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**Office design in relation to perceived indoor climate,
communication climate, and work engagement.**

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Abstract

The purpose of this study was to examine office designs, in terms of private, shared, and open plan offices. This was done by comparing the participants reported indoor climate, communication climate, and work engagement experienced in respective office design. The study was conducted with the background of the trend to use an open plan design in office spaces. Cross-sectional data on 2322 participants, age ranging from 25 to 69 ($M = 45.8$, $SD = 11.5$), of which 76 % were female, from a previous survey investigating the work environment for members of the Swedish Psychological Association was used. Questions about indoor climate and scales measuring communication climate and work engagement were included in the questionnaire. The results indicated that indoor climate creates more annoyance for workers in open plan offices compared to private and shared offices. Communication climate is not perceived differently between open plan offices and private or shared offices, but in shared offices it is perceived as better compared to private offices. Workers' experience of work engagement is not different between office designs.

This study gives indications that negative consequences of open plan offices exist and should be taken into account when deciding on this design. These findings are of importance since indoor climate factors have been found to affect performance and well-being of workers. Shared offices offer an alternative solution that could cut costs and facilitate a better communication climate compared to private offices without creating as much annoyance with indoor climate factors as open plan offices.

Keywords: office design, open-plan office, indoor climate, communication climate, work engagement

This study focuses on office design, in terms of private, shared, open plan offices, and its facilitation of indoor climate, communication climate, and work engagement. There has been a substantial increase of white collar workers in the transition from the industrial society towards the post-industrial society. White collar work is generally defined as work performed in an office, and in 2014 it was estimated that white collar workers constituted of 57% of the Swedish workforce (Larsson, 2014).

According to Haapakangas, Helenius, Keskinen, and Hongisto (2008), there is an increasing worldwide trend to build open plan offices instead of private offices. Trend leading companies such as Apple, Google, and Facebook are all building new gigantic open plan offices (Campbell-Dollaghan, 2015). Facebook has taken a lead and constructed an open plan office of 430 000 square feet (Coffee break, 2015), which facilitates over 2800 engineers in one shared space (Kruse, 2012).

Open plan office design came about already in the beginning of the 20th century, but the concept became widespread in the 1960's with the 'burolandshaft' design originating from Germany (Sundstrom, 1986, referenced in Arbejdsmiljøinstituttet, 2006). The design aimed to organize the workplace into small groups to create a better work flow and communication among workers. However, Brennan, Chugh, and Kline, (2002) argue that the benefit of increased team work seems to have been a facade, and instead economic benefits of having an open plan office seems to have been propelling the shift to open plan office designs. The debate about open plan design has been present for some time. Hedge (1982) describes a heated debate among scholars regarding on how open plan office design affects workers' well-being and their productivity (see Boje, 1971; Sommer, 1974) in the beginning of the 1970's. In the 1980's accumulated research showed negative effects of open plan offices, e.g. loss of privacy, more disturbance, and lowered performance. Consequently, architects began to re-introduce private rooms and included them in the open plan designs (Sundstrom, 1986, referenced in Arbejdsmiljøinstituttet, 2006).

The recent movements toward open plan offices seem undeniably somewhat similar to the one that society moved away from in the 1980's (Pejtersen, Allermann, Kristensen, & Poulsen, 2006). It can be questioned if technological development has prevailed and thus enabled an open plan office environment that supports workers, or if this is a repackaging of an old concept driven again by economic incentives at the cost of workers' well-being?

The relationship between work environment and well-being

I use a conceptual model by Jaakola (1998) to understand how work environment interacts with both physical and mental well-being and the interplay between them. The model presents a conceptual framework for office environment that captures work environment in different office designs. The model builds on Karl Popper's proposal of three ontologically separate worlds. According to Popper, the first world consists of physical objects in which things follow law of nature. The second world is the internal world constituting of consciousness and mental states. The third world is the intersubjective space, which is created between people. The model postulates that the worlds can interact to affect workers in the following ways; the physical and social environment can, independently, via physiological and psychological processes cause physical and psychological effects.

The model proposed by Jaakola (1998), see figure 1, consists of two circles where the outer corresponds to the work environment and the inner reflects the individual worker. The two circles are cut across the middle making a second division of the model. The lower half of the model mirrors the physical world and the upper half mirrors the psychological world. The design of the office creates different settings for how the physical and social world affect the worker's physical and psychological state. A hypothetical example of this could be that an open plan office can create more social interaction which potentially increases communication between workers, something that can affect the psychological state of the worker. In the following sections, typology and previous research on office design, indoor climate, communication climate, and work engagement will be examined.

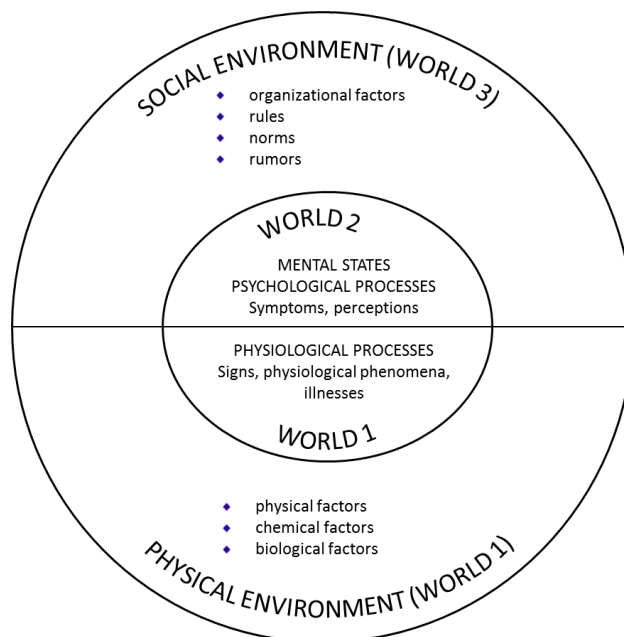


Figure 1. Office environment model (Jaakola, 1998, p. 11). This figure illustrates the three different worlds in the office environment model. Adapted from “The office environment model: a conceptual analysis of the sick building syndrome,” by J. J. Jaakkola, 1998, *Indoor Air*, 8, p.11.

