



Thinking with a tool

– What age and technology use reveals about cognition.

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Abstract

Technology is often used as a method in memory intervention but there is a gap between what we know about memory processes and the interaction with technology tools (Topo, 2009; Dascal & Dror, 2005; Hjärmedelsinstitutet, 2011). This study aims to investigate how human use our memory in a real world setting and how we value a technological memory tool developed to support mild memory decline. It is measured by a semi structured interview and user evaluation questionnaires of a technological memory aid. The opinions of two groups, one with elderly and one with young participants with a total of N=20 individuals were collected and compared to each other. The result indicates that individuals are different depending on experience and culture so that one assistive technology does not fit a whole target group. Another result also seen in the study is that internal and external memory strategies seem to be intrinsically interconnected with each other. Earlier studies show a gap in the research between how human memory processes works and how the design of technological products is outlined. Activity theory is suggested as a preferable framework for the study of human cognitive processes such as memory.

1.1 Introduction

The distribution of the study will be as follow: Background and related studies are presented. Then follow a short description of the research centre where the study took place and the prototype of a technological tool, which was used as a base for the data collection. After are method and material used in the study described, concluding with the presentation of results and discussion of the results.

1.2 Elderly

Elders are the fastest growing demographic group in many developed countries right now and the group is expected to increase in an even higher speed in the future. In both absolute and relative terms this means that there will be more elderly people within our society in a close future. The development is a consequence of different factors such as advances in health care, safety, nutrition etc combined with a drop in birth rates. The extension of life expectancy is considered both a problem and a blessing and the rapidly growing elderly population will have mayor impacts from the perspective of society and the quality of life of the elderly. One of the impacts on society is that people both live longer as at the same time there are fewer family carers and a smaller productive workforce to contribute to the financing of the new circumstances. The new demand will affect the society not only with new structural changes in the system and organisation, but also in the aspect of how to finance the care and maintenance of the quality of life of the many elderly (Emerging Trends in Socio-economic Sciences and Humanities in Europe retrieved 4/4 2011).

Age is often, for natural reasons, associated with increased dependency and need of care, both physical and mental. With

aging comes a risk of a decline of the cognitive abilities and dementia. The most common first sign is usually a mild cognitive decline. This generally includes slower information processing and/or mild memory problems which can show as for example an increased frequency of the sensation of having a word on the tip of the tongue and not be able to retrieve it, the need of longer time to associate a familiar face with the correspondent name, frequent looking for things that you forgot where they were put, or the general speed of retrieving memories. Studies reports different results depending of which assessment protocols used and population studied, but the estimations all show results in the same direction – up to 50 % of elderly people over 85 years have a measurable decline in cognitive functions (Jimison, Jessey, McKanna, Zitzelberger & Kayelders, 2006; Topo, 2009). This age group requires assistive living in many cases and a major goal of seniors, their families and of society in general, is of course to maintain our elderly fit, both physically and mentally, with the benefits of optimizing their autonomy and quality of life, and reducing unnecessary health costs.

There is not yet a way to totally prevent cognitive decline but there are ways to delay symptoms or reduce them once they appear. In some cases it is possible to compensate and support for example memory, in order to be able to function in a good way within everyday life activities. This can be done with help of different internal techniques and strategies, with the use of external aids, or a combination of both.

1.3 Cognitive technology

Many older people remain physical and mentally active and can with small interventions continue to live at home, without being institutionalized. In general elderly people tend to use more external aids than younger since assistive aids is one way to compensate for age related cognitive decline (Schmidt et al. 2001). It is then very important that the aids are adjusted to the target group in the best way possible.

The history of human beings has always been accompanied by technological advances. The first simple tools were created by our ancestors many many years ago and the last decades the technology development has proceeded in a very high speed. Such advances have been dramatic in that the new technologies have quickly been integrated to become a natural part of activities in the daily life of ordinary people (Dascal & Dror, 2005). How this accelerated progress of technology would come to affect us was predicted mainly with the conclusion that they would take over the human activities. This focus was of how the external consequences would come to affect us, but more recent research investigates how the technological development brings a lot of change in quality of life and the way we actually live our lives. Since the way we live change with technology, our cognitive competencies are also affected, developed and changed. The aids are assisting humans in their task, but the contribution of technology has come to actually taking part in human activities themselves. New, more powerful capacities arise in the meeting between the human and technological tool so the evolution is actually impacted of technology as a contextual drive (Dascal & Dror,

2005). As a result of the improved quality of life that technology brings with it, the human life is eventually changing in its very scope and nature. If the human capacities are evolved in interplay with technology, it is then necessary to include these tools as part of the analysis while studying the human mind. An example is how the education and learning in schools has changed from being a place where you were taught facts, to the more recent education on how to search for and retrieve relevant information. The innovations in technology has not replaced human labor as first predicted, but have certainly introduced deep changes in its environment and caused a move from external effects to internal implications. Another example could be how the mobile phone has changed our lifestyles to become more flexible and has resulted in a state of always being available, with the implications that come with it. An additional effect the introduction of mobile phones has had on the human cognitive processes, is that virtually no one remembers any telephone number anymore, but we do know how to look for them in the agenda of the phone. The outcome of the goal, calling, is still unchanged while requiring a different activity from the individual to reach it.

Cognitive technology, since created for and used by humans “for the achievement of cognitive aims, including either cognitive states or cognitive processes that lead to such states or help significantly to reach them” (Dascal & Dror, 2005 p.4). It can help us to cope with a vast amount of data which helps us to reach the final goal as in the example of making a phone call above. Since the technology cognizes with us and for us, it is also included in our cognitive processes in certain ways. The influence and impact the technology has on human thinking affect the very nature of cognition and are becoming constitutive roles themselves (Dror & Harnard, 2005).

1.4 A need for more research, it is complicated

In the course of an individual's life the cognition itself changes. Age and/or impairment are factors that can change both cognitive and behavioral resources and how they are used. Cognitive processing capacity, cognitive speed and a variety of compensation mechanisms are things that may be affected. Cognitive technology is then filling gaps within intervention but has often shown to be harder to fulfill its purpose than it was thought from the beginning. The access to high technological solutions is not always enough to develop well adjusted technological aids for the end users.

In a literature review of people with dementia and their caregivers, Topo (2009), describe the need for further research on technology aimed for elderly with mild cognitive decline. First of all, most of the research is biased toward the residential care setting and also toward moderate to severe stages of dementia. If most studies are conducted on elderly who are already institutionalized and in a far stage of dementia, the question is how we could provide good design on assistive technology? Without knowing how people's cognitive system work when healthy it might be hard to come up with a good match. In the same review Topo, 2009 also discovered contradictory needs associated with technology

use. Individuals suffering poor memory were often considered a need of external aids, but in the end the users did not use the technological aid prescribed. The same review showed studies with results indicating that people with cognitive decline use information and communication technologies (ITC) for communication or recreation together with caregivers, but a very limited number of studies was found where people actually use technology by themselves. According to the review there seem to be a significant gap between the intention of memory aids and technological products available, and the actual use of them (Topo, 2009).

The reasons of the perceived gap between users and technology could be a result of many different things. There could be a miss-match between technology-user, or it could be due to bad design and poor usability of the device. When the time is optimal to introduce technology and who can actually benefit from it is another problem that cognitive technology as memory aids confronts. Since cognitive decline is progressive an aid that was a useful tool for an elderly one day might not be useful a few months later. There are also in general difficulties in motivating people living at home to participate in studies where assistive technology is introduced and elderly might have preferable individual ways to handle their situation and using own developed strategies while in their own setting, which could be reasons to the gap in the research field between user and technology.

The institute of “helping aids” in Sweden, “Hjälpmiddelsinstitutet” (HI) report that users suffering cognitive problem has been put aside in the development of technology support compared to other disability groups. According to the institute the combination of technology and people with dementia is a so far uninvestigated area and there is a need of further investigation whether people, with the specific and complex difficulties that come with age and dementia, will get any help from daily and future technology (Hjälpmiddelsinstitutet, 2011).

1.5 Integration of cognitive processes and technology

To be able to design and develop useful and functional cognitive technology it is important to integrate what we really know about cognitive processes and the cognitive technology itself. The literature describes a lack of this integration and as a result the design and development is often off the mark regarding what a certain cognitive technology must fulfill in order to either replace, or interact with a given human task (Topo, 2009; Hjälpmiddelsinstitutet 2011; Dascal & Dror, 2005). When external cognitive technology or tools as the pen, the car, the mobile phone or a cane of a blind man are integrated parts and equipment of the individual, through which they think and act, we see examples of successful solutions. It is important to not just see these external artifacts as part of the environment but as an integrated part of us. On the other hand the lack of integration between cognitive processes and tools often leads to mismatches and setbacks. It can even lead to a cut off in the search for relevant and appropriate cognitive tools. If a tool is new or ill-matched it is not accepted by the individual in the same way and will

probably be rejected as not useful, in this case not becoming a part of the integration between user and environment. Clark, (2002 p.14), writes: *“the user, on this view, is not any old bag of tools but whatever bag of tools functions, at a given moment, as transparent equipment for thought and action”*.

Both strengths and weaknesses must be considered and taking advantage of in both cognitive technology and human cognition to be able to overcome the problem. Dascal & Dror, (2005) suggest an interactional and comparative view including both cognitive processes and cognitive technologies as necessary to find out how they are best intertwined. While doing this it is important to make sure that both cognitive processes and cognitive technology will merge and complete each other in the best way to give rise to new and more powerful capacities that would not be possible without one or the other. If they somehow compete with each other the result would be negative on cognitive performance. More realistic cognitive technologies would have to emerge in the light of its (successful or unsuccessful) interactions between user and technology. This would also mean a different methodology needed for the investigation of human cognition. Dascal & Dror, (2005, p5) claims that *“Unlike the Cartesian mind, whose cognitive activity was allegedly performed in isolation from the external world, we view cognition as being embodied and embedded in the surrounding context, of which the technological environment is a major component”*.

Hagen et al. (2004) tried to develop a protocol for the assessment of assistive technologies for elderly persons living at home and suffering from dementia. They found that the most important criteria to assess the use and usefulness of assistive technology for persons with dementia are:

- the impact of the technology
- the impact of the personal characteristics of the person with dementia
- the impact of the family carer
- the impact of the environment
- the impact of the research process and the researches

Hagen means that such a holistic view the model offer, is necessary to gain knowledge of the grade an assistive device will be useful (Hagen et al. 2004). According the model the social context is important. To be able to analyze strengths and gaps in the usefulness of assistive technologies it is important to understand and have knowledge about the use of technology, both in supporting people with cognitive decline and the closest carers. The environment, both social and cultural where the technology was used is something shown in the model but is often excluded of the scope of analyze (Dascal & Dror, 2005).

Problems with intervention with technological aids might emerge because of design issues, usability and general technology acceptance etc, but how the actual cognitive processes work together with these technologies seem to be something that is still unknown and hence essential to investigate. It can be that we actually don't know enough

about how the process of memory works to be able to design products that are useful for us. The literature indicate that research of this topic is still in it's beginning and both qualitative and quantitative explorative research activities to develop methods for user involvement and for studying use and usefulness of technology aids is needed (Hagen et al. 2004; Topo 2009; Hjälpmedelsinstitutet, 2011). The method how to approximate the issue is complex, but a wider framework including culture, social and environmental factors can be a solution.

1.6 Extended mind

The ongoing cognitive technological development and the emerging problems on how to interconnect it with the humans in the best way, leads to the discussion regarding what would be considered cognition. The discussion if cognition is only processes that happens within the bounds of the skull or if it is extended into the external world while using cognitive tools. To offload your working memory by writing down a note on a piece of paper, or retrieving information from Google instead of from your head is called “extended cognition” (Clark, 2001). External things in the world are then included in the process of cognition, and the distinction between external and internal cognition might not be crystal clear as seen in the first place. This leads to the contradictory question “Where do the mind stop and the rest of the world begin?” expressed by Clark & Chalmers, 1998.

