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Postponed Plans

Prospective Memory and Intellectual Disability

Anna Levén

The Swedish Institute for Disability Research

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Linköping University,

Faculty of Arts and Science

Department of Behavioural Sciences and Learning

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Anna Levén
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Abstract

This thesis deals with prospective memory (PM) in individuals with intellectual disability. The term refers to planning and executing actions that cannot be performed immediately and have to be stored in memory and retrieved either within a specified timeframe or to be associated with a specific event. Following research questions were explored:

1. Does prospective memory performance in the intellectual disability group differ quantitatively and qualitatively compared to a control group of individuals without intellectual disability? (Paper I – II)
2. What are the relations between prospective memory, working memory and episodic memory in individuals with intellectual disability, and how are these relations different from the relations found in individuals without intellectual disability? (Paper II)
3. What conditions constitute compatibility between encoding and retrieval of prospective memory tasks? (Paper III)
4. In what way might weak binding contribute to PM failure? (Paper IV)
5. Is it possible to identify high and low PM-performing groups of individuals with intellectual disability? (Paper II)

The results of the studies demonstrated that individuals with intellectual disability commit more PM errors than individuals in the control group, despite similarities in self-rated memory. Pictures as PM cues improved PM performance in comparison to words in both groups. This may be important primarily for recognition of the PM cue, particularly in the intellectual disability group. As to working memory capacity, it also shows a relation to both PM performance and binding performance in cognitively demanding situations (e.g., tasks with multiple parallel PM tasks). Furthermore, it was found that binding is related to PM performance in the intellectual disability group as there is a relationship between feature errors and recognition of cues, though not retrieving the correct intention. Finally, time reproduction was found to be weak in the intellectual disability group compared to the control group. This may be due to, for example, weak episodic memory and limited strategies for solving this type of task. These findings are discussed in relation to PM training and PM aids.

Keywords: prospective memory, intellectual disability, working memory, episodic memory, time perception

Papers

This thesis is based on the following papers, in this thesis referred to as Paper I, II, III, and IV.

I: Levén, A., Lyxell, B., Andersson, J., Danielsson, H. & Rönnberg J. (2007) The relationship between prospective memory, working memory and self-rated memory performance in individuals with intellectual disability. *Scandinavian Journal of Disability Research.* Accepted for Publication.

II: Levén, A., Lyxell, B., Andersson, J., Danielsson, H., & Rönnberg, J. (2007). Prospective memory, working memory, retrospective memory and self-rated memory performance in individuals with and without intellectual disability. Manuscript, The Swedish Institute for Disability Research, Linköping University, Sweden.

III: Levén, A., Lyxell, B., Andersson, J., & Danielsson, H., (2007). Compatibility between encoding and execution of prospective memory in individuals with intellectual disability. Manuscript, The Swedish Institute for Disability Research, Linköping University, Sweden.

IV: Levén, A., Danielsson, H., Andersson, J., & Lyxell, B. (2007). Prospective Memory and Binding in Individuals with Intellectual Disability. Manuscript, The Swedish Institute for Disability Research, Linköping University, Sweden.

Contents

Prospective Memory and Intellectual Disability

This thesis deals with the issue of prospective memory (PM) in individuals with intellectual disability. The term PM refers to acting on plans (intentions) in the future, and is composed of memory for that something should be done, what it is, and when it should be executed (Kvavilashvili & Ellis, 1996). PM is still a relatively young field of memory research that has not, to the best of my knowledge, been studied with a focus on individuals with intellectual disability. Therefore, inclusion of a heterogeneous population with a broad spectrum of cognitive skills and origins of intellectual disability, as in the present thesis, may serve the purpose of reflecting a variety of PM performances, and how they relate to other memory processes. This first step, with a focus on methodological development, can prepare the ground for future research, relating PM to a more detailed theoretical framework.

The international research community is searching for a term with more positive valence than intellectual disability (Panek & Smith, 2005). “Mentally challenged”, has been proposed, or the widely used term “learning disability”, which, with its focus on learning as an activity, fits with the terminology of the International Classification of Functioning, Disability and Health (ICF). However, since “learning disability” in some settings refers to, for example, dyslexia or mathematical difficulties, the term “intellectual disability” will be used throughout this thesis to refer to a group with more general intellectual shortcomings.

PM will be defined in a more detailed fashion on p. 19. Memory for the future is intertwined with the past, influenced by experience, cognitive processing capacity and context. Intentions are more or less constantly entering and leaving conscious awareness in a sequential or parallel fashion in everyday life. This follows from numerous PM items, each in a specific temporal phase; being created, forgotten, stored in long-term memory, retrieved from memory, acted on, and the outcomes evaluated, in every phase influenced by other actions and plans. Thus, it is essential to create, store and retrieve the association between “what to do” and information of “when to act”. That is, to “bind“ these pieces of information. (For an extended discussion on binding, see p. 27.) PM complaints are common (G. Smith, Della Sala, Logie, & Maylor, 2000), and PM is self-rated differently from retrospective memory (Mäntylä, 2003). The difference between prospective and retrospective metamemory has been proposed to be a consequence of a difference in load on executive memory processes, which for PM partially overlap with processes involved in metamemory awareness (Mäntylä, 2003). PM, such as, passing the pharmacy on your way home, is an aspect of memory function that influences everyday life. It was early identified as one aspect of memory that is characterized by the social consequences of memory failure, such as leaving someone else waiting when you do not turn up to an appointment (cf. Meacham, 1988).

Everyday life observations of staff and relatives of individuals with intellectual disability indicate a weakness in PM function that influences adaptive behaviour in this population. The origin of this limitation has not been thoroughly investigated from a cognitive perspective. Knowledge of individuals with intellectual disability and about PM in other groups, proposes some plausible contributory factors, such as, working memory (Cherry & LeCompte, 1999). PM performance is, hence, likely to differ between subgroups with intellectual disability, as one aspect of a cognitive profile (cf. genetically dissociated components of working memory, Jarrold, Baddeley, & Hewes, 1999a). That is, research on cognitive processes involved in PM performance in individuals with intellectual disability is useful for (a) guiding specific interventions aimed at supporting PM ability, such as cognitive aid or strategy training, and (b) comparisons to other groups with cognitive limitations.

About four or five of every thousand Swedes, around 37,000 children and adults, have an intellectual disability (Hjälpmedelsinstitutet, 2005), according to an administrative definition of intellectual disability. This definition is based on the need for support in everyday life and subsequent enrolment in various special education settings (Sonnander, 1997). Based on a psychological definition of intellectual disability (IQ scores < 70), the number would increase to close to 2% of the population (Sonnander, 1997). The extensive variation in cognitive functions is in part reflected in adaptive behaviour limitations associated with intellectual disability. Adaptive behaviour refers to ability to meet up to social, academic or practical demands in everyday life by adapting either your own behaviour or the situation (cf. Schalock & Luckasson, 2004).

The relation between adaptive behaviour and PM in persons with intellectual disability has not hitherto been investigated. However, PM performance is according to research related to everyday life activities in individuals with head-injuries (e.g., patients with severe closed-head injury, Carlesimo, Casadio, & Caltagirone, 2004; frontal lesion head trauma patients, Fortin, Godbout, & Braun, 2002; patients with frontal lesions and Activities of Daily Life [ADL], Godbout, Grenier, Braun, & Gagnon, 2005; patients with traumatic brain injury and normal aging, Kliegel, Eschen, & Thone-Otto, 2004; severe closed head-injury, Schmitter-Edgecombe & Wright, 2004). The link between activities in everyday life and PM is in line with difficulties in everyday life reported by caregivers. These difficulties in adaptive behaviour may reflect frequent encounters with situations that demand processing in more than one cognitive component (e.g., Stone, Dismukes, & Remington, 2001), which results in high mental workload in particular in individuals with intellectual disability. Due to limited self-awareness, motivation for use of compensatory strategies or cognitive aid may be affected. Hence, the individual is less prepared for situations involving high mental workload.

Outline of the Thesis

As was mentioned before, this thesis deals with PM in individuals with intellectual disability. A discussion of the definition of intellectual disability narrows down to a description of cognitive issues, particularly memory processing, that are central for the research on PM. The second chapter is devoted completely to memory and to what is known about memory in individuals with intellectual disability. In the third chapter I discuss, among other things, methodological issues, and disability research, and give a brief report on Papers I – IV. The last chapter includes a general discussion on the relation between prospective memory, long-term memory and working memory. Here are also discussed prospective memory in relation to binding, time, and a few suggestions for future research.

Cognitive disability has been described as “a disability that impacts an individual’s ability to access, process, or remember information” (cf. Andersen, Wittrup-Jensen, Lolk, Andersen, & Kragh-Sørensen, 2004). That is, cognitive disability implies a limitation that can be innate or follow from different diseases and injuries, such as, the early stages of Alzheimers disease or an intellectual disability. Cognitive disability, as opposed to intellectual disability, can develop at any time during the life span and does not have to occur before adulthood. This points to what may be a weakness of the new term “mentally challenged”, which suggests inclusion of both cognitively and intellectually disabled individuals. On the other hand, “mentally challenged” fits with a universalistic perspective on functioning, since most of us experience mental challenges every now and then in our everyday life.

Intellectual Disability

Intellectual disability will be discussed both as a term and in relation to its consequences for cognition and functioning. Specifically, concepts with methodological implications and implications for PM are described. This includes a discussion of the relationship between adaptive behaviour and PM and the interpretation used in this thesis.

The term intellectual disability is questioned due to the heterogeneity of its origin and pathology, reflected in the numerous names of the condition, such as, mental retardation, general learning disorder, mental handicap, learning disability, intellectual handicap (Leonard & Wen, 2002). Intellectual disability reflects that intelligence testing has some bearing, although it is far from a sufficient or even practical criteria for defining the condition (O'Brien, 2001).

Definitions of intellectual disability generally include both difficulties with everyday life skills (social and or administrative perspective), that occur before adulthood, and scores on standardized intelligence tests that are significantly below average (psychological perspective; "DSM-IV-TR", 2000; Einfeld & Tonge, 1999, "International statistical classification of diseases and related health problems", 2003, "Mental retardation: Definition, classification, and systems of supports", 2002). Everyday life skills of individuals with intellectual disability should be compared to the skills of people of the same age and culture in order to be valid ("Mental retardation: Definition, classification, and systems of supports", 2002). Stratification of intellectual disability includes three main levels of severity; mild, moderate and profound. This partitioning has traditionally been based on IQ scores ("DSM-IV-TR", 2000), but may also be related to level of functioning (intensity of support required, "Mental retardation: Definition, classification, and systems of supports", 2002), similar to stage theories of human development in childhood. Kylén (1986) described typical cognitive abilities of three strata, based on a Piagetian perspective, which in Sweden is a widespread perspective on intellectual disability (Granlund, Björck-Åkesson, & Simeonsson, manuscript). Main points in Kyléns (1986) taxonomy about, for example, level of concreteness in reasoning and time perception, are in line with description of the activity component in ICF. The medical definition of intellectual disability is based on the individual's current level of functioning (International statistical classification of diseases and related health problems: ICD-10, 1992), which may vary due to training and rehabilitation.

Intellectual disability is congenital or acquired in childhood and is due to diseases or injuries, or has a genetic origin. Thus, the intellectual disability group is heterogeneous with respect to (a) cognitive strengths and weaknesses, (b) need for support in everyday life, and (c) additional medical conditions. Part of the variation has a genetic origin, for example, stronger visual compared to language proficiency in individuals with Down Syndrome, and vice versa for individuals with Williams Syndrome (Bellugi, Wang, & Jernigan, 1994; Klein & Mervis, 1999; Mervis & Klein-Tasman, 2000). Cognitive abilities also vary extensively within groups with intellectual disability of a similar genetic origin (e.g., Williams Syndrome, Porter & Coltheart, 2005).

The approach to cognitive functions in intellectual disability, either as a developmental delay or a development with significant differences compared to development in general, may have consequences for the discussion, and the research questions that are posed (L. A. Henry & MacLean, 2002). The present thesis includes studies with control groups; thus, it has a focus on differences or lack of substantial differences. However, the present thesis also includes a developmental perspective. Development is associated with increasingly specialised cognitive functions, as may be studied by means of correlating performance on multiple cognitively demanding tasks. Furthermore, the participants with intellectual disability in this thesis can, due to the inclusion criteria, be presumed to vary in level of development. Hence, more information may be retrieved by analysing performance in sub-groups of individuals with intellectual disability. The heterogeneity of the groups and an application of quasi-experimental designs suggest interpretation of quantitative results (predominant method) in the light of qualitative data (embedded method; Creswell, 2003).

Intellectual Disability in Relation to Intelligence, Adaptive Behaviour, and Participation

Intelligence has traditionally been approached either from psychometric or cognitive processing frameworks (Sternberg, Lautrey, & Lubart, 2003). The nature of intelligence has been interpreted as either; (a) unitary or multiple, (b) an attribute of the particular individual or of humans in general, (c) static or dynamic, and (d) more or less effected by the environment. Intelligence as a dynamic process that develops over the life-span (Li, Lindenberger, Hommel, Aschersleben, Prinz, & Baltes, 2004), points to the possibility of training some aspects of intelligence, for example, verbal working memory (Haavisto & Lehto, 2004). In particular, a division of intelligence into fluid (with a biological base, for example, cognitive speed) and crystallised (acquired from experience, for example, trained behaviour) components (Baltes, 1987) has been used to explain development (and decline) of intelligence. Fluid intelligence develops during childhood, and is fairly stable in adulthood, but declines in old age (Li et al., 2004). The decline is in part compensated by crystallised components, for which the decline begins at a later stage (Li et al., 2004). This is a plausible explanation of results regarding PM (PM is related to fluid intelligence in a general adult population, Salthouse, Berish, & Siedlecki, 2004) and aging, with preserved performance on everyday tasks, and decline on tasks in experimental settings (e.g., J. D. Henry, McLeod, Phillips, & Crawford, 2004). In individuals with intellectual disability, chronological age exerts an influence on the crystallised component as it is related to experience (Facon & Facon-Bollengier, 1999). This reflects that crystallised components can be trained (Beier & Ackerman, 2005), although the effect of training can be related to the person’s knowledgebase (Beier & Ackerman, 2005) and neural efficiency (Neubauer, Grabner, Freudenthaler, Beckmann, & Guthke, 2004) before training. That is, intelligence, working memory and cognitive speed are partially interrelated (e.g., Conway, Cowan, Bunting, Therriault, & Minkoff, 2002). This calls for a careful consideration before applying widespread interventions, for example, PM training, independent of individual differences.