Office design

There is a wide range of different types of office designs and this study will categorize by differentiation on how enclosed the work environment is towards the workers that the design provides (McCoy, 2005). Three broad categories emerge through this perspective. If the workplace office is private, shared with a few people, or if it is an open plan office shared with multiple people. The three categorizes are relevant since research points towards that the number of people that share a room seems to be a key indicator for workers’ well-being. Recently, Bodin Danielsson, Chungkham, Wulff, and Westerlund (2014) reported evidence suggesting that workers in open plan offices have higher short term sick leave rates compared to workers in private rooms. Furthermore, women have higher long term sickness leave rates in open plan offices with more than 24 people. These results clearly indicate that work environment in open plan offices today creates disturbance that affects workers negatively, which shows the importance to further explore why office design correlates with heightened rate of sick leave.

De Croon, Sluiter, Kuijer, and Frings-Dresen (2005) performed a literature review, including articles starting from 1971, of the relationship between office designs and workers’ health and performance. The authors found a strong relationship between open plan office

design and a lack of privacy and lower job satisfaction among workers. Moreover, evidence indicates that a close distance between workstations intensifies cognitive strain on the worker. Although, it cannot be taken for granted that older research on office design is still valid due to technological development, these previous findings show that open plan offices have previously been found to create a work environment that has a negative influence on workers' well-being compared to private offices.

Office design and indoor climate

Indoor climate constitutes a part of the physical environment and belongs to Popper's first ontological world presented in Jaakola's (1998) model of the office environment. Indoor climate consists of several factors such as air quality, temperature, lightning, sound, and odour. There is a growing body of research which shows that physical environment is connected to workers' well-being and performance (Vischer, 2007).

Noise has been found to be one of the indoor climate factors causing most dissatisfaction (Haapakangas et al., 2008; Pejtersen et al., 2006). Furthermore, frequency of noise disturbance is related to the number of occupants in the office room, where more occupants leads to more noise disturbance (Seddigh, Stenfors, Berntsson, Bååth, Sikström, & Westerlund, 2015). Moreover, research shows that noise disturbs and affects performance negatively (Jahncke, Hongisto, & Virjonen, 2013)

Less is known about how other indoor climate factors are affected by office design, but in a study by Pejtersen et al. (2006), it was found that perceived problems with air quality, temperature, lightning, unpleasant odour, and reflections increases when the number of occupants in the office increase. These results are problematic since it is known that indoor climate factors such as too low/high and fluctuating temperature and poor air quality have a negative effect on motivation, learning ability, well-being, and performance (Wargocki et al., 2002; Tham, 2004; Cui, Cao, Park, Ouyang, & Zhu, 2013). Hence, it is of importance to investigate if indoor climate is notably different in open plan offices compared to private and shared office since worse indoor climate causes a negative strain on workers.

Office design and communication climate

The communication climate at a workplace belongs to Popper's third ontological world in Jaakola's (1998) office environment model since it is an activity in the intersubjective space and thus reflects the social environment of the office.

Goldhaber (1993, p. 16) defines organizational communication as “the process of creating and exchanging messages within a network of interdependent relationships to cope with environmental uncertainty”. Hence, communication matters both on an organizational- and personal level and therefore affects well-being and performance (Van den Hooff & De Ridder, 2004; Street, Makoul, Arora, & Epstein, 2009). Redding, considered the father of the organizational communication research field, postulates that factors of importance for good organizational communication are not the techniques or skills of the communicator, but instead the organizational climate (cited as in Buzzanell & Stohl, 1999). Climate, in turn, is defined as feelings, emotions, and behaviours that characterize life in an organization (Ekvall, 1996). Therefore, the communication climate is an important factor to account for in different office designs.

The implementation of open plan offices is commonly associated with the idea that they will improve the communication between workers (Seddigh et al., 2015). The general idea is that shared spaces will lead to more interaction, interaction that in turn naturally creates more communication between workers. However, a review of literature on open plan offices by De Croon et al. (2005) shows that the results are inconsistent regarding if open plan offices facilitate better communication climate than private offices. Additionally, Kim and De Dear (2013) argue that the positive effect of increased accessibility of colleagues does not outweigh the negative consequences of creating a more disruptive environment by an increased frequency of interactions.

The inconsistent findings that open plan offices facilitate communication better than other office designs indicate that more research needs to be done to clarify this relationship. Clarification of the relationship between office design and communication climate is important since it is an underlying assumption, that open plan offices facilitates a better communication climate, which motivates the use of open plan offices.

Office design and work engagement

Conceptually work engagement corresponds to Popper’s second ontological world consisting of inner emotions and thoughts in Jaakola’s (1998) office environment model. Schaufeli, Salanova, González-Romá, and Bakker (2002, p.74) define work engagement as: “a positive, fulfilling, work related state of mind that is characterized by vigor, dedication, and absorption”. The positive state of mind that characterizes work engagement is believed to create positive outcomes. Research evidence supports this belief and work engagement is associated with well-being and performance (e.g., Bakker & Bal, 2010; Mache, Vitzthum,

Klapp, & Danzer, 2014; Sonnentag, Mojza, Demeouti, & Bakker, 2012). Work engagement is also important since it is considered to be a counterpole to burnout which is characterized by exhaustion and cynicism (Halbesleden, 2010).

Work engagement is traditionally not a concept that has been researched in relation to office design. One of the reasons for this is that work engagement as a concept was first introduced by Kahn (1990) in 1990 which was after the wave of research on office designs in 1970 – 1980. Hence, in the foregoing literature review to this study, no prior research was found to be conducted between the two notions.

