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New technology and everyday functioning at home for persons with cognitive impairments after acquired brain injury

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ABSTRACT

The thesis comprises four studies focusing on developing knowledge about the possibilities that new technology and compensatory training can offer to enable everyday activities for persons with cognitive impairments after acquired brain injury (ABI).

In Study I the participants received a home-based cognitive training program in their own home environment. In Study II new kinds of electronic memory aids previously not used for patients with cognitive impairments were developed and installed in a training apartment in the hospital. Patients stayed for five days each to learn and use the electronic memory aids in everyday activities. In Study III the participants moved to two study apartments for long-term use (4 or 6 months) with a set of electronic memory aids. In Study IV an electronic memory aid with wireless sensors was installed in the participants` own home to give spoken reminders for selected activities.

The results in Studies III and IV demonstrated that the participants perceived the electronic memory aids to be useful and most wanted to continue to use them after the intervention. The results indicate that the use of electronic memory aids in everyday activities can increase everyday functioning and independence as well as satisfaction with performance, quality of life and safety for the user and their families, and also unburden their spouses (Studies III and IV). It was also shown that it is important to include family in decisions and assessments to be able to adapt the electronic memory aid to meet the users' and families' preferences to the extent possible (Study IV).

In Study I the results showed that the persons with memory impairments improved in memory and attention, though they had previously participated in rehabilitation at the rehabilitation clinic and spontaneous recovery was ruled out. In studies II and III, the findings showed that persons with cognitive impairments could learn to use multiple electronic memory aids by intensive training and support from an occupational therapist, but there were great differences in the time needed (Study III). The results in Study IV showed that four of five participants improved in remembering to perform the selected activities with support by spoken reminders.

The findings showed that electronic memory aids with an intuitive interface were easy to use and hardly any training was needed (Studies III and IV). Complex electronic memory aids that had to be used in different steps were difficult to learn and training was needed over a longer time (Studies II and III). Electronic memory aids that forced new behaviors on existing routines constitute hinders for learning (Studies II and III). There were problems with the technology during the studies, indicating the need for testing the usability of the technology in healthy subjects before applying the technology to persons with disabilities. There is also a need to increase collaboration with engineers to develop appropriate electronic memory aids for persons with memory impairments.

In conclusion, it is possible for persons with mild and moderate memory impairments after ABI to learn how to use multiple electronic memory aids with training and support by an occupational therapist (Studies II, III and IV). Factors influencing learning were the design of the electronic memory aid and the severity of memory impairment, which effected the time needed to learn how to use the aid (Studies II, III and IV). The results indicate that there is a large potential for electronic memory aids to enable persons with mild to moderate memory impairments after ABI to carry out everyday activities and increase independence, safety, satisfaction with performance and quality of life for the users, and also unburden their spouses (Studies II, III and IV). The results indicate the need for individual assessments of both cognitive capacity and specific activity needs to match electronic memory aids to the user (Studies II, III and IV).

Keywords: acquired brain injury, assistive technology, cognitive rehabilitation, electronic aids to daily living, memory impairments, occupational therapy

LIST OF ABBREVIATIONS

ABI	Acquired Brain Injury
AMPS	Assessment of Motor and Process Skills
APT	Attention Process Training
COPM	Canadian Occupational Performance Measure
EBIQ	European Brain Injury Questionnaire
FIM	Functional Independent Measure
HAAT	Human Activity Assistive Technology
MoHO	The Model of Human Occupation
MMSE	Mini Mental State Examination
OT	Occupational Therapist
QoL	Quality of Life
RBMT	Rivermead Behavioral Memory Test
SIP	Sickness Impact Profile
TBI	Traumatic Brain Injury
VAS	Visual Analogue Scale

LIST OF PUBLICATIONS

The thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I Boman, I-L., Lindstedt, M., Hemmingsson, H., & Bartfai, A. (2004). Cognitive training in home environment. *Brain Injury*, 10, 985-995.

II Boman, I-L., Lindberg. Stenvall, C., Hemmingsson, H., & Bartfai, A. A training apartment with a set of electronic memory aids for patients with memory difficulties after acquired brain injury. *Submitted.*

III Boman, I-L., Tham, K., Granqvist, A., Bartfai, A., & Hemmingsson, H. (2007). Using Electronic Aids to Daily Living after acquired brain injury: A study of the learning process and the usability. *Disability & Rehabilitation: Assistive Technology,* 2, 23-33.

IV Boman I-L., Bartfai, A., Borell, L., Tham, K., & Hemmingsson, H. Support in everyday activities with a home-based electronic memory aid for persons with memory impairments. *Submitted.*

CONTENTS

Papers I-IV

FOREWORD

The point of departure for the research project was an interest in examining occupational therapy interventions for persons with memory impairments after ABI aiming to enable everyday functioning in their home settings. In the first study cognitive training in the home environment was examined. Cognitive training had been used in occupational therapy for a long time. During the work with Study I, new technologies such as electronic memory aids were developed to be used in a new training apartment at a rehabilitation clinic. At that time there was limited knowledge as to whether or not persons with memory impairment could learn to use multiple electronic memory aids. There was also limited knowledge of the possibilities of home-based electronic memory aids to enable everyday functioning among persons with memory impairments. Therefore, the use of these electronic memory aids was first examined in standardized settings in a training apartment at a rehabilitation clinic in Stockholm (Study II), and two study apartments were integrated in a new building (Study III). Finally, in Study IV, the possibilities of individually adjusted electronic memory aids with wireless sensors and speech-reminders were integrated in the participants' own homes in order to enable everyday functions.

INTRODUCTION

Cognitive impairments after acquired brain injury (ABI) are frequent, (Patel, Coshall, Rudd, & Wolfe, 2003), influencing everyday function in self-care, productivity and leisure (Caprani, Greaney, & Proter, 2006; Eriksson, Tham & Borg, 2006; Fish, Manly, Emslie, Evans, & Wilson, 2007; Gentry, Wallace, Kvarfordt, & Bodisch-Lynch, 2008). Persons with cognitive impairments might, for example, forget to take medication, eat lunch, turn off the stove or turn up for appointments (Fleming, Schum, Strong, & Lightbody, 2005). Traditionally, two major approaches, the remedial or/and the compensatory approach, are used in occupational therapy to improve performance in everyday activities after ABI (Trombly, Radomski, Trexel, & Burnett-Smith, 2002). The remedial approach focuses on systematic and structured training attempting to remediate the impaired cognitive function and establishes new networks (Govander, & Kalra, 2007). The compensatory approach is a method using external or internal strategies to go around the impairment in order to be able to perform an activity (Fleming, Shum, Strong, & Lightbody, 2005). Assistive technology (AT) is an important part of the compensatory approach and has historically been frequently used in occupational therapy to enable persons to carry out activities that they find meaningful and important in everyday life (American Occupational Therapy Association, 2002; Smith, 2000). However, AT has mostly been designed for persons with physical impairments and not for persons with cognitive impairments (Lange, 2002). One reason for that could be that AT is too difficult, or impossible to learn how to use, for persons with moderate or severe memory impairments (Hart, Buchhofer, & Vaccaro, 2004; Kim, Burke, Dowd, Robinson Boone, & Park, 2000). However, advances in new technology in recent years have opened new possibilities for persons with cognitive impairments (Orpwood, 2008).

Acquired brain injury

Acquired brain injury (ABI) is an injury to the central nervous system that can affect its structure and function resulting in impairments of cognition, communication and/or physical function (Lishman, 2004). ABI is used as a generic term including both non-traumatic and traumatic brain injury (TBI). TBI may include open or closed head injuries. About 15,000 persons sustain a TBI in Sweden (Lexell, 2007). Non-traumatic brain injuries include strokes, non-traumatic hemorrhage, tumour, infectious diseases (e.g., encephalitis, meningitis) hypoxic injuries, metabolic disorders, and toxin exposure. Stroke is a generic term for disturbances of cerebral function that have a vascular origin and includes cerebral infarction (85%), cerebral hemorrhage (about 10%) and subarachnoid hemorrhage (about 5%)

(Socialstyrelsen, 2005). About 25,000 persons have a stroke each year in Sweden (Riks-Stroke, 2007). It is estimated that about one third of those who have a stroke will have residual symptoms that will influence their lives (Sundberg, Bagust, & Terént, 2003). Encephalitis is caused by an inflammation of the brain due to infection. Encephalitis can be caused by a variety of reasons, such as bacterial or a viral infection, a complication of an infectious disease, parasitic or infections, such as toxoplasmosis and malaria (Lishman, 2004). There are no statistics of how many persons there are that have persistent cognitive symptoms after ABI in Sweden.

Memory impairment is the most frequent cognitive consequence of ABI (Fish, Manly, Emslie, Evans, & Wilson, 2007). Memory impairments can reduce independence when performing basic activities of daily living (ADL) and instrumental activities (IADL) (Patel, Coshall, Rudd, & Wolfe, 2003). Persons with memory impairments might also forget things they need to do during the day and forget appointments (Fleming, Shum, Strong, & Lightbody, 2005). They might also forget that someone has called and left a message or things they did earlier in the day and wondered later if they remembered to take their medications or pay a bill (Gorman, Dayle, Hood, & Rumrell, 2003) As a result, persons with memory impairments following ABI often require rehabilitation.

Rehabilitation of persons with ABI

In Sweden, as soon as patients with ABI are medically stable, they are transferred to inpatient rehabilitation followed by outpatient rehabilitation phase, provided for those who are in need of it. Rehabilitation is provided in multidisciplinary teams, including occupational therapy, which aims at improving everyday functioning and participation in the community and to evaluating the possibilities of making a return to work (Johanson, 2004; Turner-Stokes, Disler, Nair, & Wade, 2004; Toglia, 2005). Hochstenbach (2000) has described rehabilitation as a learning process with a main goal to regain optimal functional independence. Wilson (2002) has defined cognitive rehabilitation as the process whereby persons with ABI work together with health service professionals to reduce disability and improve everyday functioning as well as participation in a person's self-selected environment. Occupational therapy plays a unique and important role in cognitive rehabilitation for a person with cognitive impairments to enable everyday functioning (Hoffman, Benett, Koh, & McKenna, 2007).

