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Prospective memory, Working Memory, Retrospective Memory and Self-Rated Memory Performance in Persons with Intellectual Disability

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Running head: Prospective Memory and Intellectual Disability

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Abstract

The purpose of the present study was to examine the relationship between prospective memory, working memory, retrospective memory and self-rated memory capacity in adults with and without intellectual disability. Individuals with intellectual disability performed at a lower level on most tasks compared to persons without intellectual disability, and the task performances were to a higher degree correlated. The groups did not differ in self-rated memory scores. Distinct prospective memory cues (pictures) were essential for prospective memory performance in persons with intellectual disability. The performance levels for this group typically dropped to floor level on the task with verbal cues. The results are discussed with respect to how working memory capacity relates to prospective memory and retrospective memory performance. Weak meta-memory awareness is suggested to restrict the motivation to use cognitive aids especially in persons with intellectual disability.

Keywords: Prospective Memory, Working Memory, Intellectual Disability, Self-Rated Memory, Retrospective Memory

Prospective Memory, Working Memory, Retrospective Memory, and Self-Rated Memory Performance in Persons with Intellectual Disability

Prospective memory (PM) refers to the ability to act on intentions (e.g., to bake) at an appropriate time or event in the future (e.g., in twenty minutes or as the bread golden brown, cf. Ceci & Bronfenbrenner, 1985; Ellis & Kvavilashvili, 2000). Intentions that are performed at once and kept in focus of attention, e.g., stirring constantly in the sauce-pan, do not load on PM, nor does memory for the past, e.g., what you bought yesterday. However, the intention has to be stored in a permanent memory during the delay preceding acting on the intention (e.g., Graf & Utzl, 2001). As PM is directed to the future, other actions that are referred to as ongoing tasks are performed during the delay between forming the intention, e.g., to bake and performing the intended action, e.g., to take the bread out of the oven. PM is typically an important aspect of everyday cognition. Previous results indicate severe limitations in PM function in individuals with intellectual disability (Levén, Lyxell, Andersson, & Danielsson, in press) that may influence adaptive behaviour skills (cf. Svensk, 2001) and their need of support in everyday life (cf., Loveland & Tunali-Kotoski, 1998, "Mental retardation: Definition, classification, and systems of supports", 2002). PM can be both a prerequisite for and a consequence of adaptive behaviour as the outcome of performing an intention may change the situation. For example, if you filled up the car as you intended or postponed going to the petrol station influence whether you get to work early or late in the morning. The new situation may call for adjustments of another intention demanding working memory capacity for short-term processing and storage of information. If you are late you may have to make a new plan for the morning, e.g., to postpone making a phone call until the afternoon (cf. Richard L. Marsh, Hicks, & Landau, 1998). PM hence demands both retrospective memory and short time storage and processing of information (working memory, West, Bowry, & Krompinger, 2006).

The purpose of the present study is to examine the relation between PM, working memory, retrospective memory and self-rated memory in persons with and without intellectual disability.

PM includes shifting between multiple phases of mental activities; plan formation, storage, cue identification (recognition), intention retrieval, performance, evaluation of the outcome (Ellis, 1996). These broad spectra of tasks, processes and operations make PM performance susceptible to weaknesses in other memory systems such as working memory and retrospective memory. Consequently, a weak PM performance is predicted in individuals with intellectual disability (e.g., in persons with intellectual disability, Levén, Lyxell,

Andersson, & Danielsson, 2004). As few studies have investigated PM in individuals with intellectual disability, we will focus on memory performance in persons with intellectual disability. However, for comparisons, PM performance in a general and in other special populations are referred (e.g., prospective memory in children with ADHD, Kerns & Price, 2001; age-related differences in prospective memory, e.g., M. Kliegel, Ramuschkat, & Martin, 2003).

PM performance loads on working memory (Richard L. Marsh & Hicks, 1998). In a general population, event-based PM performance is reduced as the attentional demand from the ongoing task increases, a reduction which most likely is even more pronounced for persons with intellectual disability. Persons with intellectual disability often express inadequacies in executive functioning (e.g., children with Fragile-X, Hooper, Hatton, Baranek, Roberts, & Bailey, 2000), particularly in situations with a high demand on working memory performance (children with learning disabilities, Cornish, Munir, & Cross, 2001; Henry, 2001).

Retrospective memory performance, specifically episodic memory, is often relatively good in persons with intellectual disability (Cohen & Bean, 1983) in comparison to the persons' working memory capacity. Implicit long-term memory processes, that is memories that cannot be consciously retrieved, are often less limited than explicit memory in individuals with intellectual disability (e.g., adults with mental retardation, Atwell, Conners, & Merrill, 2003; implicit memory, Graf & Schacter, 1985; children, Wyatt & Conners, 1998). However, retrospective memory performance of persons with intellectual disability suffers from, e.g., insufficient specificity in the remembered information (cf., Henry & Gudjonsson, 2004). This may follow from limited working memory capacity to engage in explicit memory processing. Recall may as a consequence depend on familiarity processes (implicit) which results in retrospective memory errors if the task requires recall of distinct pieces of information (e.g., Danielsson, Rönnerberg, & Andersson, 2006). PM tasks with low demand on strategic memory processing such as planning, e.g., tasks with salient PM cues and low demand from the ongoing task, can thus be predicted to be essential for PM performance in persons with intellectual disability in particular.