The central idea within extended mind and the view it implicates on cognitive technology is that the human mindfulness should be extended to include not only neural tissue and the brain but also the body, technology and social/cultural influences. It is a broader focus that could be applied when it comes to study the human thought and reasoning. The tools and aids as pens and paper, institutions etc. are all things we use while our biological brain mature and operate and are so part of cognition. Portions of the external world often function as a kind of extra neural memory store so while offloading our memory onto external things, the mental processes can work on other things, something which is seen for example in the performing of expert skills such the ones of a bartender. To be skilful is a delicate interplay between internal and environmental factors. If you take the bartender out of the familiar bar, without the external things that reminds the bartender how to use the equipment to be able to work in a fast way, the subject will have a harder time to perform the work tasks. There are other trick like leaving something where we know we will come to see it, for example the bag with sport clothes next to the door the evening before you go to work, or writing a note “bring sport clothes” and leave it on the table were you always sit eating breakfast. These are also example of how we use our environment in our cognition. The external environment affects not only the quantity of data that we can handle but also the kinds of operation we can perform. Both the arena and the things we can do changes through cognitive technology. *“If, as we confront some task, a part of the world functions as a process which, were it done in the head, we would have no hesitation in recognizing as part of the cognitive process, then that part of the world is (so we*

claim) part of the cognitive process” Clark (1998), cited in Dahlbäck et al. (2010, p2). According to this view it doesn't matter how you get to the goal, using internal strategies or external artefacts, if the outcome is the same. The part of the world used is a part of the process in the way that you can substitute a poor memory with an external memory aid, for example retrieving information from a paper note instead of from memory in the head. This is also referred to as the “Parity Principle”. It means that the two ways to recall the information and the outcome is exactly the same, the only difference being that one read written information from a paper and someone else remembers it in the head making the only difference that the paper works as an external memory.

The question is if this is that easy, that a poor memory can be substituted with an external aid and the outcome will be the same. The problems using external aids in intervention in cognitive decline suggest it is more complicated than that, something that Dahlbäck et al. (2010) also brings up. The extended mind theory has also been criticized as lacking empirical data collected from real world settings since the theory is based on thought experiments. Dahlbäck et al (2010), also suggest that an extended cognitive process where an external artefact in the world is part of a genuine process, and a process that enables a process, might differ a lot. For example while using a pen and paper to offload the working memory while performing a calculation, you still perform the real process in the head, the paper is just a way off storing information that enables the process to work out. To be able to include these aspects, experience of different individuals and also the cultural and social environment individuals grow up in; there seem to be a need of a wider framework to study human cognition. One such a framework is activity theory described in section 1.8; also suggested by Dahlbäck et al. (2010).

1.7 Distribution of memory across the human internal and external world.

We can see how humans behave and act, but still don't know much about how the cognitive processes really function. There has been a development from considering the mind as computational states, working more or less as computers with symbolic representations, to more recent theories that see cognition as dynamic processes that take part in an online real-world and in real-time interactive systems. Whether cognition is represented as mental states inside our skull or happens in the meeting with the external world, and the relation between them is something that has got a new focus (Clark, 2001).

The circumstances age brings with it could be expected to show differences in memory performance between elderly and young, but it is not always the case. In a study made by Schmidt et al. (2001) elderly adults had the same results similar to young adults while performing prospective memory tasks, as remembering things they planned to realize in the future. The study show that if the memory task was conducted in a laboratory setting the elderly participants showed less successful performance on the memory task, while in their own home environment there was no differences. This

indicates that when elderly participants had the possibility to be in their own environment and so being able to build up their own system to remember, they were as successful as younger on the task (Schmidt et al. (2001).

It can be that we need to re-think the whole traditional memory structure. The internal and external world might not be that separated as indicated of traditional theories but more intertwined with each other. Intons-Peterson (1986), listed internal and external aids and also included the variable “combined”. The latter were: *Saying out loud*: Saying something out load as a way to remember (for example, by telling another person or asking someone to repeat what you said); and *Trial technique*: Trying to write out or imagine part of the information to see if it sparks a memory.

Zhang and Wang (2009), made a study questioning the traditional hypothesis of memory aids. This hypothesis holds that “*external representations help problem solving by augmenting the limited capacity-working memory*” (Zhang & Wang, 2009 p. 1). This means that by offloading working memory and store some of the information in an external storage, you can enhance cognitive problem solving. The cognitive processes of memory then pick up and represent information only when needed and it is not necessary to remember all the information at the time. According to Zhang & Wang (2009) the view has been challenged before, showing results in both directions that it is both the cognitive processes and the external representations that are important for the memory process. The results in the study made by Zhang & Wang (2009) is that even though both things are important you can't separate them and talk about external representations and not cognitive processes that operate on the representations. It rather is the coordination between them that is most important. Within distributed cognition the research suggests that memory aids does not only consist of offloading working memory but the representations goes far behind that (Zhang & Wang, 2009). It is commonly known that external representations help memory retrieval by priming the memory so that a context with many external cues will facilitate the memory retrieval. The representational effect is something that shows that it is not only the amount external representations but also how the external representations are formed that affect cognitive performance (Zhang & Wang, 2009). What these theory hold is that external representations need not to be re-represented again as an internal representation to function in human problem solving. The process happens in real time when external presentations provide perceptual information. This information together with cognitive processes and internal representations determines the behaviour of the individual. According to distributed cognition the activity or behaviour of a human depends on the integrative processing of perceived external representations and the retrieving of internal representations. There is then interplay of perceptual and cognitive processes that work together. Both external representations and cognitive processes are important, but what is most important is the coordination between them. If someone is incapable to coordinate the retrieval of cognitive processes it does not matter how much access the individual will have to external representations and cues. They will

anyway not work out as a memory aid. The outcome is then a result of how people coordinate the use of external and internal representations.

The results in the study by Zhang & Wang, (2009) also show that external representations could both hinder as well as enhance cognitive task performance. If the task consists of information in both working memory and external representations the task difficulty was determined if the information was compatible from both sources and how it was coordinated. The task become harder if the information from the two sources did not match well with the task requirements since the information had to be re-processed in working memory. This takes longer time since the subject needed in this case to perform a sequential search or re-process the information in working memory, which lead to a decreased performance on the task. If the information is well matched on the other hand the task becomes easier. According to the results in the study of Zhang & Wang, (2009) there is a complex relation between external representations and working memory and that the memory aid hypothesis might not be taken for granted. The internal representations don't need to include or re-represent external representations but being separated when used in cognitive performance. These results are consistent with the research line of situated cognition (Zhang & Wang, 2009). Also when the task requires information from both external representations and working memory, it is the interaction of information from the two sources that determines the task difficulty.

Habits and routines are other thing that supports memory. Habits are defined as slowly developing associations between situational cues and repeatedly performed behaviour options. While performing habits almost no cognitive resources are needed, and they are then much easier to remember. Memory and habits are interrelated and behaviours that will be remembered are the once that will be performed. To change someone's habit is then an issue of memory. In a study made by Tobias, (2009) they tried to change people's habits with waste separating, providing an external memory support with reminders to make people remember their new intention. If people were reminded about the new behaviour they followed the waste separating and were able to change their behaviour also in real settings. Cognitive resources available for a task is something that affects prospective memory which in its turn is something assumed to depend on situational circumstances. But the strength of habits developed for an intended behaviour is not only what has an impact on prospective memory tasks. The model proposed by Tobias (2009), assumes that habits develops for behaviours performed in a specific situation and for similar behaviours in similar situations. The model also suggest, and get support in the study, that intended behaviours are affected of prospective memory and the recall for such memory tasks needs reduced cognitive effort. If the behaviour is not intended on the other hand a negative memory circle is created since the behaviour is not performed the memory also fades away quicker. These are some aspects of memory which are challenging traditional views.

1.8 Activity theory

To solve the problems with the interaction between cognitive technology and users in the discussion described above of cognitive technology, extended cognition and distributed memory there seem to be a need for a wider framework. Activity theory (AT) is a way to move the focus out from the device and understand technology as part of the larger scope of human activities. "*Activity theory can help bridge the gap between insights about the need for broader perspectives and the need for specific tools for thought*" (Kaptelinin & Nardi, 2006 p 6). Activity theory (AT) has its origin in Russia in the 1920's and was part of the cultural-historical school of psychology. Psychologist as Vygotsky, Rubinsthein, Leontjiev and Lurija were the main founders and the work has become an important tradition in Human computer interface (HCI). In Scandinavia, and in the rest of Europe, the U.S, Canada and Australia, AT has grown lately as a methodology, as well as continuing work in Russia. AT holds that the interesting part to study when it comes to cognition is not the individual but the activity that we are engaged in. The focus of activity theory is of purposeful, mediated, human social activities; hence the understanding and design of technology should be based on analysis of its role and place in a practical activity and is hence a way to study the processes of the mind in an alternative way (Kaptelinin, 1997; Davydov, 1999; Dahlbäck et al. 2011).

While doing an analysis with activity theory you focus on purposeful activities and when you want to study the relationship with technology AT extend the scope to include higher-level meaningful tasks that can be supported by the devices. The device is not studied separately from the user but it is the use of the device that is in focus. It also includes long-term changes both in the technology, the user, the interaction in between them and the overall context. AT holds that there is a set of basic principles that form a general conceptual system. The basic principles include the hierarchical structure of activity, object-orientedness, internalization/externalization, mental processes vs. external behavior, tool mediation and development (Kaptelinin, 1997). This means that even if it is the single individual that is of interest, it is not a sufficient unit of analysis and it is instead the activity which is the purposeful interaction of the subject with the world (Dahlbäck et al. 2011).

Activity means in this case "doing", in that people (the subject) basically works on an object and gets an outcome. The objects are the intentions and desires the subject has while performing an activity. This is also what give meaning to what people do and what separates one activity from another. The main centre of study is hence object-driven human activity, which objects as the generators and foci of attention, motivation, effort and meaning. The object is perceived as something that can meet a need of a subject and is what motivates the subject.

The human exist in a social world and is seen as bridging the gap between the subjective and objective. AT includes moral and ethical issues, social implications, critical analysis, emotions, feelings, and spirituality in the analyze scoop. Since

the theory aims to understand the human being in their natural social context through so the individual, the social entities they compose in natural settings are analysed through the structure and processes of their activities. Since human does not interact alone in the world but is a social creature and their mind is deeply influenced by language. Something very important to humans are how they success or failure together with others within the social group and community the individual belongs. The activities are performed with or through other members. The world itself is social and the entities people are dealing with are mainly other people and artefacts developed in culture.

The activity is rarely performed without some intermediating tool who works in a relationship between people and the world. These tools work as mediators to help people produce objects satisfying their vital needs and can be external as a computer, a hammer, or the use of our own body such as the fingers on the hand while calculating; and/or internal and psychological as a plan or an algebraic notation. Material tools and the production of them can both enhance the subject in the process of transform knowledge, but also limit the subject since it restricts the interaction (Davydov, 1999). The objective of a practical action is what develop tools and makes them possible and the use of the tool is what changes the structure of the activity. If there is no activity no tool is needed and this is why tools unfold within a historical frame. Human designs tools for the use of humans by purposeful changing natural and social reality. The technological creativity is something we got from our ancestors and hence a product of the development of local objects in our local environment (Davydov 1999; Kaptelinin & Nardi, 2006).

AT holds that historical and cultural creativity is what forms the activity. When environmental conditions change so does the flexible components of the activity and reverse, so there is a continual dynamic interplay and change (Kaptelinin & Nardi, 2006; Davydov, 1999). The culture in which the subject exists hence has a protagonist role and transform through the activities the subject realizes. Because of this the subjects also change and develop themselves while fulfilling the activity and both collective and individual behavior forms part of the activity so people perform activities as social beings (Davydov, 1999). In order to make a successful interaction with the world it is then what makes the human mind a developed emergent product. Culture is what forms the very production of mind and is more than something external that influence the human mind (Dahlbäck et al. 2011).

Higher mental functions are to the activity theory mediated mental processes and by that there is a difference between them as something unique to humans, compared to lower mental functions which can be seen in other animals as well. Internalization happens when an individual does not need to rely on mediated, external artifacts, which was needed before to be able to carry out the current activity. External processes can after internalization transform to take place internally in the head after a while the subject learn things. The activity and the process is from here on out mediated by internal resources rather than by external. For example when a child first learn

how to calculate and in the beginning use the fingers while counting. After a while the process is learned and becomes internal, and does not require the fingers or an external representation anymore. The processes remain to be mediated, but is not mediated by internal rather than external signs. The culture also has an impact in the two way processes of internalization and externalization of knowledge. In interaction design it has shown being very important that the end users get abilities to realize their own intentions. This makes it possible for the individual to grow and develop over time and become skillful with their device. The cultural environment provides a reconstruction of the mental processes and is a symmetrical relationship between the environment and the mental processes so that mental processes affect the environment and vice versa.