Occupational therapy for persons with ABI

A central concept in occupational therapy is activity, which means what people do in everyday life. The focus of occupational therapy interventions is on everyday functioning and to enable clients to engage in their desired everyday activities (Kielhofner, 2008). In the thesis, everyday functioning is defined as being able to perform activities that the person wants and needs to perform or is expected to perform by society. Occupational therapists build their competence on frames of references from occupational therapy and related fields, such as psychology and medicine, etc. The Model of Human Occupation (MoHO) (Kielhofner, 2008) provides theory aimed at explaining aspects of how persons engage in everyday activities and, how they are motivated, patterned and performed. The model is based on a dynamical systems theory and in the model of how the components of the person and the environment interact and influence everyday functioning (Kielhofner, 2008).

The person is conceptualized as being made up of three interrelated components: volition, habituation and performance capacity. What a person does is a function of these three components and environmental influences which interact into a dynamic whole (Kielhofner, 2008). Volition is the motivation for activity and is about awareness of a person's knowledge of his or her abilities, what one finds important to do and what is enjoying and satisfying to do. Volition requires the capacity to formulate a goal and then plan and initiate performance of an activity (Abreu, & Toglia, 1987). Habits are patterns and routines of activities that are unique to each person, provide structure in our lives and are reflected in our roles (Kielhofner, 2008). In occupational therapy, habits are central to give structure in everyday life (Dunn, 2002; Hasselkus, 2000). In cognitive rehabilitation, habits are important since persons with memory impairments often are dependent on daily routines and habits (Sohlberg, & Mateer, 2001). A routine is several skills linked together into a sequence. In order for habits to become automatic, efficient routines are needed (Worthington & Waller, 2008). In occupational therapy it is important to provide training for skill performance so that the ability to perform the activity gets easier and can become a routine (Kielhofner, 2008). Performance capacities are the physical and mental capacities we have to perform everyday activities (Kielhofner, 2008). Performance depends on musculoskeletal, neurological, cardiopulmonary, and other body systems, and the capacity to perform also depends on cognitive abilities. In order to design appropriate interventions, occupational therapists need to understand the underlying functions and mechanisms and to influence the ability to perform everyday activities (Hoffman, Benett, Koh, & McKenna, 2007).

In addition, occupational therapists must understand the environment in which activities take place. The environment affects what people do and how they do it (Kielhofner, 2008). The environment provides resources that may facilitate, hinder or demand performance. The environment is made up by social and physical, cultural, economic and political dimensions, which have an impact upon motivation, organization, and performance (Kielhofner, 2008). The physical environment includes built and natural environments and objects, which are naturally occurring or fabricated things which persons use when doing things. The spaces are the places where persons do things, for example, in the home: occupational forms or activities that are available, and/or required by the context. The social environment includes, for example, family, friends, co-workers, and neighbors. The culture affects both physical and social aspects of the environment. The political and economic contexts influence the freedom to make choices and recourses relevant to everyday functioning, especially important for persons with disabilities. In Sweden, it is possible to receive home modification service on the permanent features of the indoor or immediate home environment (Ministry of Health and Social Affairs, 1992). County councils and municipalities are obliged to provide people with disabilities with AT to improve or maintain function or ability. But county councils and municipalities themselves decide on rules for AT, such as if an electronic memory aid is regarded as AT and whether a medical prescription is available to people with disabilities. Therefore the possibilities of receiving a specific aid may vary, depending on where the person is living. According to the MoHO, a change in any one of the components in the dynamic whole can alter the total dynamic of the activity (Kielhofner, 2008).

There are several models of AT that have been developed to offer predictive theories for research and to support health professionals to match AT to the person and to predict usage (Lenker, & Paquet, 2003). The Human Activity Assistive Technology model (HAAT) (Cock, & Hussey, 2002), provides a theoretical understanding of how AT works in a context, adapted from theory of human performance and behavior by Baily (1989). The HAAT model describes the interaction of the person and the AT to accomplish an activity in a given context (Arthanat, Bauer, Lenker, Nochajski, & Wu, 2007). The HAAT model recommends that some measures be used as outcome measures of AT such as the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) (Demers, Weiss-Lambrou, & Ska, 1996), the Canadian Occupational Performance Measure (COPM) (CAOT, 2002), and the Psychosocial Impact of Assistive Devices Scale (PIADS) (Day, & Jutai, 1996). The Matching Person and Technology model (MPT) (Scherer, 1998), emphasizes the

interaction between the environment, the person and the technology. The MPT model emerged from qualitative research based on grounded theory with persons with physical disabilities who identified aspects related to the use of AT (Brown-Triolo, 2002). The MPT model includes a structured assessment to facilitate the selection of AT. The current models of AT identify diversity of factors that may influence the use of AT (Lenker, & Paquet, 2003). However, these models are not developed specifically for persons with cognitive impairments, considering cognitive impairments, difficulties with new learning, or awareness of cognitive difficulties in everyday activities and the need of AT as support. Nor, do these models consider the importance of families or carers as support in the form of reminders if the technology fails.

Occupational therapy interventions for persons with cognitive impairments

Traditionally, in occupational therapy two broad approaches—the remedial and the compensatory—are used to improve everyday functioning (Lee, Powell, & Esdaile, 2001). The remedial approach includes changes to the person (i.e., skill acquisition) (Unsworth, 2007). The compensatory approach includes compensatory strategies, adaptations or modifications on the physical environment (Toglia, 2005).

The remedial approach

The remedial approach is provided in occupational therapy using, for example, paper and pencil, computerized exercises, or worksheets (Blundon, & Smits, 2000). In the thesis the remedial approach is defined as a method to retrain body functions, i.e., attention, memory, and motor function (Unsworth, 2007). In the literature, the remedial training appears to be controversial concerning the validity and efficacy in improving cognitive impairments (Blundon, & Smits, 2000; Ylvisaker, Jacobs, & Feeney, 2002). Although the remedial approach has been criticized Uomoto (1992) has argued that cognitive rehabilitation should start with remedial training of attention since attention is a necessary basic cognitive process incorporating multiple functions in order to utilize incoming information. One attention training program that has been found to be effective is the Attention Process Training (APT) (Sohlberg, & Mateer, 1986) for persons with TBI and mild cognitive impairment (Cicerone, 2005). Sohlberg and Mateer (1989) have argued that it can also improve memory as an indirect method.

The compensatory approach

The compensatory approach is frequently used in occupational therapy to improve performance in everyday activities (Bass-Haugen, 2005). The compensatory approach includes external and internal strategies. An external strategy is defined as a method that is linked directly to the environment to support persons with cognitive impairments to carry out everyday activities (Fish, Manly, Emslie, Evans, & Wilson, 2007). Examples of external strategies are calendars, memory notebooks, diaries, checklists and AT (Toglia, 2005). An internal strategy is defined as a mental strategy that can be used to facilitate learning and remembering information (Sohleberg, & Mateer, 2001). One example of an internal strategy is mnemonics that includes anything that helps persons to remember, such as association, encoding, chunking, verbalization, repetition, self-cues, visual images, or study techniques (Blundon, & Smits, 2000). During recent years, several studies have reported the effectiveness of compensatory strategies for persons with memory impairments (Carney, Chesnut, Maynard, & Mann, 1999; Cicerone, 2005; Trombly, Radomski, Trexel, & Burnett-Smith, 2002). Studies have shown that for a successful use of a compensatory strategy, the patients have to be motivated to use a compensatory strategy, and it is important to actively involve the patients in identifying the goal of the treatment (Cicerone, 2005; Kapur, Gliskey, &Wilson, 2004).

Assistive technology (AT)

AT is an important part of the compensatory approach. AT is a broad concept that is defined as any product (including devices, equipment, instruments, technology and software) especially produced or generally available, preventing, compensating, monitoring, relieving or neutralizing impairments of body structures and body functions, restrictions in activities and problems in social participation (ISO9999). AT for persons with physical dysfunctions is rapidly developing and several studies have reported the effectiveness of AT, to enhance quality of life and decrease caregiver burden (Cook, & Hussey, 2002; Craddock, 2006; Jutai, 2000). Persons with cognitive impairments also need AT that is not cognitive challenging (Dewsbury, Clarke, Rouncefield, Sommerville, Taylor, & Edge, 2004). However, research is sparse on AT for persons with memory impairments (Orpwood, 2008). One reason for that can be that there is limited knowledge of which activities that persons with memory impairments need support for and how to design AT to be usable for persons with memory impairments.

New technology and electronic memory aids for persons with memory impairments

Advances in new technology in recent years have opened new possibilities for persons with memory impairments. New technology is a broad concept and in the thesis new technology refers to commercial yet not available, devices that are designed/developed/under development to be used generally by persons with memory impairments. There are benefits in using commercially available technologies used by the general population, eliminating the costs of specialized development aids (Hart, Buchhofer, &Vaccaro, 2004). The concept design for all is a promising approach, aiming to design products and environments that can be used by anyone, regardless of age or ability (Tahkokallio, 1998). It is important to include persons with cognitive impairments to the greatest extent possible in design for all. Commercially available technologies such as cell phones and handheld computers have been successfully used by persons with mild memory impairments to carry out things they needed to do with training in how to handle them (Gorman, Dayle, Hood, & Rumrell, 2003; Thöne-Otto, & Walter, 2003).

There are a variety of portable electronic memory aids such as pagers, cell phones, voice organizers and handheld computers with adapted software programs found to be effective for persons with memory impairments (O´Neil- Pirozzi, Kendrick, Goldstein, & Glenn, 2004; Thöne-Otto, & Walther, 2003; Wilson, Emslie, Quirk, & Evans, 2001; Wright, Rogers, Hall, Wilson, Evans, & Emslie, 2001). Such portable electronic memory aids are more effective than traditional external compensatory aids, such as calendars, diaries or notebooks as they include alarm functions to remind persons to carry out activities (Caprani, Greaney, & Porter, 2006; Fish, Manly, Emslie, Evans, & Wilson, 2007). Even if commercially available technologies are designed to be usable by all people, the user interface might be too difficult or impossible to learn how to use for persons with cognitive impairments (Kim, Burke, Dowd, Robinsson.Bone, & Park, 2000). Some electronic memory aids can only be used by caregivers to enter reminders; thus, families need to be involved as well. There is a lack of knowledge relating to the concept design for all, regarding how to design a more suitable interface to increase the possibilities for persons with memory impairments to use new technology (Wang, Badley, & Gignac, 2006).