Work engagement is viewed from the perspective of the JD-R model. Work engagement is generated from a balance between job demands and job resources (JD-R) (e.g., Xanthopoulou, Bakker, & Fischbach, 2013). Evidence from previous studies suggests that job resources have a buffering effect on job demands, which increases as demands grows and generates work engagement (Hakanen, Bakker, & Demerouti, 2005). When job resources are insufficient to buffer the negative consequences of job demands it leads to ill health, mediated via burnout (Hakanen, Bakker, & Schaufeli, 2006).

The JD-R model is a broad theory and it can be assumed that it fits all workplaces since demands and resources are present in all jobs. Job demands are factors that cause strain on individuals, these strains can be emotional, mental, and physical (Schaufeli & Bakker, 2004). Job demands become negative first when they exceed an individual's adaptive capability (Schaufeli & Bakker, 2004). Job resources are physical, psychological, social, or organizational features that work enhancing in reaching ones goals, ease job demands, and/or invigorate personal growth (Bakker & Demerouti, 2007). In the JD-R model two underlying processes are present. The first process is that job demands, created by physical and psychological strain, leads to energy loss, which potentially leads to negative health outcomes due to exhaustion. The second process is that job resources are believed to facilitate motivation both intrinsically, by stimulating personal growth, and instrumentally, by serving as tools to reach goals (Bakker & Demerouti, 2007).

The JD-R model does not differentiate between which ontological world the demands or resources derives from, instead, it focuses on the outcome that the aggregated circumstances give on the mental state. Therefore, it can be expected that different office designs will create work environments that enables different levels of demands and resources resulting in different amount of work engagement and in turn well-being.

The present study

To evaluate work environment in different types of offices Popper's three ontological worlds consisting of physical environment, social environment, and inner mental state which were presented in Jaakola's (1998) model need to be investigated.

Physical environment is measured by looking at the physical space in which the work takes place. Indoor climate such as noise, temperature, air quality, and lighting will therefore be examined. These are all factors that have been found to effect workers' well-being and performance (Rashid & Zimring, 2008; Seppänen & Fisk, 2006).

Social environment is evaluated through assessing the communication climate. Communication between individuals builds up the intersubjective space in which the social environment exists and is of importance for workers well-being and ability to be productive for the organization (Van den Hooff & De Ridder, 2004; Street et al., 2009).

The inner state of the worker is evaluated by investigating how engaged employees are in their work. Work engagement is a positive state of mind characterized by vigour, dedication, and absorption (Schaufeli et al., 2002) and a counterpole to burnout characterized by exhaustion and cynicism (Halbesleden, 2010). Work engagement can thus be seen as an indicator of the mental state of the worker, where a higher level is associated with more well-being.

The entire work environment is not claimed to be captured by the physical environment in the indoor climate factors, the social environment in communication climate and the inner world of mental states in work engagement, these three measures are merely an attempt to tap into the three separate ontological worlds presented in the guiding model, and should be seen as indicators that show a slice of reality.

Target population. Focus in this study is psychologists in Sweden, the reasons for this are threefold. Firstly, little is known about psychologists' work environment which makes it an interesting group to study. Secondly, psychologists fall into the category white collar workers. Finally, the type of work that psychologists perform can be considered to be cognitively demanding and in that aspect demands concentration from the worker, in this way work performed by psychologists' is representative for work being done in the post-industrial society.

Aim. The aim of this study is to explore the relationship between private, shared, and open plan offices and the work environment which the office designs facilitate. The study is done with a background of older research been forgotten, which indicates that, in general, open plan offices have a negative influence on workers well-being. This study will accomplish its aim by investigating the relationship between office design to indoor climate,

communication climate, and work engagement. By taking this approach this study can investigate if prior findings between office design and indoor climate hold true in a different population. Furthermore, it can add knowledge to clarify the inconsistent findings on whether open plan offices facilitate communication better than private and shared offices. This study can also shed light on the previous unexamined relationship between office design and work engagement.

Research questions. Evidence in the presented literature indicated, firstly, that indoor climate becomes more problematic for workers as office size increases. Secondly, findings are inconsistent on the relationship between office design and communication climate. Thirdly, job demand is higher in open plan offices compared to private and shared offices, and at the same time no clear evidence suggests that job resources are higher in open plan offices compared to private and shared offices. Based on these indications the following four research question were posed:

- 1. To what extent is working in private, shared, or open plan offices associated with perception of a) problems in indoor climate, b) communication climate, and c) work engagement?*
- 2. Is the indoor climate in open plan offices perceived to create more annoyance for workers compared to, firstly, private and, secondly, shared offices?*
- 3. Is the communication climate perceived differently in open plan offices compared to private and shared offices?*
- 4. Is work engagement perceived to be experienced to a lower degree in open plan offices compared to private and shared offices?*

Method

Study design and procedure

Cross-sectional data was collected to describe and explore psychologists work environment in Sweden. The data for the present study was gathered during the fall of 2014, and was part of a larger survey of psychologists' well-being and work environment in

Sweden (Schad, Nipe, & Persson, 2015). Data on self-reported perceived indoor climate, communication climate, and work engagement was analyzed in relation to which type of office design participants worked in.

A questionnaire was created and distributed via an online survey tool named 'www.Webbenkater.se'. The distribution of the survey was carried out by the administration office of the Swedish Psychologist Association to members' email addresses. Two reminder letters were sent out to members with a one week interval after the initial dispatch was made in October 2014. Upon completing the questionnaire, which was estimated to take 15 minutes, participants were thanked for their cooperation in the survey.