Another view that Activity theory hold is that higher psychological processes are outside the isolated world from the beginning, and not organism centered. The organism is born into a world which has previously developed and accumulated a range of cognitive mediators, both physical and psychological. The mediators are little by little appropriated and internalized during the process of development. Higher cognitive functions exist mostly in the world and are gradually internalized and not extended into the world as proposed by extended cognition described before (Dahlbäck et al. 2011). This means that cognitive processes such as memory exist in an intrinsically interplay between the external world and the brain. An external memory support is in this case as much a question of how information finds its way into the external memory support as it functions as a memory support (Dahlbäck et. al 2011).

The first models of human-computer interaction were primarily based on information-processing psychology which is something it has in common with activity theory, it is the interaction between human beings and objects (interactive systems) that is the unit of analysis. The purposeful interaction with the world can be compared with interaction between user – interface but as a part of an activity. There is often a deeper meaning with the use of human-computer interaction, for example writing a mail to keep up the relation with a friend. The meaningful context, also the social context of the subject should then be included in the analysis and it is therefore the activities of people using technology that is of interest. A wider framework as activity theory is suggested to be a preferable way to study these processes. Activity theory affords a wide framework where the individual is not the centre of analyze but the performed activity of individuals. This means that the culture, environment, tools and social factors are also included in the scoop.

2. Ingema & the Hermes project

Ingema Foundation is a research center located in San Sebastian, Spain. It was founded in 2002 by Matia foundation which currently runs one geriatric hospital, seven gerontology centers and seven daycare centers in San Sebastian. Ingema is short for Fundación Instituto Gerontológico Matia, and is one of the leading privately funded institutes conducting research

in ageing and disability in Spain. The main aims of the institute are: (1) to generate knowledge which can maximize personal autonomy, safety, physical and mental health care and generally anything which helps to improve conditions and quality of life for the elderly and the disabled; (2) Apply this knowledge to improving existing processes, services and products and generating new ones, with greater added value and efficiency. Ingema currently employs more than thirty researchers from different countries with multidisciplinary backgrounds such as psychology, medicine, chemistry, biology, sociology, nutrition, statistics and economics. Ingema takes part in basic research initiatives on both European and International levels. In Europe, Ingema actively plays a key role in projects funded by the European Commission (www.ingema.es, retrieved 30/3 2011).

One of the projects carried out by Ingema is the Hermes project that started in January 2008 and run until March 2011. For a closer look see www.fp7-hermes.eu (retrieved 30/3, 2011). The project is supported by the EU under the Framework Program 7 and there are 6 European research centres and organizations involved in the project:

- CURE (Austria), coordinator of the project
- AIT (Greece)
- TXT E-Solutions (Italy)
- IBM (Israel)
- University of Bradford (UK)
- Fundación INGEMA (Spain)

The aim of the Hermes project is to achieve cognitive care through an assistive technology. The target group is elderly people suffering normal and age related cognitive decline, with mild memory problems. The system is thought to maintain the individual's functional skills and assist when needed. By the use of an assistive technology as Hermes the subject is thought to experience enhanced independent living and improved everyday living, and thereby reduce need for active care and support. The system is based on intelligent audio/visual processing and reasoning, and is a combination of one home-based (computer) and one mobile device (PDA) which are interconnected with each other. The information can be recorded in both devices and are then synchronized between them so that the PDA offers support outside the home and the computer is used at home. The system also includes cameras thought to be installed in one room in the user's house, for example the living room. The cameras are equipped with face recognition that recognize who's in the room; this is thought to make it easy for the user to later on search information connected with a certain person.

The main objectives of the Hermes system are described on the official webpage:

1. Facilitation of episodic memory through the capture of content in audio and image including when, where, who, what and why of a moment, including additional contextual information, such as date and time, the amount and name of

people present and derivatives, and information from other sources.

2. Cognitive training through games with moments that have been captured previously that are related to contextual information.

3. Advanced activity reminding to assist the user's prospective memory in performing everyday tasks and to support independent living. Modelled after human associative memory, contextual cues remind the user automatically and non-disruptively.

4. Conversation support on the grounds of interactive reminiscence based on the recordings of important moments in everyday life.

5. Mobility support to address the needs of the user outside of the house with cognitive support when and where needed.

(<http://www.fp7-hermes.eu/project-summary.html> retrieved 30/3, 2011).

The user could enter information in the system through different applications, either by recording information through the cameras, entering information in the computer or the PDA. It is also possible to use the PDA to record conversations or to take photos. The devices are thought to have an interface adapted to an elderly person with clear and easy user interface. Both devices have touch-sensitive displays which makes them intuitive and easy to use. A prototype of the system was installed in the laboratory of Ingema during January-March 2011 when the second user evaluation took place.

3. Aim and hypotheses

When the author of the present study was incorporated in the project (January 2011) the Hermes project was in its last phase. There was a final prototype of the Hermes system developed and the second user evaluation section was to be prepared and executed. During the stay at Ingema the author got the opportunity to conduct the user evaluation trials and to collect data for the actual study. Method, material and procedure is described in detail in section 4.

The actual study has the following aim and objectives presented below:

Objective 1: To collect empirical data about how we carry out memory strategies.

Objective 2: Investigate how people perceive a cognitive memory tool.

Objective 3: Suggest Activity Theory as a preferable framework to study human cognition.

While investigating these objectives that were based on the background and related studies described in the introduction, the hypotheses that were expected to be found in the study are presented below:

- A device is not enough to substitute a bad memory.
- Individuals use different memory strategies due to experience and internal abilities.
- Elderly users will like the idea of the Hermes system as a memory support, but would not be willing to use it if the system would be available.
- Memory is interrelated between the external world and the internal processes.

General preparations

The laboratory at Ingema was set up with the correspondent equipment for conducting the sessions. To get to know the Hermes system the researcher spent plenty of time exploring and learning the system. The manual for the test sessions was prepared and adjusted. A role play was performed to train before the actual trials and to check that all material needed was prepared. To test the questions and the trials further a pilot study was conducted. A written manual was created as support for the researcher so that the data collection was carried out at the exact same way and in the same order, equally for all the participants hence securing a stronger validity and reliability.

Pilot study

The pilot study was tested on three elderly people participating in another project at Ingema. The results show that the users had problems understanding what to answer, and had a hard time remembering different memory strategies they use in everyday life. The questions in the semi structured interview were adjusted and a standard example connected with the tasks to be performed later on in the user evaluation was added after each question. That way the user would be stimulated to start to talk about own experiences.

Procedure

The user trials consisted in participants visiting the laboratory at Ingema. Due to the interest of comparing older and younger in the actual study to see differences between the cultures you grow up in, a young group of participants were also recruited. The young participant group performed the trial in only one visit to the laboratory since they performed the trial a lot faster than the elderly group. The elderly participant group visited Ingema twice to avoid fatigue.

First the participants got instructions of how the procedure of the trial was to be carried out and asked about their permission to record the trial with a voice recorder, and to sign the informed consent. The trial started with the users participating in a semi structured interview where information about their everyday memory strategies was gathered. Second the participants were introduced to fictive scenarios and an example of when and what you can do with the different applications in the Hermes system. Third the participants got introduced to the interface on the PDA and the main screen and were required to perform some tasks with the system. The participants got to fill in user evaluation questionnaires. To close the trial all participants passed the CANTAB cognitive evaluation. And at last in the trial session there was a neuropsychological cognitive test battery controlling for eventual cognitive levels that may influence the results in the study

After performing the first trial the elderly participants got an appointment for the second session (young participants completed the trial in one visit). While the user performed the

4. Material and method

4.1 Method

Participants

There are two different participant groups in the actual study. An elderly group (E group) who visit Ingema twice within a week N=10 M=70,3 years. The following inclusion criteria had to be met by potential users: be more than 60 years of age, not suffering from any severe sensorial and/or motor problems, living independently in their own homes and being without previous experience with the actual user interface of Hermes. The participants from the E group were recruited from elderly centers around in San Sebastian.

The second participant group was the young adult group (Y group) mainly recruited from the psychology department at the university of the Basque country (UPV) N=10 M=26,9 years. Requirement criteria for this group were to be younger than 35 years old without previous experience with the Hermes user interface.

Data collection

The data collection was conducted during February and March 2011. It was collected while the second user evaluation of the final Hermes prototype was conducted. The user evaluation was prepared between the different partners within the project and was performed in Austria and in Spain. Included in the actual study is the performance and data from the user evaluation from Spain only, which the author had the opportunity to conduct. The data from the young sample was added for the present study, performing the same trial session as the elderly group.

The data collection of the two groups was performed at the laboratory of Ingema. Due to the long user evaluation, around 3-4 hours in total for the older group, the visit was split in two occasions to avoid fatigue. The older user group attended the second visit within a week from the first. The younger user group, who completed the evaluation faster, within two hours, performed the trial at only one visit.

tasks different observations and comments made by the participants were noted down by the researcher.

The notes and recordings was analyzed qualitatively using constant-comparative methods of analysis in which the researcher read and listened through the data for emergent themes, coding them along the way based on the method by Glaser & Strauss, (1967). The salient categories and patterns were extracted noting emerging patterns, which were compiled and reanalyzed in order to confirm and disconfirm evidence for the patterns. The author and a colleague were independently classifying the data into the different categories. The categories were compared and discussed until consensus was met of which categories where the most salient patterns and hence chosen to be included.

4.2 Material

The material used is: a half structured interviews (see appendix 1), the quantitative questionnaire from Hermes 2nd user evaluation (see appendix 2-5) and CANTAB cognitive evaluation test (see appendix 9). To conduct the trials the equipment within the Hermes system was used which included a computer with touch screen, a PDA, scales with the points 1-5 and 1-7 as support when answering questions measured on the likert scales, the CANTAB test computer, and a voice recorder to tape the sessions.

4.2.1 Semi structured interview

The aim with the interview was to find out how the users use different strategies in their everyday life. There was a short introduction to the subject to make the user comfortable and relaxed (see appendix 1).

To complete comments said during the user evaluation and get as close as possible to how the participants use memory support in their ordinary life these questions were administered. The user got to answer the questions after a short introduction to the Hermes system before seeing the interface. Results from the pilot testing showed that participants who found it hard to start thinking of different strategies, were helped by having an example following the question. There was a standard example added after each question to guide the participant if he/she didn't start talking himself. The questions where adapted to be as natural as possible to the conversation and to the user evaluation that followed.

4.2.2. User evaluation

The user experience evaluation (UX) refers to the assessment carried out with participants in the laboratory in which the users were faced with the second prototype and required to perform some tasks with it. In the same evaluation the participants also answered some questions related to the usability and acceptance of the system. The goal of the user evaluation was to evaluate (1) User perception of performance;

(2) Usability and user experience; (3) Effectiveness and acceptance of the Hermes system as a cognitive tool.

The functionalities tested in the UX evaluation were as follows:

- Hermes main application: The launcher application for all Hermes sub applications: Calendar, MyPast, People, Locations, Shopping List and Cognitive Games.
- Hermes mobile application with the sub applications: Calendar, Conversation, localisation, People and Shopping list

The user evaluation included different questionnaires presented below:

Technology usage and frequency

The first part of the user evaluation is a questionnaire including some general questions regarding the technology usage and the attitude towards technology (see appendix 2) This questionnaire aims to obtain information about: (1) ICT products or services you use and how frequently you use them; (2) memory support tools you use and how frequently you use them; (3) opinion towards the usefulness of several devices. These questions are included to control for general technological acceptance and the acceptance for the Hermes system.

Task and usability

The second part was questions about the different applications and if the system was helping the subject to complete the task in the different applications. While the users performed the task, they were observed by the interviewer and they were asked to think aloud any thought, comment or doubt they had. After completing each task a specific questionnaire aiming at collecting opinions about how the user experienced the system during the task, how well the system supported the user and what can be improved were administered (see appendix 3).

Emocards

This is an instrument specifically developed for measuring emotions elicited by product appearance. After the completing the different tasks with the applications, the Emocards (appendix 5) were introduced to the subject. The Emocards are 14 different figures, 7 of them with faces who express positive and 7 faces who express negative emotions. The cards are put on the table into two different groups: positive and negative emotions. Within each group, the cards were put in random order. Also, the two groups (left or right) were switched randomly before each selection. The user was required to choose the faces which best express his or her emotions after performing the specific task with the mobile phone, games and main screen (Desmet, Hekkert & Jacobs, 2000).