The use of multiple electronic memory aids

However, one single portable electronic memory aid might not be enough as support to carry out everyday activities for persons with memory impairments after ABI (Ellis, & Kvavilashvili, 2000). In a home environment they might need various kinds of memory aids

such as alarm functions for the stove, the water and the front door. Recently, sensor-based electronic memory aids that can be used in the home environment to communicate with sensors through a wireless network in order to monitor if activities have been performed. No studies have been found that examine the use of electronic memory aids that include wireless sensor systems to support persons with memory impairments in carrying out everyday activities in a home setting. There is also a lack of knowledge of the possibilities of installing sensor-based electronic memory aids in the person's own home environment, regardless of the type of accommodation, and regardless of whether the person lives alone or with a family.

Teaching and learning methods

What is learning? Simon (1990) defines learning as changes to the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn from the same population more efficiently the next time. In order to provide individualized training that responds to each person's strengths and limitations, occupational therapists need to know something about learning theory to understand how persons think and how they store and use information (Stern, 2008; Suinicki, 2004).

Memory is a complex function that can be broadly defined as the capacity to store experiences and perceptions for recall and recognition (Abreu, & Toglia, 1987). Two major types of long-term memory can be distinguished: declarative (explicit) and non-declarative (implicit) memory. Declarative memory concerns the ability to report something explicitly and implies conscious awareness (Sohlberg, & Mateer, 2001). It is made up of two subsystems: semantic and episodic memory. Semantic memory is the storage of facts and episodic memory is the recall of personal experiences in time and place (Sohlberg, & Mateer, 2001). Non-declarative learning ranges from very simple forms of learning such as conditioning to complex forms such as cognitive, motor and emotional learning. Persons with cognitive impairment after ABI often have difficulties with episodic memory, which has a negative impact on their ability to learn new knowledge (Evans, Wilson, Schuri, Andrade, Baddeley, & Bruna, 2000). According to Wilson (2002), the limitations with models of memory are that they could identify problems and describe what to train—but not how to do it.

Two systematic teaching and learning methods have shown to be particularly successful for persons with cognitive impairments after ABI. The vanishing cues method was designed specifically to tap into the patient's preserved abilities to produce recently produced

words in the presence of fragment cues (Glisky, Schacter, & Tulving, 1986). Errorless learning is a teaching method, whereby patients are prevented from making mistakes or rather reducing errors during the learning (Wilson, 2002). In clinical practice the method of errorless learning was a major breakthrough for rehabilitation of persons with severe and moderate memory impairments (Hunkin, Squires, Parkin, & Tidy, 1998; Wilson, 2002). However, the method of errorless learning limits a person to a restricted range of activities, while persons with mild and moderate memory impairments need a wider range of learning methods (Bartfai & Boman, in manuscript). Even if errorless learning has been used in rehabilitation in recent years, it is not yet know whether this is the best method of learning for persons with other cognitive impairments than memory impairments.

In occupational therapy a strong emphasis is put on individually adjusting interventions to fit each person at "just the right challenge" to facilitate performance (Yerxa, 1998; Eriksson, Karlson, Söderström, & Tham, 2004). Ayres (1972) introduced the concept "just the right challenge" as a key principle in occupational therapy with a sensory integration approach designed to guide interventions to enable performance in everyday activities. The concept "just the right challenge" is based on Vygotskij's model of the Zone of Proximal Development (ZPD) that is a model about children's learning (Vygotskij, 1978). The ZPD is defined as the distance between what a child can do independently and what can be helped to achieve with competent assistance. This means that occupational therapists should provide "just the right challenge" for persons with memory impairments to encourage optimal use of the person's capabilities for performance to reach occupational goals.

Generalization and the transfer of learning

Generalization of remedial and compensatory training is a key issue in occupational therapy. Generalization occurs when the patients can perform an activity that is similar to, but not the same as, the learned activity (Bass-Haugen, 2005). One difficulty with training in rehabilitation clinics is that the transfer of learning across very different activities and environments does not occur spontaneously (Sohlberg, & Raskin, 1996). Fleming and colleagues (2005) have pointed out that the training should be provided in a variety of settings, to facilitate the transfer of learning. Toglia (2005) has recommended that in order to facilitate the transfer of learning of an activity in the hospital, occupational therapists should train the transfer of learning into the patients' real life performance situations. Other studies have shown that compensatory training should be conducted in the familiar environment where the activity should be performed (Eriksson, Karlsson, Borell, & Tham, 2007; Trombly,

Radomski, Trexel, & Burnett-Smith, 2002; Von Koch, Widén Holmqvist, Wohlin Wottrich, Tham, & Pedro-Cuesta, 2000).

In summary, the thesis aims to contribute to the knowledge and methods of new technology for persons with memory impairments in order to enable everyday functioning in a home setting and to study the use of multiple memory aids. It is of importance to investigate and describe how the design can facilitate or hinder learning, in order to better understand how electronic memory aids should be designed for persons with memory impairments. Furthermore, there is a lack of knowledge about how to provide individually adjusted training for persons with memory impairments to learn how to use multiple electronic memory aids.

The intention is to contribute to the knowledge of how occupational interventions of electronic memory aids should be provided and to contribute to develop methodological approaches in future studies on how to implement electronic memory aids in the home settings. One additional intention is to provide recommendations regarding the design of future home-based electronic memory aids.

AIM

General aim

The general aim of the thesis was to contribute to the development of occupational therapy interventions in the home settings of persons with memory impairments after ABI. The focus for the thesis was to explore possibilities for support from electronic memory aids to enable everyday functioning in the home environment for persons with memory impairments.

Specific aims

- To examine the efficacy of cognitive rehabilitation for persons with ABI in their everyday environment and to evaluate the effects not only on impairment, but also on activity and participation levels (Study I).

- The aim of this study was twofold: 1) to investigate whether patients with memory difficulties after ABI are able to learn how to mange multiple electronic memory aids designed for supporting memory integrated in a training apartment in a hospital during a stay of five days, and 2) using the same setting for identifying everyday activities among a defined set of activities that these patients tend to forget **(**Study II).

- To describe the learning and long-term use of a pre-selected set of electronic memory aids for persons with memory impairments after ABI, and to describe change in function and quality of life (Study III).

- To examine the possibilities of a home-based, individually adjusted electronic memory aid with wireless sensors in the original home environment as support for persons with memory impairments (Study IV).

METHODS

During the research project, occupational therapy interventions for persons with memory impairments have been in focus. The possibilities of different intervention methods have been explored and evaluated in different settings. Studies II, III and IV, the possibilities of new technologies in forms of electronic memory aids were examined. Since these interventions are new, there was a need to develop and apply new research designs and methods for data collection and analysis. Therefore, the methodological approaches used in the project are innovative and need to be discussed in order to further develop the methodological approaches in future studies of how to implement electronic memory aids in the home settings of persons with memory impairments.

Study design

Studies I, II and III were pilot studies and in Study IV a single-subject design with a multiple baseline AB design was used. Pre-post assessments were conducted in all studies and follow-up assessments were made in Studies I and IV. For an overview see Table 1.

Table 1. Overview of the study goals, some aspects of the intervention, study setting and design in the thesis.

	Study I	Study II	Study III	Study IV
Study goals	To improve in attention, to be able to generalize the attention training into everyday activities and to use internal and external compensatory strategies to improve in activities prioritized by the participants	To learn how to use multiple electronic memory aids as support in everyday activities in a home like training apartment	To learn how to use multiple electronic memory aids and to use as support in everyday activities	To use a home-based electronic memory aid with wireless reminders as support in everyday activities in the home environment
Intervention	Remedial and compensatory training using internal and external strategies	Compensatory training using a set of electronic memory aids	Compensatory training using a set of electronic memory aids	Compensatory training using an electronic memory aid with wireless reminders
Time for the intervention	9 days, 3 times during 3 weeks	5 days during one week	4 or 6 months	12 weeks
OT support for learning	Extensive	Extensive	The first 3 weeks and more if needed	During the first day when the electronic memory aid was installed
Study setting	Home environment or work	A training apartment at the rehabilitation clinic	Two study apartments in the inner city of Stockholm	Home environment
Study design	Pilot study, pre-post follow-up assessment design	Pilot study, pre-post assessment design	Pilot study with pre-post follow-up assessment design	Single-subject study with a multiple baseline design, and pre-post follow-up assessment design

Participants

All participants in the thesis had reported memory problems in everyday activities and were motivated and interested in learning how to use compensatory strategies or electronic memory aids as support. This group was selected since memory impairment is the most common cognitive consequence after ABI. The participants ranged in age from 22-76 years (median 51 years). The participants in Studies I, III and IV were discharged from the rehabilitation clinic and were living independently in the community. In Study II, nine of the patients were inpatients at the rehabilitation clinic just before discharge and the other five patients were outpatients. The participants in the thesis had minor or no motor dysfunction after ABI, except for one participant in Study III who used a wheelchair. Most of the participants in the thesis were on sick leave as they were not able to work. For a description of the characteristics of the participants in the thesis see Table 2.

Table 2. Characteristics of the participants in the thesis.

	Study I	Study II	Study III	Study IV
Gender F/M	5/5	6/8	2/6	4/1
Age: median, (range)	52.5 (22-60)	52.5 (25-76)	36.5 (24-53)	47 (33-58)
Diagnosis	Stroke n=7 TBI n=1 Encephalitis n=2	Stroke n=11 TBI n=3	Stroke n=2 TBI n=6	Stroke n=5
Time since onset: median, (range)	12.5 months (9-40 months)	4.5 months (2-41 months)	7 years (2-16 years)	1.5 years (1-8 years)
RBMT profile* median (range)	18 (12-22)	19.5 (10 -24)	18 (11-20)	15 (6-21)

*RBMT, Rivermead Behavioral Memory Test (Wilson, Cockburn, & Baddeley, 1991): normal memory function 22-24, poor memory function 17-21, moderate memory function 16-10, severe memory function 9-0. Observe that moderate memory function denotes worse memory function than poor memory function.

Procedure and interventions

The occupational therapy interventions in this thesis were designed to enable the participants to carry out everyday activities. The interventions took place in different home settings, the training apartment (Study II), the study apartments (Study III), and the participant's own home (Studies I and IV). For an overview see Table 1.