Ethical considerations. Participants were informed in a cover sheet before accessing the questionnaire that participation was voluntary and that they had the right to withdraw their participation at any time during the process. Furthermore, the cover sheet informed that their participation was anonymous and their responses treated in accordance to the Swedish Data Protection Act, and that the result would be used in a master thesis. The participants' have been able to contact me via an email address if questions arose regarding the survey. The study was not expected to cause any negative consequences for the participants.

Participants

The participants were psychologists that were members in the Swedish Psychologist Association. The study sample included 2322 participants and 76 % of them were female. In comparison the gender distribution within members of the Swedish Psychologist association 72% were female (M. Lenerius, the Swedish Psychologist Associations' secretary, personal communication, November 5, 2014). Participants' age ranged from 25 to 69 ($M = 45.8$, $SD = 11.5$). For further demographic description of the participants see Table 1.

Inclusion criteria to be part of the study sample was that participants spend more than 50 % of their work time at the office and that they are not undergoing practical training for psychologists.

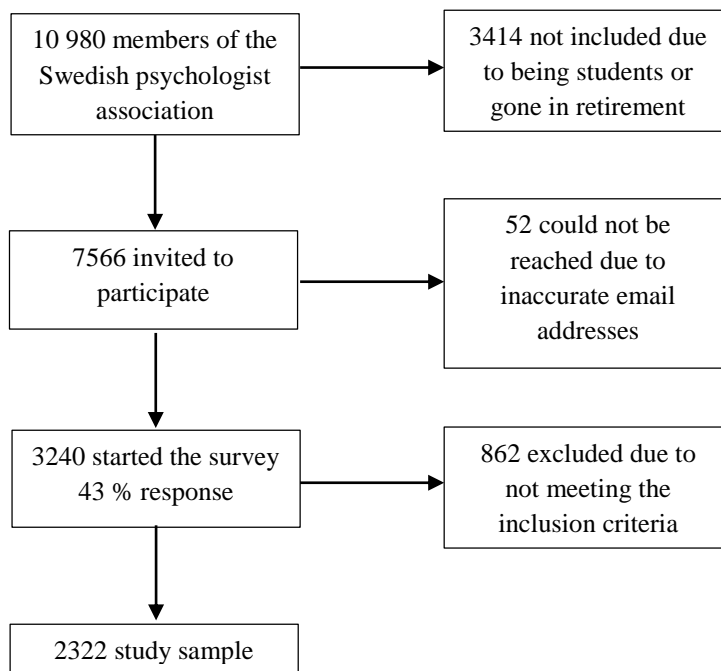


Figure 2. Participants flow chart. This illustrates response rate and loss of participants.

Measures

The questionnaire contained a total of 102 questions, which were structured as follows: demographic, work experience, employment, indoor climate, work situation, treatment from colleagues, work engagement, work role, communication climate, health, sick leave, exercise habits, work in relation to leisure time, and sleep.

Indoor climate. Indoor climate was measured with indicators from Andersson and Stridh's (1990) investigation model on buildings with disturbance in the indoor climate. The question 'Have you during the last 3 months felt uncomfortable by any of the following at your workplace?' was asked in relation 12 factors: drafts, too high room temperature, varying room temperature, too low room temperature, trapped ('bad') air, dry air, unpleasant odour, static electricity that easily gives you shocks, other people's tobacco smoke, noise or high sound levels, lightning that is too weak or blinding and/or reflecting light, dust and dirt. The question was answered on a Likert scale ranging from 1 (no, never), 2 (Yes, sometimes) 3 (yes, often). Participants also had the option of answering 'not relevant' on each question.

Communication climate. The communication climate was measured with a scale consisting of 5 items compiled from Ekvall (1990). The questions (e.g. 'on our workplace the interaction and conversations between people are open and straight forward') were answered on a 4 point Likert scale ranging from 1 (does not correspond at all) to 4 (corresponds

precisely). Participants also had the option of answering 'not relevant' on each question. The Cronbach alpha was .87.

Work engagement. The Swedish short version of the Utrecht work engagement scale (Schaufeli & Bakker, 2004) was used to measure work engagement. It consists of 9 items, grouped in 3 blocks with 3 questions in each block, reflecting 3 dimensions of work engagement: vigor, dedication, absorption. The questions (e.g. 'at my job, I feel strong and vigorous') were answered on a 7 point scale ranging from 0 (never) to 6 (daily). A factor analysis was performed on the scale, and the analysis indicated that only 1 factor was present. Work engagement will, therefore, be treated in the study as consisting of 1 factor instead of the suggested 3 factors. To treat work engagement as one dimensional was not considered a problem since the research purpose was to investigate the construct in general (Seppälä et al., 2009). The Cronbach alpha was .92.

Statistical analysis

The IBM/SPSS statistical software for social science (version 22) was used for the statistical analyses. The alpha value was generally set to 0.05 (two-tailed). Demographic data was presented by mean values, percentage shares, and standard deviation, by private, shared, and open plan offices. Pearson's Chi-square test was used to identify significant differences in distribution of various characteristics among groups.

Pearson's Chi-square test was used to assess differences between office designs on reported problems in the indoor climate. Number and percentage of participants in private, shared, and open plan offices were presented. Two sided Z-test of equality for column proportions was used to compare the difference between groups.

Mean scores for private, shared, and open plan offices on communication climate and work engagement were examined for differences using unadjusted univariate analysis of variance (ANOVA). The demographic data showed an uneven distribution of office design across main employer (see table 1). The uneven distribution of office design across main employer was adjusted for in two separate univariate ANOVA. However, since the adjustment for main employer merely generated marginal differences, only the unadjusted mean scores were presented. The data was tested for the assumptions necessary for an ANOVA to be consistent, these are, homogeneity of variance and normal distribution. The data was found to not violate the homogeneity of variance assumption and to be in proximity of normal distribution. Additionally, no outliers were found.