The ambiguity of intelligence as a concept imprints the definition of intellectual disability, although restrictions in social, academic and practical skills (adaptive behaviour) is usually included in diagnostic criteria for intellectual disability ("Mental retardation: Definition, classification, and systems of supports", 2002). There is no strong link between intelligence and adaptive behaviour in individuals with mild or moderate intellectual disability, but the link is stronger for groups with more severe intellectual disability (cf. de Bildt, Sytema, Kraijer, Sparrow, & Minderaa, 2005). Adaptive behaviour is tapped by subjective ratings of everyday functioning made by staff, relatives, friends (Cuskelly, 2004), and in part reflects the outcome of cognitive limitations in, for example, memory function (Vicari, Bellucci, & Carlesimo, 2000). The consequences for everyday functioning and demand for support vary between individuals, although some features seem to be more general, for example, relying on familiar and structured tasks. Activities of Daily Life (ADL) performance (sensitive to frontal lesions, Godbout et al., 2005) has been interpreted as activation of schemata comprising action sequences (Shallice, 1988), which resembles the description of activity-based PM. PM capacity can be interpreted as the potential to include planning and performance of actions (intentions) in the future, adding a dimension to the individual’s adaptive behaviour. However, a person’s adaptive behaviour skill can also influence PM performance indirectly; that is, in case a specific adaptive behaviour skill (e.g., high degree of automaticity when making coffee) reduces the load on cognitive processes involved in PM performance (e.g., focused attention on amount of water). Thus, PM failure may be one aspect of limited adaptive behaviour skill.

With the terminology of The International Classification of Functioning, Disability, and Health (ICF), the focus on functioning highlights activities and participation, such as learning and applying knowledge, general tasks and demands, communication, mobility, self-care, domestic life, interpersonal interactions and relationships, as well as major life areas, all of which can be more or less restricted for individuals with intellectual disability (Granlund, Göransson, & Arvidsson, manuscript). Environmental factors, such as, products and technology, attitudes and ideologies of the society, amount of physical or emotional support, and, services, systems and policies, can potentially facilitate the person's participation by compensating for impairments in body functions. Body functions are relevant for describing intellectual disability, particularly mental functions that include memory, thought and higher level cognitive functions, in other words, the central theme of this thesis.

The investigation of cognitive consequences of intellectual disability suffers from a history of assumptions and misconceptions, later dismissed on the basis of research results, for example, regarding attention (Iarocci & Burack, 1998). Memory tasks with norms for a general population may underestimate the individual's actual cognitive capacity (W. F. McDaniel, Foster, Compton, & Courtney, 1998b), reducing the valence for planning of habilitation. Cognitive limitations in, for example, cognitive speed (attentional capture; Merrill, 2005) and capacity for mental processing (L. A. Henry, 2001; Sterr, 2004) associated with intellectual disability, usually affect at least some aspect of adaptive behaviour, although the need for support varies extensively in the group. Research on PM in other populations suggests an influence also on PM performance.

In sum, intelligence, adaptive behaviour and PM are multifaceted concepts implicating influence from a variety of cognitive processes and contextual factors. PM is suggested to be related to the level of adaptive behaviour with influence on the individual's autonomy.

Outerdirectedness and acquiescence. "Outerdirectedness" refers to the strategy of solving tasks by relying on external cues, physical objects, or persons. This type of strategy is used pervasively particularly by children with intellectual disability (Bybee & Zigler, 1992), also in situations when such strategies are far from optimal. Furthermore, it is more preserved during development in children with intellectual disability compared to controls (cf. Tanaka, Malakoff, Bennett-Gates, & Zigler, 2001). It is however unclear whether this is a consequence of frequent experience of failure or whether it reflects the effect of a specific cognitive capacity limitation. "Outerdirectedness" is important to bear in mind during task construction, since it is influenced by task difficulty, perceived task difficulty, and perceived personal competence (Bybee & Zigler, 1998). External cues can be a powerful source of information for PM performance, in particular when an external cue is anticipated.

Acquiescence (agreement) is related to outerdirectedness, and is also frequent among individuals with intellectual disability. Acquiescence has been interpreted as a response to questions that are too complex or demand difficult judgements (Finlay & Lyons, 2002). Cognitive inertia, that is, rigidity in choice of response alternative or cognitive behaviour, has also been described for individuals with intellectual disability (Dulaney & Ellis, 1997). For PM tasks that concern physical alterations in the environment, for example, when the task is to turn on the oven, the hot oven itself can serve as a cue that counteracts repetitions of the task. Tasks that leave no cues, for example, delivering a verbal message, demand retrospective memory of having performed the task.

Language, conceptual knowledge and meta-memory. The severity of the intellectual disability is in general reflected in the degree to which the individual depends on concrete compared to abstract reasoning (cf. Lindström, Wennberg, & Liljegren, 1996; Owen & Wilson, 2006), that is, abstract meta-memory competence that has been proposed to correspond to abilities of importance for PM function (e.g., time; Mäntylä, 2003). Limitations in abstract reasoning may have consequences for academic skills (Katims, 2001) and influence ability to acquire reading and writing skills (e.g., Bird, Cleave, & McConnell, 2000). Consequently, reading is often less automatic among individuals with intellectual disability compared to individuals without intellectual disability (Swanson & Trahan, 1996). Even in case of efficient decoding of written material, it does not necessarily imply full understanding of the content (e.g., Barnes & Dennis, 1992).

Strategies. Limitations in cognitive abilities, such as working memory, cognitive speed, and language proficiency, have secondary effects for strategic processing. Rehearsal is one example which is often delayed in individuals with intellectual disability even when compared to groups matched on mental age (Bebko & Luhaorg, 1998). Compromised controlled acquisition of strategies, referring to construction of personal strategies, has been proposed to reflect weaknesses in executive functions in individuals with intellectual disability. This group has a tendency to use fewer types of strategies (Bray, Fletcher, & Turner, 1997), though strategic behaviour improves when objects are used as physical representations of the task situation (Bray et al., 1997; Bray, Huffman, & Fletcher, 1999). Another type of strategy is learned by controlled acquisition more closely linked to a specific situation (e.g., N. R. Ellis, Deacon, Harris, Poor, Angers, Diorio, Watkins, Boyd, & Cavalier, 1982). Individuals with intellectual disability have been shown to need more support in order to transfer skills between different settings (Todman & McBeth, 1994), or to transfer skills bilaterally (Mohan, Singh, & Mandal, 2001). Strategic behaviour can be applied to different aspects of PM performance, for example, when linking the time of execution of a PM task to a distinct cue, or directing attention to information that is relevant for a specific PM performance. That is, PM strategies that include physical objects as cues are more likely to be performed than tasks such as turning up to an appointment at three o'clock which involves manipulation of abstract concepts, such as time. Learned strategies are important in everyday life, in particular for individuals with intellectual disability, due to cognitive limitations that affect adaptive behaviour. For example, an individual with intellectual disability may not be able to form a new plan if he or she gets delayed and misses the bus (cf. Svensk, 2001). Thus, the strategic skill of individuals with intellectual disability often depends on experience and external cues. Limitations in adaptive behaviour is one potential consequence.

Intellectual Disability and Time

The concept of time is gradually mastered during development, both on perceptual (duration, sequence, reproduction) and conceptual level (meaning of words, for example, past, future, hour). This includes knowledge about objective (physical) and subjective (experienced) time, and strategies for controlling time (Flaherty, 2002). That is, time is an example of a particularly abstract concept that is difficult to handle for many individuals with intellectual disability (cf. Lindström et al., 1996; Owen & Wilson, 2006), part of which may be a result of limitations in memory capacity. Time perception is related to, for example, attention (e.g., Coull, 2004; Grimm, Widmann, & Schroger, 2004), working memory processing (Meck, 2006; Ulbrich, Churan, Fink, & Wittmann, 2007), but also to long-term memory (Mangels & Ivry, 2001). Pharmacological, neurophysical and neural network modelling suggests a possible difference between sub- and supra second durations; sensory control for short durations (< 500 ms) and cognitive control for longer durations (Rammsayer & Ulrich, 2005). Neuroimaging data agree with a general system for cognitive time in right prefrontal cortex (Lewis & Miall, 2006). Time studied from ecological perspectives has attracted little research in relation to intellectual disability. Owen & Wilson (2006), however, discuss implications of difficulties in understanding time and highlight the connection to capacity for prediction and control in the natural and social environment including oneself. They focus on the development of understanding of time, the relation between subjective and physical time, and language, where a literal understanding of a time concept can be misleading (e.g., “Just a minute”). The proposed solution was to associate experiences in every day life with concrete representations of time, for example, clock-faces. Applications used in the intellectual disability population, such as the “quarter-hour clock” use a row of lights (each light represents 15 minutes) to show the time left before an activity. Janeslätt, Granlund, Alderman, & Kottorp (2007) investigate time processing ability as a concept which, like working memory, is related to daily functioning, with consequences for level of activity and participation (Lagren, 1999). Time processing ability includes; time perception, time orientation, objective time and time management (Janeslätt et al., 2007). These aspects are often limited in individuals with intellectual disability (e.g., Kylén, 1986). Individuals with intellectual disability, who do not reach full time perception skill, can master skills such as identifying clock faces associated with specific activities, using special cues to indicate time, or they may completely lack a sense for time passing (cf. Lindström *et al.*, 1996).

PM does not necessarily demand a full understanding of the concept of time as it may be event-based and, thus, linked to concrete cues. However, some sense of the existence of a future, is, in most cases, a necessary condition. An exception could for instance be when a sequence of actions should be performed and it is sufficient to store the links between consecutive actions. Time perception may, however, serve as a cue to when the event (retrieval cue) is close in time, which can benefit strategic behaviour. Since PM involves a delay (in time) it can be difficult to understand that the PM task should not be performed immediately, especially since acting on an intention immediately is a strategy that prevents omission (e.g., to post an urgent letter).

Intellectual Disability and Memory

Memory processes are in general compromised in individuals with intellectual disability, although this restriction is more pronounced for some memory systems (e.g., working memory, L. A. Henry, 2001; Numminen, Service, Ahonen, Korhonen, Tolvanen, Patja, & Ruoppila, 2000) and less restricted for others (e.g., episodic memory, R. L. Cohen & Bean, 1983). Generally, memory performance in individuals with intellectual disability and controls converges in situations with a low demand on explicit memory processing that allows for non-linguistic processing (Atwell, Conners, & Merrill, 2003; Bebko & Luhaorg, 1998). The converging trend may be due to working memory capacity related to general intelligence (Colom, Abad, Rebollo, & Chun Shih, 2005) and most likely to contexts with a low demand on general encoding speed. Encoding speed is slower for the intellectual disability group, supposedly due to semantic retrieval which partly depends on mental age (Merrill, Sperber, McCauley, Littlefield, Rider, & Shapiro, 1987). None the less, encoding speed reflects intelligence more than mental age (Schweizer & Moosbrugger, 2004). Familiarity (including both episodic and semantic memory components) tends to be essential for both recognition (cf. Danielsson, Rönnberg, & Andersson, 2006a) and functioning in situations in everyday life for individuals with intellectual disability (e.g., social knowledge in children, Soodak, 1990). Familiarity, hence, reflects a high level of proficiency in the situation. Thus, the load on working memory capacity may be reduced by the use of established skills stored in a permanent long-term memory. Improved PM performance in familiar situations by means of, for example, correct sequencing of activity-based PM actions (to put on socks before shoes) also proposes involvement of the episodic buffer component of working memory which is involved in linking information to long-term memory (Baddeley, 2000).

Intellectual disability and prospective memory. The definition of intellectual disability includes limitations in adaptive behaviour skill. Adaptive behaviour skill is related to PM function, in particular aspects of adaptive behaviour that involve retrieval of an intention from long-term memory after a time delay (cf. Kvavilashvili, Messer, & Ebdon, 2001).

The intentionality in PM formation requires an ability to "entertain future scenarios" (Suddendorf & Busby, 2005). Suddendorf and Busby (2005) also point out that this does not necessarily demand having the language skill required to describe the intended action. They propose a paradigm where a desired future outcome can be obtained by an action in the present, presumably to reveal ability for "mental time-travel". Later stages in the PM process load on other memory functions which often are limited in individuals with intellectual disability. Working memory is one such example (limitations related to aging, Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). In the general population, visual stimuli support PM performance (cf. M. A. McDaniel, Robinson-Riegler, & Einstein, 1998a), which may be even more essential for individuals with intellectual disability, considering a reduced demand on language proficiency (Bebko & Luhaorg, 1998). Furthermore, PM involves aspects related to episodic memory performance; recognition of when to act (cue identification) and recall of the action to be performed (intention retrieval, Simons, Scholvinck, Gilbert, Frith, & Burgess, 2006). PM involves associating an action to perform with a cue for when the action should be performed (Clark, 2005). Thus, PM errors due to an insufficient association may be compared to binding errors.

Children with intellectual disability can recall features as well as chronologically age matched controls, with no more feature intrusions after a short delay, despite lower performance on, for example, open ended questions (Michel, Gordon, Ornstein, & Simpson, 2000). However, after a delay, the frequency of intrusions and the suggestibility increases (Michel et al., 2000). Adults with intellectual disability commit more binding errors compared to controls, on a visual binding task (Danielsson, 2006).

