminate, minimize or mitigate these risks as far as possible.

Table 1. Professional role and organization of the interview respondents.

Professional role	**Organization**
HR manager	Large cleaning company > 250 employees
Manager	Large cleaning company > 250 employees
Manager	Small cleaning company < 50 employees
Manager	Small cleaning company < 50 employees
Work environment specialist	*Visita* Employers 'Association, representing 7 000 hotels, restaurants and other hospitality enterprises.
Ombudsman	*HRF* Hotel & Restaurant Workers Union
Regional safety delegate	*HRF* Hotel & Restaurant Workers Union
Regional safety delegate	*Fastighets*, Building Maintenance Workers Union
Manager, intendant	Municipal school
Manager	Municipal pre-school
HR manager	Large hotel > 250 employees

[1] Reporting of work-related severe injuries or incidents to the SWEA is mandatory under the Work Environment Act (AML) chapter 3, 3a§.

[2] AFA Insurance (AFA Försäkring), insures employees working within the private sector, municipalities, and county councils. Reporting is voluntary, but necessary to receive compensation for work-related injuries.

3. Results

The presentation of the results and analysis is structured in the following order. First, the statistics analysis is presented, showing the number and type of incidents reported to the SWEA and approved by AFA Insurance, respectively. Followed by the results from the interviews, workplace visits and stakeholder workshop, presented on the themes of working conditions, communication, and suggested preventive measures.

3.1. Reported accidents and injuries due to work-related threats and violence

The results of the statistics analysis originating from SWEA and AFA Insurance are presented in Table 2. Events that can be classified as accidents without intent to harm, have been excluded from this analysis, making the number of analysed incidents smaller than the total number of officially recorded incidents.

Table 2. Number of occupational injuries related to threats, violence or sexual harassment of cleaners, reported to the SWEA and approved by AFA Insurance.

Type of injury	Examples of situations	SWEA	AFA
Physical assaults	Disgruntled customers, mentally instable patients, conflict between colleagues, criminal persons, solitary work, remote location.	41	27
Verbal threats	Disgruntled customers, mentally instable patients, conflict between colleagues, criminal persons, unknown persons, solitary work, remote location.	16	8
Animal attacks	Assualted of unattached dog, attacked of dog when cleaning staircases	0	6
Ball kick	School children/pupil kicked ball against the head of an employee.	2	5
Robbery	Attempted robbery in a staircase	4	2
Sexual harassments	Attempted rape .	3	1
Total		**66**	**49**

Table 3. Perpetrators of threats and violence, as reported in the free text responses.

Reported perpetrator	SWEA	AFA
Colleague employed in the same company	20	9
School student	10	9
Hospital patient	5	4
Customer, employee at customers company	7	-
Criminal person, robber	2	-
Dead person found at work place	2	
Bomb threat	1	-
Undisclosed person	25	37

The results show that cleaners' working conditions contain many features that can escalate to situations of threat, violence and sexual harassment. A closer examination of the free text responses in the reports to SWEA and AFA Insurance shows that offenders are often found in the cleaners' proximity by people who have legitimate reason to be on the premises where the cleaning work is carried out (Table 3).

3.2. Working conditions with perceived elevated risk

The interviews show that some workplaces and working conditions are perceived as particularly prone to threats and violence. Examples include cleaning of public transport facilities, such as metro and train stations, in stairwells, at schools, hospitals and other healthcare facilities. Also, transport to and from some workplaces is perceived as an elevated risk, especially when working at remote premises, during late evenings, night or early mornings. In the interviews, several of the respondents confirm what is seen in the statistics; that perpetrators of threats and violence often are known to the victim, such as a customer or a colleague.

Examples of situations described during interviews involve dissatisfied customers, mentally ill or demented patients at a health care establishment, or intoxicated individuals in the public. Especially when cleaning is performed during inconvenient working hours when the cleaners may be the only other person present, becoming an unfortunate channel for a perpetrator to let out anger or frustration for other reasons. Thus, the cleaners who are exposed to threats and violence are often not part of any conflict; they just happen 'to be in the wrong place at the wrong moment'.

Conflicts at the workplace sometimes occur between cleaners with different ethnic background, or between supervisors and employees, especially when language barriers add to misunderstandings.