Results

Descriptive demographic characteristics

In table 1, distributions of various characteristics across office design are shown. A significantly uneven distribution can be seen depending on what type of business participants work in and what type of office they occupy. Gender and manager did not show any significant relationship to office design. Moreover, for years at current employer, employment form and percent of working time at main employer, some of the groups had too few participants which made it unsuitable to analyse these variables with the Chi-square test for independence.

Table 1. Distribution of demographic characteristics across office design

| Demographic Variables | Categories | Office design | | | | | | Chi-square test <i>P</i> Value |
|--|----------------|---------------|------|--------|------|-----------|------|--------------------------------|
| | | Private | | Shared | | Open plan | | |
| | | N | % | N | % | N | % | |
| Gender | Men | 454 | 23.4 | 57 | 28.2 | 43 | 29.3 | .11 |
| | Women | 1486 | 76.6 | 145 | 71.8 | 104 | 70.7 | |
| Manager | Yes | 160 | 8.2 | 17 | 8.4 | 13 | 8.8 | .97 |
| | No | 1780 | 91.8 | 185 | 91.6 | 134 | 91.2 | |
| Years at current employer | 0-1 | 451 | 23.2 | 63 | 31.2 | 26 | 23.6 | <i>P</i> <.001 |
| | 2-5 | 751 | 38.7 | 75 | 37.1 | 67 | 39.0 | |
| | 6-10 | 354 | 18.2 | 29 | 14.4 | 17 | 17.5 | |
| | 11-20 | 248 | 12.8 | 26 | 12.9 | 22 | 12.9 | |
| | 21-30 | 102 | 5.3 | 8 | 4.0 | 15 | 5.5 | |
| | >31 | 34 | 1.8 | 1 | 0.5 | 0 | 1.5 | |
| Percent working time at current main employer | <25% | 3 | 0.2 | 1 | 0.5 | 1 | 0.7 | .30 |
| | 26-50% | 48 | 2.5 | 10 | 5.0 | 1 | 0.7 | |
| | 51-70% | 72 | 3.7 | 6 | 3.0 | 5 | 3.4 | |
| | 71-90% | 448 | 23.3 | 46 | 22.9 | 34 | 23.1 | |
| | 91-100% | 1923 | 70.3 | 138 | 68.7 | 106 | 73.1 | |
| In what type of business do you have your main employment? | Private | 265 | 14.4 | 20 | 10.4 | 29 | 20.4 | <i>P</i> <.001 |
| | Municipal | 149 | 8.1 | 31 | 16.1 | 7 | 4.9 | |
| | County council | 1249 | 67.8 | 98 | 50.8 | 36 | 25.4 | |
| | Government | 180 | 9.8 | 44 | 22.8 | 70 | 49.3 | |
| Form of employment | Permanent | 1734 | 89.4 | 166 | 82.2 | 135 | 91.8 | <i>P</i> <.01 |
| | Temporary | 108 | 5.6 | 28 | 13.9 | 8 | 5.4 | |
| | Hourly | 6 | 0.3 | 1 | 0.5 | 0 | 0.0 | |
| | Probationary | 31 | 1.6 | 2 | 1.0 | 0 | 0.0 | |
| | Different | 61 | 3.1 | 5 | 0.2 | 4 | 2.7 | |
| Age (years) | | Mean | SD | Mean | SD | Mean | SD | |
| | | 46.0 | 11.5 | 44.0 | 10.9 | 45.8 | 11.2 | |

Note. The variation in sample size is due to different number of participants completing the specific part in the survey. Pearson Chi-square test was used to evaluate the difference between groups.

Indoor climate

In order to investigate the association between private, shared, and open plan offices with experienced annoyance with indoor climate chi square test for independence and two sided test of equality for column proportions was performed. Table 3 shows that, there are, generally, an association between prevalence of indoor climate problems and the type of office participants' occupy. Specifically, Chi-square test for independence indicated significantly different associations between private, shared, and open plan offices and reported problems with drafts, varying room temperature, too low room temperature, trapped (bad) air, dry air, noise or high sound levels, and lighting that is too weak or blinding and/or reflections. For the two factors, problems reported with static electricity that easily gives you shocks and other people's tobacco smoke, there were not enough participants in three of the groups to be suitable for a Chi-square test for independence.

The two sided test of equality for column proportions, generally, shows significant differences between participants in open plan offices answering 'yes, often' to the question if they feel uncomfortable by the indoor climate in comparison to participants in private offices. Furthermore, fewer differences are found between private and shared offices, respective, shared and open plan offices.

Table 2. Distribution of reported problems with indoor climate across office design