Elaboration of a familiar situation (e.g., passing the local post office) can be specific and concrete. To imagine the future situation when the prospective task is to be performed can be used as a successful strategy for improving PM performance. Familiarity with the PM retrieval context and intention may hence be essential for PM performance in persons with

intellectual disability (a general population, cf. M. A. McDaniel & Einstein, 1993; Titov & Knight, 2001) as verbal skill and abstract reasoning are often limited. Individuals with intellectual disability improve in strategic behaviour in situations with concrete cues (cf. Bray, Fletcher, & Turner, 1997) and tasks (e.g., to bring a book to the library), as opposed to tasks that include manipulation of abstract concepts (e.g., to compare the time left before the bus leaves to the time needed for preparing the breakfast). Weaknesses in time perception, is a common obstacle for obtaining satisfying adaptive behaviour in persons with intellectual disability (Lindström, Wennberg, & Liljegren, 1996). PM failure may thus follow from insufficient strategic processing of representations and perception of abstract time concepts (cf., effects of delay on prospective memory performance in old age, Mark A. McDaniel & Einstein, 2000; implicit and explicit memory processes, Down's syndrome, Vicari, Bellucci, & Carlesimo, 2000).

In the present study working memory and retrospective memory performances to further elucidate the relationships between these two memory systems on PM performance in persons with mild to moderate intellectual disability. Profound variation in cognitive strengths and weaknesses is predicted in individuals with intellectual disability, thus, proposing partitioning of persons with intellectual disability into high and low performing sub-groups. A control group of age-matched persons without intellectual disability is included. Ratings of memory function are also assessed in order to relate one aspect of meta-cognitive competence to performance on the other tasks of the present study. Individuals with intellectual disability also performed a time conception task. Evident differences in performance levels between the intellectual disability and the control group are expected, apart from retrospective memory performance. Task performances are predicted to be related to a higher extent in the persons with intellectual disability (cf. Bayliss, Jarrold, Baddeley, & Leigh, 2005). Hence, the groups are compared with a focus on differences between the groups as well as on the relationship between performances in different tasks within the groups.

Method and Material

Adults with mild or moderate intellectual disability (20 female, 14 male, mean age: 35.4, SD = 9.1 y) who was employed at day activity centres or/and by their own choice attended adult education participated in the present study. Participants with intellectual disability varied in language, reading proficiency and motor function. Inclusion criteria were based on adequate vision and verbal communication of, e.g., "yes" or "no" and digits. Verbal communication of actions in the prospective memory task could however partly be replaced by returning specific objects to the experimenter. Furthermore, a control group with persons

without intellectual disability matched on chronological age (11 female, 7 male, mean age: 39.1, SD = 11.3 y) was included.

General Procedure

The present study was introduced verbally to larger groups of people where participants were recruited. Written information was also provided. Staff participated when persons with intellectual disability was informed and could thus answer or transfer questions, also when the researchers had left. The participants had met the researchers before giving their consent to participate and the initial task was performed. The tasks were performed at a place that was familiar to the participant (e.g., Beail, 2002; Levén et al., 2004). Two PM tasks (Picture-Based and Remind-Me), a Retrospective Memory Task (Subject Performed Tasks, SPTs) and three working memory tasks (Listening Span, Picture Span, Digit Span), were distributed in an experimental setting (separate room with a portable computer) at the participant's work-place (day activity centre) or at school. The procedure also included a Time Conception Task, ratings of how you experience your own memory function and ratings made by another person collected on a later occasion for individuals with intellectual disability. Furthermore, a naturalistic third PM task ("Post-a-Letter") was distributed. All tasks were distributed in a balanced order, except for the Remind-Me-Tasks and the Post-a-Letter Task. Pauses were introduced when needed. The collection of data was ended when the participants went on vacation.

Prospective Memory

Three different PM tasks were included in the present study: Remind-Me, Picture-Based PM and Post-a-Letter Task. As the Remind-Me and the Post-a-Letter-Task are based on everyday activities no training tasks were used for explaining the task procedure since it was assumed familiar to the participants. The Picture-Based PM Task, however, was introduced by training tasks (see below).

Remind-Me Task

The Remind-Me Task (range 0-7) was performed in the experimental setting, even though reminding someone was considered to be an activity common in everyday life. This task was introduced first as it was intertwined with consecutive tasks. The participant was demanded to "ask for a question" in response to the verbal cue "a new task begins". Changes, such as, the experimenter getting a new paper instruction or starting up a new task on the computer were thought to serve as a complement to the verbal cues. However, there is a limited time at which the Remind-Me Task should be performed. If the Remind-Me Task was

performed, the participant got to rate the difficulty of the task most recently performed (three response alternatives, scored as easy, medium or difficult). Task instructions were repeated half-way through performing the Picture-Based PM Task, for those persons who had forgotten to ask for a question altogether. Remind-Me Task performance was scored as the number of times the participant asked for a question (maximum seven times).