In sum, adaptive behaviour limitations involved in intellectual disability (e.g., outerdirectedness) in part reflect limited memory processing that, in general, is more pronounced for working memory compared to long-term memory processing (e.g., episodic memory and implicit memory processes). Major variation in performance is often demonstrated both on different tasks and between different individuals. An intervention aimed at improved PM performance has potential to be more specific taking this variation in memory processing into account.

Prospective Memory and the International Classification of Functioning, Disability, and Health (ICF)

Disability and functioning are consequences of the interactions between health conditions and contextual factors. One example of a function is PM. According to attitudes in the social environment a certain level of functioning is demanded. For example, a person who fails to meet an appointment due to poor PM, may be excluded from social events. Personal factors influence the individual's experience of disability, which originate in a discrepancy between the individual's activity (what the individual can do) and participation (can the individual take part in the situations he or she wants to). PM functioning represents one aspect of body function that, if it is impaired, can result in activity limitations (e.g., unable to postpone planned activities) and even participation restrictions. That is, if you repeatedly omit to act on plans in the future (e.g., going to the bus stop) you may limit your activity (e.g., having dinner with your friends), and thereby restrict participation in that social setting (e.g., contributing with your opinion). PM represents a unique cognitive ability (body function; cf. R. E. Smith, 2003), that depends on an interplay between the individual's cognitive abilities (personal factor; e.g., Patton & Meit, 1993), motivation (e.g., Meacham, 1988), support and the situation requiring a PM (contextual factors; e.g., Marsh, Hicks, Hancock, & Munsayac, 2002; Nowinski & Dismukes, 2005).

Memory – Structure and Process

Memory concerns storage and processing of information for short and long time spans, in different memory structures or memory processes (Nyberg & Tulving, 1996). Long-term memory involves both memory for past events (retrospective memory), and memory for intentions to perform in the future (PM). Both these aspects of memory demand a short-term storage and processing of information (working memory), at encoding and retrieval of information.

Encoding and retrieval processes diverge in breadth and degree of cognitively effortful elaboration (Craik & Jacoby, 1979). The contrastive value of information (distinctiveness) at encoding impinges on the nature of retrieval. Retrieval is furthermore shaped by the task demands that affect processing of the retrieval cue (Craik & Jacoby, 1979). Memory processing is reflected in changes in the pattern of brain activation, for example, between noticing the PM cue and searching for the task to perform in long-term memory (e.g., West, Herndon, & Crewdson, 2001).

The structural view of memory is based on memory systems. The long-term memory structure comprises sub-systems for episodic, semantic, perceptual and procedural memory content (Cabeza & Nyberg, 2000; Nyberg &

Tulving, 1996). The counterpart for working memory most frequently used separates between a central executive function and its slave systems (Baddeley, Logie, Bressi, Della Sala, & Spinnler, 1986; Repovš & Baddeley, 2006). Phonological information is processed in the phonological loop, visual and spatial information to the visuo-spatial sketchpad, and the process linking pieces of information together load on the episodic buffer (for a review, see Repovš & Baddeley, 2006).

Long-Term Memory

Long-term memory refers to permanent storage of information, according to type of information (semantic, episodic or procedural memory, Schacter & Tulving, 1994). Long-term memory is often described either in terms of a spatial metaphor, or in terms of stored connections among units (Jacoby, Yonelinas, & Jennings, 1997). Theories based on long-term memory processing usually focus on the dynamic nature of memory (memory is changing and influenced by other aspects of cognitive activity) as well as the interconnectedness to other memory processes. With respect to PM, cue identification and intention retrieval both demand memory for the past, particularly episodic memory. Access to this information is influenced by context, which brings semantic memory processes to the fore. However, semantic memory processes does not have to be consciously retrieved in order to influence PM performance in this example.

Implicit memory concerns memories or knowledge that we cannot consciously retrieve or express (Graf & Schacter, 1985). Explicit memory is what we use when we consciously retrieve information that we can put into words (Graf & Schacter, 1985). Cues may facilitate (e.g., by explicit or implicit associations) or interfere with recall and recognition (overshadowing or misleading associations). In daily life, we tend to notice failure to retrieve information, such as forgetting the name of that famous movie star. On the other hand, the information is often recognised if someone else remembers the name. Recognition can be interpreted as a composite of familiarity (more implicit process), and recollection (explicit process; Jacoby, Woloshyn, & Kelley, 1989). These processes may be studied by collecting subjective reports of "remembering" and "knowing" that specific items of information have been encountered before. In relation to PM the counterpart could be recognising the event (target), but having forgotten what the intended task was (retrieval of the intended action and time of performance; Ring & Clahsen, 2005; Sturt, 2003).

Episodic memory may underpin PM function by; (a) providing recall of the encoding situation; and (b) supporting strategic behaviour, such as imagining the future situation associated with performance of the PM task.

PM tasks that can only be successfully performed within a limited time span depend on efficient retrieval of the PM task, which in turn is influenced by amount and type of memory processing at encoding and retrieval. Thus, PM performance is in part influenced by working memory capacity.

Prospective Memory

"Prospective memory" refers to remembering to act on plans that should be executed in the future, such as, remembering to phone a friend at a later occasion if the line is engaged or remembering to keep an appointment. Procedural approaches to PM focus on overlap in processes at encoding and recall of the intended action. Performance of the PM task is based on an overlap between memory processing at the time of encoding and at the time of recognition of when to act on an intention. Structural approaches, on the other hand, assume establishment of representations that can or cannot be activated. From this point of view, PM is generally more driven by intentions than retrospective memory, and the level of activation is of key importance. The task performed during the delay between encoding and performance of a PM is defined as the ongoing task (J. Ellis & Kvavilashvili, 2000). Traditionally there has been a distinction between time- and event-based PM, where the former refers to a relation to a specific point in time and a high demand of self-initiation, while the latter refers to actions performed in response to a specific event (Einstein & McDaniel, 1990). The relevance of this distinction may be questioned, since time is always at issue in PM tasks and can often be handled by associating the point in time with a specific event. Furthermore, performance on event-based tasks is influenced by the individual’s sense of time (e.g., Cook, Marsh, & Hicks, 2005). The influence of contextual cues may be more important for PM actions that are postponed and which may be performed irregularly and repeatedly, particularly when actions are to be performed in correct sequential order (Kvavilashvili & Ellis, 1996).

The processing of PM tasks is a complex activity that is both data-driven and conceptually driven (e.g., A. L. Cohen, West, & Craik, 2001). It relies on coordination of a composite of cognitive functions and processes (e.g., J. Ellis, 1996). Specifically, successful PM performance demands formation and encoding of actions and their timing in long-term memory until recall and performance. PM task performance should be initiated in response to recognition of the cue associated with performance timing (J. Ellis, 1996). The retrospective aspect concerns the content and retrieval of what the action or intention was. PM is, thus, influenced by task characteristics that support retrospective memory function; distinctiveness, familiarity, motivation, cues (e.g., Brandimonte & Passolunghi, 1994), and strategies, such as, extensive processing (e.g., enactment; Schaeffer, Kozak, & Sagness, 1998) and rehearsal. Comparison of the immediate and the intended context is required to evaluate whether a planned action should be performed, withheld, cancelled or replaced by a new plan. Timing when to act tends to be the main contributor to PM errors (Einstein & McDaniel, 1990), although retrieval processes associated with PM (recalling what to do) demand cognitive capacity (R. E. Smith, 2003). R. E.

Smith and Bayen (2004) propose a model of PM with preparatory attentional processes and retrospective memory processes. The multiprocess view on PM (Einstein & McDaniel, 1990) is less focused on the demand for cognitive capacity. It predicts that cue detection will be more automatic in specific circumstances, specifically, if the PM cue is either; (a) strongly associated with the planned action, (b) associated with the ongoing task, (c) salient, or (d) has relevant features that come into focus of attention as a result of processing associated with the ongoing task (M. A. McDaniel & Einstein, 2000; M. A. McDaniel, Guynn, Einstein, & Breneiser, 2004).

PM function changes during the life span (e.g., Logie, Maylor, Della Sala, & Smith, 2004), as do working memory and episodic memory (Tulving, 2002). PM performance increases during childhood due to, for example, improved strategic behaviour (Ceci & Bronfenbrenner, 1985; Guajardo & Best, 2000; Kerns, 2000; Nigro, Senese, Cicogna, & Zirpoli, 2003). PM performance often declines in old age (65+) in experimental settings (for a review, see J. D. Henry et al., 2004), although preserved or even augmented PM performance is sometimes found on tasks in everyday settings (e.g., logging specific times during a week, Rendell & Thomson, 1999). This somewhat counter-intuitive trend has been attributed to a more structured everyday life or strategic skills. That is, an old person is assumed to benefit from acquired strategic skills, which are less useful in an experimental setting in which a decline in working memory resources, among other things, may limit PM performance (R. E. Smith, 2003). Furthermore, age-related changes in PM performance over the life-span are in line with crystallised components that are acquired during childhood and more intact in aging than fluid components.

Interventions aimed at enhancing PM function have focused on changes due to aging (e.g., Perfect & Stollery, 1993) and brain injuries (Sohlberg, White, Evans, & Mateer, 1992). Improved PM performance and increased use of diaries have resulted from training elements of self-awareness, selection of appropriate organisational device, analysis of cueing, use of organisational strategies, in particular with a focus on transfer of strategies to situations beyond the therapy environment for individuals with traumatic brain injury (Fleming, Shum, Strong, & Lightbody, 2005). Reduced self-awareness and equal or increased PM performance have been found in individuals with traumatic brain injuries (Knight, Harnett, & Titov, 2005), even though the task was more artificial.

PM performance is strongly influenced by motivation and is, thus, also a result of socially constructed roles, for example, gender, and expectations (cf. Meacham, 1988). For example, women in middle-age report more frequent use of external PM aids than male peers (cf. Long, Cameron, Harju, Lutz, & Means, 1999).

In sum, PM refers to performance of intentions at a planned time in the future. It thereby demands coordination of multiple memory processes involved in planning, storage, recall, execution and evaluation of outcome, and is, thus, susceptible to memory limitations, for example, in working memory capacity.

Executive Functions and Attention

PM requires attention to changes in the situation in order to detect PM cues, and establish a sense for time. There is an intimate link (e.g., activation in pre-frontal cortices, Burgess, Quayle, & Frith, 2001) between PM and executive processes such as planning (Leynes & Bink, 2002), task shifting (Shapiro, Shapiro, Russell, & Alper, 1998), response inhibition (Marsh, Hicks, & Bryan, 1999) to partial match cues (e.g., Marsh & Hicks, 1998). Limitations in PM performance have further been observed in other populations with weaknesses in executive functions, for example, persons with ADHD (Kerns, 2000), and persons with schizophrenia (Kondel, 2002).

Executive function refers to “deliberate, goal-directed thought and action” (Zelazo, Craik, & Booth, 2004, p 167-167). It includes actions such as goal-directed behaviour, planning, organised search, and impulse control (Welsh, Pennington, & Groisser, 1991), that is, skills with major impact on everyday life. However, memory processes are an essential part of these skills (Miyake & Shah, 1999b). Executive functions include different sub-processes, for example, attentional control; focused attention, divided attention, and switched attention (Baddeley, 2002). Attention has been studied as (a) an aspect of the central executive component of working memory (e.g., Baddeley, 2002; Jefferies, Lambon Ralph, & Baddeley, 2004; Schweizer & Moosbrugger, 2004), (b) in relation to memory processing (Iarocci & Burack, 1998), and (c) with respect to perceptual processes (Huguenin, 2004). This diversity is exemplified by the numerous specifications of attention; sustained attention, focused attention, attentional switching, divided attention, attention according to the supervisory attentional system, attention as inhibition, spatial attention, attention as planning, interference, attention as arousal, and attention within assessment (Iarocci & Burack, 1998). Today there is no consensus on how and to what extent attention and executive functions overlap. However, these terms both refer to processes that are essential to PM performance.

Different constellations of executive functions are limited in different individuals with intellectual disability, and contribute to weak executive functioning on a group level (Pramuka, 1998). With respect to attention, differences are found especially between experimental and control groups matched on chronological age, and for groups with undifferentiated intellectual disability. For individuals with Fragile X Syndrome, weak attention-switching capacity has been suggested to result from weak inhibitory control (Cornish, Sudhalter, & Turk, 2004). Successful performance of multiple tasks loading on different subsystems of working memory suggests attention allocation without impairment (Oka & Miura, 2007). Structural modelling of attention suggests a relationship to intelligence (Schweizer, Moosbrugger, & Goldhammer, 2005), which may reflect the common variance between scope-of-attention and storage-and-processing (Cowan, Elliott, Saults, Morey, Mattox, Hismjatullina, & Conway, 2005).

Working Memory

Working memory is the system or mechanism underlying the maintenance of task-relevant information during the performance of a cognitive task (Miyake & Shah, 1999a, 1999b), that is, temporary storage and simultaneous processing of new information. Perspectives on working memory are often functional or content-oriented, with a focus on restrictions in capacity (cf. Barrouillet & Camos, 2001; Daneman & Carpenter, 1980) or the type of information in different working memory components (Baddeley, 2000; Repovš & Baddeley, 2006). Working memory is seldom considered as completely unitary, and most perspectives acknowledge an influence from long-term memory, or knowledge and skill, on working memory performance.

Baddeley's multi-process view (Baddeley et al., 1986; Repovš & Baddeley, 2006) on working memory includes a central executive and three slave systems; the phonological loop, the visuo-spatial sketchpad, and the more recently added episodic buffer (Baddeley, 2000). The phonological loop typically handles verbal information and language processing. Visual and spatial information is instead directed to the visuo-spatial sketchpad, for further processing. Pearson et al. (2000) suggests representation of visual images in a specific visual buffer of the visuo-spatial sketchpad. Images can be retrieved due to either information stored in long-term memory or perceptual input. The episodic buffer component forms episodes based on integration of information in working memory with information stored in long-term memory. The episodic buffer may be considered a separate working memory component or a storage-component of the central executive (cf. Towse & Hitch, 1998), but see also (Repovš & Baddeley, 2006; Rudner & Rönnberg, in press).