3.3. Communication of risks, preventive actions and reporting

The interviewed managers report a perceived lack of effective channels for knowledge transfer and communication of risks and incidents. Some incidents did not become known to the employer until the afflicted employee had reported sick of other causes, such as physical stress injuries. Documentation of threats and violence is often poor within the companies, making it difficult to investigate who did what and during which circumstances.

Among the reasons stated for employees not reporting incidents are language barriers, the employees having poor knowledge of their rights, or that a victim feels ashamed of what they have been exposed to. Employees on temporary employment contracts might fear a risk of losing their job if reporting.

3.4. Identified measures to reduce the risk of threats and violence

Effective prevention measures can be found at an organisational, technical and individual level. At the *organisational level*, prevention is facilitated by a functioning systematic work environment management that examines and assesses the risk of threats, violence and harassment. Managers and supervisors need to have good knowledge and understanding of what and why certain situations can occur, how often, and what kind of preparedness is needed to mitigate effects of potential

incidents. An important part of preventive work is how the work is organized and planned in time and space to reduce the risk of employees being at the *wrong place at the wrong time,* and that solitary work is avoided where this is inappropriate. For this planning, the employer needs clear procedures for how risks can be assessed and managed. Often, it needs to be performed together with the customer or co-ordinator for the property. Cleaning can for instance be co-ordinated with other staff in the workplace so that the cleaner does not have to work alone. For example, setting up meetings with other employees (own colleagues or others), guests, caregivers, students and the public who are present where the cleaning is to be performed. Here, it is important to discuss where the cleaning will take place, what sort of cleaning tasks that will be performed, and whether there are any special needs or requirements to increase safety. This applies especially for cleaning in environments with a lot of people present or moving through, such as hotels, schools, waiting venues for air, train or public transport, or other places with a lot of queues. Other environments that could increase the risk include hospital environments, social offices or other similar public administration offices; places where there may be people who are exhausted, stressed, sick or affected by alcohol and drugs.

Technical issues include design of parking and access roads, alarm and lock functions, lighting, and so forth. It is important to clarify how the cleaner can easily get in contact with a supervisor when needing assistance, and if special procedures are needed to check that the cleaner leaves the workplace at the scheduled time. Exactly how contact can be held between cleaning staff, supervisors and colleagues depends on the situation and the workplace. Sometimes it is enough with a telephone call or a text message, in other situations where phone coverage is poor, it may be justified to wear portable communication radio. Cleaners working alone or in particularly exposed places can be equipped with personal alarms. It may be a so-called *man down alarm* with a GPS that indicates if a person falls. There are also alarms that enables an external operator to follow and monitor an event, communicate with the victim and, if necessary, alert appropriate emergency services.

At the *individual level*, the cleaning staff also needs knowledge of how the cleaning work can be carried out as safely as possible and how to act in various threatening situations. The staff also needs to feel confident in having the support of the workforce, for example, work needs to be interrupted in a threatening or unpleasant situation. Before cleaning in a new location, all employees need a good introduction to the new object, what occupational safety hazards may exist and what security measures should be taken. In many cases it is appropriate that the cleaning staff be included in the customer's regular protection work such as alarms, surveillance cameras, security guards and working during office hours when the customer's staff are in place. If security-creating measures are implemented in a workplace for the customer's own staff, or for students at a school, such as action programs against bullying, threats and violence among students or violent caregivers, these measures could also include the cleaners in the workplace.

In a cleaning company, it is important to agree on how any customer complaints are dealt with. The customer and the cleaning company can for example agree that the customer's staff should raise complaints to their own organization and not to the

cleaners directly. This can be a good strategy, but there are also benefits that the cleaners have good direct contact with the customer in the workplace.

4. Discussion

The results show that workplace threats and violence constitute a small part of the reported incidents, about 2.5 per cent of the accidents and injuries reported to the SWEA, and about 9 per cent of the work-related injuries reported to AFA Insurance. It is however reasonable to assume that there is a major underreporting of work-related threats and violence. If an incident did not result in sick leave or a permanent damage, the victim would not be eligible for compensation from AFA Insurance, and would probably not report it. Furthermore, serious threats and violence that cause physical damage or where weapons are involved are generally reported more frequently (BRÅ, 2017), as is violence that occurs between people unknown to each other. It is also largely depending on how the victim perceives the situation. In a study of work-related threats and violence against municipal inspectors, fear of retaliation was often behind a decision not to proceed and report (Horn af Rantzien, 2014).