Picture-Based Prospective Memory

The Picture-Based Prospective Memory Task (range 0-5) is based on pictures presented one by one on a computer screen. The participant is told to memorize different pictures (the PM cues) as a preparation for the next step of the task. This is followed by a delay and performance of a filler task. Thereafter, single pictures are presented on the computer screen. The subject is told to judge whether the picture on the screen is used indoors or outdoors (the ongoing task) and if the picture is identical to a picture encoded previously (PM cue identification). In case it is a PM cue the intended PM task is to be performed before proceeding to the next picture. The task includes lures, e.g., with visual resemblance or no connection to the PM cues. The purpose is twofold; (a) to make an error analysis, and (b) to separate PM cues in time to distinguish the Picture-Based PM Task from a vigilance task where task instructions could be kept in short-term memory. Picture-Based PM Task errors are either a false alarm (identifying a lure), or an omission (omitting performing the intended PM task). Therefore, the Picture-Based PM Task is scored by d' . Each section ends by a Recognition Task based on the PM cues and new lures presented on the computer screen as previously. This Recognition Task is scored as the total number of correct judgements.

The present study included a Picture-Based PM Task with four parts (opportunity for pauses in between) used in a balanced order. The four parts were based on photos of non-living objects that are familiar from everyday life (5 PM cues and 15 lures per part). An equal number of lures with visual resemblance, a semantic relation, or no connection to the PM cues or the other types of lures was used. The delay between encoding of PM cues and presentation of pictures (PM cue and lures) was filled by a verbal discussion of a topic that was not related to the task (e.g., What did you think about the hockey-game last night?). The PM task to perform (intention) was to raise your hand in the first two (2*5) parts and replaced by to put a plastic piece in a box on the table in the two last parts (2*5).

The Recognition Task (range 0-5) at the end of each of the four parts included 50% lures with a maximum performance of ten correct answers.

Post-a-Letter Task

The Post-a-Letter Task (nominal 0 or 1) is based on whether a letter is returned by mail (or handed in to the person distributing the tasks at a later occasion) and filled in or not as an example of a naturalistic task (e.g., Meacham & Leiman, 1982). The letter included questions concerning, e.g., how entertaining the Picture-Based PM task had been and hence was performed last of the prospective memory tasks. The participant filled in the letter by marking one response alternative (e.g., sad, neutral, or happy smiley; Levén et al., in press). Pictures reduced the need for reading skills and an address-labelled envelope was provided. The Post-a-Letter task could be performed at different occasions, which in part reduced the load on attentional resources. As some participants needed help to post the letter and handed them into their teacher (who they met once a week), latest accepted posting date was set to ten days after receiving the task.

Working Memory

Working memory was taxed by three different procedures: Picture Span, Listening Span and Digit Span Tasks. The three span procedures all began by training tasks where the participant became familiar with the procedure. A lenient approach to when to abort the span tasks was used (e.g., recall of one out of three spans) due to considerable fluctuation in attention among participants with intellectual disability. For example; to look away from the material presented on the computer; or to talk about subjects unrelated to the current situation.

Listening Span Task

The listening span procedure (range 0-42) was based on verbal presentation of short sentences consisting of short and common words (cf. Daneman & Carpenter, 1980). Two sets of sentences per span length (1-6) were included. The task demands (a) consecutive judgements of sensibility for each sentence (range 0-42), which was read out by the experimenter and (b) recall of the first word of the sentences when the entire span had been presented. The order of the words was not considered with the result of a maximum score of 42 (one word per sentence), as for the sensibility judgements.

Digit Span Task

Digit Span Task performance theoretically ranges from zero to thirteen. The ability to read digits was checked by identification of digits on the keyboard which preceded the training task of this task. The digits were presented on the computer screen (presented for 2 s, inter-stimulus interval 0.075 s) and followed by verbal recall of the span. Performance was rated as the total number of digits recalled in correct serial order. The Digit Span Task was

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aborted when the participant failed to recall at least one of three spans of a certain length. The Digit Span Task may mainly tax short-term memory although the limited working memory capacity in individuals with intellectual disability suggests a demand for more complex memory processing.

Picture Span Task

Picture Span Task performance theoretically ranges between zero and 81. Pictures of non-living objects are presented one at a time in a central position for 1 s (inter-stimulus interval 0.075 s; cf. Picture Span, Levén et al., in press)). When the last picture has faded, all the pictures in the current span are presented simultaneously (not in order). The task is to recall the order in which the pictures were presented initially. The participant either points or names the pictures when answering. Span length (i.e., number of pictures, 2-7) is increased by one picture at a time if the participant successfully recalls at least one of the three spans of a certain length or the maximum length of seven pictures is reached. Scoring of the Picture Span Task is made with respect to the total number of pictures recalled in the correct serial position with a maximum performance of 60.

Retrospective Memory

Retrospective memory performance theoretically ranges between zero and 48. Verbal presentation of SPTs (e.g., Point at your nose., one SPT per second) was included to tap retrospective memory (e.g., Cohen & Bean, 1983; Molander & Arar, 1998). Performance was scored as the number of recalled subject performed tasks (0-12), collapsed over four lists of tasks rendering a maximum performance of 48. Successful recall was to perform or verbally repeat an encoded SPT. A strong resemblance between tasks (e.g., involving actions with the hands or the head) increased the difficulty of the task. As a consequence, verbally recalled SPTs were rated as correct given that the specificity of the answer discriminated it from the other tasks on the list.