Working memory limitations can result from information-decay (Towse & Hitch, 1998), lack of knowledge (e.g., children, Roodenrys, Hulme, & Brown, 1993), similarity-based interference (cf., Oberauer, Lange, & Engle, 2004), and switching-costs (Baddeley, Emslie, Kolodny, & Duncan, 1998). Individuals with intellectual disability are often more limited in working memory capacity than individuals without intellectual disability (L. A. Henry, 2001; Jarrold et al., 1999a; Jarrold, Baddeley, & Hewes, 2000; Numminen et al., 2000; Numminen, Service, Ahonen, & Ruoppila, 2001; Numminen, Service, & Ruoppila, 2002), as predicted from the relation between working memory, cognitive speed and intelligence (Conway et al., 2002). Individuals with Down Syndrome perform on a par with their peers on recall of phonologically similar words (Kittler, Krinsky-McHale, & Devenny, 2004), which suggests a specific influence of long-term memory processes and language proficiency. However, on tasks with phonologically similar, semantically similar, and long words compared to short dissimilar words, performance declined the most in individuals with Down Syndrome. More detailed investigations of the phonological loop in individuals with intellectual disability revealed specific weaknesses in sub-vocal rehearsal (no word-length effect), but an intact phonological store (phonological similarity effect), compared to a control group (matched on verbal span length; Rosenquist, Conners, & Roskos-Ewoldsen, 2003). Rehearsal of visual information (visual complexity effect) was not limited in the intellectual disability group, nor was the visual cache of the visuo-spatial sketchpad (picture similarity effect, Vicari, Bellucci, & Carlesimo, 2003). Children with Williams Syndrome demonstrate intact verbal span but shorter visual span than a control group matched on mental age (Jarrold et al., 1999a).

In sum, working memory capacity is in most cases limited in individuals with intellectual disability, but performance levels can be equal to controls matched on fluid intelligence for tasks based on familiar semantic information. Strategic competence has been offered as part of the explanation of superior working memory performance for children with intellectual disability compared to groups matched on mental age, despite lower working memory capacity than groups matched on chronological age (L. A. Henry & MacLean, 2002). Furthermore, genetic causes to the intellectual disability are to some extent associated with specific limitations in working memory.

Mental workload and prospective memory. Limitations in adaptive behaviour in individuals with intellectual disability may reflect weak capacity for distributing activities, for example, changing plans in order to meet the task demands. This may be a consequence of compromised executive functions and memory processing capacity that also threaten PM performance, for example, as shifting between the ongoing and the PM task is required. PM performance is susceptible to high mental workload, which individuals with intellectual disability are likely to experience in their daily life more frequently than controls, for example, due to more limited strategy competence (Bray et al., 1997).

Mental workload is the effort invested by the human operator into task performance (Svensson, Angelborg-Thanderz, & Wilson, 1997-1999), usually measured by means of subjective ratings (Svensson, Angelborg-Thanderz, Olsson, & Sjöberg, 1992), performance or psychophysiological methods (Wilson & Eggemeier, 1991). Human errors are more likely to occur in situations when the mental workload is (a) very high and there is little capacity left or, (b) very low, which can make the operators inattentive and less prepared for unexpected events. Performance measures are focused on changes in performance of either the primary task (the ongoing task, when referring to PM) or the secondary task. Thus, secondary tasks that are sensitive to increased mental workload are potentially useful tools for investigating mental workload. PM performance is, in general, more sensitive to mental workload than to delay in time (Stone et al., 2001). This suggests that once an intention is stored in long-term memory it is sensitive to the capacity to retrieve the intention (e.g., to notice and process cues concerning when to execute the intention). Thus, PM has also been investigated as a secondary task (Juergen Sauer, 2000), and proven more sensitive than reaction time in a measure of mental workload (Jurgen Sauer, Wastell, & Hockey, 1999).

A number of theories regarding the origin of task interference between the PM and the ongoing task state a relation to working memory capacity (e.g., Hicks, Marsh, & Cook, 2005). Matching of stimuli to production rules for event-based PM tasks and the ongoing task loads on working memory (Marsh & Hicks, 1998). For time-based tasks performance improves, if the time is associated with an event (Sellen, Louie, Harris, & Wilkins, 1997). Smith (2003) suggests non automatic monitoring and rehearsal as contributors to load on working memory associated with PM (Preparatory Attention and Memory, PAM). Working memory is required for clock-monitoring in association with time-based PM tasks, as it involves shifting focus of attention from the ongoing to the prospective aspect of the task (thinking of the PM task was reported at 2% of the interruptions in low-ability younger adult individuals, Reese & Cherry, 2002).

Binding

Binding refers to the process of forming, retaining and retrieving associations between different pieces of information (components or features) in episodic memory, for example, colour and shape (e.g., Xu, 2002), or between "what to do" and "when to act" in a PM task. Binding the "what" and "when" of a PM task may be either (a) cognitively demanding, especially in situations that are novel or abstract with primarily internally generated cues, or (b) fairly automatic (cf. reflexive-associative process, M. A. McDaniel et al., 2004), especially when it’s semantics establish an association between the “what” and “when” components. Although such a semantic relationship may support retrieval of the action (buying tooth-paste from the dentist), it may also make recognition more susceptible to false memories by reduced PM cue distinctiveness (Lekeu, Marczewski, Van der Linden, Collette, Degueldre, Del Fiore, Luxen, Franck, Moonen, & Salmon, 2002). Binding errors represent a specific type of false memories for lures (conjunctions and features) composed of erroneously mixed pieces of information. For example, encoding of the intentions “to bake tomorrow” and “to meet a friend tonight”, and recall of “to meet a friend tomorrow” is a conjunction error consisting of an erroneous mix of pieces of two old intentions. Recall of “to meet a friend next week” would represent a feature error, as “old” information (to meet a friend) is mixed with “new” information (next week). The consequences of binding errors are likely to be even more salient for individuals with intellectual disability due to limited adaptive behaviour.

The dual-process approach to binding errors predicts conjunction errors to be more frequent than feature errors, since the former are composed only of familiar material. Another approach (e.g., the binding approach) to binding is focusing on memory for the configuration (figure of associated pieces of information) and processes involved when rejecting a conjunction or feature. Conjunction errors result from either recall of components but not complete configurations (e.g., Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996), or weak encoding of the association between features (cf. effect of divided attention, Reinitz, Morrisey, & Demb, 1994). Recognition or recall of new configurations (feature and conjunction errors), or episodic tokens (Reinitz & Hannigan, 2004), are influenced by information in long-term memory.

The binding concept has been proven valid for multiple situations and modalities, for example, different parts of sentences (e.g., Groh-Bordin, Zimmer, & Mecklinger, 2005), features of faces (Experiment 2, Kroll et al., 1996), and sounds and visual stimuli (e.g., Lewald & Guski, 2003). Furthermore, binding has been studied in special conditions, such as, schizophrenia (e.g., Gold, Wilk, McMahon, Buchanan, & Luck, 2003), old age (Schacter, Israel, & Racine, 1999), and intellectual disability (Danielsson, Rönnberg, Levén, Andersson, Andersson, & Lyxell, 2006). Binding errors are probably more frequent in PM task performance for persons with intellectual disability than in the control group, since PM loads on working memory and executive functions (Marsh & Hicks, 1998) and may result from inadequate association between pieces of information. Retrieval based on familiarity rather than recollection may be a consequence of extensive cognitive load, as can be assumed particularly in individuals with intellectual disability (cf. Working Memory Conjunction Error approach [WMCE], Danielsson, 2006). This can result in (a) intentions performed on the wrong occasion due to an over-lenient approach to recognition of the PM cue, or (b) performance of an erroneous but highly familiar action on the correct occasion.

Prospective Memory Demands and Intellectual Disability

Knowledge about cognitive functioning and other aspects of memory processing in adults with intellectual disability, gives ground for predictions based on comparisons to PM performance in other populations. PM functioning is likely, in part, to be related to adaptive behaviour skills, such as a sense of time which can indicate when the PM cue can be expected to be present. A relationship between working memory capacity (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980) and PM performance has been demonstrated in other special conditions (old age; Cherry & LeCompte, 1999; thalamic damage; Daum & Ackermann, 1994; Einstein, Smith, McDaniel, & Shaw, 1997; ADHD;

Kerns, 2000; Parkinson; Kliegel, Phillips, Lemke, & Kopp, 2005; Martin & Schumann-Hengsteler, 2001; Park et al., 1997; Reese & Cherry, 2002; West & Craik, 2001). A similar pattern could be expected for the intellectual disability group, as a consequence of a similar limitation in working memory and executive processes. Working memory load has been proposed to interfere primarily with attentional processes involved in cue identification (West, Bowry, & Krompinger, 2006). This puts focus on the working memory demands of the ongoing activity. West et al. (2006) propose that these working memory demands may attenuate processes involved in a specific PM task. That is, the amount of memory processing used for PM cue identification is in part influenced by the individual's working memory capacity. Extensive processing of PM cues and actions at encoding is likely to support performance by reducing the demand for explicit memory at retrieval, which may be a bottleneck for PM performance, especially for the intellectual disability group. That is, the effect of working memory restrictions is shaped by attributes of the PM task in relation to the individual's experience and cognitive capacity.

In sum, experience of a situation demanding PM benefit performance in the intellectual disability group likely due to support from long-term memory processes. Increased demands on cognitive speed and working memory capacity are likely to limit PM performance in the intellectual disability group in particular.

Empirical Studies

Disability Research and This Thesis

WHO is attempting to change the focus from disability to health by emphasising activity (something that can be done) and participation (what the individual engages in) and introduced the "biopsychosocial" model ICF. This is a response to medical and social models of disability, which differ in their interpretation of disability, in terms of their framing of the concept, either as an attribute of the individual or of the context.

Disability research can be performed either vertically across multiple strata (from a molecular level to the society) or horizontally, where an issue may be studied in different contexts (disabilities) or from different perspectives within the same stratum (Rönnberg & Melinder, 2007). PM function involves interplay between processes from molecular (e.g., signals directing blood-flow in the brain), psychological (e.g., working memory and episodic memory), interpersonal (e.g., socially desirable behaviour, such as, to keep appointments), to societal levels (e.g., socio-economic consequences of faulty ingestion of medication). Intellectual disability has been studied from different perspectives, together covering all strata. This thesis, however, is concerned with PM primarily from a psychological perspective, with a focus on individual differences, that is, along the horizontal dimension, although retrieving results with potential applications along the vertical dimension.

Purpose

The overall purpose of this thesis is to investigate PM function in individuals with intellectual disability, and to explore the relation to working memory and episodic memory. Five more specific research questions were raised in the studies. Regarding the PM-measures associated with each research question, see Table 1.

Research Questions

1. Does prospective memory performance in the intellectual disability group differ quantitatively and qualitatively compared to a control group of individuals without intellectual disability? (Papers I – II)
2. What are the relations between prospective memory, working memory and episodic memory in individuals with intellectual

disability, and how are these relations different from the relations found in individuals without intellectual disability? (Paper II)

3. What conditions constitute compatibility between encoding and retrieval of prospective memory tasks? (Paper III)
4. In what way might weak binding contribute to PM failure? (Paper IV)
5. Is it possible to identify high and low PM-performing groups of individuals with intellectual disability? (Paper II)

Participants

The participants in the empirical part of this thesis were adults with moderate or mild intellectual disability who used or were about to acquire a time aid and were employed at municipal day activity centres or attending adult education programmes. Furthermore, persons with similar chronological age but without intellectual disability (control group) participated. The relationship between chronological age and different aspects of mental age is partly dependent on the memory functions (Iarocci & Burack, 1998) central to this thesis. The intellectual disability group was heterogeneous with respect to the origin of their disability, as well as to social, academic and practical skills in everyday life. Adequate vision and ability to communicate with the researcher were fundamental inclusion criteria as they were essential for task performance. Language skills varied in the intellectual disability group. The communication with the researcher was predominantly verbal although it was occasionally supplemented by gestures or total communication signs (Heister Trygg, 2004). Many but not all individuals could decode single written words, for example, enabling text messaging. However, all participants could identify single digits. The participants all possessed a calendar of sorts, although some used it only sporadically and had poor understanding of time as a concept. A few individuals used quarter-hour clocks, or were able to identify specific clock-faces, and several individuals used ordinary watches. Thus, all participants with intellectual disability in the empirical studies belong to the B- or C-level according to Kylén (1985, 1986). The B-level is associated with abilities such as talking, counting, understanding pictures and the near future. On the C-level the individual can read, write and reason about concrete situations, although with limited ability for purely abstract reasoning (Kylén, 1985).

Ethical Standpoints

Methodology and procedures and, in part, also the research questions in this thesis have been influenced by ethical standpoints. As pointed out by Hellström (2005), despite general guidelines, there are special considerations to be made in research with vulnerable persons, such as individuals with intellectual disability (Arscott, Dagnan, & Kroese, 1998). The planning and preparation for this research have sought to strike a balance between under- and overestimations of the participants' abilities, theoretically intriguing research questions, optimal experimental designs and adjustments to reality, the limited amount of research on PM in individuals with intellectual disability, and concern for the participants' well-being and integrity.