| | Answer: | Office type | | | | | | Chi-square test P Value |
|---|----------------|-------------------|------|----------------------|-----|----------------------|-----|-------------------------|
| | | Private | | Shared | | open plan | | |
| | | % | N | % | N | % | N | |
| Drafts | Yes, often | 5.9 _a | 113 | 6.0 _{a, b} | 12 | 11.0 _b | 16 | .02 |
| | Yes, sometimes | 21.8 _a | 418 | 20.5 _a | 41 | 28.8 _a | 42 | |
| | No | 72.3 _a | 1384 | 73.5 _a | 147 | 60.3 _b | 88 | |
| To high room temperature | Yes, often | 9.1 | 176 | 11.1 | 22 | 12.9 | 19 | .59 |
| | Yes, sometimes | 34.2 | 659 | 38.2 | 76 | 41.5 | 61 | |
| | No | 56.6 | 1090 | 50.5 | 101 | 45.6 | 67 | |
| Varying room temperature | Yes, often | 14.4 _a | 274 | 18.5 _a | 37 | 29.9 _b | 43 | <i>P</i> > .001 |
| | Yes, sometimes | 44.1 _a | 839 | 43.5 _a | 87 | 43.8 _a | 63 | |
| | No | 41.5 _a | 791 | 38 _a | 76 | 26.4 _b | 38 | |
| Too low room Temperature | Yes, often | 23.2 _a | 447 | 19 _a | 38 | 32.7 _b | 48 | .03 |
| | Yes, sometimes | 41.5 _a | 799 | 47.5 _a | 95 | 39.0 _a | 58 | |
| | No | 35.3 _a | 679 | 33.5 _a | 67 | 27.9 _a | 41 | |
| Trapped (Bad) air | Yes, often | 28.5 _a | 550 | 36.1 _b | 73 | 36.1 _{a, b} | 53 | .01 |
| | Yes, sometimes | 40.4 _a | 779 | 30.7 _b | 62 | 40.8 _{a, b} | 60 | |
| | No | 31.1 _a | 599 | 33.2 _a | 67 | 23.1 _b | 34 | |
| Dry air | Yes, often | 21.4 _a | 408 | 21.6 _a | 43 | 34.5 _b | 50 | .01 |
| | Yes, sometimes | 32.3 _a | 616 | 28.1 _a | 56 | 24.8 _a | 36 | |
| | No | 46.3 _a | 883 | 50.3 _a | 100 | 40.7 _a | 59 | |
| Unpleasant odor | Yes, often | 6.6 | 126 | 9.0 | 18 | 6.9 | 10 | .06 |
| | Yes, sometimes | 25.5 | 490 | 23.5 | 47 | 35.2 | 51 | |
| | No | 67.9 | 1303 | 67.5 | 135 | 57.9 | 84 | |
| Static electricity that easily gives you shocks | Yes, often | 0.8 | 15 | 1.0 | 2 | 2.1 | 3 | .40 |
| | Yes, sometimes | 6.7 | 129 | 6.0 | 12 | 9.0 | 13 | |
| | No | 92.5 | 1779 | 93.0 | 186 | 88.9 | 128 | |
| Other people's tobacco smoke | Yes, often | 1.4 | 27 | 2.0 | 4 | 0.7 | 1 | .21 |
| | Yes, sometimes | 9.0 | 173 | 7.0 | 14 | 13.8 | 20 | |
| | No | 89.6 | 1719 | 91.0 | 183 | 85.5 | 124 | |
| Noise or high sound levels | Yes, often | 10.8 _a | 209 | 15.8 _b | 32 | 33.8 _c | 49 | <i>P</i> > .001 |
| | Yes, sometimes | 37.9 _a | 731 | 36.1 _a | 73 | 40.7 _a | 59 | |
| | No | 51.3 _a | 991 | 48.0 _a | 97 | 25.5 _b | 37 | |
| Lighting that is to weak or blinding and/or reflections | Yes, often | 9.5 _a | 183 | 9.0 _a | 18 | 17.7 _b | 26 | <i>P</i> > .001 |
| | Yes, sometimes | 25.6 _a | 494 | 30.8 _{a, b} | 62 | 34.7 _b | 51 | |
| | No | 64.9 _a | 1250 | 60.2 _{a, b} | 121 | 47.6 _b | 70 | |
| Dust and dirt | Yes, often | 8.3 | 159 | 6.5 | 13 | 14.3 | 21 | .09 |
| | Yes, sometimes | 31.8 | 612 | 30.8 | 62 | 27.9 | 41 | |
| | No | 59.9 | 1154 | 62.7 | 126 | 57.8 | 85 | |

Note. The variation in sample size is due to different number of participants completing the specific part in the survey. Values in the same row that do not share the same subscript number, are different at $p < .05$.

Communication climate

A univariate ANOVA was performed to compare experience of communication climate in private, shared, and open plan offices. Office type was the independent variable, and communication climate the dependent variable. Table 4 shows that a significant difference was found between office designs and communication climate. A post hoc test,

with Bonferroni correction, showed that the difference found was between the groups private and shared offices, $P = .006$. No significant differences were found between open plan office and private or shared offices.

Work engagement

A univariate ANOVA was performed to compare experience of work engagement in private, shared, and open plan offices. Office type was the independent variable, and work engagement the dependent variable. Table 4 shows that no significant differences were found between private, shared, and open plan offices on work engagement.

Table 4. Means score analysed with univariate ANOVA

| Variables | Office design | | | | | | Univariate Anova | | | |
|-----------------------|---|------|--|------|---|------|------------------|------|---------|------------------|
| | Private (n=1724 _a , 1869 _b) | | Shared (n=183 _a , 195 _b) | | Open plan (n=137 _a , 142 _b) | | df | F | P value | Partial η^2 |
| | M | SD | M | SD | M | SD | | | | |
| Communication climate | 2.61* | .63 | 2.76* | .61 | 2.63 | .62 | 2 | 5.03 | .01 | .01 |
| Work engagement | 3.96 | 1.23 | 3.87 | 1.33 | 3.76 | 1.23 | 2 | 1.95 | .14 | .00 |

Note. The variation in sample size is due to different number of participants completing the specific part in the survey. _a = Number of participants in univariate Anova with communication climate as dependent variable. _b = Number of participants in univariate Anova with work engagement as dependent variable. M = Mean. SD = Standard deviation. *post hoc t-test $P < 0.01$.

Discussion

The purpose of this study was to investigate the relationship between private, shared, open plan offices and the work environment which the office design facilitates. The main findings were the following: indoor climate creates more annoyance for workers in open plan offices especially in comparison to workers in private office, but also to workers in shared offices. The communication climate is not perceived differently in open plan offices compared to private and shared offices, but workers in shared offices perceive their communication climate as better compared to workers in private offices. Work engagement is not perceived to be experienced as worse in open plan offices compared to private and shared offices.

The first research question was aimed towards describing to what extent participants in private, shared, and open plan offices are associated with perception of a) problems in indoor climate, b) communication climate, and c) work engagement. The results showed that

a larger proportion of participants in open plan offices compared to private and shared offices report problems with factors that constitute the indoor climate. That workers in open plan offices report that they experience problems with indoor climate more often indicates that indoor climate is overall worse in open plan offices compared to private and shared offices.