Ratings and Time Conception

Time Conception

Maximum Time Conception Task performance was twelve correct answers compared to six in case of random level performance. Time Conception Task performance (e.g., order of future events and time duration) was estimated from a questionnaire with 12 items, with two response alternatives each, e.g., “What do you put on first, shoes or socks?”. This task was inspired by Lindström et al. (1996). The position of the correct response was varied to counteract response bias.

Self-Rated Memory

Self-Rating scores of prospective and retrospective memory theoretically varied between eight and 24. Self-rating of retrospective memory and PM was based on a modification of a Swedish translation of the PRMQ (Crawford, Smith, Maylor, Della Sala, & Logie, 2003). The questionnaire consists of eight retrospective and eight prospective questions of the type; “How often do you”, e.g., “decide to do something in a few minutes’ time, and then forget to do it?”. Concrete examples were provided, from the participant’s everyday life, if needed. The number of response alternatives was reduced from five to three which was considered to better correspond to the average working memory span among persons with intellectual disability (cf. Henry, 2001; Jarrold, Baddeley, & Hewes, 2000). Response alternatives were presented verbally, in text and by Pictogram Ideogram Communications Symbols (e.g., Buekelman & Mirenda, 1998; cf. Levén et al.). Performance was rated as the cumulative sum of responses (each between one and three) for prospective and retrospective questions respectively yielding performance between eight and twenty-four.

Staff ratings of time perception

Time perception skills were rated from one to seven by a teacher or person who knew the participant with intellectual disability. Minimum scored capacity was seven and maximum where persons needed minimum support was forty-nine. The participant with intellectual disability had first given his or her consent specifically with respect to this task (n = 19). The form was composed of seven questions about behaviour in the work situation, e.g.,

need of support to follow a plan, and how often a book brought home one week was brought back as intended the following week.

Results and Discussion

The results will be presented in three sections; descriptive statistics and group comparisons for all tasks, correlations between task performances, and analyses of performance in sub-groups of the individuals with intellectual disability. The sub-groups were formed based on Picture-Based PM performance since this aspect of PM performance ranged from chance level to performance on a par to control group performance (maximum and minimum scores for the two groups, see Columns 5 and 6, Table 1). As performance of persons with intellectual disability is in focus in the present study and working memory and Retrospective Memory performances in the general population are thoroughly documented in other studies using the same type of tasks as we do, a smaller number of participants in the control group were sufficient for determining that the performance levels of this population were in line with previous research (number of participants for each task and group, see Table 1 Columns 2 and 7).

An alpha level of .05 was adopted for all statistical tests unless otherwise reported. Group-comparisons did not assume equal variance if a significant result was obtained on Levene's test for equality. Statistical methods were chosen in consideration of the frequency of missing values, that is, few individuals with intellectual disability performed all tasks (Table 1). Thus, an unequal number of participants may have had the opportunity to perform different tasks before the collection of data ended. Additional analyses of transformed data; $\sqrt{x}$, $\log(x)$, $1/x$, and $2 \cdot \arcsin(\sqrt{x})$ were performed. If the relations that were significant remained unchanged the raw scores are reported.

All PM tasks were modified to be appropriate to use for persons with intellectual disability, e.g., by excluding written instructions. Furthermore, the tasks were scored with accordance with the cognitive characteristics of the persons with intellectual disability. As cognitively demanding tasks increase the risk for acquiescence for persons with intellectual

disability (Beail, 2002; central executive functioning, Conners, Carr, & Willis, 1998; working memory sub-systems, Gyselinck, Cornoldi, Dubois, De Beni, & Ehrlich, 2002; Levén et al., in press) d' that accounts for false alarms (Puff, 1982) was applied. The Picture-Based Prospective Memory Task performance was not based on deviance from the appropriate time of execution since the individuals with intellectual disability varied a lot in (a) motor functions, requiring support from the experimenter (b) experience with the computer, and (c) communication skill.

In the first section, results on individual tasks will be presented in the following order: PM performance, performance on the working memory tasks, Retrospective Memory performance, memory ratings and time conception.

Descriptive Statistics and Group-Wise Performances

Generally, across all tasks (except for self-ratings of memory skills and the Post-a-Letter Task) the group with intellectual disability was outperformed by the group with no intellectual disability (see t^* -scores to the right in Table 1). Group-wise performances are also compared to minimum and maximum performance levels (Columns 4, 5, 8 and 9 in Table 1). The Picture-Based PM Task tapped PM performance in persons with intellectual disability but the control group made few errors (Columns 3 and 8 respectively in Table 1). The Remind-Me Task tapped PM performance in the control group but performance of individuals with intellectual disability was well-nigh undetectable (Columns 3 and 8 in Table 1). Thus, group differences in performance remain significant (Table 1), although a few individuals with intellectual disability outperform some controls on specific tasks (e.g., The Digit Span Task, see Column 6 and 9 in Table 1). Ninety percent of the individuals with intellectual disability performed below mean of the control group on the Picture-Based PM Task and the Recognition Task based on PM cues.

Table 1 in about here

Prospective Memory

Statistically significant group differences in performance were found for the Remind-Me and for the Picture-Based PM Tasks (Table 1). However, the Post-a-Letter Task rendered equal group performance. False alarms (responding to lures) on the picture-based PM was almost exclusively made by persons with intellectual disability ($t(32) = 2.56, p < .05$) and equally often for lures with visual and semantic relations to PM cues. Performance on the Recognition Task (based on PM cues) was without error in the control group and for 58% of the persons with intellectual disability. Tasks to perform in response to PM cues (e.g., to raise your hand or to put a plastic piece in a box) had no significant effect on picture-based PM performance.