Study I

In Study I, ten participants with memory impairments received individual cognitive training, one hour, three times weekly, for a period of three weeks, in the their own home or at work. The occupational therapy intervention was carried out in the environment where the

compensatory strategy should be conducted in order to facilitate learning (Hart, Buchhofer, & Vaccaro, 2004). The occupational therapy intervention was based on the principle of mixing the remedial and the adaptive compensatory approaches (Pepin, Loranger, & Benoit, 1995). The intervention included remedial training with APT (Sohlberg, & Mateer, 1989) for 20 minutes. The APT material includes graded worksheets and audiotapes that are systematically graded to place increasing demands on different aspects of attention. The APT-material is based on a model of attention with training tasks that are hierarchically arranged (Sohlberg, & Mateer, 1989). The OT picked out a task at "just the right challenge" (Ayres, 1972) for each of the participants.The second part of the intervention consisted of teaching strategy generalization tasks for everyday activities related to the APT training. For example, problems in performing particular APT tasks and parallels between difficulties in everyday activities were discussed. The last 20 minutes of the training focused on possible compensatory strategies for self-selected memory difficulties in everyday activities. The participants listed the number of activities that they would like to perform better and assigned an order of priority, i.e., which problem to start with first.

Treatment effects were evaluated with neuropsychological, occupational therapy instruments, as well as questionnaires, before and after the-three-week periods of training and the follow-up after three months.

Study II

In Study II, fourteen patients with memory impairments stayed for five days in a training apartment to learn how to use multiple electronic memory aids. A training apartment equipped with multiple electronic memory aids and security functions was built in a Swedish rehabilitation clinic. The purpose of the training apartment was to provide a safe opportunity for patients to get experiences of living in a homelike environment before returning home. The training apartment was designed to be safe, homelike, and aesthetically furnished with a private atmosphere appropriate for patients with cognitive impairments to carry out everyday activities and social life. During the stay the patients were expected to care for themselves and to participate in their regular treatment activities on the ward. In order for the patients to be able to stay alone in the training apartment, a set of electronic memory aids were developed. These electronic memory aids were prototypes and are not commercially available.

The electronic memory aids in the training apartment included:1) a daily schedule and address book, 2) control panels, and 3) kitchen alarms. The control panels and the kitchen alarms were based on a communication bus system, the European Installation Bus

(EIB) system and sensors. The EIB system listened to the sensors and talked to the appropriate electronic memory aid in the training apartment in order to initiate an alarm signal.

1) The daily schedule and the address book were installed on a standard stationary personal computer. Important activities that the patients wanted to be reminded of were entered in the daily schedule. The address book included pictures of relevant caregivers to remind the patient who is who.

2) The control panel should be used before the patients left the training apartment or went to bed to check if they had forgotten to close the windows or the terrace door, or turn off the TV.

3) The kitchen alarms included warning signals for the refrigerator and the freezer, the stove and running water.

The occupational therapy intervention included individually adjusted training at "just the right challenge" (Ayres, 1972) based on the patients' ability to learn how to use the electronic memory aids. The OT assisted the patients to integrate the use of the electronic memory aids in everyday activities as much as possible during the stay of five days in the training apartment. The training method was influenced by certain principles of errorless learning (Wilson, Baddeley, Evans, & Shiel, 1994), since the literature suggests that if patients are prevented from committing errors during the learning process, they will learn more quickly (Kapur, Glisky, & Wilson, 2002).

To measure the patients' ability to learn how to operate the electronic memory aids independently, the OT conducted daily structured observations using "the status protocol" (a checklist). The patients' use of the control panels and which activities that the patients had forgotten to perform were automatically registered in a computer as well as the activation of the kitchen alarms.

Study III

Eight participants with memory impairments stayed for four or six months in two study apartments to learn how to use multiple electronic memory aids to enable everyday functioning. The study apartments were located in a new building in the inner city of Stockholm that consisted of 126 apartments of varying sizes, all equipped with new technology designed to be used by all. The two study apartments also included electronic memory aids designed for persons with memory impairments. Most of the electronic memory aids in the study apartments were prototypes and had not previously been used in real home environments.

The functions that were designed to be used by all in the new building included an "away lock" for the front door, which could turn off equipment and activate alarms in the study apartment. There was an electronic key to open the door to the lobby and common areas. A laptop computer installed in the kitchen had a calendar and functions for bookings of common facilities, etc. The participant could see and talk to visitors via a video camera before letting them into the building.

The electronic memory aids that were designed for persons with memory impairments included a remote control with two buttons. One button should be used in the evening to turn off all lightning, power to the stove and the coffee machine. If the front door was left open, there was a voice message. The other button should be used in the morning to turn on a selection of lamps, power to the stove and the coffee machine, and to raise the Venetian blinds. If someone stayed in bed in the morning, a timer should be used to switch on the electricity in the kitchen. Motion detectors turned on a soft light in the bedroom and the hall when somebody got up in the night. There was a stove guard in the kitchen and photo controlled water taps in the bathroom. A telephone combined with photos was installed to enhance telecommunication and facilitate the handling of received telephone messages.

The occupational therapy interventions included an introduction period of the electronic memory aids in the training apartment in the rehabilitation clinic for 2-3 days before the participants moved into the study apartments. In the study apartments the participants received training at "just the right challenge" (Ayres, 1972) based on the participant's ability to learn and his/her level of fatigue in order to learn how to use the electronic memory aids during the first three weeks of the stay. The participants received additional training if needed. The training was individually adjusted to fit each participant's daily routines and habits and the OT assisted the patients in integrating the use of the electronic memory aids in everyday activities as much as possible. The training method was influenced by certain principles of errorless learning (Wilson, Baddeley, Evans, & Shiel, 1994), since the literature suggests that if patients are prevented from committing errors during the learning process, they will learn more quickly (Kapur, Glisky, & Wilson, 2002).

To measure the patients' ability to learn how to use the electronic memory aids independently, the OT conducted observations once a month using "the status protocol". Everyday functioning and quality of life were assessed with self-rating questionnaires during the introduction period at the end of the intervention. Usefulness of the electronic memory aids was assessed with self-ratings.

Study IV

Five persons with memory impairments received a newly developed home-based electronic memory aid with sensors installed in their own home as support to carry out self-selected activities in the home environment. This electronic memory aid was chosen since it communicated with sensors, via a wireless network, was rather easy to install and could be individually adjusted in the user's home. However, the electronic memory aid was newly developed and had never been installed in the user's own home. The electronic memory aid consisted of a computer which operated as a network terminal, through radio units and wireless connection, with sensors in the home environment. The system was programmed to give spoken reminders for self-selected activities at scheduled times. The system could also send a short text message (SMS) to the user's cell phone, make a phone call or send an e-mail to a person not present in the home environment.

The occupational therapy intervention included six steps: 1) To examine the need of an electronic memory aid; 2) The participants identified three activities each that they had difficulties to remember to carry out and two control activities that they usually remembered to carry out on a daily basis. Families were invited to take part, since the installation of the electronic memory aid affected the whole family; 3) A plan for the reminders was planned together with the participants (for example, the times for the reminders to be activated, the time intervals and the number of reminders); 4) A home visit was conducted in order to formulate a plan for the installation of the electronic memory aid. The participants and their families were involved to ensure that the plan for the installation would fit the participant's and the family's needs and situation; 5) The electronic memory aid was installed in the participant's home. The reminders were demonstrated to make sure that they were appropriate for the participants. The OT showed the participants how they should respond to the reminders and carry out the activities. They received written information about the electronic memory aid and phone numbers for technical support in case of any problems with operating the electronic memory aid; and 6) The reminders were started one at a time with one-week intervals. The OT telephoned each participant every time a reminder had started to check that the electronic memory aid was working accurately. In case of problems, the reminder was adjusted.

The number of reminders and performance of the selected activities were automatically registered in the computer and were used as an objective measure of completed activities. Assessments of occupational performance and satisfaction of occupational performance, quality of life and memory function were conducted before and after the

intervention and at the follow-up after two months. After the intervention and at follow-up, the participants were telephoned and asked if they were satisfied with the electronic memory aid and if they wanted to continue to use it.

Data collection

Data for the thesis were collected with: automatic computer registrations of performance (Studies II and IV), structured observations (Studies II and III), assessments instruments (Studies I and IV), measurement of occupational therapy intervention needs (Studies II, III and IV), self-rating instruments (Studies I, III and IV), field notes (Studies II and IV) and instrumentation for inclusion and exclusion (Studies I, II, III and IV).

Automatic computer registration of performance

In Studies II and IV, there were 24-hour computer registrations to monitor performance for selected activities. In Study II there were registrations if the patients activated the control panel to check if they had forgotten to close the front door, terrace door, windows or turn off the TV. Alarms for the refrigerator, the freezer, stove or water were registered by the exact time for activation. The alarm was activated if the patients had left the door of the freezer or the refrigerator open, or if the stove was left on, or if the water was running for more than 20 minutes. In Study IV there were registrations of completed selected activities.

Structured observations

In Studies II and III the learning process on how to use each electronic memory aid was measured by structured observations according to a "status protocol," a checklist developed for this research project. The learning process was rated on a four-point scale: (1=Used the electronic memory aid independently; 2= Needed one reminder from the OT to recall how to operate the electronic memory aid; 3= Needed two to five reminders from the OT to recall how to operate the function; and 4= Not able to recall how to operate the function even with >5 reminders from the OT. In Study II, the OT conducted daily observations of the learning process on how to use the daily schedule, the address book and the control panels during the five days stay. In Study III, the observations were conducted after the teaching and learning period of three weeks and once a month during the stay of four or six months in the study apartments.

Assessments instruments

The instruments were used to measure occupational therapy intervention effects.

The Assessment of Motor and Process Skills (AMPS) (Fisher, 2003) was used to measure the everyday skills on two instrumental activities of daily living (IADL) (Study I). It is an observational assessment consisting of two scales that separately measure motor and process skills while engaging in activities of daily living (ADL) or IADL. Motor skills are a person's observed skill when moving oneself or task objects as needed for ADL task performance. Process skills are actions the person uses to logically organize and adapt behavior over time in order to complete an activity. There are 16 motor items and 20 process skills items that are scored with a four-point rating (Bernspång, & Fisher, 1995).

The Attention Process Training (APT) test was used to determine the level of difficulty for the attention training with the APT and to measure improvement in attention (Study I). The APT test consists of five tasks that are designed to measure sustained, selective, alternating and divided attention.