The mean value on communication climate for participants was almost the same for those in private and open plan offices but slightly higher for those in shared offices.

There was a small not statistically significant difference in mean value for work engagement, ranging from higher to lower in private (3.96), to shared (3.87) and to open plan offices (3.76), with value 4 corresponding to the answer 'once a week'. These results can be put in comparison to the norm data from the UWES manual (Schaufeli & Bakker, 2004) which has a mean score of 3.74, and an average score is considered to be 2.89 – 4.66. The central tendency is higher for participants in this study in each office design compared to the norm data, however, still in the range of an average score.

Office design and indoor climate

The results show in general an association between indoor climate factors and office design, where the experience of feeling uncomfortable from the indoor climate depends on the type of office one works in. Specifically, participants in open plan offices significantly report "yes, often" more frequent than those in private offices, to the question concerning feeling uncomfortable due to indoor climate factors. Fewer differences on experience of indoor climate are found in comparison to shared offices. This can be expected since the contrast is likely to be smaller compared to both private and open plan offices with regards to size of the office and number of occupants.

Workers experience more annoyance with noise or high sound levels, air quality, temperature, dust and dirt, as well as lighting in open plan offices. This suggests that there are more problems with disturbances in open plan offices compared to private and shared offices. These results fit with the pattern of results reported by Pejtersen et al. (2006). The study by Pejtersen and colleagues is the only one to have investigated a broader spectrum of indoor climate factors in relation to office design.

Previous work, examined in the introduction, has revealed that small differences in the indoor climate effect workers' well-being and performance. With regards to these findings, it can be expected that the indoor climate in open plan offices has a more negative impact on workers compared to private and shared offices. The implications of these findings are that there are some clear disadvantages in terms of indoor climate for workers who work

in open plan offices compared to private and shared offices, something that is of interest for both the worker and the employer. The results from this study are potentially pieces in the puzzle that can explain why workers have higher short term sick leave rates and women have higher long term sick leave rates in open plan offices (Bodin et al., 2014).

If economic incentives drive the trend of moving to open plan offices, an alternative is to consider shared offices instead. The results from this study indicate that shared offices have a less uncomfortable indoor climate compared to open plan offices and are only slightly more problematic than private offices. Shared offices with few people can be expected to still cut costs for employers compared to private offices, without providing a worse indoor climate that risks affecting the well-being and performance of workers.

Office design and communication climate

The results regarding communication climate show that there is a significant difference between private and shared offices, but there is no significant difference in communication climate between open plan offices and private and shared offices. The small effect size, partial $\eta^2 = .01$, indicates that even if communication climate is significantly better in shared versus private offices the impact is small. While non-significant results are no proof that there are no differences between open plan offices compared to private and shared offices on communication climate, these findings add to previous research and can be regarded as more evidence that supports the case that communication climate does not improve in open plan offices.

It can be the case that the number of interactions are larger for workers in open plan offices compared to private offices. However, the number of interactions does not indicate anything about the meaning of an interaction. Technological advancement may also have made it easier for non-physical interaction and reduced the need for physical proximity to have smooth communication. However, communication climate, which is measured in this study, is a measure of the feelings, emotions, and behaviours that characterize the exchange of messages between workers that occurs to cope with uncertainties. It is therefore of importance on a personal and organizational level to have a good communication climate since it fosters trust, commitment, and knowledge sharing between workers (Van den hof & De Ridder, 2004; Street et al., 2009).

The implications of these results are that a better communication climate cannot be expected in open plan offices compared to private and shared offices. Although, there may be

several reasons for changing office design from private or shared to open plan, it should not be made on the expectations to improve the communication climate, even though it is an argument commonly associated with open plan offices (Seddigh et al., 2015). Since the idea that open plan offices facilitate a better communication climate can be expected to play a role in the trend of moving to open plan offices, it is of importance to clarify that the idea yields no support in this study.

Office design and work engagement

There are no statistically significant differences in the association between any of the office designs with regards to experience of work engagement. On the other hand, the mean values are in the expected direction, which means a larger mean score in private offices and a smaller in open plan offices. Furthermore, it cannot be excluded that a larger difference may have been found between the office designs on work engagement, with a larger sample of participants in open plan offices and raising the cut-off point for the selection criteria closer to 100% at time spent at the office. Thereby, observing a more homogenous group with less noise.

The research question, that work engagement will be experienced to a lower degree in open plan offices compared to private and shared offices was made on the assumption that more disturbances in the work environment drains job resources, but does not increase job demands. However, a possible explanation as to why no difference were found in work engagement between different office designs could be that the differences between office designs on work engagement are small due to nature of the buffering effect of job resources on job demands. Implicating that if job demands increase in open plan offices but workers have sufficient with resources to handle it, work engagement is generated. This highlights the problems with a theory like the JD-R model since all variables can be assumed to be demands or resources at different time points, e.g. the effect of a worsened indoor climate on work engagement could drain job resources or increase job demands or both, making it hard to create predictions based on the theory. Even though the JD-R model provides a helpful conceptual framework it is desirable that future research aims to specify under what circumstance variables are job demands and job resources.

In light of the trend of offices with an open plan design becoming more popular, it must be considered a positive result that no significant difference was found between private, shared, and open plan offices on the experience of work engagement. This since the results can be interpreted as indicating that workers' well-being and performance are not affected

negatively by working in open plan offices from the aspect of workers feeling less work engagement.