Group differences were found for PM tasks with limited time for execution (the Remind-Me and Picture-Based PM Tasks; see Table 1), but not for the task with multiple opportunities for execution (the Post-a-Letter Task; Table 1). PM performance on the picture-based task ranged from chance level to performance without error for the persons with intellectual disability (Table 1). Recognition of Picture-Based PM cues following the main PM tasks was not without error in persons with intellectual disability suggesting less robust picture recognition capacity than in the control group (see Columns 6 and 11, Table 1).

In sum, the influence from task characteristics on PM performance in the present study reflected the cognitive capacity of the group (low and high span performance groups, cf. Gyselinck et al., 2002; Levén et al., in press). That is the Picture-Based PM Task performance reflected inter-individual differences in primarily persons with intellectual disability. Equal group performance was found on the everyday Post-a-Letter Task. Further analyses of PM performance are made group-wise with a focus on the interrelation between task performances.

Working Memory

Working memory performance of persons with intellectual disability was at a lower level than for individuals in the control group in all tasks in the present study (see Table 1,

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The Listening Span, Digit Span, Picture Span Tasks; cf. effect of memory rehearsal in children, Hutton & Towse, 2001). Three individuals with intellectual disability were excluded from the Listening Span Task, due to problems to follow for the instructions for the task. The sensibility judgements of the Listening Span sentences were performed without error by thirteen persons with intellectual disability. Individuals with intellectual disability were overall prone to repeat words from former sections of the task when they failed to remember. At least one individual with intellectual disability used an in part visuo-spatial strategy on the Picture Span Task (“this one was there, and this one was there [pointing at the screen]”), although the pictures had been presented in an identical position. Digits in the Digit Span Task were often read aloud by persons with intellectual disability. This revealed chunking, a strategy also reported by the control group. Single individuals with intellectual disability on occasions performed on a par with or even exceeded average performance of the control group (Columns 6 and 9 in Table 1), despite profound differences in performance at the group level. Taken together, observations suggest less appropriate use of strategies among some persons with intellectual disability, or restricted ability to benefit from strategies such as rehearsal (e.g., influence of cue distinctiveness, M. A. McDaniel & Einstein, 1993).

Retrospective Memory

Individuals with intellectual disability recalled fewer SPTs than the control participants ($t(37) = 7.19, p < .05$; see Table 1), thus, not equal to the control group as is the result in Cohen & Bean (Cohen & Bean, 1983; cf. central executive functioning, Conners et al., 1998; cf., category learning in children with mental retardation, Hayes & Taplin, 1993). Individual variation in performance on the retrospective tasks was vast for both groups, both in terms of scored performance and in other aspects of observed behaviour during the test session. Strategies, e.g., to perform the tasks immediately, to look in another direction or to rehearse (moving lips or hands), and comments on performance strategies that could be used were observed within both groups during encoding of the task.

Both working memory and Retrospective Memory performance mirror individual differences within each group. That is, groups exhibit similar behaviour in the task situation, but differ both in level and range of performance primarily due to inter- and intra-individual variability in the performance of individuals with intellectual disability (cf. memory strategies in children with mental retardation, Kamioka & Matsumura, 2000).

Ratings and Time Conception

The present study used (a) a simplified questionnaire for self-rated prospective and Retrospective Memory, (b) ratings made by teachers or staff, and (c) a short questionnaire about time concepts (only distributed to persons with intellectual disability). Self-rated prospective and Retrospective Memory were correlated for both groups (persons with intellectual disability: $r(29) = .59$, control group: $r(16) = .65$). Levels of self-rated memory did not differ significantly between the groups (Levén et al., in press), thus, did not reflect the group difference in levels of performance on most memory tasks in this study (comparisons of PM performance levels see Table 1 and correlations in each group see Table 2). However, Retrospective Memory was rated as better than PM for the control group ($t(15) = 3.15$, $p < .05$), but not for persons with intellectual disability ($t(28) = 1.57$, $p < .15$).

The time conception questionnaire was associated with considerable differences; (a) in performance level (t -test vs. chance see Column 3, Table 1, 60 % performed above chance level, 30 % without error) that in part corresponded to the observed PM performance level, and (b) in observed behaviour (e.g., to read and easily fill in the form yourself, or to guess). Some persons overtly performed actions in order to reach a correct answer. However, other persons repeatedly expressed the correct response but doubted their response. Thus, guessing was encouraged. Performance on the time concept questionnaire was correlated with staff rated performance on time related issues in the work situation ($r(17) = .65$, $p < .01$).

Correlations

Because the individuals with and without intellectual disability differed both in level of and variation in performance, relations between task performances were analysed for each

group separately (Table 2). Performance near or at ceiling level in the control group and near floor level in individuals with intellectual disability hinders the comparison of correlations between the groups. It was, however, possible to compare the pattern of correlations based on Listening Span, Digit Span and SPTs performances. This revealed significant correlations only for individuals with intellectual disability (Table 2).