Participants involved in this thesis were approached as a group, as pupils or employees at specific schools, day activity centres or the university. Participants and other persons coming in touch with the studies, for example, relatives, staff, assistants, were informed about the studies in larger groups, and in combination with written information about the research, including names, portraits, and contact information of the researchers involved. Information to potential participants stated the purpose, procedure, and estimated time required to complete the tasks (with reservations, due to predicted individual variation), and the participants right to abort participation without a motivation, the code of silence, and handling of the information (based on guidelines for "Swedish that is easy-to-read ", "Lättläst svenska", "Lättläst - vad är det?" 2003). The tasks were performed in a separate room, either at work, school or university. That is, the setting for the research made it important, also to stress that the code of silence was to be kept also in relation to staff and relatives, unless the participant him- or herself approved of otherwise. It was also pointed out that results would not necessarily come to immediate detectable application that would serve the participant in the short run. Following information in larger groups, potential participants with intellectual disability were approached by someone they knew who asked if they were interested in taking part in the study. This served multiple purposes, such as, to provide a contact who was present both more often than the researcher, and after the tasks had been performed, and who could help to get in touch with the person responsible if the participant had unanswered questions after the study was finished. This was relevant, especially since the ability to communicate varies in the group. It was invaluable to get some guidance to which individuals were likely to be interested in participating. In particular since some participants who wanted to take part in a study, needed extra assurance that they would manage solving the tasks, and that they could have a break from the task they had at hand.

The project has been approved by municipal officials and by the regional ethical committee of Linköping University. The results from the studies have also been presented to the participants and presented both verbally and in short versions written with ordinary words.

Methodological Issues: Possibilities and Limitations

The empirical work in this thesis is primarily based on quasi-experimental designs, supplemented by interviews and observational data from the task situation. Quasi-experimental designs provide an opportunity to compare non-randomized groups with each other in designs resembling experimental designs. As a consequence, generalisation of the results demands additional support from theory and needs to be put in relation to results from other studies. There was reason to expect differences in level of performance for individuals with and without intellectual disability. Therefore, the investigation was focused on the relationship between task performance within each group, and on general relationships between task performances on a group level. Performance was further analyzed by categorizing the data into sub-groups based on one or multiple criteria such as, for example, performance measures (Papers II and IV) with the purpose to detect what constitutes the heterogeneity in group performance. Of course, the data in this thesis do not allow too general conclusions concerning all individuals with intellectual disability. However, the results within the group can be related to theoretical constructs and compared to results in other groups, for example, who share a cognitive characteristic with the group in question. Hence, results of sub-group analyses may point out issues for further inquiry. This in turn influences the usefulness in considering an association as causal (Olsen, 2003). Sub-group analyses may detect component causes although causality as based on probability cannot be determined. Strong component causes are sufficient and necessary, unlike weak component causes that are only sufficient given a specific set of other component causes (Olsen, 2003). The external validity of the results become more transparent as similarities and differences between the participants are identified in the sub-group analyses (Green & Glasgow, 2006). The reason for including, for example, practitioner experience and comparisons to previous research in relation to methodological possibilities and limitations, is to increase the weight of evidence.

It may be too offensive to state that all questions cannot be asked in studies of PM in individuals with intellectual disability, but at least intellectual disability adds to challenges always included in memory research, such as “yea”-saying, keeping the task performance within reasonable time limits, the outcome within a range of variability, and, not least, to keep the participant motivated. In reality, for the intellectual disability group, this ideally meant assuring that the task would be finished in time for coffee or lunch, designing tasks that could be used in spite of major individual differences in experience, interests, cognitive and motor speed, and that did not collapse when the cell phone calls for attention, or attention wanders off to forthcoming or past festivities, or emotional everyday dilemmas.

Language and reading skills are frequently assumed in methods for measuring PM performance in general populations (Einstein & McDaniel, 1990). This is unlikely to be optimal in studies with individuals with intellectual disability who vary extensively in language proficiency. Pictures could improve PM performance, particularly in the intellectual disability group, for example, due to distinctiveness, and reduced load on language skill (for details, see Table 1). Therefore, the papers (I – IV) used PM tasks based on pictures or video.

Subjective factors as motivation (Bennett-Gates & Zigler, 1999) and response style (Finlay & Lyons, 2002) may influence performance even more for individuals with intellectual disability than for persons with a corresponding general level of development (e.g., Barrett, Eysenck, & Lucking, 1986). This was one reason for using a game structure in one of the PM tasks. In order to reduce a potentially confounding effect, such as, hobbies or language skills the tasks were based on everyday concepts. This introduced a risk for both increased difficulty due to the semantic link between different items, and for the task to be experienced as boring. Familiar cues and tasks in combination with limited working memory capacity may also counteract memory distinctiveness. However, familiarity could have a positive impact on PM performance for the intellectual disability group, as a consequence of, amongst other things, less complex strategic behaviour and abstract reasoning. Experience is often essential for performance, and so instructions included demonstrations that could be adapted to the individual and accompanied by trials and feedback. This was to limit the effect of training on task performance.

Extended trials contribute to the time needed to complete a task, which in general is prolonged for individuals with intellectual disability compared to those without. Motor function also varies extensively in the intellectual disability group, which slowed down the response time. Thus, tasks were chosen that allowed for breaks and assistance from the experimenter when needed. Performance was, thus, rated with respect to attributes other than response times.

Memory, per se, implies a delay that for a PM task is filled by the ongoing task, designed to prevent active rehearsal of intentions in working memory (discussed in, e.g., Kvavilashvili, 1998). The interpretation of PM performance in experimental settings is repeatedly threatened either by ceiling or floor effects (cf. Titov & Knight, 2001). That is, performing an item in a PM task serves as rehearsal for the items that follow, which result in an "all or nothing" situation. It is, thus, essential to separate presentation of PM cues, either in time or by secondary tasks that at some point demand a shift in attention away from the PM task. Thus, either the ongoing task or a number of PM items should be adjusted to the capacity of each participant, or the delay would increase. This results in time-consuming PM tasks. Adapting task difficulty to participants with major variations in performance could, however, be misleading, as the variation may reflect fluctuations in, for example, attention. The adaptation itself may also conceal specific cognitive strengths and weaknesses.

The methods and designs of Papers I – IV, are results of choices made along the way, such as not recording interviews on tape, or adding verbal instructions to encoding with pictures in the PM Game (to limit amount of instructions at the beginning of the task), all with their specific advantages, limitations, and disadvantages.

Prospective Memory Task Development

The PM task of Paper I is video-based (e.g., Einstein & McDaniel, 1990; Knight et al., 2005; Kvavilashvili, 1998; Nowinski & Dismukes, 2005) and connected to low performance levels in the intellectual disability group. The PM task in Paper II, therefore, aimed at increasing PM performance in the intellectual disability group, by using pictures as cues both at encoding and retrieval. Thereby, the cognitively demanding requirement of matching a verbal description with a visual event in the video was removed. Thus, the task resembled a recognition task, although it included a delay with a distractor task and an ongoing task performed between encoding and PM performance. Performance increased, but led to a question about the compatibility between cue presentation at PM encoding and retrieval. The compatibility was investigated for words and pictures as cues in Paper III. Altogether, PM failures due to a mismatch of PM cues and tasks, and weak working memory in the intellectual disability group, inspired the investigation of binding in relation to PM errors in Paper IV.

Paper I

Topic: The relationship between prospective memory, working memory and episodic memory in individuals with intellectual disability

Questions:

1. Does prospective memory and working memory performance differ between persons with and without intellectual disability?
2. Is prospective memory and working memory performance related in individuals with intellectual disability?

Methodological issues:

3. Is a video-based prospective memory task useful for studies of prospective memory in individuals with intellectual disability?
4. Does Picture Position Span measure working memory capacity?

Method. Five individuals with mild to moderate intellectual disability (three women and two men, chronological age: *M* = 27.5, *SD* = 5.97) and ten persons without intellectual disability (nine female and one male, matched on age: *M* = 27.3, *SD* = 5.0) participated. The tasks included were a PM task based on a video with Laurel and Hardy (Table 1), a verbal episodic memory task, self-rating of PM (Crawford, Smith, Maylor, Della Sala, & Logie, 2003), digit span and a Picture Position Span, the latter two tapping either short-term or working memory capacity. Individuals with intellectual disability were also interviewed about their use of time aids in everyday life.

Results and Discussion. Individuals with intellectual disability varied in PM and working memory performance on both digit and Picture Position Span, and performed at a lower level than the control group. The action to perform was recalled more often than the prospective component, during performance of the Video-Based PM task. However, only one person with intellectual disability performed above chance level on the episodic memory task based on recognition of the PM cues that followed the Video-Based PM task. The episodic memory performance could reflect a group difference, or be a consequence of the task construction.

The PM performance was interpreted as a result of differences in working memory capacity with consequences also for episodic memory. Observations in the study situation proposed that mistakes were partly due to fluctuating attention, particularly in the intellectual disability group.

It was questioned whether the participants with intellectual disability had made the connection between verbal descriptions of the PM cues and the events in the video. In a subsequent analysis this could be ruled out by identical presentation of PM cues at encoding and recognition, that is, as a video-clip for video-based tasks. There was a tendency to ceiling effect in the control group in the Picture Position Span with pictures of objects, but not in the Picture Position Span with pictures of faces. This difference could reflect that strategies based on language were less efficient in the latter condition, since faces were more difficult to name. Paper I does not allow for far reaching conclusions regarding to what extent Picture Position Span tap working memory, but the performance resembles Digit Span performance.

Paper II

Topic: Prospective memory, working memory, retrospective memory and self-rated memory performance in individuals with and without intellectual disability.

Questions:

1. Are working memory and episodic memory related to prospective memory?
2. Does prospective memory performance in the intellectual disability group increase for a prospective memory task with pictures compared to verbal cues?
3. Do group performances converge on a familiar everyday task (posting a letter)?
4. Is prospective memory performance better for individuals with intellectual disability who have good conceptual knowledge of time?

Methodological issues:

5. Is performance above chance level on the Picture-Based prospective memory task with identical cue at encoding and recognition?

6. What is the relationship between picture, digit, and listening span performances?
7. Does the time conception scale reflect individual differences?

Method. The participants were adults with mild or moderate intellectual disability (20 female, 14 male, mean age: 35.4, *SD* = 9.1 y) and a control group matched on chronological age (11 female, 7 male, mean age: 39.1, *SD* = 11.3 y). PM was tapped by three tasks; a Picture-Based task, a "Remind-Me" task and "Post-a-Letter" task (Table 1). Recognition of the pictures serving as cues was investigated after task performance. The Remind-Me task was verbal and based on recognition of the phrase "now a new task starts". The Post-a-Letter task was based on returning a letter with symbols representing mood, the weekdays and the weather.

Working memory was investigated by three different tasks; Digit Span, Picture Span, and Listening Span (based on three word sentences). Digit and Picture Span Tasks were based on stimuli presented on the computer screen. An episodic memory task was also applied (Subject Performed Tasks, SPTs).

Self-rated memory was reported by answering the PRMQ questionnaire (Crawford et al., 2003), read out aloud by the experimenter. A questionnaire related to Time Conception (concepts, duration, frequencies, order) with two response alternatives per question was also used. With consent from the participant, the staff at the workplace or a teacher rated the conceptual time skill of the participants.

Results and Discussion. Picture-Based PM performance was on a par with performance in the control group for approximately one third of the participants with intellectual disability (the high performing subgroup). Recognition of PM cues was almost without error, particularly in the control group. The verbal Remind-Me task was less easily distributed, since the participants with intellectual disability often performed one task at a time. Performance in the intellectual disability group was close to floor level and ranged from one reminder to the maximum in the control group. The groups performed on a par in the Post-a-Letter task. Performance on all working memory tasks and SPTs suggest weak working memory capacity and episodic memory in the intellectual disability group compared to the control group. Individuals in the intellectual disability group with high Picture-Based PM performance were also less restricted than the rest of the intellectual disability group with respect to Digit, and Picture Span. Furthermore, participants in the intellectual disability group with high Picture-Based PM performance performed perfectly on the Time Conception Task. Performances on different tasks were more inter-correlated in the intellectual disability than in the control group. This was interpreted as a general effect of a lower level of development, in line with the plausible overestimation of the self-rated memory in the intellectual disability group.

The Picture-Based PM Task (Table 1) loaded strongly on picture recognition, which has been described as a fairly automatic process (Kvavilashvili & Taylor, 2004). This is in line with the high performance in individuals with intellectual disability, who are often more limited on explicit memory tasks. Division of the intellectual disability group based on Picture-Based PM Task performance gave a high-performing subgroup with intermediate working memory (apart from listening span) and episodic memory performance. The division could have been made based on other premises. However, with PM in focus, the more distant goal concerns how to support PM function to reach an adequate performance level. PM failures are part of most people’s everyday life, which motivates comparisons with a control group.

The interrelatedness between task performances in the intellectual disability group resembles results associated with less differentiated cognitive processes in children (e.g, Berk, 2006, p. 220). The plausible limitation in the self-rating aspect of meta-cognition in the intellectual disability group points in a similar direction. PM ratings have, however, been proposed to be developed earlier than retrospective ratings as a result of the social significance of PM (Bebko & Luhaorg, 1998).

PM performance in this study is in line with the increase in limitation for tasks that involve language, for individuals with intellectual disability. Performance on the verbal Remind-Me task was well-nigh undetectable, unlike Picture-Based PM performance in parts of the intellectual disability group. This difference could also be attributed to time for execution and detection of the cue. The Picture-Based PM task was self-paced, meaning that the participant had to act in order to proceed in the task. This constraint demanded that the participant focused on the computer. Regardless of this explanation, the difference in level of performance between the Remind-Me and the Picture-Based PM Task is intriguing. Are PM cues detected more rapidly in either one of these two tasks? Is the difference due to task modality? If so, is support from pictures as essential at encoding as at retrieval of a PM task?

Paper III

Topic: Compatibility between prospective memory cues at encoding and retrieval in individuals with intellectual disability

Questions:

1. Is congruent cue presentation at encoding and retrieval related to compatibility?
2. Are pictures compatible with words as cues at both encoding and retrieval in prospective memory?