The Claeson-Dahl test (Nyman, 1998) was used to measure verbal learning and memory (Study I). The Claeson-Dahl test is a standardized list-learning task with 10 words that should be learned after repeated presentation (maximally 10 times) and a free recall retention task after 30 minutes. Two scores are given: a learning-profile and a retention score. Claeson-Dahl test reports good reliability and validity for learning of new material (Bergman, Bergman, Engelbrektson, Holm, Johanneson, & Lindberg, 1988).

The Digit Span test (WAIS-III, 2003), was used to measure auditory attention and short-term retention capacity (Study I). The Digit Span is a test of verbal short-term memory, comprising two different tests, Digits Forward and Digits Backward. The person is read series of digits and then requested to repeat them in the same order and using Digits Backwards in an exactly reversed order. The Digit Span test has been shown to have good reliability at the Swedish standardized version (Bartfai, Nyman, & Stegmann, 1996).

The RBMT (Wilson, Cockburn, & Baddeley, 1991) was used to measure everyday memory functions before and after the intervention and at the follow-up (Studies I and IV).The RBMT was chosen since it is an ecological valid test designed to detect impairment of everyday memory functioning and monitor change over time (Wills, Clare, Shiel, & Wilson, 2000). There are four parallel versions of the test, comprising 11 subtests that aim to be analogues of everyday memory tasks (Wills, Clare, Shields, & Wilson, 2000). The RBMT measures prospective memory such as tasks that require remembering to do something later without being explicitly told to do so. The RBMT reports good reliability and

validity and correlates with observed memory failures in therapy sessions and with subjective ratings of memory problems from patients and carers (Wilson, Baddeley, Cockburn, & Hiorns, 1989).

Measurement of occupational therapy intervention needs

The instruments were used to measure occupational therapy intervention needs.

The Occupational Case Analysis Interview and Rating Scale (OCAIRS) (Kaplan, & Kielhofner, 1998) was conducted before the patients moved into the training apartment (Study II) in order to identify the patient's habits, roles, interests and to make an individual program that considered the patient's abilities, needs and requirements. The OCAIRS is a semi-structured interview that provides a structure for gathering data regarding a person's values, goals, personal causation, interests, habits, roles, skills, environmental issues, participations and adaptation (Kielhofner, 2008). OCAIRS have been found to be a valid measure of occupational adaptation (Lai, Haglund, & Kielhofner, 1999).

The Canadian Occupational Performance Measure (COPM) (CAOT, 2002) was used to measure whether the electronic memory aids were related to perceived improved occupational performance and satisfaction with occupational performance in everyday activities (Studies III and IV). The participant rated occupational performance and satisfaction with performance of the self-selected activities on a 10-point scale. Higher scores reflected better performance and satisfaction. The COPM has been shown to have good validity for patients with a variety of disabilities (Dedding, Cardol, Eyssen, Dekker, & Beelen, 2004). The COPM has been validated as an outcome measure and shown to be responsive to change over time (Wressle, Samuelsson, & Henriksson, 1999).

Self-rating instruments

The self-rating instruments were used to measure occupational therapy interventions effects.

The European Brain Injury Questionnaire (EBIQ) (Teasdale, Christensen, Willmes, Deloche, Braga, Stachowiak, et al., 1997) was used to measure self-perceived experience of difficulties that the participants experienced in their everyday lives before training and at the follow-up after three months (Study I). The EBIQ consists of 63 items that are grouped into nine domains of everyday life: somatic, cognitive, motivation, impulsivity, depression, isolation, consequences, communication and core. The EBIQ has been shown to have good reliability and validity and to be useful in research for persons with stroke (Björkdahl, Lundgren-Nilsson, & Stibrant.Sunnerhagen, 2004).

The Quality of Life (QoL) Visual Analogue Scale (VAS) was used to measure self-perceived quality of life (Studies I, III and IV). The participants rated their overall quality of their current life in comparison with their notions of the best and worst possible ratings of QoL before the intervention and after the intervention. In Studies I and IV, the participants also rated the QoL at the follow-up. The QoLVAS has been found to be more reliable than complicated questionnaires for stroke patients (Ahlsiö, Brittton, Murray, & Theorell, 1984).

The Sickness Impact Profile (SIP) (Berger, Bobitt, Carter, & Gilson, 1981) was used to measure self-perceived dysfunction according to health (Study II). The SIP contains 136 items across 12 specific categories: mobility, body care, ambulation, emotional behaviour, social interaction, alertness, communication, sleep and rest, eating, home management, recreation and work. The SIP has been shown to have good reliability and validity (Berger, Bobitt, Carter, & Gilson, 1981)

In Study III, a visual analogue scale (VAS) was used to measure the participants' perceptions concerning the usefulness of the electronic memory aids, and how difficult it was to learn how to use these electronic memory aids. At the end of the stay in the study apartments each participant rated how useful each electronic memory aid was by using a visual analogue scale (1= not useful and 10=very useful). They also rated how easy it was to learn each electronic memory aid (1= very easy and 10=very difficult).

Field notes

In Study II the OT kept field notes if the patients had problems with handling the electronic memory aids due to the design of the functions and if there were technology problems with the electronic memory aids. In Study IV, field notes were kept during the whole intervention period, e.g., during the home visit, the installation of the electronic memory aid and for occasional technical failures.

Instruments for inclusion and exclusion

The following measurements, obtained from medical records, were used to characterize participants for inclusion and exclusion. The Functional Independent Measure (FIM) (Grimby, Gudjonsson, Rodhe, Stibrant. Sunnerhagen, Sundh, & Östensson, 1996) was used as an inclusion measure (Studies II and III). The Mini Mental State Examination (MMSE) (Fohlstein, Fohlstein, & McHugh, 1975) was used in Studies I and II and the Neurobehavioral Cognitive Status Examination (NCSE) (Kiernan, Mueller, Langston, & Van Dyke, 1987) was used in Study II as an exclusion measure for severe cognitive dysfunction. The Block Design

(WAIS-III NI, 2003) was used in Study IV as an exclusion of persons with spatial or visual impairments. The Ruff 2 x 7 (Ruff, & Allen, 1996) was used in Study IV as an exclusion for severe attentional dysfunction. The Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Ky, & Curtiss, 1993) was used in Study IV as an exclusion measure for severe executive dysfunction.

Data analyses

Statistical analyses were done using STATISTICA (Version 6.0-8.0, StatSoft, Inc.). Descriptive statistics were used to describe the characteristics of the participants, the number of times equipment was forgotten in the training apartment and to analyze measures. Changes over time at group level were analyzed by using the non-parametric method, the Wilcoxon's matched pairs test (Studies I, II and III). The percentage of completed activities was calculated and the t-test was used to analyze improvement of completed activities at group level in Study IV. Spearman's rank order correlations was used in Study II in order to analyze whether the activation of the alarms and the number of occasions that the patients forgot to close or turn off equipment were associated with memory function and/or months since injury.

A line graph was plotted for each participant in Study IV, visual inspection, and the level, the change in mean, the variability and autocorrelation were used to analyze improvements of the number of completed activities over time (Ottenbacher, 1986). A qualified statistician conducted the statistic analysis in Study I and gave supervised statistic analysis in Studies II, III and IV.

A content analysis approach was used to analyze the field notes in Studies II and IV (Dahlgren, Emmelin, & Winkvist, 2007). Notes were read through to get a good understanding of the contents as a whole. The analysis was close to the data. In Study II, the focus was to find data that showed the difficulties the patients had in using the electronic memory aids, and in Study IV the focus was on data that showed the effectiveness or disadvantages of the technology or technology failure or other things that could be important for the aim of the study.

RESULTS

Home-based cognitive training (Study I)

The results in Study I indicted a positive effect of home-based cognitive training to improve some attention and memory functions. Ten persons with memory impairment improved

significantly in performance from pre- to post-training measurements in complex sustained attention (Z=2.20. p< 0.05), selective attention (Z=2.4. p< 0.05) and alternating attention (Z=2.7. p< 0.01). There were significant improvements in attention and concentration measured by the APT test on the more complex tasks between the pre-training session and the three month follow-up for complex sustained attention (Z=2.39. p < 0.05), selective attention (Z=2.08. p < 0.05) and alternating attention (Z=2.71. p < 0.01). Memory measured by RBMT improved significantly at three month follow-up (Z=2.21. p < 0.05). No significant improvement was observed on measures of everyday functioning (AMPS, EBIQ) and QoL (VAS). Thus, the results showed an additional positive effect of home-based cognitive training after completed outpatient rehabilitation in a chronic phase when spontaneous recovery was ruled out. However, improvements there only found in body function, but not on an activity level.

Learning how to use multiple electronic memory aids in a training apartment (Study II)

The results indicated that persons with memory impairments can learn how to use multiple electronic memory aids during a stay of five days in a training apartment. Analysis showed that there were significant improvements on a group level in learning how to use the electronic memory aids. The time needed for learning, however, varied. Some patients still needed support and reminders from the OT the last day in the training apartment (Table 3). Thus, the results indicated the importance of individual training and support over time in order to be able to learn how to use multiple electronic memory aids independently. The computer registrations provided the OT with important information about the participants' needs and assistance when returning home and showed that the refrigerator and the stove were most challenging to remember.

Four patients scored normal memory function according to the RBMT, and they were among those getting the most reminders and alarms during the stay; one of them received the most alarms of all patients, which indicated the need for a more comprehensive neuropsychological assessment. The study gave some valuable insights into how electronic memory aids should be designed to be usable for persons with memory impairments after ABI. For example, there were too small differences in the sound of the alarm signals and some patients had problems with distinguishing between the alarms signals and the doorbell, and this ability did not improve during the stay.

Table 3. The median number and range of reminders needed to recall how to operate the daily schedule, the address book and the control panels from day 1 to day 4 (n=14).