UTAUT

In order to assess the acceptance of the Hermes system two different questionnaires were administered. The first was UTAUT (appendix 7). This questionnaire was adapted from the Unified Theory of Acceptance and Use of Technology (Venkatesh et al. (2003). The UTAUT test is a test measuring general technology acceptance. The test captures the correlation between “technology acceptance and actual utilization behaviour”. According to the TAM, a users’ decision to use a new technology is determined by the behavioural intention to use the technical system. This behavioural intention is in turn determined by the perceived ease of use of the technical system and its perceived usefulness. UTAUT assumes some key constructs which are direct determinants of technology usage intention and behaviour.

TAmi test

This is a technology acceptance questionnaire that has been applied on different technological devices. There are five categories measured in the test. These are: Perceived benefits, Perceived disadvantages, Attitude, Outcome expectations and Intention (Jan, van Dijk & Peters, 2009).

4.2.3 Cognitive evaluation

To control for the participants general cognitive status, three different tests were conducted. The participants prospective memory was evaluated, a self evaluating memory scale (MAC) and a neuropsychological test (CANTAB).

Prospective memory

First there was a set of different questions evaluating the prospective memory of the participant. These questions were administered during the trial:

Two of them were time based:

- Please, remind us in 15 minutes we will make a rest.
- Please ask me in 2 minutes when we are going to finish the session.

Two of them were based on events:

- When I give you a piece of paper, please write down your address.
- When I give you a pen please sign this paper.

These questions were taken from the Memory for Intentions Screening Test (MIST) (Raskin & Buckheit, 1998). According to this test the general rules for the prospective evaluation are: (1) there must be a delay between the encoding of the intention

and the execution of the intention; (2) this delay must be filled with a secondary ongoing task; (3) there cannot be an obvious external reminder by another person, rather the person must be aware of cues or prompts from the environment.

MAC-S

Memory Assessment Questionnaire (MAC-S) (Crook, Fether & Larrabe, 1992; Montorio & Izal, 2002, for the Spanish version) MAC-Q is a self report questionnaire of 5 questions addressing daily activities, three questions addressing overall memory functioning comparing present moment to when the person was on the top (where the respondents must choose one of the 5 options ranging from “very good” to “very bad”), 1 question addressing the sense of worry about one’s memory and 4 questions about the perceived frequency of specific types of forgetfulness typically associated to age.

CANTAB

To raise the validity and to control for the participants cognitive status, a visual memory and new learning test was administered. This was administered to see if the participants suffered any cognitive decline that might have had an impact on the results and the evaluation of the Hermes system. The Cambridge Neuropsychological Test Automated Battery (CANTAB) is a suitable assessment tool for the diagnosis of mild cognitive impairment (MCI) and early detection of Alzheimer’s disease and other types of dementia (Facal et al. 2009). See Appendix 9 and for more info www.camcog.com.

5. Ethics

All users’ signed a consent form that declared that their dates would only be used in the study and that data was treated confidentially.

The participants were informed that the researcher was observing and taking notes during the trial but that it was not their performance that was observed but rather their opinion of how the system worked. They were also informed that there was no right or wrong answers, that it was their sincere opinion that was requested so that the prototype could improve further.

The participants were informed that if they wish they could have the CANTAB test results send to their home address after the study was done.

6. Reflection over the method

The choice of semi structured interviews was mainly due to the benefits of face to face conversations and the possibility to catch comments and opinions not written down in the user evaluation. The aim of the questions was to find out what kind of memory support the users are using in everyday life and it was important that the participants got time for own reflection and development of their ideas. The interview took place before the participants saw the Hermes interface with the

purpose of not make them biased by the system. The face-to-face interview was preferable since it offers an opportunity to be able to adjust the questions to the different individuals to create a better understanding between interviewer and participant. When the participant interacted with the system, observations were made to further catch up comments made by the participant. Interviews made face to face is a good way if the person interviewed wants to show something in connection with the interview, for example how a system or an artifact is used (Preece et al. 2002). Semi structured interviews combine attributes with both structured and nonstructural interviews. To cover the same areas, the interviewer had a manual as help.

6.1 Limitations

There were some limitations when it comes to the method. The data collection was made in a laboratory setting which might have influenced the participant to answer in a certain way. The semi structured interview about the internal and external memory strategies might have been more accurate and detailed if collected in the real environment at home. The participants might be limited to what they remember since not being in their natural setting at the moment of the interview. Also external memory aids in the environment can be unconscious and already internalized routines which are hard to self report. Another thing is that older people often suffer memory problems and while asking elderly about memory, they might feel like if it was their capacity that was actually measured which could influence the participants to answer in a different way. This problem was handled by the researcher saying before every trial that there were no correct or incorrect answers and that it was a prototype, not yet finished and that we wanted comments to be able to improve the prototype. There's a risk of interview effect to bias the participants, but in this case the problem was handled by the support of a written manual to try to keep the trials as similar as possible with all participants.

7. Results

7.1 Qualitative material

The qualitative material was analyzed and the patterns which occurred frequently (3 or more times) were included and have its own heading. There are examples presented under the headings that show typical answers. The material is taken from the interviews and comments made during the test evaluation. The patterns that showed throughout the test sessions were the following:

Tools to offload memory and where information is stored

Almost all the participants mentioned using different tools to organize, offload and better structure their lives and to remember things. Post-it, agenda, notes in the mobile phone (young), photos, another person, pen and paper, calendar, notebook, boxes and maps for important papers etc. The interesting thing here was where the information was stored. Everyone had a strategically chosen place for where the

information was stored. An elderly participant expressed: "The calendar is always in the kitchen and when I change month I know I'll see the appointments and important things in the upcoming month"; elderly participants reported in several cases that: "things and information such as what kind of medication I must take I usually write down on the package". One young participant reported "to remember things like birthdays, Facebook takes care about that and let you know when one of your friends is having his birthday" so I don't need to remember. Another report on where to store information was a young participant saying: "I write and put notes in my purse and when I get home I put them in one of two boxes. One of the boxes is for urgent things, and the other for things in a further distant future. I look and organize the papers in the boxes every now and then, and pass things over to the urgent box or throw them away if they are not actual anymore". An older participant say: "sometimes I take notes, which I store next to the phone. If someone calls and gives me some important information I write it down; my husband also writes a note if he leaves the house while I'm outside, so I know where he is". Several participants both young and elderly made comments like "post-its are stored on top of the desk". To carry written down information in the wallet is another popular technique "I write down information and then I read it, on post-its and then I bring it in the wallet".

Several participants complained over their own behaviour if the information was not stored at a good place. A young participant made the comment that "usually I write down important stuff on notes but then I don't have a good system where to store it". The participant expressed frustration over the system that it did not work out, and the notes were often to be found far behind the important date, or far before when it was not relevant to remember the thing. Another young participant reported "since I don't always bring my agenda with me, sometimes I miss important things". A young participant said "If it is important as medical appointments I make a note on a post-it and keep it in my purse. But then I forget to look in my purse so there is no really order. If I'm lucky I find the note in the right moment". Another young participant said: "To remember things I have to do I usually make notes in the calendar application in the mobile phone. If what I have to do is at a special time, I add an alarm, usually so it reminds me the day before; I don't have any comfortable calendar".

Almost all participants 19 mentioned having strategies about where the information was stored. "When I see it I remember". "I always leave things at the same place always, so I know where I have them"; "I always put my keys next to the door, so I know where to find them. The first thing I do when I step inside is to leave the keys on the table, and when I go out I take them again" were other comments made in the same category. And when not having a good place to store the information they complained and mentioned that.

Comments about shopping list.

Since the example that followed one of the qualitative questions was about shopping and how they remembered

things when needed to buy something, it is obvious that the answers are related to shopping. The participants answers were mainly that they either do lists or don't make lists. One pattern shown in this answers is that the one that do make shopping list often have a special technique while doing it. Either making a mental picture over the store to write things down in the order they will show up in the store, in this case the comments showed that it is necessary that the store is well-known. There were also cases where participants thought about the order in which the meals were to be served which helped them structure the list. As well as writing down the different categories in the store, in the order they were to be found for example vegetables, fish etc.

The ones that did not make lists went everyday to the store and bought more or less the same things, or there spouse told them to go to the store and told them specifically what to buy. There were also some users reporting not having to remember anything, that while standing in front of the shelves and seeing the things they remembered.

Usability issues:

The ones giving most examples of how the system could be better were the young participants, they reported a lot of things that they did not like with the prototype for example that it was "hard to use", "it takes to many steps to reach the goal", "the save button is not located at the same place all the times" etc. For example one user made the comment: "I don't like the Hermes system because my mobile phone is easier to use than this system".

Plan ahead to be prepared:

This title was added because there was a tendency among participants to plan ahead and structure things they would had to perform in the future. They made a mental plan of what to do during the week, or where to go first to be able to save time. To associate upcoming tasks with external reminders were a common strategy. Comments like: "Usually I try to visualize what I have to do during the upcoming week; I separate it from the weekend when I mainly do fun things. I also visualize and organise the day mentally" or "Before having a conversation I plan ahead what to say and what to expect from the conversation"; "At night I take a look in the fridge to see what there is and what to buy the following day"; "I prepare my bag with the things I have to bring the night before if I have an early appointment.

Re-live the moment to find things

This was a common memory strategy among both elderly and young participants. To remember what happened in the past was mentally pictured to be able to retrieve things in the present. Common comments like: "to find the keys, I had to think where I had the keys last time, what did I do in that moment"; "To remember what someone told me I tell a little story to myself to remember the things. In the order things happened and that way I remember"; "Many times I forget

why I entered a room, what I was looking for. To remember I usually go back to the place I was before, and then I normally recall again"

Memorize or repeat

Some participants reported not doing anything special to support their memory. Comments like: "Appointments with friends I normally don't do anything special, I just try to memorize them"; "Right now I just work and a have a few appointments during the week so I remember them without doing anything special"; "I pay attention and that way I memorize..."; "I don't use an agenda. I remember from day to day what I have to do. I do have a calendar but I don't like to make notes there as my daughter does, her calendar is full of little not understandable notes and signs"; "If I don't remember names which happen every now and then, I ask again and then tries to memorize it". The participants also tried to remember things in the future by more conscious strategies: "I repeat things in the head to remember information later on"; "I make notes, or repeat several times to memorize or just memorize".

Help of another person

To use other persons as support is another way to support memory shown to be important to the participants. Common comments were: "Or I phone or speak with the person that was with me in this moment and while talking with someone else I remember"; "my mother remind me about things like doctors appointments so I don't have to worry too much"; "besides I use Facebook a lot and there the information is written in the messages so when the date is getting closer there is always someone of my friends or myself that ask what time do we meet on Saturday for example and that way I remember the appointment"; "I remember events in the past mainly by talking to other people, together we remember the details"; "My wife remember much more than I do. We have organized the life and between us we have the things controlled". Together with other individual we seem to distribute the memory between us.

Technology tools.

All comments about technology use were made by younger participants. They reported using technological tools as support for memory. Computer, Internet, software programs as Facebook, digital calendars with alarm, Google to fresh up the mind, looking for photos on Facebook/Internet were common strategies for the young participants. Comments were all in line with: "If it is something important I make notes in the calendar application in my mobile phone. I make an appointment with an associated alarm; To remember things like birthdays Facebook takes care about that and let you know when one of your friends is having his birthday"; "Usually I make notes in the calendar application in the mobile phone. I also set an alarm to the information introduced. When I get home I always connect the Iphone with my computer so that the information is synchronized, that way every time I either

sit next to the computer or wear the mobile phone with me ill receive the reminders”.

Written information

On the question of how the participants deal with a lot of information at the same time many of them reported that they asked for written information: “To remember information, I normally write down in the note application of my mobile phone- if it is a lot of information I ask for it in written form. In the mobile phone I just note keywords or short messages. If it is a lot I write it on a paper”; “If I want to remember an amount of information for example at the telephone company I ask for a folder”. The participants offload their memory with the use of paper, to store information external.

Trouble with names

Many of the participants both young and elderly reported having trouble remembering names: “To remember persons and names which I’m pretty bad at, I usually ask again or ask a friend what the name was. If the name is important I try to pay attention, and if they are unusual I remember them better because of that”; “I’m generally bad at remembering names, I usually ask others and hearing it many times I tend to remember it in the end. Peoples name from abroad is usually harder to remember. Sometimes I also try to associate the name with someone I already know well”; “I associate things or persons with events and they make me remember”. It seems that there is not a very good way or strategy when it comes to remember names. Writing them down is not enough to remember, when you bump into persons in the street you need the information at once to make the association between the person and the name, which makes it complicated.