Methodological Issues:

3. Do the Prospective Memory Game manipulations change performance and is this detected in both groups?

Method. The participants with intellectual disability were either enrolled in the municipal upper secondary special programme for pupils with intellectual disabilities, or employed at day activity centres (6 female, 5 male; *M* age: 30.55, *SD*: 8.08). The control group was composed of individual with similar chronological age (5 female, 9 male; *M* age: 25.07, *SD*: 4.34). PM was investigated by means of a PM Game (Table 1), with a board presented on the computer screen. Cue modality (picture or word) was manipulated at encoding and retrieval of PM items in the game, thereby constituting four conditions with specific items (Item-Specific Task); i.e., picture – picture, picture – word, word – picture, word – word. Pictures as cues were named at encoding and included on the board on the screen. The picture – picture and the word – word conditions were referred to as congruent, since the picture shown at encoding was also the retrieval cue. The word – picture and picture – word conditions were referred to as incongruent conditions as the picture was present either at retrieval or at encoding in each of these two conditions, that is, despite the verbal naming of the pictures at encoding of the picture – word items, which would have made it congruent with a focus on the verbal component. The compatibility of cues at encoding and retrieval was determined from performance in each of the four conditions.

Two PM tasks, the “Start” and the “Event-Card” task (Table 1), ran in parallel with the four conditions in the PM Game. The Start task was to be performed in the beginning of each lap, and the Event-Card Task was cued by a picture on the board, indicating when to demand an Event-Card (6 per lap). The game included episodic memory tasks, based on questions on the Event-Cards.

Furthermore, tests of working memory, time conceptualisation, time reproduction and non-verbal intelligence were performed.

Results and Discussion. The intellectual disability group was outperformed by the control group on all tasks, apart from the episodic memory task in the condition without any Item-Specific PM Task. Congruency and modality interacted in both groups, based on superior performance in the picture – picture condition. Compatibility between pictures and words increased when the picture was used in the retrieval phase, either due to higher distinctiveness in the pictures than in the words, or due to the visual presentation of the pictures on the board which may have facilitated access to the retrieval context at encoding. The PM errors in the intellectual disability group were almost exclusively complete omissions. The difference between words and pictures in the PM Game confirmed, (a) performance benefits for visual cues and visual representation of the retrieval context, (b) major performance differences between the groups, stressed in the more verbally loaded conditions, and (c) that encoding of verbal cues with support from pictures does not necessarily increase PM performance compared to encoding of verbal cues. That is, results of the present study point to the essence of cue distinctiveness and familiarity with the retrieval context for PM performance, especially in the intellectual disability group. Furthermore, it highlights that distinctiveness is an outcome of the interaction between a cue and the individual's cognitive capacity in a context (e.g., working memory, episodic memory, and non-verbal intelligence), not just an attribute of the cue per se. Verbal cues demanded more effortful memory processing in contrast to the ongoing task (to reach distinctiveness). The results are in line with a decline in performance on tasks with demand for language proficiency for individuals with intellectual disability.

Task performances were correlated primarily in the intellectual disability group, for example, episodic memory performances. However, working memory and non-verbal intelligence were correlated in both groups. Thus, the high degree of inter-correlations in the intellectual disability group could reflect the influences of a general cognitive process, for example, working memory capacity, affecting multiple other cognitive processes.

To conclude, as suggested, pictures as PM cues support performance. However, in case of incongruent cues at encoding and retrieval, pictures at retrieval yielded higher performance, and emphasised the benefit of knowledge about the retrieval context.

Paper IV

Topic: Prospective memory and binding in individuals with and without intellectual disability

Question:

1. Are prospective memory errors a type of binding error?

The line of reasoning in Paper IV emanates from the interpretation of PM errors as partially a result of a failure in binding the PM components, “when to act” and “what to do”. This particular binding is essential for an automatic associative (bottom-up) retrieval (reflexive-associative theory, Einstein & McDaniels, 1996; M. A. McDaniel & Einstein, 2000; M. A. McDaniel et al., 2004; reflexive-associative theory, M. A. McDaniel et al., 1998a) of the intended action, as the time to act is indicated by the target event. Partially correct PM performance, either recognition of the cue but not remembering the correct action, or performance of the intended action, although in response to the wrong (false) cue, was investigated further. The former demands recognition of the cue, and the latter demands retrieval of the intended action, though both could suggest a lack of specificity at encoding or retrieval.

Method. Two studies of PM and feature binding were compared, with a focus on a plausible connection between the concepts based on their mutual relationship to episodic memory. The participants with intellectual disability were in both studies either enrolled in the municipal upper-secondary special programme for pupils with intellectual disabilities, or employed at day-activity centres. The participants were individuals with intellectual disability (in Study 1; 20 female, 14 male, mean age: 35.4, SD = 9.1 y, and in Study 2; 6 female, 5 male; M age: 30.55, SD: 8.08) and a control group matched on chronological age and gender in Study 1; 11 female, 7 male, mean age: 39.1, SD = 11.3 y, and in Study 2; 5 female, 9 male; M age: 25.07, SD: 4.34). The first study included a Picture-Based PM task and a visual binding task based on faces as stimuli (in part presented previously in paper II and, in Danielsson et al., 2006). The second study included a PM Game and a visual binding task based on photos of faces as stimuli (in part presented previously in Paper III and, in Danielsson, Rönnberg, Levén, & Andersson, 2007). Two PM tasks of the PM Game were included; the Event-Card Task, with the same cue and task for each item, and an Item-Specific Task, with cues encoded and performed throughout the game. The first part of an episodic memory task preceded the Item-Specific PM task, whilst the second part was integrated as an ongoing task in the PM Game. Working memory and non-verbal intelligence tasks (Raven, Court, & Raven, 1995) were included in both studies.

The binding tasks were based on reported recognition of four picture types; old (encoded) pictures, conjunction (mix of old pictures), feature (mix of old and new pictures), and new pictures. The Picture-Based PM responses were correct or not. Performance is reported by means of d’. The event card task was scored as per cent items performed, and the Item-Specific Task as either correct, recognition of cue, performed task, or omitted (thus, the remaining items).

Results and Discussion. Binding scores were adjusted, by subtraction of performance on the new pictures (Paper II, Paper III, and Danielsson et al., 2006). In Study I, the intellectual disability group made more errors than the control group on the Picture-Based PM, working memory, episodic memory and binding tasks, except for recognition of old pictures. The latter could result from picture recognition being a fairly automatic memory process (Einstein, McDaniel, Thomas, Mayfield, Shank, Morrisette, & Breneiser, 2005). For the subgroup of individuals with intellectual disability who committed Picture-Based PM errors, this performance correlated to both recognition of old pictures (adjusted; r (20) = .58, $p < .01$), and conjunction errors (adjusted; r (20) = .46). ANOVA of binding performance (group-wise median split) and picture based PM performance revealed a relationship to conjunction errors in the control group.

In study 2, the groups differed in level of performance on binding and correct PM scores, and episodic memory, working memory, and non-verbal intelligence. The number of partially correct PM performances of each type did not differ significantly, in any group. Task performances were more inter-related in the intellectual disability group compared to the control group, not only due to working memory capacity differences. Recognition of cues though failing to perform the correct action was related to feature errors ($r(11) = .76$, $p < .01$), and there was a tendency to a correlation with conjunction errors ($r(11) = .57$, $p < .07$) in the intellectual disability group. The results suggest limited strategy distinctiveness, for example, relying on familiarity of single features, in line with correlations for recognition of cues but not for retrieval of intended actions in association with the wrong cue.

In sum, the intellectual disability group made more PM and binding errors than the control group, both in Study 1 and in Study 2. The link between PM and binding based on episodic memory was in part confirmed in the intellectual disability group. The high degree of inter-correlated task performances in the intellectual disability group compared to the control group could reflect, for example, (a) a developmental difference related to differentiation between cognitive functions, or (b) high mental workload leading to indistinct strategies. However, further investigations are needed to rule out influences from factors not included in these two studies, for example, plausible candidates, such as, executive functions. Regardless, the limited number of partially performed PM items suggests that false recognition of PM cues is a minor reason for PM errors on PM tasks with visual presentation.

The four papers of this thesis are concerned with PM in relation to short- and long-term memory processes in individuals with intellectual disability. Furthermore, PM performance is investigated for tasks with visual and verbal cues, respectively. As expected, weak PM, retrospective memory and working memory performance are found in the intellectual disability group compared to controls. PM performance in the intellectual disability group also depends on support from pictures. Pictures are likely to be required in order to achieve a level of distinctiveness that differentiates information belonging to the PM task from the surrounding contextual information.

General Discussion

The empirical part of this thesis investigated PM, long-term (episodic) memory and working memory performance in individuals with intellectual disability. Furthermore, self-rated memory performance, and aspects of time conceptualisation and time reproduction were included. The remaining part of the general discussion is organised as follows: First, the results (Papers I – IV) will be summarised briefly. Secondly, memory issues are discussed, followed by methodological issues, binding and time. The general discussion is summarised in a few conclusions preceding suggestions for future research.

Collectively, the results from the four papers can be summarised in five main points: (1) individuals with intellectual disability committed more PM errors than individuals in the control group, despite similarities in self-rated memory, (2) pictures supported PM functioning in cognitively demanding situations and may be important primarily for recognition of the PM cue (particularly in the intellectual disability group), (3) working memory capacity influenced both PM performance and binding performance in relatively complex tasks, that is, Item-Specific PM tasks or binding tasks with morphed photos of faces, (4) there was a relationship between binding errors and PM, specifically between feature errors and recognition of cues, though not retrieving the correct intention in the intellectual disability group, (5) time reproduction in the intellectual disability group was weak compared to the control group, suggesting a limitation in strategies for solving this type of tasks, due to, for example, fluctuating attention or weak episodic memory.

Prospective Memory Frameworks

PM depends on both working and long-term memory systems. PM models differ as to what memory processes that are involved in, for example, target identification and retrieval of the intention. For example, spontaneous retrieval (automatic association; e.g., Einstein & McDaniel, 1996; M. A. McDaniel et al., 2004; M. A. McDaniel et al., 1998a) of the intention is compared to monitoring (active search) in the context and in memory for presentation of the target (in retrieval, e.g., Einstein et al., 2005). According to the multiprocess view, the relationship between task specifics and the cognitive capacity of the individual determines the type of memory processing involved in PM (Einstein & McDaniel, 1990; Einstein et al., 2005; M. A. McDaniel & Einstein, 2000). For example, recognition of the target has been proposed to be to a large extent automatic, if the ongoing task makes the target get in focus of attention (Einstein et al., 2005). Two stage models (e.g., Kliegel, Guynn, & Zimmer, in press) of PM retrieval propose that noticing the cue induces a directed search in memory. Retrieval of the intention should follow if the cue is identified as a target (West et al., 2001).

Manipulations of the PM situation may influence performance, in particular for the individuals with limited working memory capacity, such as individuals with intellectual disability, who, in general, have a more limited working memory capacity than age-matched controls (e.g., Numminen et al., 2002). According to associative theories, working memory processing is required at encoding in order for the target to evoke retrieval of the intention. Theories that stress monitoring propose a demand for working memory processing in the active search for the target. Regardless of the theoretical framework topics concerning retrospective memory processes are brought to the fore as a delay is an inherent part of PM.

The design of the empirical work of this thesis was focused on PM performance in individuals with intellectual disability. The purpose was not to compare different models of PM, since PM performance in this group has attracted little attention from a cognitive perspective so far. However, as the presence or absence of a link between PM and working memory is investigated, the empirical results will be discussed in relation to different PM models. The tendency for different memory processes to be more strongly coupled in individuals with intellectual disability than in the general population may cloud the picture, as, for example, limited working memory capacity may constrain other aspects of memory processing.

Working Memory Issues

The second research question in this thesis explicitly includes working memory. However, all four studies (Papers I – IV) investigated working memory by means of single or multiple span procedures (cf. children with or without intellectual disability, L. A. Henry & MacLean, 2002). The expected limitation in working memory in the intellectual disability group was observed. The design of the studies in this thesis does not allow for precise conclusions about what aspect of working memory that constitutes the group difference.

However, a few indications can be found in observations from the experimental setting, for example, verbal picture naming in the intellectual disability group (Paper II). An overt verbal encoding strategy was applied exclusively by participants with intellectual disability (Papers I – IV). These individuals were often not able to adapt their behaviour to the task demands and suppress overt picture naming (cf. inner speech and retrieval cues, Miyake, Emerson, Padilla, & Ahn, 2004) as the task also required an overt verbal response for each picture. Unspecific strategic behaviour (e.g., spatial position when the positions for picture presentation were superimposed) that misleads performance is suggested especially in individuals with intellectual disability. This difference in task performance strategy between individuals with and without intellectual disability, with influence on the task demands, exemplifies the risk of using tasks tapping various cognitive aspects in groups with, for example, low language proficiency. However, with a focus on capacity, these span tasks can still be argued to measure similar processing capacities in the groups, as memory processing capacity is involved in forming and selecting strategies.

Furthermore, significant correlations between working memory performance and performance on Ravens Coloured Matrices (Papers III and IV) suggested that span tasks with pictures, at least with faces, may load primarily on fluid components of intelligence (Paper III and IV; cf. serial position memory in the visuo-spatial domain, Smyth, Hay, Hitch, & Horton, 2005). For the control group, this correlation was significant only for the span task that demanded judgement for each picture. These results could follow from a lower level of working memory performance in the intellectual disability group, (a) that made judgements, such as, he or she, a more efficient strategy than on longer spans, since fewer pictures exceed the number of categories (two), (b) that the judgements of he or she made up a better strategy than the one used spontaneously, for example, a face, and (c) that the level of performance itself restrained the possible performance reduction due to performance of the verbal task, for example, for participants with span length two. Span procedures suffer from the low resolution at short span lengths, in part compensated for by multiple lists (four in Paper I, two and three in Papers II – IV).

In sum, working memory capacity in the intellectual disability group was low, as we expected. Working memory performance declined drastically as the demand for memory processing was increased for individuals with intellectual disability (cf. performance of children with mild and moderate intellectual disability, L. A. Henry, 2001). Less robust level of performance also suggests a relation to strategic behaviour (low level of strategy competency, cf. Bray et al., 1997).