Table 2 in about here

For individuals with intellectual disability, working memory and Retrospective Memory Task performances were correlated and in part related to picture-based PM performance. Furthermore, recognition of PM cues was correlated to Digit Span Task performance in this group which suggests a relation to a basic cognitive capacity (e.g., West et al., 2006).

The pattern of correlations suggest that the tasks in this study tap cognitive processes that are coupled especially for individuals with intellectual disability, as may be predicted for children or for persons in old age (cf. Li, Lindenberger, Hommel, Aschersleben, Prinz, & Baltes, 2004). No correlations were significant in the control group.

Subgroups of Persons with Intellectual Disability

The relation between working memory, Retrospective Memory, ratings and PM performance was investigated further in individuals with intellectual disability. These individuals were divided into a *high-* and a *low-performing subgroup* with respect to performance on the Picture-Based PM Task as less is known about PM performance in persons with intellectual disability than the other memory processes investigated. Persons who performed at mean value, or up to two standard deviations from mean performance of the control group (see Table 1, 24.2%) formed the high-performing subgroup. The remaining part of the persons with intellectual disability made up the low-performing subgroup. Apart from PM performance ($t(24, 7) = 5.41$), Listening Span and Retrospective Memory performance

differed between the high- and low-performing subgroups ($t(24, 7) = 3.46$ and $t(15, 4) = 2.67$; n varies as all tasks had not been performed by all participants). Furthermore, the high-performing subgroup was outperformed by the control group on the Retrospective Memory Task (SPTs, $t(4, 17) = 2.56$), Digit Span ($t(5, 16) = 3.61$) and Picture Span ($t(6, 17) = 5.56$) but not on the Listening Span Task with a distinct demand on processing capacity. Thus, individuals in the high performing subgroup may have used more complex processing for recognition of the PM cues than persons in the low-performing subgroup.

The highest performing individuals with intellectual disability in the three working memory tasks and the Retrospective Memory Task also performed without error on the Time Conception Task and belonged to the high-performing subgroup based on Picture-Based PM performance. Four out of five individuals in the high-performing subgroup had staff ratings above mean. The person rated lower by the staff performed more than two standard deviations from control group mean on all working memory tasks, and below mean of the persons with intellectual disability on both the Listening and the Digit Span Tasks. Pictures could be a special strength of this person, based on comparisons of performance on the picture-based working memory and PM task, and similar tasks with more evident relations to language. One person in the high-performing subgroup has a distinct drop in performance on the Listening Span Task, and picture-based PM performance at the lower level in the group.

In sum, the PM performance of the persons with intellectual disability remains also for each of the two subgroups, with respect to substantial variation in performance on the Picture-Based PM Task, working memory and Retrospective Memory Tasks that is not reflected in the self-rated memory. That is, PM performance was as expected related to cognitive aspects such as Listening Span Task performance and Retrospective Memory Task performance (cf. R L Marsh, Hancock, & Hicks, 2002), though not to self-rated memory (cf. memory strategies in children with mental retardation, Kamioka & Matsumura, 2000).

General Discussion

The present study is focused on the relationship between PM and other memory functions; working memory, retrospective memory, and self-rated memory, in persons with or without intellectual disability. PM performance of persons with intellectual disability was restricted by limitations in Retrospective Memory and working memory capacity compared to persons without intellectual disability. For most tasks, a few persons with intellectual disability performed on a par with the control group (often different persons for different tasks, see Table 1). The high-performing subgroup of persons with intellectual disability (who performed on a par with the control group on the Picture-Based PM Task) furthermore outperformed the remaining part of the persons with intellectual disability on working memory (not on Listening Span) and Retrospective Memory Tasks. PM performance, particularly in persons with intellectual disability, depended on distinct PM-cues (pictures compared to verbal cues). The group differences in PM and Retrospective Memory performance had no counterparts in self-rated memory, which suggests a weakness in meta-memory in individuals with intellectual disability. Thus, unawareness of omissions may limit the individual's motivation to use any aid, although pictures as support to PM performance could be useful to meet up to the demands in everyday life.

The impact of task characteristics on performance was prominent for individuals with intellectual disability. PM tasks with visual cues (e.g., the Picture-Based PM and Post-a-Letter Tasks) rendered better PM performance than tasks with verbal cues (the Remind-Me Task). Similarly, a comparison between Picture Span and Listening Span performances suggests a decrease in working memory performance for the task with verbal (not visual) elements and a high demand for simultaneous processing. This can reflect that processing of pictures demand less cognitive effort in order to achieve the specificity required for solving the task.

PM performance depends on a composite of multiple cognitive abilities. False alarms on the Picture-Based PM Task may reflect inadequate specificity at encoding of cues (i. e., decline in PM, but not retrospective memory in old age, Matthias Kliegel, McDaniel, &

Einstein, 2000; children, Kvavilashvili, Messer, & Ebdon, 2001) as the PM cues were similar to the lures and the all equally present false alarm categories. Erroneous recognition of PM cues and PM performance may be due to forgetfulness, inability to avoid responding to non-cues (cognitive load of processing component, cf. Gavens & Barrouillet, 2004), to execute strategies for task performance (adults, e.g., Salthouse, Berish, & Siedlecki, 2004) or fluctuations in attention (e.g., Sterr, 2004). Previous research has demonstrated that Retrospective and PM performance are sometimes unrelated (young and old adults, Mantyla, 1993). However, working memory, Retrospective Memory and PM performance were related in persons with intellectual disability in the present study (see also Lebiere & Lee, 2002).