Distant and close future

There was a pattern among the users that they were aware of their memory limits. Things that would take part within a close future were memorized many times while things in distant future were written down somehow. Common comments are: “Things that will come in a future like some weeks or months I might write down but in general I don’t”; “Things that will happen in a distant future, the things I have to do today is controlled. Sometimes I make notes and when the date is getting closer I check the notes”; “If necessary I put a cross or make a little note in the calendar, but not often and only if it is events that take part in distant future, months”.

Photos

To use photos as a way of reliving passed events was one common strategy to remember things in the past. People reported feeling as they were in the moment again while looking in the photo album. One elderly talk a long time about her daughters wedding and how she used to look at the photos to remember how beautiful it was. A young participant made the comment: “Things in the past I remember with photos, the ones I’ve taken with the mobile phone, a photo album online,

or a photo album”; “Sometimes I use photos to remember things, but they also make me remember sad things and persons that are not here anymore so I usually don’t like to do that”, was a comment from an elderly participant.

Remember while writing

Some participants reported remembering better after having writing it down. Comments like: “I write down information and then I read it, on post-its and then I bring it in the wallet. When I’ve read it twice it sticks”; “When I write down information and put my own words on it is when I really understand it”; “If I want to study something I write and write and write and then I remember”. When studying something, it is common known that structuring information with your own words help you remember afterwards.

Making associations

To make purposeful external and internal associations is a common memory strategy. Both young and elderly participants reported using it frequently. Common comments were: “Sometimes I associate words with something to remember them better (while learning a new language)”; “I associate things or persons with events and they make me remember”.

No strategies

Some of the participants claimed not using any memory support or just making an extra effort to remember: “To remember things in the past I don’t use any special strategies”; “I remember from day to day what I have to do”; “I don’t takes notes for anything, I memorize things that I have to buy. I go everyday to the store so I don’t have to remember many things once I go”; “The thing with remembering is to make an effort. If you make an effort you remember. Sometimes I also forget where I put the keys, then I do another lap in my head and I will hopefully remember” “If I don’t remember things in the moment I try to make an effort I’m very stubborn in this way”.

Elderly not wanting to use the Hermes system

During the interview and the comments that were made during the user evaluation a lot of interesting thoughts were brought up, mainly by elderly participants. These are listed below: “A system like Hermes is very good when you have a lot of practise and also a lot of things to do (activities). But I won’t use it, I already have my life organised”; “The system is good, there is nothing to improve. Well maybe the system could say also with a voice what to do with the different moments”. “This device doesn’t make things easier for elderly”. “I don’t like technology, it gives me negative energy”. “The fewer things I have the better”. “For an old person it would be very difficult but for young people it would be great, they have more things to remember and would use it more”; “We weren’t born in this time area, technological devises are for young people. Besides young people don’t know how to count anymore, they do everything with devices. I don’t want to

become like that and I think by not noting everything down, I train my memory by forcing myself to remember. If I learned how to use a device like that I wouldn't have to remember anything and my memory might be worse"; "If I had a lot of things to remember I might have used a device like that, but since I'm old I don't have so much to do so I remember everything in the head"; "It takes longer for me to write things down and later on retrieve the information than keeping it in my head"; "Devises are useless since if you have a bad memory you would not remember to add information in the system or remember to consult it"; "If you loose your head you cannot take notes"; "Also it would take longer time looking for information everywhere then retrieving it from the head"; "The best computer of them all is the brain"; "If the head doesn't work you will not be able to use the device in a good way. How will you remember to add information in the device if your head doesn't work? And if you add wrong information the result will be wrong as well"; "You see not only with the eyes but with the brain, you can also have eyes without seeing"; "I don't like to write down a lot of things because I like to keep my mind fit. If I write everything down then I don't have to remember anything and I will probably loose my memory. Also if I would write everything down in a system like Hermes and if I suddenly would loose it, I wouldn't know anything"; "I don't need a system like Hermes, if I want to remember a street name I associate it with names that are easier to remember"; "I don't want to use this system because I would stop to use my mind. I think that we should help us with our own resources"; "The Japanese people have a saying which goes: Don't bring in your head what you can bring in your pocket – I think the opposite"; "I don't like this kind of technological devices, it might be comfortable for fast things but I don't really like it. For example with the telephone we lost the beauty of writing letters. No one writes letters anymore which is sad I think. You might gain some things but also loose a lot with new technology"; "For young people who have grown up with this kind of things it will be great. But if you remember things, why need a thing like this?".

7.2 Quantitative data

The quantitative data for the user experience was entered in a SPSS data base. Since the main interest of the study was to compare the young sample with the old on the evaluation, the data was analyzed with cross tables. The normal curve was not significant so non parametric tests were conducted. Frequencies, means and percentage were calculated with crosstabs between the two groups. Correlation between age and item was calculated for the different questions to see on what question age was a significant factor. Whitney Mann test was conducted to compare the means between the two groups. Cronbach's alpha was calculated on the acceptance questionnaires to see if the questions measured what they aim to measure. The results of the differences between the two groups evaluating the Hermes system are presented below:

7.2.1 Technological profile

Previous Technology usage

To know the technological profile and the use of memory supports the following questionnaires were administered. Participant's usage of ITC products and memory support tools was measured on a 5 point Likert scale. The 5 alternatives were: 1: never 2: almost never 3: once a month 4: once a weekend 5: once every day. The mean results between the two groups and the items which showed significant correlation on Pearson's test (*p<0,005; **p<0,001) between age and question are presented in the table 1 below.

Which ICT-products or services you use and how frequently	Mean young	Mean old	Significant correlation between age and usage of ICT-products (Pearson)
PC or Laptop	5	1,2	r=-,806**p=,031
Mobile phone	5	2,9	
Digital Picture Frame	1,2	1,4	
TV	3,2	5	
Which memory support tools you use and how frequently?	Mean young	Mean old	Significant correlation between age and memory tool use
Notepad	2,9	1,4	r=-.489**p=.029
Post Its	3,4	2	r=-.463* p=.040
Diary	2,3	1	r=-.503* p=.024
Blog	1,1	1,1	
Calendar	2,9	3,2	
Digital calendar	2,6	1	r=-.484* p=,031
Photo albums	2,5	2,4	
Online photo albums	3,2	1,2	r=-.739**p=,000
Video recordings	2,1	1,3	r=-.538* p=,014
Online videos	2,3	1,1	r=-.605**p=,005

Table 1. Mean results and significant correlations of ICT-products and memory tool usage.

The results of the correlation between age and technology and memory support tool show: the less years of age, the more usage of computer and laptop. Younger participants prefer the use of digital devices but also traditional as notepad and post-it. Elderly participants prefer the use of post-it, calendar and photo album as memory tool.

Attitude towards new technology:

This questionnaire was presented with a 5 point Likert scale ranging from 1 to 5 where 1: completely disagree; and 5: completely agree. The results are presented in table 2.

Attitude towards new technology	young	old	Significant correlation on age and attitude (Pearson)
Technical appliances (such as mobile phone and Internet) help to better organize my personal life	4,6	2,8	$r=-,596^{**}$ $p=,006$
I find it good that I can keep in touch with people I care via technical appliances (such as mobile phone and Internet).	5	3,4	$r=-,627^{**}$ $p=,003$
The disadvantages which some technical appliances can cause just belong to this kind of appliance	3,6	3,5	
It is good that all kind of administrative forms are available via Internet (for example a change of address form).	4,1	2,9	$r=-,480^{*}$ $p=,032$
With the arrival of the Internet, the possibility for everyone to participate in society has grown.	4,7	3,5	$r=-,553^{*}$ $p=,011$
I find it good that when I want to know something, I can also get that information via technical appliances.	4,9	3,3	$r=-,771^{**}$ $p=,000$

Table 2. Mean results in both groups and correlation on "Attitude towards new technology".

Young participants had an average mean $M=4,48$ and elderly $M=3,23$ for all the questions on the attitude scale of new technology which indicates that the young participant group in average has a better attitude towards new technology than elderly.

The Pearson correlation show: - the less years of age, the more participants agree with the state that mobile and internet help to organize their personal life; the better the participants think it is that they can use mobile and internet to keep in contact with people they care; the better they think that administrative forms are available on internet; the more they agree that the possibility to participate in society has grown, and that it is good that information can be found via technical appliances.

Regarding attitudes towards technology Mann-Whitney test was carried out to see in what questions there was a significant ($p<0,005$) difference between in the two groups. Results show differences in following questions:

- Technical appliances (such as mobile phone and Internet) help to better organize my personal life
- I find it good that I can keep in touch with people I care via technical appliances (such as mobile phone and Internet).
- With the arrival of the Internet, the possibility for everyone to participate in society has grown.
- I find it good that when I want to know something, I can also get that information via technical appliances.

In all these questions the averages were higher in the young sample which means that they agree more on these sentences.

To check the reliability of the answers Cronbach's alpha was calculated. On the questions of attitudes towards new technology the results showed a value of $\alpha=0,814$ for all participants, which indicates that the scale do measure what it is meant to measure.

7.2.2 Acceptance of the Hermes system

Perceived support of the system

This test measured the usability of the Hermes system while the participants performed the tasks. The mean of the questions of how well the system supported the tasks with the system was measured on a 5 point Likert scale where 1: The system has not supported me at all; and 5: The system has supported me at every moment (Appendix 3). The average mean for the usability on the tasks within the system was: Young: $M=4,3$ Old: $M=3,8$. This shows that young in average rated the usability of the Hermes system higher than the elderly group when measuring the perceived support of the system while performing the tasks. Mean item for item in the two groups are shown in table 3 below:

How well the system supported you in solving the task?	young	old
new_appointment	3,6	3,2
change_appointment	4,3	3,6
record_conversation	4,4	3,8
view_take_foto	4,1	3,7
create_shopping_list	4,9	4
main_screen_browse_appointment	4,9	3,8
main_screen_new_appointment	3,9	3,7
main_screen_change_appointment	4,6	3,6
main_screen_MyPast_time_search	4,8	4,1
main_screen_MyPast_people_search	4,7	4,1

Table 3. Mean values on how the system supports the users while performing the tasks with the Hermes system.

Cronbach's alpha showed a result of $\alpha=0,877$ for both groups which show that the scale measures what it is supposed to measure in the sample. When run for the different groups elderly got the value of $\alpha=0,770$ and young $\alpha=0,810$.

Emocards:

The Emocards were administered after each of the applications. The following figure (figure 1.) presents the frequency of EmoCard selected after each one of the

applications and after each one of the cognitive games. Figure 2 show the percentage of the Emotions selected after the different tasks performed with the system. The young sample selected positive cards 82% of the times after performing the tasks, the elderly sample 97% of the times.



Fig 1. Emocards

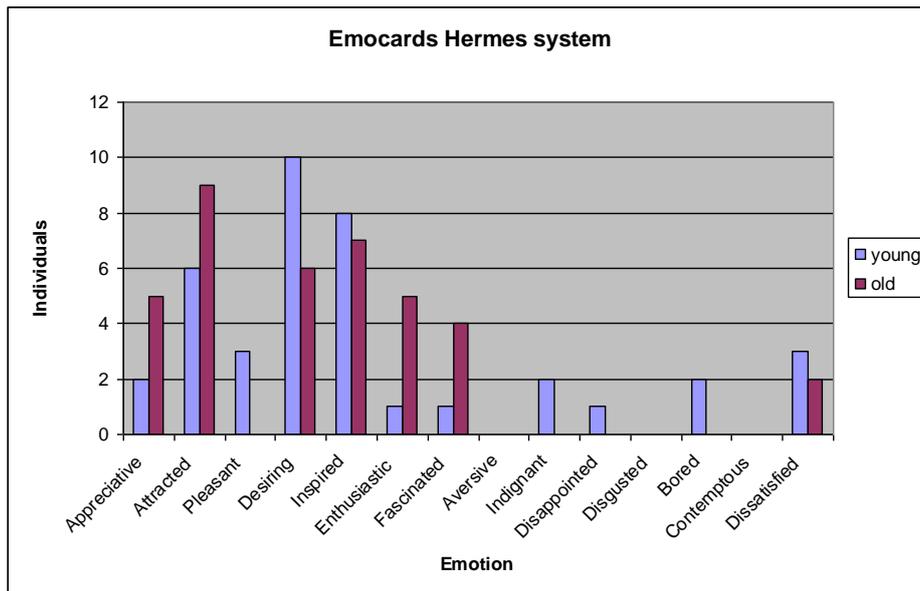


Fig 2. Emotions selected in the Emocard test, to represent the emotional state after using different Hermes applications.