Cleaners are affected by workplace violence in many different environments, but especially during solitary work, at night or at times where it is difficult to get assistance. Preventive measures should be directed towards minimizing the risk of cleaners being in hazardous situations and avoiding solitary work. Measures include design of work tasks and work organization, as well as design of the physical work environment, work equipment and personal alarms. Cleaners should also receive training on how to act in environments where there are many other people, such as schools, health care facilities, and public environments. An evaluation of various training measures for managing work-related threats and violence, including verbal and non-verbal techniques to calm down and cope with a threatening situations in other areas of work has shown positive effects not only for cleaners, but also increased customer satisfaction (Beech & Leather, 2006).

5. Conclusion

By organizing and planning the cleaning work in time and space, the risk that an employee happens to be in the *'wrong place at the wrong time*' can be reduced, and solitary work can be avoided as far as possible. Cleaners must have sufficient knowledge of how the cleaning work can be carried out as safely as possible and how to act when threatening or precarious situations occur. They must also be able to rely on managerial support if the cleaning work needs to be interrupted by a threatening or unpleasant situation. Suggested measures to reduce the risk include:

- Implement prevention of workplace threats and violence in the work environment management system to systematically identify and manage situations with elevated risks.
- Plan and coordinate the work with the customer or with other work tasks performed at the premises, to avoid solitary work.
- Work in particularly hazardous situations or environments need routines for keeping contact with the cleaner(s). Such a routine can be combined with an alarm or so-called man down alarm with GPS function.

- Workplace introduction with guidelines on how to perform work safely, and instructions on what to do in a threatening or unpleasant situation Training on how to act to avoid and handle threatening situations may include verbal and non-verbal techniques to calm down and cope with various situations.
- Training for managers about threats, violence and sexual harassment, to be able to identify and manage risks.
- Company routines that clearly indicate that cleaners can cancel work if the situation becomes threatening and promptly contact their supervisor.

In addition to these preventive measures, routines and measures may also be needed when something happens. Preparedness may need to include access to first aid equipment, means of transport, interpretation assistance and information about the closest relative.

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PART III

PROCEEDINGS OF NES STUDENTS PRICE

Improving the organisational and social work environment: A case study in Swedish construction industry

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Our physical, social and mental health are all important for our wellbeing and no one should feel ill or mistreated because of their work situation. Despite this, an increasing number of people are suffering from unhealthy workload or victimization at work. Mental illness is an increasing problem and cost society around 70 billion SEK each year, 50 % of which can be related to loss in production caused by sick-leave. In addition to the immeasurable human costs, Sweden now faces one of its greatest challenges in modern time. In order to counteract this development, the Swedish Work Environmental Authority released new provisions regarding the organisational and social work environment called AFS 2015:4 which are aimed at all activities where an employee perform work on the employers account. The purpose of this thesis is to contribute to the understanding of difficulties and possibilities when revising current work practices to fulfil the provisions. The thesis uses a case study approach taking place in an organisation within Svevia, a Swedish construction company, using a literature review, a document analysis, interviews and a questionnaire. The findings indicate that even though the organisation had major efforts put into their work environment management, there were improvements to be made regarding the organisational and social work environment. Furthermore, what can be improved and how the organisation can support the improvements to fulfill the provisions and work towards a better work environment is concluded. The results are of great practical use not only to the case organisation but to all organisations similar in nature.

Keywords. Organisational and social work environment, AFS 2015:4, Construction, Systematic Work Environment Management, Unhealthy Workload, Working Hours, Victimization, Leadership

Analysis of the physical load on the musculoskeletal system during industrial vacuuming

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The objective of this thesis was to examine the ergonomics of the industrial vacuum cleaners and the benefits of using a vacuum cleaner nozzle with the full-body motion analysis system. In the study, the effects of the nozzle on the spine was examined as well as the shoulder, wrist, hip and knee joint angles. Based on the results of this study, there were both advantages and disadvantages to using the nozzle. The further development of the nozzle may lighten the physical load in industrial vacuum cleaners.