The correlations that are specific for the persons with intellectual disability may reflect a basic cognitive capacity needed for task performance (e.g., due to weaknesses in attention, Sterr, 2004) that is less restricted in the control group, e.g., to notice cues, which either indicate time of execution or support recollection of PM content (in relation to prospective memory, cf. Kvavilashvili *et al.*, 2001). Developmental differences are likely to explain, in part, differences in PM performance for persons with intellectual disability, as a result of ability to make proper use of for instance cue identification skill or time perception (*Mental retardation: Definition, classification, and systems of supports*, 2002). Further research will be needed to reveal a more detailed description of the interplay between cognitive functions and characteristics of the PM situation. Post-a-Letter Task performance proposes strategy training that makes a specific task familiar as a possible support to PM for persons with intellectual disability.

In sum, PM, working memory and long-term memory performance of individuals with intellectual disability was inferior to performance of individuals without intellectual disability. This difference in level of performance had no counterpart in Self-Rated Memory scores. Furthermore, PM performance of individuals with intellectual disability required distinct PM-cues such as pictures.

References

- Atwell, J. A., Conners, F. A., & Merrill, E. C. (2003). Implicit and explicit learning in young adults with mental retardation. *American Journal on Mental Retardation*, (1), 56-68.
- Bayliss, D. M., Jarrold, C., Baddeley, A. D., & Leigh, E. (2005). Differential constraints on the working memory and reading abilities of individuals with learning difficulties and typically developing children. *Journal of Experimental Child Psychology*, (1), 76-99.
- Beail, N. (2002). Interrogative suggestibility, memory and intellectual disability. *Journal of Applied Research in Intellectual Disabilities*, (2), 129-137.
- Bray, N. W., Fletcher, K. L., & Turner, L. A. (1997). Cognitive competencies and strategy use in individuals with mental retardation. In J. MacLean, W. E. (Ed.), *Ellis' handbook of mental deficiency, psychological theory and research* (3 ed., pp. 197-217). Mahwah, NJ: Lawrence Erlbaum Associates.
- Buekelman, D. R., & Mirenda, P. (1998). *Augmentative and alternative communication*. Baltimore: Paul H. Brooks Publishing Co.
- Ceci, S. J., & Bronfenbrenner, U. (1985). "don't forget to take the cupcakes out of the oven": Prospective memory, strategic time-monitoring, and context. *Child Development*, (1), 152-164.
- Cohen, R. L., & Bean, G. (1983). Memory in educable mentally retarded adults: Deficit in subject or experimenter? *Intelligence*, 287-298.
- Conners, F. A., Carr, M. D., & Willis, S. (1998). Is the phonological loop responsible for intelligence-related differences in forward digit span? *American Journal on Mental Retardation*, (1), 1-11.
- Cornish, K. M., Munir, F., & Cross, G. (2001). Differential impact of the fmr-1 full mutation on memory and attention functioning: A neuropsychological perspective. *Journal of Cognitive Neuroscience*, (1), 144-150.
- Crawford, J. R., Smith, G., Maylor, E. A., Della Sala, S., & Logie, R. H. (2003). The prospective and retrospective memory questionnaire (prm-q): Normative data and latent structure in a large non-clinical sample. *Memory*, (3), 261-275.
- Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 450-466.
- Danielsson, H., Rönnerberg, J., & Andersson, J. (2006). What am i doing in timbuktu: Person-environment picture recognition for persons with intellectual disability. *Journal of Intellectual Disability Research*, 127-138 Part 122.
- Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. A. Brandimonte, G. O. Einstein & M. A. McDaniel (Eds.), *Prospective memory: Theory and practice* (pp. 1-22). Mahwah (NJ): Lawrence Erlbaum Associates.
- Ellis, J., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present, and future directions. *Applied Cognitive Psychology*, 1-9.
- Gavens, N., & Barrouillet, P. (2004). Delays of retention, processing efficiency, and attentional resources in working memory span development. *Journal of Memory and Language*, (4), 644-657.
- Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic patients. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 501-518.
- Graf, P., & Uttil, B. (2001). Prospective memory: A new focus for research. *Consciousness & Cognition: an International Journal*, (4), 437-450.