UTAUT

The general acceptance of the Hermes system was measured with the UTAUT questionnaire. All items are measured on a seven point Likert scale.

The questions are divided in 5 different categories which got the following Cronbach alpha value: Performance Expectancy (PE) young $\alpha = 0,955$ old $\alpha = 0,830$, Effort Expectancy (EE) young $\alpha = 0,963$, old $\alpha = 0,643$, Attitude toward Using Technology (AT) young $\alpha = 0,876$, old $\alpha = 0,963$, Facilitating Conditions (FC) young $\alpha = 0,620$, elderly get $\alpha = 0,654$, Anxiety (AX), young $\alpha = 0,766$ old: $\alpha = 0,548$; Behavioural Intention to Use the System (BI) young $\alpha = 0,990$ old $\alpha = 0,990$.

The average mean of the different categories are presented in table 4 below:

	Young	Old
(PE)	3,29	4,29
(EE)	5,55	5,26
(AT)	4,3	5,26
(FC)	5,48	4,42
(AX)	2	3,63
(BI)	3,63	4,58

Table 4. Mean results of the acceptance of Hermes system (UTAUT)

The questions were correlated on the factor age, by using Pearson's (* $p < 0,005$; ** $p < 0,001$). The results show a significant correlation on following questions: Hermes is not compatible with other systems I use: $r = -,484^* p = ,030$; It scares me to think that I could lose a lot of information using Hermes by hitting the wrong key: $r = ,602^* p = ,005$; I hesitate to use Hermes for fear of making mistakes I cannot correct $r = ,711^* p = ,000$.

Whitney Mann test was carried out to see if there was a difference between the two groups. For the significance level ($p < 0,005$) following items show results:

- I have the resources necessary to use Hermes system.
- I have the knowledge necessary to use Hermes system.

In these questions the averages were higher in the young sample which means that they agree more on these sentences. Both questions are within the Facilitating Conditions (FC).

Summary UTAUT

There was not a very big difference between the two groups; however the means in the anxiety category elderly show more concern which show that with age comes a tendency not to trust the interaction between them and the tool as being safe.

Pearson correlation also shows a positive correlation between age and these two anxiety questions. A negative correlation is found between age and the perceived compability between Hermes and other systems used. Whitney-Mann test showed a difference on two questions in the Facilitation and indicate that younger perceive being helped of the system in a higher rate than elderly. Elderly tend to have a higher value when it comes to the intention to use the Hermes system if available, also Cronbach's alpha show a very high value on this category $\alpha = 0,990$ on both groups. In general Chronbach's alpha is high a value of $\alpha = 0,861$ for both groups, separated elderly got $\alpha = 0,881$ and young $\alpha = 0,848$ which indicates that the questions measures what they aim to measure.

Tami

There was a second test administered to measure the general acceptance of a technological memory device. The items were measured on a 5 point Likert scale and divided into 5 categories. Average mean for the different groups are shown in each category presented in table 5 below:

Category	Mean young	Mean old
Intention	3,1	3,2
Perceived benefits	3,76	3,71
Perceived disadvantages	3,71	3,83
Attitude	4,31	3,95
Outcome expectations	3,04	3,17

Table 5. Average mean of the different samples in the categories in Tami questionnaire.

Pearson correlation was carried out to see in which items there are a significant correlation (* $p < 0,005$ between age and item. Following questions showed results:

- Question number 33. How likely are the following reasons for you to use HERMES? To feel less lonely. $r = 0,539^* p = 0,014$
- Question number 40. How likely are the following reasons for you to use HERMES? Because it belongs to my lifestyle $r = -0,484^* p = 0,031$.

Whitney Mann test showed significant ($p < 0,005^*$) difference between the two groups on following items:

- Question 5: How likely are the following reasons for you to use HERMES: -To feel less lonely.
- Question 33: Do you expect that HERMES offers you more or less convenience in using a memory support tool?
- Question 40: How likely are the following reasons for you to use HERMES: -Because it belongs to my lifestyle

The mean was higher in the old sample on the question 5 which indicates that this group agrees more on this phrase. The

mean was higher in the young group on question 33 and 40 which indicates that young agree more on these phrases.

Cronbach's alpha show a result for the different categories and groups: Perceived benefits, young $\alpha=0,804$ old $\alpha=0,675$; Perceived disadvantages young: $\alpha=0,620$ old $\alpha=0,285$; Attitude young $\alpha=0,903$ old $\alpha=0,924$; Outcome expectations young $\alpha=0,971$ old $\alpha=0,969$; Intention, young $\alpha=0,920$ old $\alpha=0,209$.

Summary Tami

There were only minor differences between the means in the two groups. Pearson's correlation show that with age comes a higher concern of interacting with the Hermes system as a way to feel less lonely. There is a negative correlation showing that the younger the participant, the more the subject perceive Hermes as belonging to it's lifestyle.

The low value of Chronbach's alpha show that the questions did not have a significant measure in the categories: Perceived disadvantages and Intention for the elderly group.

Whitney-Mann test show that the young group thinks that a memory tool as Hermes is convenient and that it belongs to their lifestyle. The same test shows that elderly group show to use Hermes as a tool for feeling less lonely than the young group.

7.2.3 Cognitive evaluation

The differences in the mean valuation of perceived memory capacity on the MAC-scale are showed in table 6. It was measured on a Likert scale ranging from 1-5. 1 means that the participants perceive having a bad capacity for that item and 5 that they perceive having a good memory on the corresponding state.

MAC

	young	old
The name of a person recently introduced to you	2,9	3,1
Specific data from an article or newspaper you have recently read	3,3	3,2
Switch off the lights, unplug the electronic devices and lock the door of your house when you go out	4,5	4,8
Intend to take something with you (for example, an umbrella or a letter), before leaving a room or going out	3,7	3,8
Remember something as a house address that you were told a few minutes ago	3,7	2,8
How would you describe your memory capacity comparing to the rest of the society?	3,2	3,5
How would you describe your memory capacity if you compare it with the highest capacity you got in the past?	3,1	2,6
Think about the moment your memory was at the highest level, how would you describe your speed ability now to process information?	3,2	2,4
How often do you get upset or frustrated due to your actual memory capacity?	2,8	1,7
How often do you have difficulty remembering a word that you want to use?	3,3	2,4
How often do you have difficulty remembering a word that is on the tip of your tongue?	3,5	2,7

Table 6. Mean points on the evaluation of the self reporting memory scale

A Pearson bivariate correlation was conducted between age and perceived memory capacity. Results show significant correlation ($*=p<0,005$) ($**=p<0,001$) between following questions: Think about the moment your memory was at the highest level, how you would describe your speed ability now to process information? $r=-.473*$ $p=,035$; How often do you get upset or frustrated due to your actual memory

capacity $=-.621**$ $p=.003$; Repeat the same story to the same person on different occasions $r=-,455*$ $p=,044$

Whitney Mann test was carried out between the two groups and showed significant ($p<0,005$) mean differences in the following items:

- Think about the moment your memory was at the highest level, how would you describe your speed ability now to process information?
- How often do you get upset or frustrated due to your actual memory capacity?

Summary MAC

The mean scores were in general lower for the elderly group which means that they perceive themselves having a worse memory capacity compared to the young group.

The negative correlation indicating that the more years a participants has the higher the feeling of that the speed of the memory is going down and the more upset or frustration over the actual memory capacity. Mann-Whitney test also confirm a significant difference between the means in the two groups on these two phrases. Further the correlation show that the more years a participant has the more the subject perceive repeating the same story to the same person on different occasions.

Prospective memory:

The young participants got an average mean of M=1,7 and old M=1,5 where 1 is no and 2 is yes. This indicates that the young group answered the questions about prospective memory correct 70% of the times and elderly 50% of the time.

CANTAB

CANTAB neuropsychological test showed following results:

Since the MOT test in mainly a screening test, the results are not presented. The PAL test that assesses visual memory and new learning and is used as a tool for assessing patients with questionable dementia, Mild Cognitive Impairment, Alzheimer’s disease and age-related memory loss shows following results in table 7.

CANTAB	young	old
PAL Stages completed on first trial	6,7	5,5
PAL Total errors (6 shapes, adjusted)		10,67
PAL Total errors (adjusted)	5,2	53
PAL Mean trials to success	1,275	2,34
PAL First trial memory score	22,6	15
PAL Stages completed	8	0

Table 7. Average means comparing young with old in the CANTAB PAL test.

The item “PAL Stages completed on first trial” measures the subject’s visual memory (working memory). Young got

M=6,7 of 8 in total and Elderly M=5,5 of 8 which show the average score on completing the levels the first time.

The Item “PAL Total errors (6 shapes, adjusted)” show the mean error result on level 6, where the old sample had an average on 10,67 errors compared to the young sample 0 before being able to complete the level.

The Item “PAL Total errors (adjusted)” show the total errors adjusted to all the levels. Young received an average of 5,2 while elderly got a result of 53 errors counted for all the levels.

The Item “Mean trial to success” shows the average number of trials the subject needed to complete the levels. Young had a mean of 1,275 and elderly 2,343 on this item.

The Item “PAL First trial memory score” is a measure of the subjects ability of visual memory (working memory) on a scale of 0-26. The young found the right pattern of M=22,6 on the first trial, while the old group managed to find M=15 on the first trial.

Summary CANTAB

The conclusion of the CANTAB test is that the elderly group in general did not perform as well as the young group on the visual memory and new learning test.

9. Discussion

All participants reported using external representations as memory cues like the calendar; post its notes etc. and one crucial detail for both young and elderly was where information was stored. They all had strategies on how to support internal processes in the best way, something that goes in line with distributed and situated cognition. Things were always stored at visible locations; the calendar was almost always placed in the kitchen; the keys just beside the door, and the medical information written on the box. It seems like where other activities during the day will take place, like for example eating which is something they know they will remember to do, and it is necessary to pass the door before going out, so consciously leaving things at certain places is a strategically choice. It seems to support the hypothesis that the external world and the internal processes are intertwined. To offload important information to an external memory and strategically use the perceptual information and internal processes when the occasion is right is a tendency seen in the actual study. A young participant confessed that the method of having a not organized way where to place notes was a bad way of remembering. At the time the information on the notes were found it was irrelevant because the information was not longer actual. How to organize the information between external representations and internal cognitive processes described by Zhang & Wang, 2009) seem to be supported.

The usability issues were something that mainly young participants commented. It was a prototype so the participants reacted since they had seen a lot of products that were more developed than this prototype. Elderly in general did not make a lot of comments on usability, they thought the prototype was good and were fascinated by the applications, something that probably comes from lack of experience with new technology. The acceptance of the different applications shows that young participants valued the system as more supportive than the elderly while performing the tasks, but elderly was not far behind. This indicates that both groups did not have any general difficulties in the interaction with the system. The higher value among the young is probably due to previous experience with technology. Older participants needed much more time to perform the evaluation and often reported needing more practise.

Elderly reported in general more detailed their memory strategies compared to young participants. They also showed a big concern towards offloading memory on technological tool since they thought that the machine would perform the cognition for them and they would become useless in some way, not using their own memory capacities. This would, according to the elderly participants lead to a worse memory. Elderly also show a higher concern on Anxiety in the UTAUT questionnaire, something that goes in line with the comments. Most of them did not think about offloading information on their environment as something equal to offloading it on a technological device. The result is interesting since it seems that elderly make an active choice not using technology support. It is not because they don't like the technology or have too much usability problems with the prototype, there does not seem to be an interest in substituting a bad working memory with a technological device. I think elderly also have a point in the comments concerning having a bad memory. How would you remember to use the device? Where the device is, when to enter information, when to search for information (even though that can be done with the help of alarms), and what to do with the information are issues that show how complex memory really is. Also small everyday things, if your memory is bad would be hard to enter in the system. For example if someone tells you to go upstairs to get your glasses, it would take too long time to enter the things in the device to carry it upstairs consult the information, which you at this point might already have forgot, take the glasses and go back downstairs.

Young participants were the ones that mainly use technological tools to support memory. They have grown up with this kind of devices and did not show any concern of not using their memory if using devices. Maybe their brains are already formed after this new thinking, something that Dascal & Dror, (2005) brings up. The technology seems to have had an impact on the way we use our brain and changed the processes themselves. We are in an interesting time area to study this since the existing generation live almost different lives in the same countries. The technological development has divided the generations to live totally

different lives, something that also affects the structure of thinking.