Keywords: Industrial vacuum services, Joint angles, Vacuum cleaner nozzle, Motion analysis system

1. Introduction

Sickness absence is one of the most important factors which cause a lot of costs for both society and employers. Sickness absenteeism accounts for €3.4 billion a year (Rissanen & Kaseva 2014.) In the municipal sector, musculoskeletal disorders have been the main cause of a disability retirement (KT Kuntatyönantajat, 2012). A poor working posture or movement may cause an employee a musculoskeletal disease, and recovery or rehabilitation may take weeks. For example, if the average total cost of one day of absence is estimated at around €300, then a two-week absence for a company costs €3,000. By developing ergonomics, the disadvantage may not necessarily recur and the employee can continue working as usual after the sickness absence. (Launis & Lehtelä 2011.) In Finland, half of sickness absences and invalidity pensions are due to spinal disorders. By investing in good ergonomics, society can save money and health. (Mertanen 2015.)

The process of the Bachelor's thesis presented in this paper, started in spring 2016. A point of interest was utilized motion analysis system to measure movements, combined with work ergonomics. The objective of the thesis was to examine the ergonomics of the industrial vacuum cleaners and the benefits of using a vacuum cleaner nozzle during vacuuming. Lassila & Tikanoja company was our partner during the study.

Lassila & Tikanoja is a service company that cooperates with its customers to transform consumer society into an efficient recycling society. With operations in

Finland, Sweden and Russia, Lassila & Tikanoja employs 8,000 persons. (Lassila & Tikanoja 2013c.) The main services are environmental, industrial, real estate and forestry services. Lassila & Tikanoja offers process cleaning and suction services for industrial and production facilities of all sizes. Industrial vacuuming (high-power vacuum services) is one of the company's services. (Lassila & Tikanoja 2013a.)

A high vacuum cleaner is a large vacuum cleaner that uses high air volume, vacuum, and various filters and tanks (Figure 1). Vacuum cleaner hose can have a length of more than 100 metres and a diameter of over 100 millimetres. High-power vacuum cleaner is used to get rid of various wastes, for example in the industrial workplaces. The vacuum cleaner can be used to remove materials that can fit through the vacuum cleaner hose, for example, materials such as sand, insulations, wet concrete, dust, ash, sludges and wood chips. (Rakentajanetti 2016.) Lassila & Tikanoja uses a high vacuum cleaner for transferring gravel, concrete and insulations, for example. The company's high capacity air handling units are 9,000 m^3/h and the capacity of the tanks is 15 m^3. Using the middle tanks, the material can be used to vacuum hundreds of cubic metres per day. (Lassila & Tikanoja 2013b.)



Figure 1. High-power vacuum cleaner

The ergonomics of cleaners had previously been examined based on a safety and ergonomics development project, but it had not been previously examined with a full-body motion analysis system in this company. The company can take advantage of the results to develop ergonomics of employees in their company. Poor ergonomics during industrial vacuuming (see example of working postures in Figure 2) causes musculo-skeletal disorders for employees of the company. For this reason, cause sickness absences and loss of work ability which at worst may lead to early retirement. Sickness absences and early retirements will incur additional costs for the company and society (Hämäläinen, personal communication, 2016.)