- Gyselinck, V., Cornoldi, C., Dubois, V., De Beni, R., & Ehrlich, M.-F. (2002). Visuospatial memory and phonological loop in learning from multimedia. *Applied Cognitive Psychology*, (6), 665-685.
- Hayes, B. K., & Taplin, J. E. (1993). Development of conceptual knowledge in children with mental retardation. *American Journal on Mental Retardation*, (2), 293-303.
- Henry, L. A. (2001). How does the severity of a learning disability affect working memory performance? *Memory*, (4-6), 233-247.
- Henry, L. A., & Gudjonsson, G. H. (2004). The effects of memory trace strength on eyewitness recall in children with and without intellectual disabilities. *Journal of Experimental Child Psychology*, (1), 53-71.
- Hooper, S. R., Hatton, D. D., Baranek, G. T., Roberts, J. P., & Bailey, D. B., Jr. (2000). Nonverbal assessment of iq, attention, and memory abilities in children with fragile-x syndrome using the leiter-r. *Journal of Psychoeducational Assessment*, (3), 255-267.
- Hutton, U. M. Z., & Towse, J. N. (2001). Short-term memory and working memory as indices of children's cognitive skills. *Memory*, (4-6), 383-394.
- Jarrold, C., Baddeley, A. D., & Hewes, A. K. (2000). Verbal short-term memory deficits in down syndrome: A consequence of problems in rehearsal? *Journal of Child Psychology & Psychiatry & Allied Disciplines*, (2), 223-244.
- Kamioka, Y., & Matsumura, T. (2000). Early memory strategies in children with mental retardation. *Japanese Journal of Special Education*, (3), 33-38.
- Kerns, K., & Price, K. (2001). An investigation of prospective memory in children with adhd. *Neuropsychology, Development, and Cognition. Section C, Child Neuropsychology: a Journal on Normal and Abnormal Development in Childhood and Adolescence*, (3), 162-171.
- Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2000). Plan formation, retention, and execution in prospective memory: A new approach and age-related effects. *Memory & Cognition*, (6), 1041-1049.
- Kliegel, M., Ramuschkat, G., & Martin, M. (2003). Executive functions and prospective memory performance in old age: An analysis of event-based and time-based prospective memory. *Zeitschrift fur Gerontologie und Geriatrie*, (1), 35-41.
- Kvavilashvili, L., Messer, D. J., & Ebdon, P. (2001). Prospective memory in children: The effects of age and task interruption. *Developmental Psychology*, (3), 418-430.
- Lebiere, C., & Lee, F. J. (2002). Intention superiority effect: A context-switching account. *Cognitive Systems Research*, (1), 57-65.
- Levén, A., Lyxell, B., Andersson, J., & Danielsson, H. (2004). Prospective memory, working memory and self-rated memory in individuals with intellectual disability. *International Journal of Psychology*, (Special Issue).
- Levén, A., Lyxell, B., Andersson, J., & Danielsson, H. (in press). The relationship between prospective memory, working memory and self-rated memory performance in persons with intellectual disability. *Scandinavian Journal of Disability Research*.
- Li, S.-C., Lindenberger, U., Hommel, B., Aschersleben, G., Prinz, W., & Baltes, P. B. (2004). Transformations in the couplings among intellectual abilities and constituent cognitive processes across the life span. *Psychological Science*, (3), 155-163.
- Lindström, E., Wennberg, B., & Liljegren, F. (1996). *Grepp om livet: En väg till begåvningsstöd* (1. uppl. ed.). Vällingby: Handikappinstitutet.
- Loveland, K. A., & Tunali-Kotoski, B. (1998). Development of adaptive behavior in persons with mental retardation. In J. A. Burack & R. M. Hodapp (Eds.), *Handbook of mental retardation and development* (pp. 521-541). New York, NY, US; New York, NY, US: Cambridge University Press; Cambridge University Press.

- Mantyla, T. (1993). Priming effects in prospective memory. *Memory (Hove, England)*, (3), 203-218.
- Marsh, R. L., Hancock, T. W., & Hicks, J. L. (2002). The demands of an ongoing activity influence the success of event-based prospective memory. *Psychonomic Bulletin & Review*, (3), 604-610.
- Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, (2), 336-349.
- Marsh, R. L., Hicks, J. L., & Landau, J. D. (1998). An investigation of everyday prospective memory. *Memory & Cognition*, (4), 633-643.
- McDaniel, M. A., & Einstein, G. O. (1993). The importance of cue familiarity and cue distinctiveness in prospective memory. *Memory*, (1), 23-41.
- McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, (SpecIssue), S127-S144.
- Meacham, J. A., & Leiman, B. (1982). Remembering to perform future actions. In *Memory observed: Remembering in natural contexts* (pp. 327-336). San Francisco: Freeman.
- Mental retardation: Definition, classification, and systems of supports. (2002). (10 ed.). Washington, DC: American Association on Mental Retardation.
- Molander, B., & Arar, L. (1998). Norms for 439 action events: Familiarity, emotionality, motor activity, and memorability. *Scandinavian Journal of Psychology*, (4), 275-300.
- Puff, C. R. (Ed.). (1982). *Handbook of research methods in human memory and cognition*. New York: Academic Press.
- Sterr, A. M. (2004). Attention performance in young adults with learning disabilities. *Learning & Individual Differences*, (2), 125-133.
- Svensk, A. (2001). *Design av kognitiv assistans*. Lunds tekniska högskola. CERTEC, Lund.
- Titov, N., & Knight, R. G. (2001). A video-based procedure for the assessment of prospective memory. *Applied Cognitive Psychology*, (1), 61-83.
- West, R., Bowry, R., & Krompinger, J. (2006). The effects of working memory demands on the neural correlates of prospective memory. *Neuropsychologia*, (2), 197-207.
- Vicari, S., Bellucci, S., & Carlesimo, G. A. (2000). Implicit and explicit memory: A functional dissociation in persons with down syndrome. *Neuropsychologia*, (3), 240-251.
- Wyatt, B. S., & Conners, F. A. (1998). Implicit and explicit memory in individuals with mental retardation. *American Journal on Mental Retardation*, (5), 511-526.