Office design and work environment

The shift in society from open plan offices in the 1980's (Sundstrom, 1986, referenced in Arbejdsmiljøinstituttet, 2006), that came out of accumulated research pointing towards a bad work environment in open plan offices, may not necessarily repeat itself. The contemporary open plan office draws on technological development, such as laptops, mobile phones, and headphone equipment that make people flexible to create a good work environment. The office design often includes some smaller enclosed rooms where workers can go and work if they need some privacy (Arbetsmiljöverket, 2015). Technological devices make it possible, for example, to take a laptop and go into a smaller room to be alone, to leave the desk to make a call if privacy is needed, or to create your own sound room via a pair of headphones to shut out disturbing noise. It can be expected that technological development has brought with it a new work pattern, but how this affects workers is not easy to evaluate.

Strengths and Limitations

Both strengths and limitations are present in this study. The large dataset that is used and that it is composed by a relative homogenous group of white collar workers are strengths which make it possible to interpret the results with more accuracy.

It is not possible to infer causality from cross-sectional data, yet the design of this study draws on the advantage that type of office is exogenously since it is a physical factor. It is unlikely that the perception of indoor climate, communication climate, and work engagement affect what type of office one works in. Although, one cannot be sure that office design does not correlate with another variable that affect indoor climate, communication climate, and work engagement. However, it is of course not the office design in itself that is assumed to cause the effect but rather the environment it facilitates.

Who responded to the online questionnaire is a factor that could not be controlled, which carries the risk that certain groups did or did not respond, considering the response rate of 43%. Possibly, some participants in the sample with certain characteristics are more prone to answer e-mails from the Swedish psychologist association, such as; those experiencing some sort of problems could be more prone to answer the questionnaire. Another issue is, how the questionnaire is interpreted, conducted, and with what accuracy data is reported by

the one who choose to participate. These factors are something that has to be taken into account when interpreting the results.

The study's respondents also affect who the results of the study are generalizable to. The demographic variables reveal that a vast majority of the participants are employed in the public sector, and, specifically by the county council, hence, the results becomes weighted more to represent their experience. Psychologists can be expected to perform cognitive demanding work that demand high level of concentration and it can be expected that the results from this study are generalizable foremost to similar groups in the public sector and secondarily towards workers in the private sector. Although, psychologists can be labelled as white collar workers, it can be questioned how homogenous the group of white collar workers is. For many psychologists one differentiating characteristic from other white collar worker is that a natural part of their work is treatment of patients, which is an activity that is not suitable to perform in open plan offices. Therefore, psychologists may spend less time at the office than other groups.

For the purpose of this study an inclusion criteria to participate is that one had to spend more than 50 % of their working time at the office. It is considered important that participants' actually spent time at their office to be able to detect a relationship between office design and other factors. The 50% cut-off point is made to have a balance between a large enough sample and to be sure that participants actually spend time at the office. It is a limitation that the sample did not consist of participants that spent closer to 100% of their working time at the office since this could have generated clearer results of the relationship between office design and other factors. However, on the other hand a cut-off point where the participants spent 50% of their working time at the office potentially enables the inclusion of workers who to some extent experience discomfort by the office environment and avoids it.

Limitations and potential confounds are also connected to how office design is measured in this study. No specific number of people in an office is used as criteria for what type of office the participants should self-report. This leaves room for different interpretations, especially with regards to if participants work in shared or open plan offices. The results would have been clarified if boundaries had been set by defining office design by providing a range of number of workers that occupy the same office. However, there is no convention for how many workers that make it a shared office respective an open plan office, this makes it problematic to provide such a range without risking forcing participants into a category that does not reflect their reality.

Future research

The evidence from this study and previous research support that there are differences in work environment in private, shared, and open plan offices but the antecedents are not clearly mapped out. Seeing that experiences of many indoor climate factors are associated with differences in office design makes the subject important, and to understand why this is the case. A first step to attain more knowledge on this phenomenon could be to visit office buildings and with the help of instruments measure, e.g. the acoustics and sources of disturbances in offices, and from that basis try to create practical interventions to improve the indoor climate (see e.g., Persson, Kristiansen, Lund, Shibuya, & Nielsen, 2013). Furthermore, it becomes important to inform relevant stakeholders about these findings since the practical interventions are somewhat outside the scope of psychological research and more towards civil engineering. Finally, it is of interest with regards to the difference found in private, shared, and open plan offices on indoor climate to investigate the effect of these factors on physiological aspects on the worker, e.g. prevalence of headache, to further understand the impact of indoor climate on workers' well-being.

Furthermore, it is of interest to measure indoor climate in relation to short and long sick leave rates, since Bodin et al., (2014) found higher frequency of short term sick leave rates in open plan offices compared to private offices. It would also be valuable to investigate differences in office designs from an epidemiological perspective, e.g. less enclosed office environment allows for airborne viruses to spread more easily among workers.

Since this is the first study to my knowledge on the relationship between private, shared, and open plan offices on work engagement, it is important to see if the results hold true for other groups. It could be, as discussed above, that the work psychologists do differs in comparison to work by other groups in a way that affects the relationship between office design and work engagement.

Conclusion

The implications of the ongoing global trend of moving to open plan offices are complex to comprehend, but this study gives indications that negative consequences of open plan offices exist and should be taken into account when deciding on this design. The results from this study show that, feeling uncomfortable by factors in the indoor climate is associated with working in private, shared, or open plan offices. Generally the indoor climate creates more annoyance in open plan compared to private offices and to a less extent shared offices. Furthermore, the results indicate that there is no difference in how the communication climate

is perceived in private and open plan offices, but a slightly better communication climate is found in shared compared to private offices. Finally, no difference is found between how workers in private, shared, and open plan offices experience work engagement.

These findings are of importance since indoor climate factors have been found to affect performance and well-being of workers. It is also important to clarify the relationship between the design of offices and communication climate since it is used as an argument that communication will improve in open plan offices, and therefore, in this way play a role as an argument in the trend of moving to open plan offices. Work engagement, reflecting the inner mental state of workers, showed no difference between the office designs indicating that the real impact of differences in work environment on workers may be small.

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