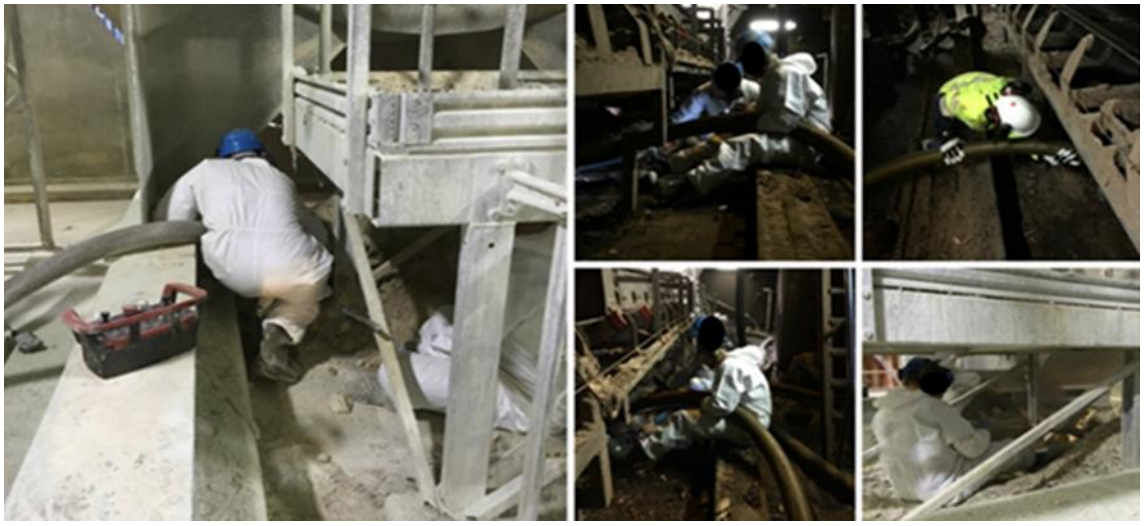


Figure 2. Postures during industrial vacuuming

2. Method

The study involved three test persons who use industrial vacuum cleaners in the company Lassila & Tikanoja in South Karelia. The three persons were chosen using a cluster sampling method. The time dimension was transverse. There were two measurements for each test subject, vacuuming with and with-out the nozzle (Figure 3) and those measurements were carried out in a simulated work environment (the measurement date that had been agreed in advance did not come up for the industrial vacuuming work orders). After the measurements, test subjects completed the questionnaire which was 5-point Likert scale.

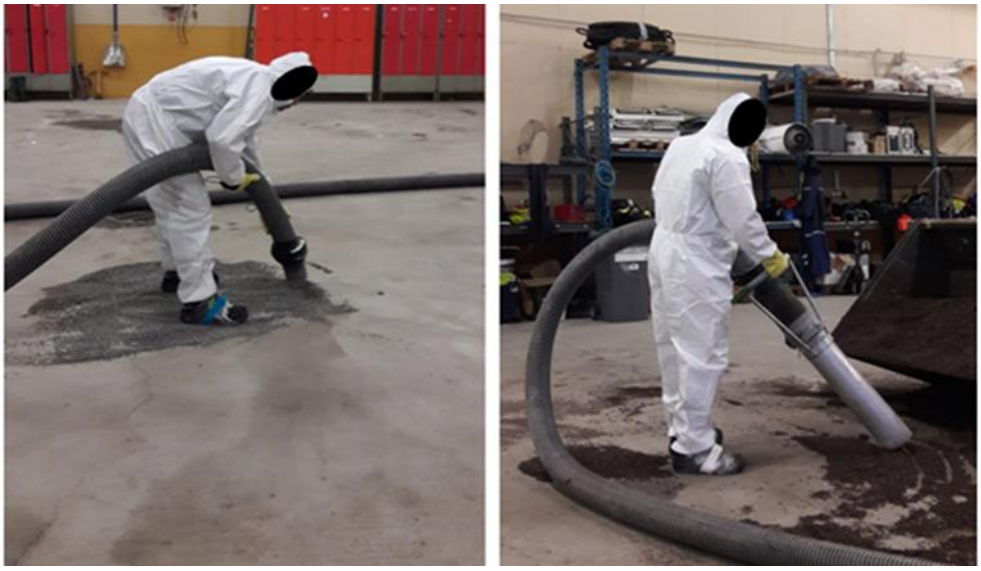


Figure 3. Vacuuming with and without the nozzle

The joint angles were measured with the full-body Xsens MVN BIOMECH motion analysis system and the effects of the nozzle on the spine was examined as well as the shoulder, wrist, hip and knee joint angles (Figure 4). In addition, the purpose

was to find out the subjective physical load experienced by test subjects using a structured questionnaire.

The use of miniature inertial sensors has become a common practice in ambulatory human movement analysis (Roetenberg 2006). Xsens MVN BIOMECH configuration is wire-less and consist of 17 motion trackers for full-body motion capture and are easy to transport. The sensors include 3D gyroscope, accelerometer and magnetometer. Inertial sensors have been successfully applied for measurements outside the lab. For this reason, it is ideal for measurements of ergonomics (Xsens 2013.) In many studies, it has been found to be a reliable measuring instrument and the results showed that this system could also detect micro and macro movements of the body. The magnetometer is sensitive to the Earth's magnetic field and for this reason magnetic disturbances may occur during the measurement (Roetenberg 2006, Wixted et al., 2010, Zhang et al., 2013, Norris et al., 2014, Muro de la Herran et al., 2014, Dinu et al., 2016).



Figure 4. Xsens full-body motion capture lycra suit equipped with sensors

The results were analyzed with quantitative and qualitative methods. The results were compared with the test results of industrial vacuuming with nozzle and without the nozzle (Figure 5). Collected data was examined and studied in a point of interest being calculated joint angle measurements. The results were transferred to average values by calculating. Average values were compared between measurements with and without nozzle.