Prospective memory and working memory performance (i.e., Picture-Based PM Task and Picture Span) in the intellectual disability group covered a wide range of outcomes, from chance level to levels on a par with the control group. Performance of individuals with intellectual disability and the control group diverged on tasks with high complexity and a relatively high load on language skill (e.g., The Remind-Me Task in Paper II, listening span; cf. Bebko & Luhaorg, 1998; cf. short-term memory in children with Down Syndrome, Jarrold, Baddeley, & Phillips, 1999b). Working memory limitations in the intellectual disability group concur with compromised PM performance in situations with multiple simultaneous processes, for example, the PM Game (Paper III). In line with Bebko's and Luhaorg's (1998) reasoning, less automatic language skill demands more effortful processing, which in the present case should have reduced the working memory capacity available to engage in other aspects of strategic processing. That is, (a) reducing the ability to use semantic memory (cf. M. A. McDaniel et al., 1998a) for interpreting the board or encoding of specific PM items, (b) the amount of associations formed between a PM cue and the intended action, (c) rehearsal strategies during the delay, (d) sequencing the intended actions, (e) switching between the ongoing and the main PM task, (f) inhibiting pre-potent responses, (g) monitoring other aspects of the game, such as the score (plastic discs in the bowl), or (h) when it was time for coffee or lunch break. Thus, the numerous examples of how limited working memory capacity may have affected PM performance could also have restricted the robustness of PM performance (cf. reasoning about intelligence and robustness, Li et al., 2004). Task specifics that favour PM performance (e.g., familiarity or motivation) may, hence, have been vital for performance better than chance level.

Limited working memory capacity is offered as one explanation of effects of task manipulations (e.g., target modality) on PM performance in Papers I – IV. That is, PM performance may have been susceptible to lures, as the individual had less capacity for processing information and for adapting to the current task demands.

Long-Term Memory Issues

Long-term memory, in particular episodic memory, is a fundamental aspect of PM due to the delay between formation and execution of the intention. Long-term memory is explicit in the second research question in the thesis and was investigated in Papers I – IV by means of recognition and recall performance. Although episodic memory task performance of individuals with intellectual disability may be on a par with the control group (e.g., the first part of the Episodic Memory Task in Paper III), performance is less robust as the task demand is increased (cf. the Episodic Memory Task in Paper III). The intellectual disability group recalled fewer SPTs (categorical-relational and order-relational, Haring & Engelkamp, 2003; motor element, Helstrup, 2005; integration, Kormi-Nouri, Moniri, & Nilsson, 2003) than controls (Paper II), contradictory to previously published results (SPTs, Cohen, 1983). This contradiction may partly be explained by a higher demand for distinctiveness at encoding and retrieval in Paper III (due to items from one category) compared to Cohen (1983).

Self-ratings of memory involve metamemory which requires episodic memory in association with working memory processing. Weak metamemory in individuals with intellectual disability is a plausible explanation for the lack of a difference between the groups in self-rated memory scores (Paper II).

Prospective memory and long-term memory. The PM performance in Paper II with congruent stimuli at encoding, retrieval and post experimental recognition suggested a benefit in PM performance, plausibly due to the overlap in memory processing. PM has typically been related to episodic, semantic, and working memory processing at encoding and retrieval in adults (cf. R. E. Smith & Bayen, 2004), for whom a higher degree of overlap in processing supports performance (e.g., Meier & Graf, 2000).

Recognition of intentions and targets after performance of the PM task rendered perfect performance for the control group in Papers I and II, and for one third of the intellectual disability group in Paper II. However, individuals with intellectual disability frequently committed episodic memory errors (verbal or enacted responses) in Paper I. This may be a result of less distinct encoding in long-term memory of gestures compared to pictures, and thereby an increased susceptibility to false memories and suggestibility (Uttl, Graf, Miller, & Tuokko, 2001).

The episodic memory performance was close to perfect for the control group (Paper III), also when the episodic memory task had been encoded as an ongoing task with respect to a PM task (cf. integration and coordination of tasks, Emerson, Miyake, & Rettinger, 1999). Better episodic memory performance in conditions with congruent PM cues indicated either a reduced overlap in demands on explicit memory capacity due to an easer PM task, or that at least one of the two tasks loaded more on implicit processes. For the intellectual disability group episodic memory performance differed significantly between the PM game conditions associated with the highest and lowest PM performance. That is, episodic and PM, to some extent, load on similar memory processes (possibly, some aspects of working memory). Cognitive processes in individuals with intellectual disability may also be less differentiated than in the control group, as is the case in children (e.g, Berk, 2006, p. 220), as suggested by group differences in patterns of correlations (Papers II – IV). The implication is that the groups may have applied partly different strategies and memory processes. Persons with intellectual disability could have overestimated their own capacity to remember and hence relied on, for example, familiarity although a more specific strategy was more optimal.

Task Characteristics

PM performance is governed by an intricate interplay between memory processes and characteristics of the PM task situation. Research questions three and five, concerning compatibility of encoding and retrieval of PM, and high- and low PM-performing subgroups, respectively, will be discussed in relation to task characteristics, specifically with respect to strategic behaviour, familiarity, ongoing task, and modality.

Task Characteristics and Strategies. The PM Game (Paper III) is based on everyday experience which may have facilitated forming associations, in particular, in individuals with intellectual disability, who often depend on experience due to a limited capacity to engage in abstract reasoning. Everyday experience should also guide when to anticipate the targets. However, PM performance on time-based tasks is reduced, if the information about the retrieval situation turns out to be wrong (Cook et al., 2005), a result that may also be valid for event-based PM tasks, such as the PM Game. Thus, knowledge about the retrieval situation may guide when a person should be prepared to act, increase memory processing and the amount of context specific associations, or direct performance by providing support for forming distinct plans. The latter may be essential for distinguishing a familiar PM target from an equally familiar context. However, familiarity with the background (ongoing) does not always reduce detection of the PM targets in an experimental setting (Cook, Marsh, Hicks, & Martin, 2006). The PM game included four conditions and performance was not significantly different between conditions performed first, second, third or last. Thus, the result did not reveal any effect of increased familiarity with the background task. Thus, both active search for the targets (Meier et al., 2006) and pop-up experiences (Meier et al., 2006) are likely to contribute to PM Game performance.

Familiarity. In PM tasks with multiple items that are all based on the same PM target and intention (e.g., Event-Card Task, Paper III) acting on one item serves as a repetition for consecutive items. Thus, each item that is performed is assumed to further familiarise the participant with the task, in contrast to the PM task with specific items (Item-Specific Task, Paper III) which can be more demanding. The experienced cognitive demand of the participant may influence to what extent this person relies on monitoring versus spontaneous retrieval for prospective performance (Einstein et al., 2005).

Familiarity with the local context can support retrospective memory processes (e.g., knowledge about physical cues, cf. Titov & Knight, 2001) and the use of various strategies and, thus, be beneficial to PM performance. Variation in experience in the intellectual disability group in particular therefore motivated a neutral choice of video (Paper I). The retrieval context is part of the board on the computer screen in the PM Game condition with pictures as cues at retrieval and, hence, known at encoding of the item. This should stimulate monitoring of the target. The complex retrieval situations in the PM Game suggest that both automatic and more explicit monitoring should be used for optimal performance, that is, to avoid erroneous mixing of targets and intentions. The PM items in the game are, to some extent, associated as they all are based on everyday situations, which stimulates more automatic retrieval processes. Meier et al. (2006) conclude that less is known about the retrieval experience in situations with unique PM items, for example, as in the PM Game. Participants in the control group may have adapted their behaviour to the task attributes more successfully than the individuals with intellectual disability due to, for example, ability to process more information simultaneously in memory. Furthermore, an intention "to buy bread", and a retrieval cue "when you pass the bakery", are semantically related. Thus, priming effects support PM performance (Mäntylä, 1993) and reduce the demand for explicit memory processing, such as, forming a link between the intention and target to prevent interference between different items (Marsh, Hicks, & Cook, 2006). Priming may be essential for PM performance especially in situations with a high attentional load and typical cues (Penningroth, 2005).

In sum, the impact of stimuli characteristics in part depends on the context, for example, the ongoing task and complexity of the PM task (e.g., one or multiple steps of action), in relation to the individual's cognitive capacity. Individuals with intellectual disability performed more on a par with the control group in tasks with multiple targets associated with the same intention (e.g., the Event-Card Task, Paper III) than on tasks with different targets and intentions (e.g., the Item-Specific Task, Paper III). This may, however, in part be due to a tendency for ceiling effects in the control group.

Ongoing Task. Making out the target in the context of the ongoing task is essential and has been proposed to be more automatic if the target enters the focus of attention as the ongoing task is performed (focal cue; Einstein & McDaniel, 1990; Einstein et al., 2005). This could explain part of the advantage for pictures compared to verbal cues in Paper II. As intended, performance was more on a par with the control group on the Picture-Based PM Task (Paper II) compared to the Video-Based PM Task (Paper I). The Picture-Based PM Task was based on pictures presented one by one which should make it easier to discriminate the cue from the background (white screen) compared to words as cues (Remind-Me Task) or events in a video (Video-Based Task). The result for words as cues in Paper III points to weak performance despite inclusion of the cues in a phase of the ongoing task that demands attention to the verbal message. Words as PM cues demand noticing the cue also when embedded among other sentences, that is, in a new verbal context which is unknown at encoding. Thus, the demand for explicit monitoring of the target is increased. This may in part explain declining performance for PM tasks with verbal compared to visual targets for individuals with intellectual disability.

Modality. The result on the Picture-Based PM Task suggests that pictures can support PM performance in the intellectual disability group, as 25% of the participants performed on a par with the control group. Performance was on the other hand at a floor level on a verbal task (Paper II) also for the high-performing sub-group with intellectual disability. Further investigation of PM cues at encoding and retrieval revealed superior performance in situations with a picture at retrieval compared to words as cues (Paper III), especially in individuals with intellectual disability. Presumably these performance differences are partly linked to the strategic component of PM, which is more important in case of less distinct perceptual stimuli (e.g., pictures compared to words; M. A. McDaniel & Einstein, 1993) in the intellectual disability group. High distinctiveness may, for example, reduce the demand for explicit (top-down) memory processing at encoding or make it easy for the intended action to “pop-up” in memory in response to a target event. Transient PM targets, such as words, may increase the demand for more automatic retrieval processes, especially if the person’s working memory capacity is limited. However, extensive memory processing may be required at encoding in order to remember words with distinctiveness on a par with a picture. Hence, the distinctiveness of pictures increases the ability to compete for attention with the ongoing task, which was first and foremost relevant in the intellectual disability group. The conclusion is that the effect of level of distinctiveness overshadowed other aspects influencing PM performance, especially for individuals with intellectual disability, who most likely were less prepared to shift between multiple strategies for task completion.

The visual layout on the screen of the PM tasks in Papers II and III differed (one picture at a time in the Picture-Based PM Task vs. the board in the PM Game). The PM cues (pictures) were included in the board and constantly presented in the game, where they should be noticed when they were passed compared to PM cues occurring among other pictures presented sequentially one-by-one on the screen (Paper II). That is, position along the trail on the board represented a spatial and temporal dimension that was not familiar in Paper II. The trail could be described as a route with landmarks in pictorial space, segmented by pictures that give the route a visual as well as semantic structure (Albert, Reinitz, Beusmans, & Gopal, 1999; cf. Jansen-Osmann & Berendt, 2005), thus, fostering a survey knowledge of the game as an environment. Position on the board in the game could support strategies, such as monitoring, since (a) a lap represented 24 hours and everyday experience could be a support, and (b) pictures were included along the trail. Verbal proficiency and reasoning capacity could compensate for visuo-spatial shortcomings, but they are in most cases compromised in individuals with intellectual disability. However, the pictures were part of the board on the computer screen in Paper III and plausibly served episodic memory by stimulating repetition of the task instructions.

In sum, the intellectual disability group was outperformed by the control group, regardless of verbal support or support from pictures at encoding and retrieval in Paper III, but the difference in performance was reduced for tasks with pictures at retrieval. Hence, the immediate distinctiveness of pictures is essential for PM performance primarily in the intellectual disability group, as the control group has the cognitive capacity required to compensate for increased task demands (words as PM cues). Furthermore, performance on the PM Game indicates that visual presentation of "the future" (what is to come in the task setting) assists the intellectual disability group.

Binding and Prospective Memory

Binding is referred to in research question four. PM relies on forming and retaining associations (binding) between targets and intentions (cf. M. A. McDaniel et al., 2004) until the goal has been accomplished. The link between target and intention has to stay intact in the retrieval process in order to avoid PM errors, that is, to avoid mixing targets and intentions erroneously, for example, touching the nose instead of the cheek in Study I. Working memory influences both binding and PM performances, for both concepts with multiple explanations. A recent approach to binding (WMCE, Danielsson, 2006) suggests that the individual's working memory capacity has an impact on the extent to which recognition in a binding task relies on more automatic familiarity or effortful retrieval processes. This approach, hence, agrees with the multiprocess approach to PM, which acknowledges that the capacity of the individual influences to what extent performance is conceptually or perceptually driven. With respect to PM, familiarity may suffice for recognition of a target but is unlikely to support retrieval of the intention unless acting is highly automatic or guided by semantic memory, for example, to drink from a glass.

Cognitive speed deficits (Goolkasian & Foos, 2005; Smyth et al., 2005) may have contributed to binding errors on PM tasks that were not self-paced (Paper I), especially for individuals in the intellectual disability group, thus, resulting in inadequate distinctiveness and susceptibility to lures (Paper II). Limited processing of a target event due to an increased attentional demand and high load on working memory should reduce PM performance as inadequate distinctiveness may result in mixed stimuli. Individuals with intellectual disability were more prone to commit conjunction errors based on mixed targets and intentions than the control group in the Item-Specific PM Task (Paper III), although omissions were the most frequent error in this group. The correlation between feature errors (mixture of old and new features) and correct recognition of PM cues, though failing to retrieve what action to perform, suggests a low level of distinctiveness as a consequence of insufficient capacity for memory processing of the stimulus material. Thereby, strategies based on familiarity may be the best option given the individual's cognitive capacity. The empirical work of this thesis confirms that fewer errors were committed by the control group which may be due to more extensive processing of both specific features and complete configurations or a better capacity to adapt their behaviour to the task demands.