The main aim of comparing the two groups conducting a user evaluation was to see if age and culture played a role in how to perceive technological a memory tool. Results show that both young and elderly use memory tools and different strategies to support memory in their everyday living. As in the qualitative data there is a difference in which tools the participants use that seems to depend on age and hence by the culture grown up in. Younger users are overrepresented in computer and mobile use, while elderly users are overrepresented in TV use which is a technological device that came into their life while they were kids. Both groups use calendar as a way to support prospective memory, with the difference if it is digital (in the mobile phone) or the kitchen version that is used.

The young group shows higher results on acceptance of new technology in the "Attitude towards new technology test, and in the category "technology attitude in the Tami questions, but not in the category Attitude towards using technology in the UTAUT. This result was not expected and the tests did receive high values on the Chronbach's alpha Tami: young $\alpha=0,903$ old $\alpha=0,924$; UTAUT: young $\alpha =0,876$, old $\alpha =0,963$. The contradicting results can be due to the few questions in the UTAUT (only 4). Even though elderly valued new technology with lower score than young they have a positive attitude in general. The attitude in the UTAUT test showed that elderly had better attitude towards the system regarding the technology questions, the young sample did have higher value in the Technology profile and the Tami.

A negative correlation is found between age and the perceived combination between Hermes and other systems used something that also indicate that younger better accept a technological tool as Hermes. Mann-Whitney test showed a difference on two questions in the Facilitation and indicate that younger perceive being helped of the system in a higher rate than elderly.

The results on the acceptance of the system questionnaires UTAUT and Tami show no mayor differences between the two groups. Elderly rated $M=4,58$ of 7 on the category Behavioural intention in the UTAUT questionnaire, which was slightly higher value than the young sample $M=3,63$. This is something contradictory to the results in the qualitative data where elderly were the ones indicating not want to use the system. Both groups are still very close to the middle points which mean that they do not have either very high intention or low intention to use the system. The result can depend again on previous technology use, that young users had more practise and could perform the tasks easier, and that elderly thought the system was intelligent. It can also depend of a methodology problem, when comparing means it is hard to say something about these results since eventual differences is hard to see while putting them all in one group.

The elderly rated higher than the young sample on the Emocards that was administered after each task. This was not expected since it is not in line with how they perceived the support the system affords. Many elderly thought the faces were funny which might give the result on voting on the cute, happy ones; and not relating the faces to their actual experience with the applications in the Hermes system.

The differences between the participant groups on the cognitive evaluation show a normal cognitive decline in the elderly group when measuring prospective and working memory tasks, as well as a decreased ability to learn new things. Elderly participants do receive fewer scores than younger both on the CANTAB measure and on the MAC-scale which means that elderly are well aware of their memory decline. Even though elderly in general show mild memory problems in the CANTAB and prospective memory test and also perceived memory capacity MAC and so could be expected to be willing to use a technological support, they showed in comments that they did not intend to use it if available. Elderly also perceived having less memory capacity now than when they were in their best state, something that also indicated more awareness of their age related memory decline.

The comments made in the category “Elderly not wanting to use the Hermes system” indicate that elderly already have a preferable system that they have built up during the years. The routine of shopping seem to be a well established task that elderly perform without a lot of effort. They didn’t see the use of an external memory system as very useful, since they were already satisfied with their actual system. The habits in general need less cognitive processes since they are well known and frequently performed tasks that goes almost automatically in line with the research by (Tobias, 2009). Comments as “I don’t have time to learn something like this, it works well as it is”; and “I don’t need any technological device to do this” indicates that a routine system is something that elderly prefers. This also points at that the external world and internal processes are intertwined as suggested in the introduction and that it is not easy to introduce something new in an already structured life. The saying: “you can’t teach an old dog how to sit”, might have a significant value in this case meaning that once a system is well integrated in the everyday living between an individual and its external world it can be difficult to change. To prefer old patterns are something that also supports the theories that less cognitive resources are needed when performing well known tasks, hence a support for memory (Tobias, 2009). The things that are performed often are things easier to remember, many participants reported always shopping in the same store, buying the same products. Things that were written down were things that were important or not used frequently. This indicates routine and also of having internalized tasks that once were external in line with Activity Theory (Kaptelinin & Nardi, 2006).

The participants reported the social importance of remembering, the relation with their spouse, family or friends. They offloaded not only information on external

storage but the memory process involved other individuals. Within the elderly group there was utterances as “my husband takes care of that”, or “my wife tells me what to buy so I don’t have to think about that”. Younger had parents reminding them of important things as medical appointments and both groups reported talking with others as a good support for the retrieval of memory. Together and through the conversation they perceived an enhanced memory capacity. This is something indicating that the social interplay and context is important for memory as activity theory suggest.

According to activity theory tasks are gradually internalized and not needed to rely on external representations. It would be interesting to make future studies that test if a decline in memory means that internalization of tasks goes back to externalization. More studies with the activity of humans in the focus could lead to further knowledge of the memory processes and challenge the traditional memory structure. This would maybe lead to the gap between what we know about cognitive processes and technology.

10. Conclusion

Age and hence culture seems to impact the way you perceive a cognitive technology.

Since elderly seem to be well aware about their age related cognitive decline it seems like if they make an active choice not using cognitive technology. They have an already well developed and integrated system between their internal cognitive resources and the external environment.

When designing helping aids most of the focus is directed towards homogenate groups, even when held to be user centred design, for example targeting the group “elderly”. In practice the use of an aid is different for different people, for example the social context and the environment and culture individuals live in do affect the way individuals use memory processes. This means that the suggestion of putting cognition in a wider framework such as Activity Theory could give a better understanding of how cognition actually works and of how to approximate the complex empirical world in an alternative way. The examples from the real world settings could be used to better understand complex cognitive strategies and by that provide a better design of products aimed to enhance cognitive processes, as memory.

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Appendix 1. Semi structured interview questions

Before we start to get to know the interface of the Hermes system I would like to ask you a couple of questions regarding how you do in everyday life to support memory. We all use different strategies how to remember things. These strategies can be external or internal. Take the time needed to think about your strategies.

How do you usually do to remember the following:

- When you want to remember an appointment? For example you bump into a friend on the street. You start to chat but decide to meet up for dinner during weekend since you have a lot of things to do for the moment. How would you do to remember the appointment?
- To remember things in the past? How do you do to remember conversations, information etc.? For example a birthday lunch that took place a month ago?
- To remember something that someone is telling you? For example you are at the doctors and he explains the kind of medication you have to take, and you want to remember that when you arrives home?
- To remember names and persons? For example your doctor has a new receptionist. You want to remember the name, how would you do that?
- To remember something you have to buy? For example your friends are coming in for the weekend and you must buy milk, bread, coffee etc.

Appendix 2. Technology usage, memory tool usage and attitude towards new technology

Please indicate which ICT-products or services you use and how frequently you use them.

Product:	Usage:				
	Never	at least 1x a day	at least 1x a week	at least 1x a month	more rarely
PC or Laptop	<input type="checkbox"/>				
Mobile phone	<input type="checkbox"/>				
Digital Picture Frame	<input type="checkbox"/>				
TV	<input type="checkbox"/>				

Please indicate which memory support tools you use and how frequently you use them (create or look at entries).

Tool:	Usage:				
	Never	at least 1x a day	at least 1x a week	at least 1x a month	more rarely
Notepad	<input type="checkbox"/>				
Post Its	<input type="checkbox"/>				
Diary	<input type="checkbox"/>				
Blog	<input type="checkbox"/>				
Calendar	<input type="checkbox"/>				
Digital calendar	<input type="checkbox"/>				
Photo albums	<input type="checkbox"/>				
Online photo albums	<input type="checkbox"/>				
Video recordings	<input type="checkbox"/>				
Online videos	<input type="checkbox"/>				

What is your opinion towards the following statements?

Technical appliances (such as mobile phone and Internet) help to better organize my personal life.

Disagree Agree

I find it good that I can keep in touch with people I care via technical appliances (such as mobile phone and Internet).

Disagree Agree

The disadvantages which some technical appliances can cause just belong to this kind of appliance.

Disagree Agree

It is good that all kind of administrative forms are available via Internet (for example a change of address form).

Disagree Agree

With the arrival of the Internet, the possibility for everyone to participate in society has grown.

Disagree Agree

I find it good that when I want to know something, I can also get that information via technical appliances.

Disagree Agree

Appendix 3. Task with Hermes Home System

HERMES System was explained and tested by giving users several tasks. The users were encouraged to think out loud while doing the tasks and the interviewer took notes while the users performed the tasks.

Tasks with HERMES Calendar.

1. **Create new Entry:** Please, imagine that you have to see the doctor next Monday at 11:30 for a check-up. You do not want to be late / forget it, and a good way to be sure of that it is introducing the appointment in HERMES. Try to enter this appointment in HERMES Calendar. If you want, you can also record a voice note with additional details.
2. **Browse and View Appointments:** Imagine now that later on you are at home and you want to look up the time of the medical check-up you introduced in the system before. Please, browse the entries in Calendar and view the details of the appointment. Apart from the medical check appointment, can you see other entries in the calendar? Is any entry associated with an audio note? Can you hear it? What is it about? Can you re-record it?
3. **Change entry:** The doctor calls you to change your appointment on Monday at 11:30. The new time for the doctor's appointment will be on Friday at 12 noon. Please change the time and date of the appointment with the doctor.

Task with Hermes MyPast.

1. **Time Search:** Last June, several activities were conducted in the laboratory. Some people were celebrating a birthday, drinking coffee, playing cards, reading, eating and visiting the doctor.
2. **People Search:** Jose's birthday was last June. He met all his friends in the laboratory to celebrate. Teresa, his wife, was there. Also, they were playing cards and drinking coffee. Please find entries between May and July where your friend Teresa and Jose are involved. How many entries do you find?
3. **Photo search:** Esteban and Antonio are two friends who are very fond of playing cards. They were in the lab and they taught us a new card game. All were playing this game. Please find the entries associated with your friend Esteban and Antonio. Also, Esteban were reading a poem. Where was the last entry with Esteban recorded?
4. **Event search:** Jose's birthday was very fun, especially when he had to blow the candles on his birthday cake. Please find this entry, which took place between May 2010 and July 2010. What happened?

Tasks with Locations, People and Shopping List applications.

1. **Viewing Locations:** Browse the locations. Which places are on your list? Set a reminder for "Flower shop". The next time you come by there, you want to be reminded to buy flowers for Rosie. (this application was not tested in the end due to technological problems with the GPS, researchers comment)
2. **Viewing Photos of People:** Browse the pictures of people. Who is on your list? Set a reminder for "Peter". The next time he visits you, you want to remind him to give him back a book you lent.
3. **Managing Shopping Lists:** Browse the shopping lists. Which items are on your shopping lists so far? Add a new item: "Bread".

Task with Cognitive Games

4. **Play the Maze game:** Please, imagine that you arrive home and sit in your sofa. You start using HERMES, and the system suggests you to play a Cognitive Game.
5. **Play the Puzzle game:** Please, imagine that you don't want to play the Maze game anymore and select another game in the game menu of the system.
6. **Play the Who Is Who Game:** Please, imagine that you have played the Puzzle game for quite a time and the system suggests you to play the Who is Who game. It explains you that this game consists of matching names and personal traits of your friends and relatives, so you decide to play it.

Task with Hermes Mobile

1. **Creating a New Appointment:** You meet David, a friend of yours. You begin to talk, but then you decide that you could meet on the weekend because now you have something to do. Please enter this new appointment.
2. **Changing an Appointment:** Your friend calls you to change the weekend's appointment. You will see next week, on Tuesday at 3 p.m. Please modify the appointment to the new date.
3. **Recording a Conversation:** While you are at the doctor, the doctor tells you some information about the medication you need to take. In order not to forget any important details, you record the conversation. Please use HERMES Mobile to record some seconds of conversation.
4. **Setting a Location Reminder:** You are looking for a present for your friend David. You see something nice, but you don't have any time because you have a doctor's appointment. You decide to add this location and a reminder associated with it in your HERMES Mobile. When you pass by this location, the device will remind you. Please go to an outdoor position. Then use the system to introduce this location ("book shop") and a reminder ("buy present for David"). They used the GPS functionality to add location reminder when there was 3G coverage. (this application was not tested in the end due to technological problems with the GPS, researchers comment)
5. **Viewing and Taking Photos of People:** Your doctor has a new receptionist. In order not to mix her up, you decide to store her name and a picture of her on your HERMES Mobile. Use HERMES Mobile to save name ("Anna – receptionist") and a photo of her. Browse the other persons. Who else is already on your list?
6. **Creating a Shopping List:** Your friends will come to visit you so you need to buy coffee, tea, milk and some cookies. Please use HERMES Mobile to introduce these items into your shopping list.
7. **Synchronisation:** The system includes a synchronisation process. All things you enter on your HERMES Mobile device can be synchronised with the HERMES system in your home. Please sync HERMES Mobile with the home system by attaching it to the connection cable.