The daily schedule, the address book and the control panels	Day 1	Day 2	Day 3	Day 4	Z	P value
The daily schedule						
React and check activity	3 (1-3)	2 (1-3)	2 (1-3)	1 (1-2)	2.93	0.003
Confirm activity	3 (1-4)	2 (1-3)	2 (1-3)	1 (1-3)	3.05	0.002
The address book						
Find the programme	2 (1-4)	1 (1-4)	1 (1-3)	1 (1-3)	2.66	0.007
Find the correct page	2 (1-4)	1 (1-4)	1 (1-3)	1 (1-4)	3.06	0.002
Find the correct picture	3 (1-4)	2 (1-4)	2 (1-4)	1 (1-4)	2.67	0.008
The control panels						
Initiate and check	2 (1-3)	2 (1-4)	1 (1-3)	1 (1-2)	2.66	0.007
Complete and confirm the required response	1 (1-4)	2 (1-4)	1 (1-4)	1 (1-4)	1.98	0.047

1= Used the function independently; 2= Needed one reminder from the OT to recall how to use the function; 3= Needed two to five reminders from the OT to recall how to use the function; and 4= Not able to recall how to use the function even with >5 reminders from the OT.

Learning how to use multiple electronic memory aids in study apartments and the effects of long-term use on performance, satisfaction and the QoL (Study III)

In Study III, eight persons with memory impairments learned to use multiple electronic memory aids in two study apartments. The participants perceived that the electronic memory aids were very useful. The results showed that all participants could learn to use all electronic memory aids, but there was a great variation (2–24 weeks) between individual participants in the time needed. It was easiest to learn the intuitively designed electronic memory aids (4 weeks, median). The more complex electronic memory aids used combined with codes in different steps, were more difficult to learn for participants who scored moderate memory function on the RBMT. These patients had to use a checklist to remember the steps and codes. Electronic memory aids such as the stove guard and the timer forcing new patterns on existing routines, were also difficult to learn how to use. In spite of the OT's ratings, the participants themselves perceived that the electronic memory aids were easy to learn how to use.

There was a significant improvement at group level on performance rating in the COPM between the pre- and post-intervention periods ($Z=2.10$. $p<0.05$) and also on satisfaction with performance between the pre- and post-intervention periods ($Z=2.38$. $p<0.05$) (Figure 1).The SIP was used to measure the participants' self-perceived dysfunction in everyday activities, and there were significant improvements on two categories between the pre- and post-intervention periods regarding body care ($Z=1.99$. $p<0.05$) and psychosocial function ($Z=2.02$. $p<0.05$). No significant improvements were found on the other 10 categories, but the change in total SIP score was approaching the $p<.05$ level. The participants rated their own perception of quality of life using the VAS and there was a significant improvement between the pre-and post-intervention periods ($Z=2.19$. $p<0.05$).

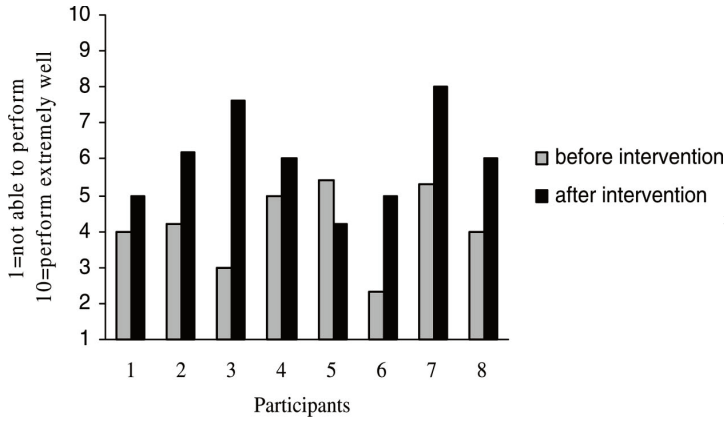

Figure 1. Change in self-perceived ability to perform selected activities before and after interventions were measured by the Canadian Occupational Performance Measure (CAOT, 2002).

Using a home-based electronic memory aid in the home environment (Study IV)

In Study IV a wireless electronic memory aid with sensors and speech-reminders was installed in five homes. Four of the five participants improved in remembering to perform a set of self-selected activities (Figure 2). After the intervention these participants wanted to continue to use the electronic memory aid, and at follow-up two participants reported decreased need for reminders, as they remembered to carry out one of the selected activities without reminders.

Two participants rated a clinically significant improvement on activities and two on satisfaction with occupational performance after the intervention and at the follow-up. Ratings of QoL were also improved (median 19 %, range 7- 42%) after the intervention. At follow-up, one participant had a major life event which affected the ratings. The other four participants rated an improvement of QoL (median 14%, range 39-54%). There were no changes in memory function after the intervention and at the follow-up using the RBMT.

According to the field notes, there were technical problems during the whole intervention which affected the participants negatively.

In conclusion, the study showed that the electronic memory aid could enable everyday functioning. Four of the five participants continued to use the electronic memory aid. It was positive that hardly any training was needed to teach them how to use the electronic memory aid. The findings indicated that the electronic memory aid can be used to re-establish routines in order to be able to remember to carry out everyday activities without reminders. The study showed the difficulties of matching electronic memory aids with the user's expectations, which is complex and highly individualized.

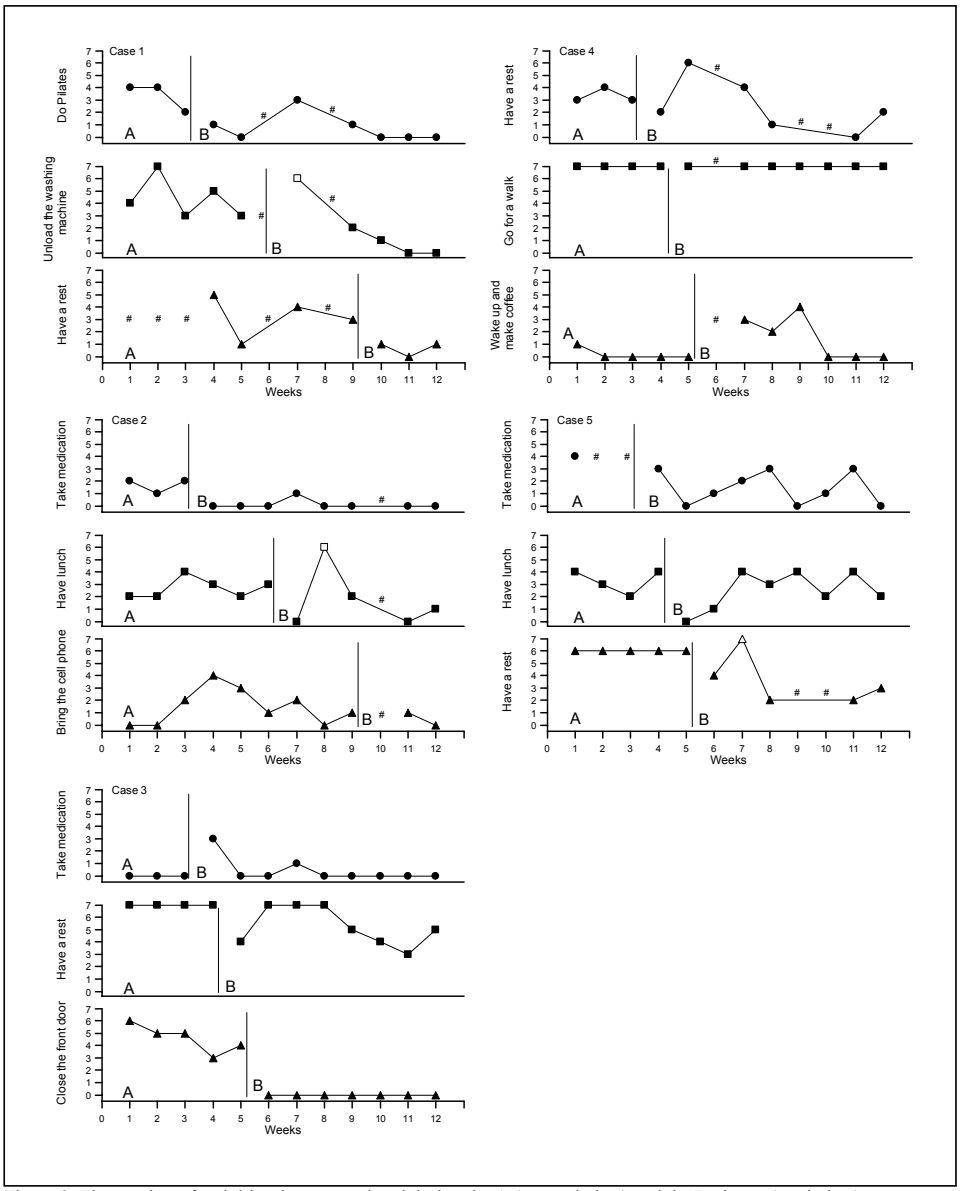

Figure 2. The number of activities that were missed during the A (no reminders) and the B phases (reminders).

The technology did not work.

GENERAL DISCUSSION

The goal of this research project was to gain knowledge on the possibilities of new technology and compensatory training for persons with memory impairments after ABI. The main focus was to examine the possibilities of multiple electronic memory aids in enabling everyday functioning for persons with memory impairments in different home settings.

Electronic memory aids enable everyday functioning

The results indicate that there is a large potential for electronic memory aids to enable persons with mild to moderate memory impairments after ABI to carry out everyday activities (Studies II, III and IV). The results showed that the participants perceived that the electronic memory aids were useful and wanted to continue to use the electronic memory aids (Studies III, and IV). The results also indicated that having the possibilities to use electronic memory aids in everyday activities can increase performance and independence as well as quality of life (Studies II, III and IV) and showed that participants who lived with a partner could carry out everyday activities without support by their spouse, unburdening the spouse (Studies III and IV). This could be an important issue since studies have shown that everyday life situations rest much more on the spouse after an ABI (Glader, Stegemaeyer, Johansson, Hulter-Åsberg, Staaf, & Wester, 2001).

On the other hand dependency on technology might be a problem. When the technology did not work, the participants did not get any reminders and spouses had to interfere again. The participants who lived alone probably forgot to carry out activities. The findings indicated that the participants perceived that safety and security were increased by the electronic memory aids (Studies III and IV). However, it was in someway a false security since the technology sometimes failed. Therefore, it is of utmost importance that technology is reliable and service is available as soon as possible. For that reason, electronic memory aids should always be tested in real environments by healthy subjects, since some persons are living in new houses and some in old houses, as well as taking into account the complexity of real-world behavior that is often missing from laboratory environments.

Occupational therapy interventions

The results in Studies II, III and IV showed that the participants could learn to use multiple electronic memory aids. But there was a great variation between individual participants in the time needed to learn how to use each electronic memory aid. The OT provided training that was individually adjusted based on the participant's interest and motivation, ability to learn, and the complexity of the interface of the electronic memory aid in order to facilitate learning.