PM and binding performance may reflect less robust episodic memory in individuals with intellectual disability compared to the control group. In combination with limited executive and working memory capacity this may reflect inability to resist acting on familiar stimuli or to choose the first intention that comes into mind.

Time and PM

PM as a practical application in everyday life that often involves time may stimulate development of understanding of the time concept, which individuals with intellectual disability often do not fully master. Time as a concept relates to both working memory and long-term memory issues (Research question 2).

The papers in the present thesis included tasks that required a conceptual understanding of time (Paper II and III) and time reproduction (Paper III). The conceptual aspect is relevant despite the focus on event-based PM performance as, for example, the Post-a-Letter Task involves performance outside the experimental setting or as some questions concerned sequential order of everyday events. Working memory span tasks demand attention and updating of the sequential order of items for shorter periods of time, and, hence, may be sensitive to discontinuities in time (cf. time monitoring, Mäntylä, Carelli, & Forman, 2007). Attention is essential for time reproduction performance, which is sensitive to the level of mental workload (Brown & Boltz, 2002), and which can be considered low in Paper III. Maintenance of time is even more essential for time reproduction, although episodic memory processes also are involved for longer time spans, the latter, in particular for event-based PM tasks, in case external cues are essential, as suggested by Mäntylä et al. (2007).

Performance on the conceptual task was high in the subgroup of participants with intellectual disability with high Picture-Based performance (Paper II). The conceptual task requires working memory capacity for processing and selecting one out of two response alternatives. The few individuals with intellectual disability with a working memory capacity in the range of one or two may have focused on remembering at least one response alternative. However, abilities other than conceptual understanding of time, for example, experience, are likely to influence PM performance. This may be more important in natural settings, or for tasks such as Post-a-Letter, than in the other PM tasks included in this thesis. The load on attentional resources is more evident for time reproduction or for the PM tasks performed in the more experimental settings. That is, performance in the intellectual disability group may have declined as a result of load on attention and cognitive speed, indicated by weak time reproduction and not flawless performance on the Event-Card task in the PM Game (Paper III). Similarly, in old age PM performance is sometimes superior in naturalistic settings compared to experimental settings with a stronger demand for immediate responses. This, however, calls for further investigations of other tasks and contexts, for example, including longer time spans, and time spans in everyday life.

In sum, both perceptual and conceptual understanding of time potentially support PM performance, for example, as a component in strategies for how to meet PM demands in every-day life. However, self-rated memory performance suggests limited metamemory skill with plausible implications for motivation to use memory support to guide performance in individuals with intellectual disability. As a consequence, correct PM performance may depend on explicit cues that reduce the demand for explicit memory processing at target identification, for example, strategies that relate time concepts to external cues or events and, thereby, limit the requirements for abstract internally generated cues.

Conclusion

PM performance in individuals with intellectual disability was less robust and associated with more errors than in individuals in the control group. Distinctive PM targets, for example, pictures, were essential for performance. This result was discussed as a consequence of limited working memory capacity, as this also influences access to information in episodic memory. A relationship between feature errors and recognition of PM cues without retrieval of the correct action was demonstrated (Paper IV, Study 2) and may either reflect weak binding or be a consequence of fairly automatic picture recognition skill. The relationship between self-rated memory and more objective memory scores suggests limited metamemory, particularly in individuals with intellectual disability. Hence, the individual’s interest in interventions with improved PM function as aim may be weak.

Practical Implications of the Present Thesis

Three practical implications of this thesis will be further discussed; Pictures as PM cues, PM tasks and training, and motivation to improve PM. The results point to pictures as support to PM performance. However, the cross-modal situations (word – picture, picture – word presentation of cues) does not reveal any benefits of pictures at encoding, if a verbal cue is used in the retrieval situation for individuals with intellectual disability. Considering the parallel to calendars with pictures, this may be somewhat contra-intuitive, and the result definitely requires further replication before drawing far reached conclusions. Since the items of the PM game were based on concrete everyday situations, the verbal instructions may have evoked specific associations and memory processing that were sufficient for the task. This calls for further investigation with items with less concrete verbal cues. To conclude, pictures support PM performance in most situations, especially at target identification.

Despite limited transfer of knowledge between different settings in the intellectual disability group, the PM Game or similar procedures have potential to be developed further and adapted to the person's capacity or to a relevant situation. The Video-Based procedure in Paper I (Table 1) can be adapted to the individual, for example, to keep a doctor's appointment can be practised by using a video of the home environment to identify cues which indicate that it is time to go to the doctor (intention retrieval). The PM Game has also been discussed in these terms, but the transfer of information from this game to natural settings is likely to be more cognitively demanding. However, for some individuals who get bewildered by too much information at once, it could (with modifications) be useful as a simplified version of situations in everyday-life.

PM performance between the groups differed except for self-rated PM sores. This discrepancy brings to the fore the challenge of how to motivate the person to use time aids and other aspects of support to improve PM performance. Training, for example, strategies as support to PM performance may be even harder to carry out with great success.

Suggestions for Future Research

This thesis aims to investigate PM functioning in individuals with intellectual disability. A need to modify established methods for studying PM to accommodate the cognitive strengths and weaknesses in the intellectual disability group was identified. These suggestions for future research, hence, concern methodological challenges of applied and theoretical interest. Methodological refinement prepares the ground for research on more specific theoretical questions. First, methodological issues thought to be central for PM research in individuals with intellectual disability will be raised. Second, suggestions for areas of research on interventions with the purpose to support PM performance will be discussed. Third, a few concepts worth further investigation in relation to PM in individuals with intellectual disability will be suggested.

PM research is a relatively new research area and includes an increasing number of special populations as well as links to other cognitive concepts. Experimenting with individuals with an intellectual disability calls for care with respect to inclusion criteria (specific diagnosis, mental or chronological age) and matching of control group.

Methods used for studying PM, working memory, episodic memory, and time processing ability (Tulving, 2002) typically require either reading and language skills, motor function or long test sessions without interruption (pauses). These are task attributes that potentially threaten the result, as these aspects do not fit with the cognitive characteristics of the intellectual disability group nor with practical constrains in the test session. Inclusion of at least one measure or task in the situation on which the participant performed excellently and, thus, received positive feedback, was an attempt to stimulate motivation.

Despite modifications of specific details, for example, stimulus material and procedure, the goal of improving the task resolution at the extremes (floor and ceiling levels) remains. Solutions, such as, adapting the speed or amount of concurrent tasks to the individual’s cognitive capacity (e.g., working memory capacity, reaction time, episodic memory performance) have drawbacks, particularly since the manipulation per se implies an impact on PM performance. Inclusion of groups with profoundly different cognitive capacity (as in this thesis) draws attention to whether the task taps the same concept in the two groups. However, even if the groups use different strategies, each individual lives and acts in an environment, (a) where they face a demand for PM performance, and (b) that is governed by the same basic physical constants and constrains (e.g., three dimensions, speed of light). The adaptations of methods to the intellectual disability group were more or less successful, and point to a demand for further improvements.

Video-based methods is another alternative that has been successfully used in studies of PM in other groups (traumatic brain injury, Knight et al., 2005; Knight, Titov, & Crawford, 2006; Logie et al., 2004; college students, Titov & Knight, 2001).

The PM Game has potential to be refined in order to achieve variation in groups with varying cognitive capacities, for example, by a design similar to some computer games and working memory tasks, with gradually increased task complexity. Unsatisfactory resolution in parts of the range of performance is a weak spot for many methods that are used, including span procedures. Yet, this obstacle is often ignored, although it is a threat to task validity. Also, questions, such as whether or not two groups use similar strategies, demand detectable levels of performance. Tasks that result in performance above floor level are important in order not to foster outerdirectedness. Furthermore, with the widespread use of digital photos, picture based methods could be adapted to the individual's interests and everyday life. Thus, such methods could be used for finding out a suitable level of complexity of a cognitive aid (as support to the person's memory function in everyday life) as a complement to effortful testing in real life. The PM Game may also be modified for the study of specific theoretical research questions, for example, the difference between intentions you have generated yourself compared to intentions imposed by someone else. Thus, tasks similar to the PM Game may even be suitable for PM training, without the severity of everyday PM failures. The PM tasks used in this study were based on intentions that had been created beforehand by the experimenter. Thus, the participant was not engaged in the primary construction of the intentions but had to adopt intentions created by someone else. Using a situation for which the participant plans their own intentions may (a) support the motivation for performing the task, and (b) should improve PM performance as memory processing becomes explicitly compulsive and should favour intention retrieval.

PM training reported to date has focused on compensation for changes due to aging or brain injuries by improved strategic skill in everyday life. The Memory Compensation Questionnaire (MCQ, Dixon, de Frias, & Backman, 2001) with a focus on self-reported everyday memory compensation includes the following strategies; use of external memory aids, internal mnemonic strategies, investigating and managing time, applying more effort, and reliance on human memory aids. Examples of all of these types of strategies were found in the data gathered in the studies included in the present thesis although in different situations, for example, explicitly expressing a need to repeat in order to remember. The tasks used in the present thesis were, however, designed to limit the demand for language proficiency, hence, not with the purpose of detection of self-reported strategic behaviour. A more detailed study of objective PM performance in relation to strategic behaviour and self-reported memory performance in individuals with intellectual disability would presumably reveal a wide variety of strategic behaviours, skills and shortcomings. That could result in better understanding of the challenge of acquiring a PM capacity and what stages in the PM process that are most likely to require support.

From a theoretical perspective, the results propose further investigation of the cause of variability in PM performance in the intellectual disability group, that is, to link components on a more detailed level of, for example, working memory and executive functions (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000) to PM performance, to gain better understanding of the grounds for the outcome of specific task attributes, for example, to investigate the effects of contextual associations on PM performance (Marsh et al., 2006) in individuals with intellectual disability. Furthermore, in combination with previous research about cognitive functions, such results could reveal plausible diagnosis specific aspects of PM.

Because PM is an “everyday” memory, used on many occasions during an ordinary day (e.g., Harris, 1984; Meacham, 1988), observations in everyday life are likely to implicate other aspects than working memory and episodic memory that influence PM functioning, particularly, to disclose when PM failure is perceived as a problem for and by whom. Limited meta-memory awareness is one possible interpretation of the relationship between objective and subjective PM performance in the intellectual disability group.

Further investigation of the understanding of time (more thoroughly than the questionnaire used in Papers II and III) and the relationship with PM performance in individuals with intellectual disability has potential to result in more specific guidelines for how to support PM functioning, with the purpose of improved adaptive behaviour and autonomy in everyday life.

PM for intentions to be performed is often defined in relation to retrospective memory, for example, for performed intentions. There are different opinions of the demand on working memory processing, for example, for recognition of when to act on an intention. Research on the relationship between PM and other cognitive concepts continues. With respect to working memory, the general picture points to the involvement of attention (e.g., West et al., 2006) and executive functions (e.g., Marsh & Hicks, 1998; Salthouse et al., 2004).

This thesis includes an attempt to link PM in the intellectual disability group to two specific aspects of episodic memory; binding errors and time reproduction.

PM performance requires the individual to understand his or her perspective in a future situation, thus, proposing a link to theory of mind (ToM). ToM is often limited in the intellectual disability group (e.g., Yirmiya, Solomonica-Levi, Shulman, & Pilowsky, 1996), probably due to limited language skill (cf. Abbeduto, Short-Meyerson, Benson, & Dolish, 2004), and also differ qualitatively between diagnostic groups (e.g., Cornish, Burack, Rahman, Munir, Russo, & Grant, 2005). Thus, investigation of the impact of language proficiency on PM performance in individuals with intellectual disability would be preferred if relating the concept to ToM.

The investigation of concepts, for example, PM, may have been left behind more or less on purpose, as a result of major methodological challenges, referred both to the concept itself and to cognitive characteristics of the group. If a general opinion favours terms such as individuals with physical or mental challenge, should not we, as researchers, ourselves take on the challenge to develop tools that can give a fair picture of the challenge and its consequences?

Table 1. *The phases in the prospective memory tasks*

Prospective Memory Tasks	Paper	Task Setting	Encoding [a]	Storage [b]	Retrieval	Response Mode [c]
Video-Based	I	laboratory natural ongoing task focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions	short-term	event in video momentarily	specific gestures
Picture-Based	II	laboratory focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions, visual support	short-term	picture on computer screen self-paced momentarily	general gesture
Self-Rated	I, II	laboratory	neutral, relatively unimportant, verbal and written instructions	long-term	question	by own choice
Post-a-Letter	I, II	natural non-focal cue	neutral, relatively unimportant, one-stage, step, verbal and written instructions, visual support, known retrieval context	long-term	by own choice event	post-a-letter
Remind-Me	II	laboratory natural action focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions	short-term	event momentarily	General reminder

Prospective Memory Tasks	Paper	Task Setting	Encoding [a]	Storage [b]	Retrieval	Response Mode [c]
Prospective Memory Game						
Item-Specific	III, IV	laboratory medium – non-focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions, for pictures with visual support and known retrieval context	short-term	event momentarily	specific verbally described tasks
Event-Card	III, IV	laboratory medium focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions visual support, known retrieval context	short-term	event momentarily	general task verbally described
Start	III	laboratory focal cue	neutral, relatively unimportant, one-stage, episodic, pulse, verbal instructions with or without visual support, known retrieval context	short-term	event momentarily	general task verbally described

[a] step vs. pulse, task can be performed during a long interval after a cue event, or has to be performed at a specific limited time (J. Ellis, 1988).
[b] long-term vs. short-term, the prospective memory task is performed during, or outside the test session
[c] general vs. specific, identical or different tasks-to-perform for different test items

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