Post task questionnaire

After each task with the system the participant was asked to answer the post task questionnaire followed:

How well did the system support you in solving the task?

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1: The system has not supported me at all	2: The system has supported me only in some parts of the task	3: Undecided	4: The system has supported me in almost all the tasks	5: The system has supported me at every moment

If you think the system should provide a better support (mainly responses 1 and 2), please think of the technologies you are currently using in your daily life and write down / tell us how it could be improved:

Have you identified specific difficulties by completing this task? Yes No

If Yes, please specify:

Problems understanding the icons on the screen? Yes No

Problems reading text on the screen? Yes No

Problems with colours of the screen? Yes No

Problems following the changes on the screen easily after tapping it? Yes No

Problems understanding which action / response is expected from you? Yes No

Other: _____

Appendix 4 – Memory Assessment Questionnaire (MAC-Q)

How would you describe your capacity to remembering the next activities?

	1	2	3	4	5
	Very poor	Poor	Average	Good	Very good
The name of a person it has just been introduced to you					
Specific data from an article or newspaper you have recently read					
Switch off the lights, unplug the electronic devices and lock the door of your house when you go out					
Intend to take something with you (for example, an umbrella or a letter), before leaving a room or going out					
Remember something as a house address that you were told a few minutes before					

Please indicate the answers that suit you better:

	1	2	3	4	5
	Much worse	Worse	Same	Better	Much better
How would you describe your memory capacity comparing to the rest of the society?					
How would you describe your actual memory capacity if you compare it with the highest capacity you got in the past?					
	Much slower	Slower	Same	Faster	Much Faster
Think about the moment your memory was at the highest level, how would you describe your speed ability now to process new information?					
	Never	Rarely	Sometimes	Quite often	Very often
How often do you get upset or frustrated due to your actual memory capacity?					

The following questions are about minor memory mistakes that everyone makes from time to time, but some of them happen more often than others. We would like you to tell us how often in your opinion these things happen to you.

	1	2	3	4	5
How often do you feel you are in this situation?	Never	Rarely	Sometimes	Quite often	Very often
Repeat the same story to the same person on different					

occasions?					
Have difficulty remembering a word that you want to use?					
Have difficulty remembering a word that it is on the tip of your tongue?					
How often do you come up with familiar faces without knowing why do you know them?					

Appendix 5. Emocards



The following table shows the correspondence between the code of the EmoCards and the label of the emotional expression from right to left in the picture above:

Desiring
Dissatisfied
Contemptuous
Inspired
Disgusted
Aversive
Indignant
Appreciative
Bored
Disappointed
Attracted to
Pleasant surprise
Fascinated
Enthusiastic

Appendix 6 - Questions for the evaluation of the prospective memory

EPISODIC MEMORY 1: Please, in 15 minutes tell me that we have to make a rest.

Result: _____

EPISODIC MEMORY 2: When I give you a pen, please sign in this paper (*give the participant the pen in 20 minutes*).

Result: _____

EPISODIC MEMORY 3: Please ask me in 2 minutes when we are going to finish the session.

Result: _____

EPISODIC MEMORY 4: When I give you a piece of paper, please write there your address.

Result: _____

Appendix 7: UTAUT

All items are measured on a seven point Likert scale, where

- 1 = completely disagree,
- 2 = moderately disagree,
- 3 = somewhat disagree,
- 4 = neutral (neither disagree nor agree),
- 5 = somewhat agree,
- 6 = moderately agree
- 7 = completely agree.

Scales / Items
Performance Expectancy (PE)
PE1: I find the HERMES system useful in my life.
PE2: Using the HERMES system enables me to accomplish tasks more quickly.
PE3: Using the HERMES system Mobile increases my productivity.
PE4: Using the HERMES system increases my chances of leading an active lifestyle.
Effort Expectancy (EE)
EE1: My interaction with the HERMES system is clear and understandable.
EE2: It is easy for me to become skilful at using the HERMES system.
EE3: I find the HERMES system easy to use.
EE4: Learning to operate the HERMES system is easy for me.
Attitude toward Using Technology (AT)
AT1: Using the HERMES system is a good idea.
AT2: The HERMES system makes life more interesting.
AT3: Living with the HERMES system is fun.
AT4: I like living with the HERMES system.
Facilitating Conditions (FC)
FC1: I have the resources necessary to use the HERMES system
FC2: I have the knowledge necessary to use the HERMES system
FC3: The HERMES system is not compatible with other systems I use.*
FC4: A specific person (or group) is available for assistance with the HERMES system difficulties.
Anxiety (AX)
AX1: I feel apprehensive about using the HERMES system.
AX2: It scares me to think that I could lose a lot of information using the HERMES system by hitting the wrong key.
AX3: I hesitate to use the HERMES system for fear of making mistakes I cannot correct.
AX4: The HERMES system is somewhat intimidating to me.
Behavioural Intention to Use the System (BI)
BI1: I intend to use the HERMES system in the next semesters if I would have access to it.
BI2: I predict I would use the HERMES system in the next semesters if I would have access to it.
BI3: I plan to use the HERMES system in the next semesters if I would have access to it

Note: * indicates reversed scale.

Appendix 8 – TAmi Technology Acceptance Questionnaire

We would like to ask you some questions about the HERMES scenarios:

Question number 1 - Would you use the HERMES system when it becomes available?

- Definitely not
- Probably not
- I don't know
- Probably yes
- Definitely

Question number 2 - Does HERMES make the use of a memory support tool more or less fun?

- Definitely less fun
- Less fun
- Neither more nor less fun
- More fun
- Much more fun

Question number 3 - What do you think; does HERMES make the use of a memory support tool easier or more difficult?

- Definitely more difficult
- More difficult
- No difference to others
- Easier
- A lot easier

Question number 4 - In your opinion, in how far would you have more or less control over the use of your current memory support tool compared with the HERMES system?

- Definitely less control
- Less control
- No difference to others
- More control
- Much more control

Question number 5 - Do you expect that HERMES offers you more or less convenience in using a memory support tool?

- Definitely less convenience
- Less convenience
- No difference to others
- More convenience
- Much more convenience

Question number 6 - With the HERMES system an attempt is made to increase personalisation of a memory support tool. How appealing do you find this?

- The personalization possibilities are not at all appealing
- The personalization possibilities are not very appealing
- The personalization possibilities don't bother me
- The personalization possibilities are appealing
- The personalization possibilities are very appealing

Question number 7 - To what extent do you find the combination of a memory support tool with all kind of information and communication technology useful?

- Not useful at all
- Not useful
- This combination doesn't bother me
- Useful
- Very useful

Question number 8 - Could you indicate in how far you are planning to buy the HERMES system when it becomes available?

- I definitely won't buy it
- I don't plan to buy it
- I don't know
- I plan to buy it
- I definitely plan to buy it

Question number 9 - If you give permission, HERMES can record any activity in your living room, in order to allow you to retrieve videos afterwards, if you don't remember what happened. How attractive do you find this possibility?

- Very unattractive
- Unattractive
- Neither unattractive nor attractive
- Attractive
- Very attractive

Please motivate your rating: _____

Question number 10 - If you give permission, the HERMES system identifies all faces detected by its cameras, so you can easily search for certain persons in your video archive. Thus you can see who was visiting you at home and when. How attractive do you find this possibility?

- Very unattractive
- Unattractive
- Neither unattractive nor attractive
- Attractive
- Very attractive

Please motivate your rating: _____

Question number 11 - Please rate the following statements: I think HERMES is ...

- | | | | | | | |
|----|-------------|--------------------------|--------------------------|--------------------------|--------------------------|------------|
| | | | neutral | | | |
| a) | bad | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | good |
| b) | unwise | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | wise |
| c) | harmful | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | beneficial |
| d) | undpleasant | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | pleasant |
| e) | worthless | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | valuable |
| f) | joyless | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | enjoyable |

How likely are the following reasons for you to use HERMES?

Question number 12 - To make remembering things easier for me.
very unlikely very likely

Question number 13 - Because it offers me more freedom.

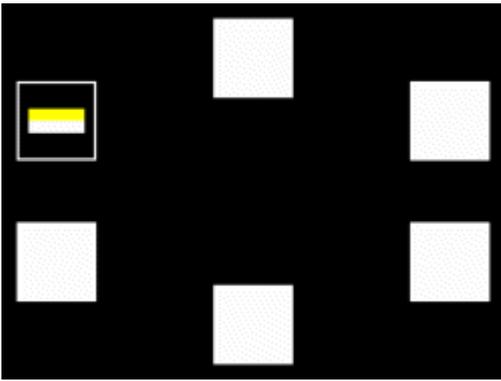
- very unlikely very likely
- Question number 14 - Because it makes task in the home more pleasant.
very unlikely very likely
- Question number 15 - To make daily domestic activities more pleasant.
very unlikely very likely
- Question number 16 - Because I like to use such appliances.
very unlikely very likely
- Question number 17 - To be entertained.
very unlikely very likely
- Question number 18 - To be able to do different things at once.
very unlikely very likely
- Question number 19 - To have more control over my daily life.
very unlikely very likely
- Question number 20 - Not to have to do everything by myself.
very unlikely very likely
- Question number 21 - To make my everyday life easier.
very unlikely very likely
- Question number 22 - Because it is convenient that I do not have to carry out certain tasks myself.
very unlikely very likely
- Question number 23 - To save time.
very unlikely very likely
- (social outcomes)*
- Question number 24 - To strengthen my relationship with family and friends.
very unlikely very likely
- Question number 25 - To be able to communicate with family and friends.
very unlikely very likely
- Question number 26 - To maintain valuable contact with others
very unlikely very likely
- Question number 27 - To belong to a particular group.
very unlikely very likely
- Question number 28 - To have something to talk about with others.
very unlikely very likely
- Question number 29 - To have something to do.
very unlikely very likely
- Question number 30 - When I am bored.
very unlikely very likely
- Question number 31 - To relax.
very unlikely very likely
- Question number 32 - When I don't have anything else to do.
very unlikely very likely

- Question number 33 - To feel less lonely.
 very unlikely very likely
- Question number 34 - As a way to pass time.
 very unlikely very likely
- Question number 35 - Because it is something new.
 very unlikely very likely
- Question number 36 - To be able to support my own memory.
 very unlikely very likely
- Question number 37 - To discover new possibilities.
 very unlikely very likely
- (fashion/status)*
- Question number 38 - Because these appliances are modern.
 very unlikely very likely
- Question number 39 - To keep up with the newest technology.
 very unlikely very likely
- Question number 40 - Because it belongs to my lifestyle.
 very unlikely very likely
- Question number 41 - Because it increases my status.
 very unlikely very likely
- Question number 42 - When HERMES becomes available, I will use it.
 very unlikely very likely

Appendix 9: CANTAB



The first, the motor screening test (MOT) is typically used in the beginning of a test session. It takes about 3 minutes to complete and the participants basically try out the system and get introduced to the use of a touch screen. The task is to simply point with the index finger at a flashing cross when it shows up at different locations on the screen. The outcome of the test is 2 measures: the subject's speed of response and the accuracy of the subject pointing. If a subject is unable to perform this simple test it's unlikely that they will be able to complete the following tests successfully. This test is then used as a screen for visual, movement and comprehension difficulties.



The second test is a visual memory test, called Pair associates Learning (PAL). It's a challenging test which takes about 10 minutes to complete depending on level of impairment. It's a test that assesses visual memory and new learning and is used as a tool for assessing patients with questionable dementia, Mild Cognitive Impairment, Alzheimer's disease and age-related memory loss. There are patterns displayed in the middle of the screen, one at a time, and the subject must touch the box where the pattern was originally located. The boxes are presented in a randomised order and the number of patterns varies between 1 and 8 and depends of the increase of the level of difficulty during the test. If the subject makes an error, the patterns are re-presented to remind the subject of their locations. The outcome measures of the test covers the errors made by the subject, the number of trials required to locate the pattern(s) correctly, memory scores and stages completed.