A finding from Study IV indicated that electronic memory aids can be used to re-establish routines in everyday life. Thus, it will be interesting in a future study to examine if electronic memory aids could be used as a training method to re-establish routines in order to be able to carry out everyday activities without the electronic memory aid. This finding is supported by a study which found that a group of persons with cognitive impairments remembered to carry out some activities without reminders from a pager after using it for seven weeks (Emslie, Wilson, Quirk, Evans, & Watson, 2007).

The results showed that most of the participants needed OT support for a longer time to be able to use complex memory aids independently (Studies II and III). The difficulties with the complex memory aids were that they had to be used in different steps and did not give any immediate feedback on actions. It was difficult for the participants to know why they were doing a specific thing, and they did not receive any information when something went wrong as the input lacked immediate feedback.

Furthermore, the results indicated that difficulties to learn how to use complex electronic memory aids could be related to the severity of memory impairment (Study III). The result is in line with a study by Thöne-Otto and Walther (2003); they found that difficulties in learning how to use a cell phone with a calendar were related to the severity of memory impairment. The OT had to develop other individually compensatory strategies and enable the participants to use these strategies in order for participants with moderate memory function to be able to mange the most complex electronic memory aids independently. Thus, occupational therapists need to be aware of and integrate in their planning that a person with moderate memory impairment might need an extended time in combination with supplementary, compensatory strategies in order to be able to manage complex memory aids.

Many aspects of how a patient with cognitive impairment manages to carry out everyday activities can be understood from traditional assessments by occupational therapists, but there are aspects, which only can be monitored with 24-hour computer registrations of performance (Orpwood, 2008). Such detailed and objective data can be very helpful for occupational therapists and patients in the discussion of what sort of intervention can be supportive. For example, if a patient has difficulties to carry out activities that are important and necessary for him or her, then assistance might be needed. If the patient forgets to turn off or close equipment, an appropriate electronic memory aid might be needed in order to be able to carry out the activity independently. Therefore, a suggestion based on the results in Study II will be to use a pre-discharged assessment period with 24-hour computer registrations of

performance in a training apartment to get a clearer picture of patients' difficulties to carry out everyday activities.

The results from Studies II, III and IV indicate that in clinical practice occupational therapists should conduct individual assessments to match electronic memory aids to the user (Scherer, Sax, Vanbiervliet, Cushman, & Scherer, 2005). The existing models of AT that can be used to help occupational therapists in providing AT are mainly developed to match AT to persons with physical disabilities. These models do not include cognitive aspects, such as how the severity of the cognitive impairment or the level of awareness of disability or fatigue influences the possibilities to be able to use an electronic memory aid. For example, Wright and colleagues (2001) have pointed out the importance of awareness into the need to use an electronic memory aid as support in everyday activities. Kapur and colleagues (2004) have found that the severity of memory impairment and concern about memory difficulties are of great importance. Models of AT point out the importance of involvement of spouse/carer to encourage use of the memory aid (Cook, & Hussey, 2002; Scherer, Sax, Vanbiervliet, Cushman, & Scherer, 2005). It is also important for persons with cognitive impairments to include the spouses or carers in decisions and assessments in order to be able to choose and adjust the electronic memory aid to meet the users' and families' preferences to the greatest possible extent. But spouses or carers also need to be involved because persons with memory impairments need backup in the form of reminders from the spouse or carer if the technology fails. Another aspect that needs to be respected is that it is important to provide individually adjusted training in how to use an electronic memory aid based on the person's ability to learn. The results indicate that there is a need to further develop AT models and instruments, which take into consideration the users' cognitive capacity, learning potential and awareness for the selection of electronic memory aids. The model also has to consider the contribution of families or carers as support in the form of reminders if the technology fails.

The results of Studies I and IV indicated that occupational therapy interventions in the person's well-known home environment have a positive effect on learning and generalization. This is in line with other studies, which have shown that compensatory training should be provided in the environment where it is used (Lee, Powell, & Esdaile, 2001; Toglia, 2005). Based on this result a recommendation is to increase occupational therapy interventions in the persons own home environment.

The design of the memory aid affects its use

The results from Studies II, III and IV revealed some knowledge about how electronic memory aids should be designed to enable the use for persons with mild and moderate memory impairment after ABI.

The results showed that the design of the electronic memory aids affected how difficult it was to learn how to use them (Studies II, III and IV). Some electronic memory aids forced the participants to develop new behaviors that seemed to be hinders for learning (Studies II and III). The stove guard, for example, which was controlled by sensors, forced the participants to act in a specific way. Other electronic memory aids, such as the timer, "the good-morning and good-night functions and the control panels," forced new patterns on existing routines. Persons with memory impairments are often dependent on daily routines and habits (Sohlberg, & Mateer, 2001). For that reason electronic memory aids should support the persons' existing routines and habits rather than requiring the establishment of new behaviors.

The findings showed that complex memory aids that had to be used in different steps and did not give feedback on actions that were difficult to learn how to use. Consequently, electronic memory aids need to be designed to be intuitive. They should have cues in the user interface in order to guide the users, instead of forcing them to use compensatory strategies to be able to manage the electronic memory aid. Thus, persons with memory impairments need electronic memory aids, which have to give clear feedback on actions.

One interesting finding was that the participants in Study II perceived that technology that was designed to be used by all was most useful. However, these devices were also most difficult to learn how to use since they had to be used in different steps and did not give any immediate feedback on actions. Design for all, put strong emphazis on equipment to the highest possible extent, to be designed to fit all persons with their different needs and abilities (Tahkokallio, 1998). The results in Studies II, III and IV showed that users are very different and their needs vary and will probably change over time. This in turns indicate that if the goal of design for all shall be reached, new technology need to be very flexible and allow for easy adjustments in order to fit each user's needs and limitations. Design for all is desirable as well as a goal, based on the results in this thesis a recommendation is that new technology should be designed to be easy to adjust individually.

Occupational therapists should be more involved in the design of electronic memory aids and design for all, since occupational therapists have knowledge about the users'

abilities and disabilities, and they can bridge the gap between the users' expectations and desires (Smith, 2000). There is also a need for close involvement of users in any design solutions of new technology to get a clear understanding of the problems they are experiencing in everyday activities (Orpwood, 2008).

In Study IV the participants received sensor-based speech-reminders. All participants, except for one, perceived that the speech-reminders were useful. For that person, the voice used was inappropriate. The speech-reminders were supposed to be effective since earlier studies have found that sensors are most useful when combined with speech-reminders (Orpwood, 2008). Orpwood and colleagues (2004) have emphasized that speech-reminders are well accepted by persons with ABI. However, other studies have reported that persons with dementia might feel anxious about voices coming out of nowhere, even if most persons are familiar with voices coming out of speaker boxes (Orpwood, 2008). The positive things with sensor-based reminders are that they can provide reminders without the users getting tired or frustrated or emotionally involved in other ways, like spouses or cares might be. The sensors-based electronic memory aids provided the participants with reminders, and they did not have to rely on their spouses (Studies III and IV). However, technology cannot replace love, personal understanding and social interaction that spouses or cares can provide (Orpwood, 2008).

The flexible radio-based wireless system with individually adjusted sensors and speech-reminders used in Study IV proved to be useful, rather quick and inexpensive to install in the user's own home compared with the EIB system with hard-wires that was used in Study II. In Study III the hard-wire communication system was built into the new building. If we had used a hard-wire system in Study IV, it probably would have been complicated to install in the participants' homes. The wires would probably have been buried in the walls or in the floor. This would probably have been unsatisfying and very negative for the participants and their families. For that reason a radio-based system was used. The negative thing with the radio-based system is that the system requires electrical power, i.e., battery power which leads to additional technical problems. Thus, the sensors-based speech-reminders proved to be more appropriate than alarm signals. The flexible radio-based wireless system with individually adjusted sensors had many advantages compared with hard-wire systems, indicating that the radio-based system will be the most effective choice for installations, even in the case of new buildings.

The results (Studies II, III and IV) support occupational therapy models stating that everyday functioning is an interaction between personal and environmental factors. The

results demonstrate that both the design of the electronic memory aid and the severity of memory impairment influenced the time needed to learn how to use the electronic memory aid. Moreover, Studies III and IV indicated that the provision of electronic memory aids (i.e., changes in the environment) might increase everyday functioning of persons with memory impairments. Thus, provision of electronic memory aids might bring about increased opportunities to perform and participate in activities in the home setting, although body functions such as cognition do not improve.

METHODOLOGICAL CONSIDERATIONS

Sample

The samples in these studies were selected on the basis that they had memory difficulties, the most common complaint in everyday activities after ABI. No distinction was made due to aetiology. The selection of participants was largely influenced by the intake policies of the rehabilitation hospital, where the studies were carried out. The hospital rehabilitates adults between 18 and 65 years. Only one patient in Study II was older. Thus, the samples in these studies are not representative of the total ABI population in Sweden, when it comes to age and aetiology (Lexell, 2007; Riks-stoke, 2007), but they are representative to the patients of a rehabilitation hospital with the aim of back-to-work rehabilitation (Tölli, & Bartfai, 2007). One limitation in these studies is the small sample size, which makes it difficult to generalize the result to the population of persons with memory impairments. An additional limitation was that persons with additional disabilities of memory impairments such as neglect, dyspraxia or ataxia are in need of additional new technology and cognitive training in enabling everyday function. These additional technical requirements were beyond the scope of the present studies; hence, patients in need of these devices were excluded. Therefore, there is a need to examine the possibilities of new technology for persons with multiple cognitive disabilities.

One source of bias in the selection might be undetected cognitive problems, such as executive dysfunction problems in the patient population included in Study II. Despite the inclusion criteria of having memory difficulties in everyday activities some patients scored a normal score on the RBMT. These confounding factors indicate the need for appropriate neuropsychological assessments in order to identify persons with memory impairments.

The design chosen

The design of the studies was influenced by the settings in which they were conducted. Knowledge of how to design and control different aspects in the home environments is lacking. Studies I, II and III were planned as pilot studies with a pre-post design due to the specific research questions. For Study II, staying alone in the training apartment was part of the intervention. From an ethical point of view, patients could not stay alone in the training apartment without support from safety and security functions. For Studies II and III, the main aims were related to the learning and use of multiple electronic memory aids, and a control group was not relevant. In order to generalize the results, these intervention studies need to be replicated.