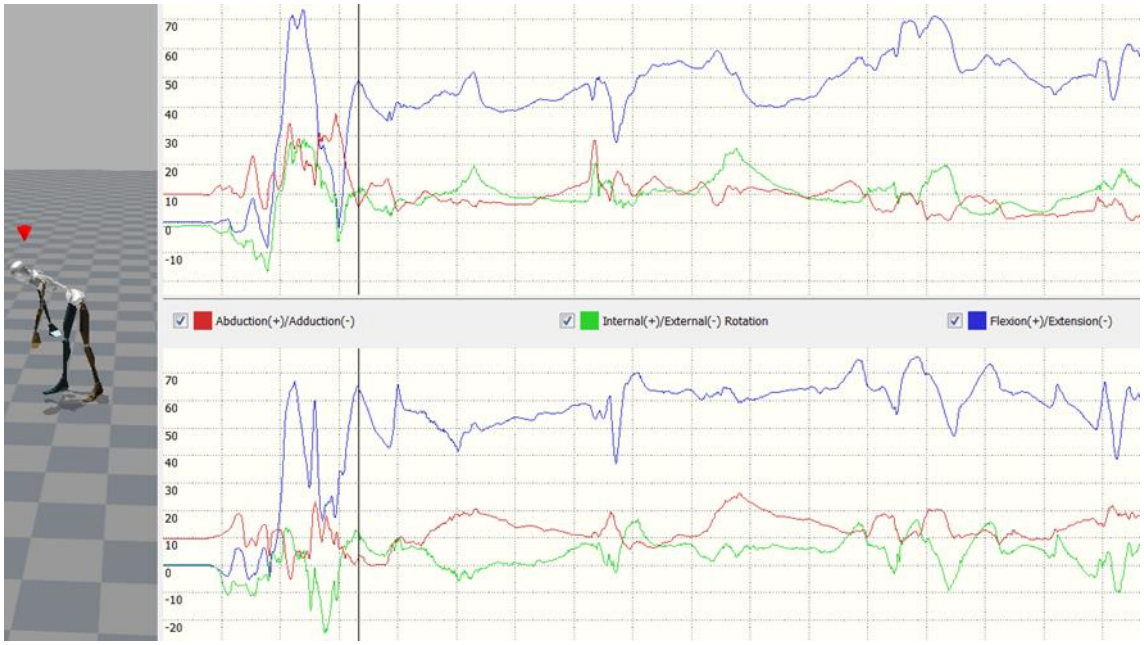


Figure 5. Example of the motion analysis data (first test subject, vacuuming without the nozzle, right (upper) and left (lower) shoulder joint)

3. Results

Based on the results of this study, using the nozzle was useful because it lightened the physical load on the lumbar spine, left shoulder, hip and knee joints, but on the cervical spine and right shoulder joint, the vacuuming with nozzle increased the physical load. The nozzle did not affect the physical load in the other joints, according due the measurements. The test subjects felt that there was no subjective advantage achieved with using the nozzle. Based on the study there were both advantages and disadvantages when using the nozzle.

4. Discussion, usefulness of the research

The work presented in this paper is work-oriented research so the company can take advantage of the results obtained by promoting ergonomics and thus affecting the physical load. Lassila & Tikanoja company has now started to use a new ergonomic working method. The early version of the vacuum cleaner nozzle which used in this study was not taken as a tool to the industrial vacuuming in this company after this study. The development of tools and nozzles continues in the company.

Due to impure work areas measurement of industrial vacuuming has been previously challenging and the most common measurements in laboratory have not been possible. The current and innovative motion analysis system allows to analysis of movements and gathering information in real working and operating environments. The measurement method provides a new information to the researchers with a new and accurate information on the physical load of the musculoskeletal system in various jobs and results are real-time used in employee ergonomic counselling and in planning work-friendly, ergonomic tools.

5. Conclusions

The research results can be considered as indicative, but the small sample size volume and industrial vacuuming in a simulated work environment cause a weakening effect on the generalizability of the results. Further development of the nozzle may lighten the physical load in industrial vacuum cleaners. The nozzle should be developed so that the neckline and wrists stay close to the center position. To the employees should be trained the ergonomic working methods vacuuming both with the nozzle and without the nozzle. Because of some cramped work environments, it is also important to know ergonomic working positions during vacuuming without the nozzle.

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