The single-subject with a multiple baseline AB design was used in Study IV to evaluate the effectiveness of the intervention. A lesson from the study was that the length of the baseline (3-9 weeks) was too short since the patients chose activities that were performed only once a day. Thus, in order to get enough data, it is important to consider that the length of the baseline is dependent on what kind of activity that is chosen. In future studies a recommendation is to increase the length of the baseline to at least nine weeks, if the chosen activities are performed only once a day.

Data Collection

It was a challenge to find instruments that could be used to identify activities that the participants had difficulties to perform and find appropriate outcome measures. Client-centered methods were used to identify activities that the participants wanted to improve performance in (Studies I, II, III and IV). In Study I, a semi-structured interview was used to identify the activities. In Study II the OCAIRS was chosen in order to identify the patients' interests, roles and habits as well as activities that were important for the patients to carry out in the training apartment in order make a schedule for the stay and to identify the patients' difficulties. Finally, in Studies III and IV, the COPM was used to identify important activities. The COPM was chosen since it has been found to be a good measure to identify goals and also because the COPM can be used as an outcome measure of using AT over time (Cook, & Hussey, 2002).

It was also a challenge to find appropriate instruments that measured outcome. In Study I the AMPS was used to evaluate the intervention effects. The AMPS was selected for its excellent psychometric qualities and flexibility as a measurement tool. However, the AMPS focus is on motor and process skills involving a wide range of activities, related in

varying degree to attention. Thus, the method requires a large change in order to obtain statistical significance. Since the intervention focused specifically on training of attention and compensatory training of self-identified activities, the AMPS was not the most appropriate instrument to observe possible changes. Therefore, more specific measurements that focus on attention and performance in self-chosen activities should be preferred. There is clearly a need for developing instruments that are sensitive enough to detect effects of improved attention in everyday functioning.

In Studies III and IV, the COPM was used as an outcome measure of using electronic memory aids. However, in Study IV the COPM created some problems with the self-ratings related to the participants' memory impairments in contrast to other studies which have found that the COPM is a good measure for showing effects of electronic memory aids over time for persons with memory impairments (Gentry, Wallace, Kvarfordt, & Bodisch Lynch, 2008; Smith; 1996). The problem was that the first two included participants in Study IV were not able to rate their current performance specific to the use of the electronic memory aid after the intervention and at the follow-up. In order to facilitate the ratings, the OT gave concrete examples of what different scores could indicate for the following participants. Instructions for modification of the procedure in this manner are not included in the manual but modifications might be necessary to facilitate the use of the assessment for persons with memory impairments. On the other hand, the COPM is a generic instrument and not a specific instrument designed to measure the outcome of using electronic memory aids. It was quite difficult for the OT to capture performance specific to the use of the electronic memory aid. Thus, there is a need to develop appropriate outcome measures that are sensitive enough to the detect effects of using electronic memory aids on everyday functioning (Bernd, van der Pijl, & de Witte, 2008; Smith, 1996). This is an area for future studies that is urgently needed.

The SIP was used in Study III to measure self-perceived dysfunction in everyday activities. The use of the SIP was not without problems. One person could not complete the questionnaire because of difficulties with comprehension of the items. Davis and colleagues (1995) have found that persons with cognitive impairments may have difficulties with comprehension and a compromised ability to recall instances of memory failure. Another problem with the SIP was its length, and some of the participants had problems with completing the questionnaire because of fatigue. The use of self-rating questionnaires in rehabilitation for persons with brain injury has been controversial (Katz, Fleming, Keren, Lightbody, & Hartman-Maeir, 2002) due to the problem that patients with brain injury in the first period of time after the injury might not show full awareness of their disability (Lezak,

2004). The participants in these studies appeared to have a basic self-awareness of their performance and realistic appraisal about how the memory impairments had impacted on their everyday functioning.

In Studies II and IV the automatic computer registrations of completed performance of predefined activities were an important outcome measure provided by the electronic memory aid. A limitation in Study II was that the computer registrations only identified the number of times that the patients, for example, forgot to turn off the stove or to close the door of the refrigerator, but not the number of times that it was used. Thus, the relation between the use and the number of activated alarms is unknown and generalization of the result should be drawn with caution. In clinical practice and in research, it would be of great value to have computer registrations of the use and the number of activated alarms; such functions could facilitate analysis between the relation of the use and the number of activated alarms. One shortcoming in Study IV was that there were no computer registrations that showed if the participants were at home. It was not possible with the present technical solution. Therefore, it was not possible to know if the participants had forgotten to perform the activity or if they were not at home and for that reason could not perform the activity.

The RBMT was selected to measure the participants' memory function because it is suggested that it has ecological validity, using tasks similar to everyday activities. In Study II four patients did not score in the range for memory impairment on the RBMT despite the inclusion criteria of having memory difficulties in everyday activities, reported and described by the patients, and observed and confirmed by the OT. These patients forgot to close or turn off equipment in the training apartment and in fact one, of them received the most alarms of all patients. The lack of correlation between the RBMT and the total number of alarms activated by the kitchen alarms and the control panels indicates that observations and computer registrations in a training apartment will give additional information regarding the patients' limitations. The results show the importance of having an assessment period in a training apartment in addition to neuropsychological tests to get a realistic picture of the patients' limitations in everyday functioning. Another explanation for the discrepancy between the RBMT and the number of alarms activated might be that these patients might not primarily have memory impairments, but executive dysfunction that is not captured by the RBMT. In a study by Emslie and colleagues (2007), findings revealed that executive dysfunction might affect the ability to use a pager, indicating that it is important to assess executive functions in combination with an evaluation for compensatory aids.

ETHICAL CONSIDERATIONS

The Ethical Committee of the Karolinska Institute, Stockholm approved the studies in the thesis. The participants gave both oral and written consent to participation. It was emphasized that participation was on a voluntary basis, and that it was possible to terminate participation at any time. The confidentiality of the data was stressed. In addition there were three major ethical issues to be considered during these studies:

1) Interventions in home settings (Studies I, III and IV); 2) Continuous data registration (Studies II and IV); and 3) The accessibility to the applied electronic aids after participation in the studies (Studies II, III and IV).

Occupational therapy interventions in the home setting require special ethical considerations. A person's home is regarded as an important place with memories and belongings, a place of privacy, safety and security, and freedom where we can be ourselves (Rowles, 2008). As guests, the OTs were alert to the participants' expression of discomfort with the intervention. The intervention was adjusted to fit each participant's needs and situation, and none of the participants expressed dissatisfaction. In Study IV it was not possible to know how sensitive the participants and family members were to even small changes in their home environments. In this study, both the participants and their families were involved to ensure that the plan for the installation should fit everybody's needs and situation as emphasized by Cook and Hussey (2002). In Study III the participants stayed for four or six months in the study apartments. The environment was unfamiliar and in order to feel more at home the participants brought things that they needed in everyday life and other things that were important for them. They also brought possessions that they had collected and cherished, which could remind them of their life history and personal identity.

The use of 24-hour registrations of the participants' performance of selected activities in Studies II and IV is an important ethical question for modern society. Orpwood (2008) has emphasized the importance that the information collected from the sensors must be available in a usable and easily understandable form to give information on how the user is getting on. The 24-hour registrations generated a great deal of data, including personal details, such as how many times a person forgot to close the door of the refrigerator or to take their medications. The recorded data in Studies II and IV were large and included a great deal of information that was not important according to the study purpose. Data was quantified to be usable for the purpose in the studies, and excess data had to be handled safely to ensure the integrity of the participants.

Most of the electronic memory aids in the thesis were prototypes and not available commercially. The participants in Studies II and III were informed that they could not receive the electronic memory aids in their own homes after the intervention, since most of the electronic memory aids were not commercially available. However, after the intervention some participants were disappointed that they could not receive the electronic memory aids, which they found were particularly useful. The OT helped the participants to find traditionally compensatory strategies as far as it was possible to be able to carry out activities that were important for them. In Study IV efforts were made to ensure the accessibility of the installation if the participants wished to do so after completion of the study. In Study IV the electronic memory aid was installed in the participants' own homes and they were informed that if they decided to keep the electronic memory aid after the study, and could not receive the electronic memory aid as a home modification or technological device, they could continue to use the aid and pay a small monthly rental fee to the manufacturing company.

CONCLUSIONS AND IMPLICATIONS

The results of the thesis provide knowledge that can be implemented in occupational therapy and in rehabilitation of persons with ABI. New methodological approaches have been designed to examine the possibilities of electronic memory aids and cognitive training.

The results demonstrate that it is possible for persons with mild and moderate memory impairments after ABI to learn how to use multiple electronic memory aids with training and support by an occupational therapist. The results indicate that the use of electronic memory aids might increase everyday functioning of persons with memory impairments after ABI. Moreover, the findings revealed that electronic memory aids might increase independence, quality of life and safety for the users and their families and, in addition, unburden the spouses. The positive results indicate that electronic memory aids should be available and provided for persons with memory impairments. Provision of electronic memory aids might bring about increased opportunities to perform and participate in activities in the home setting, even though body functions such as cognition do not improve.

The results revealed that both the design of the electronic memory aid and the severity of memory impairment influenced the time needed to learn how to use the electronic memory aid. Intuitive electronic memory aids were easy to learn and almost no training was necessary.

Complex electronic memory aids were difficult to learn and training had to be done in different steps over a longer period of time. Electronic memory aids that forced new behaviors on existing routines constitute hinders for learning. Based on these findings, electronic memory aids should be designed to be intuitive and give feedback on actions and should support existing routines and habits in order to facilitate learning. In general, new technology needs to be very flexible and allow easy adjustments in order to fit each user's needs and limitations.

An important role for occupational therapists are to make individual assessments, to select and recommend appropriate electronic memory aids, to provide proper training and to integrate the use of the electronic memory aids in everyday activities and daily routines.

An important assessment before discharge in order to get a complete picture of patients' with cognitive impairments needs and difficulties in everyday activities is a 24-hour computer registrations in a training apartment.

Models for the use of AT have to be developed to incorporate cognitive aspects, learning potential and awareness of the selection of electronic memory aids. The needs and roles of family and users should be considered more systematically. Occupational therapy instruments of specific activity needs to be related to cognitive impairments in everyday activities and must to be further improved.

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