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Prospective Memory, Working Memory, Retrospective Memory and Self-Rated Memory Performance in Persons with 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. Prospective memory was investigated by means of a picture-based task. Working memory was measured as performance on span tasks. Retrospective memory was scored as recall of subject performed tasks. Self-ratings of memory performance were based on the prospective and retrospective memory questionnaire. Individuals with intellectual disability performed at a lower level on most tasks and the task performances were to a higher degree correlated compared to persons without intellectual disability. The groups did not differ in self-rated memory scores. Distinct prospective memory cues (pictures, compared to words) were essential for prospective memory performance in persons with intellectual disability. The results are discussed with respect to how working memory capacity relates to prospective memory and retrospective memory performance.*

KEYWORDS: Prospective memory, working memory, intellectual disability, self-rated memory, retrospective memory

Prospective memory (PM) refers to the ability to act on intentions (for example, to bake) at an appropriate time or event in the future (in 20 minutes or as the bread turns golden brown; Ceci & Bronfenbrenner 1985, Ellis & Kvavilashvili 2000). Intentions that are performed at once and kept in focus of attention, such as stirring constantly in the saucepan, do not load on PM, nor does memory for the past, such as what you bought yesterday. However, the intention has to be stored in a permanent memory during the delay preceding acting on the intention (Graf & Uttl 2001). As PM is directed to the future, other actions that are referred to as ongoing tasks are performed

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during the delay between forming the intention, for example to bake, and performing the intended action, i.e. 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 & Rönnberg in press) that may influence adaptive behaviour skills and their need of support in everyday life (Loveland & Tunali-Kotoski 1998, The American Association on Mental Retardation 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, whether you filled up the car with petrol as you intended, or postponed going to the petrol station, influences 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, for example to postpone making a phone call until the afternoon (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 and 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 (Levén *et al.* in press). As few studies have investigated PM in individuals with intellectual disability, we will focus on memory performance in this group. However, for comparison, PM performance in a general population and in other special populations are referred to (for example, for prospective memory in children with ADHD see Kerns & Price 2001; for age-related differences in prospective memory see Kliegel, Ramuschkat & Martin 2003).

PM performance loads on working memory (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 syndrome; see Hooper, Hatton, Baranek, Roberts & Bailey 2000), particularly in situations with a high demand on working memory performance in 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 (on adults with mental retardation, see Atwell, Conners & Merrill 2003; on implicit memory, see Graf & Schacter 1985; on children, see Wyatt & Conners 1998). However, retrospective memory performance of persons with intellectual disability suffers from, for example, insufficient specificity in the remembered information (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 result in retrospective memory errors if the task requires recall of distinct pieces of information (Danielsson, Rönnberg & Andersson 2006). PM tasks with low demand on strategic memory processing, such as planning, tasks with salient PM cues and low demand from the ongoing task, can thus be predicted to be essential for PM performance, in particular in persons with intellectual disability.

Elaboration of a familiar situation (e.g. passing the local post office) can be specific and concrete. Imagining a 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 therefore be essential for PM performance in persons with intellectual disability (for results from a general population, see 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 (Bray, Fletcher & Turner 1997) and tasks (for example bringing a book to the library), as opposed to tasks that include manipulation of abstract concepts (for example, comparing the time left before the bus leaves to the time needed for preparing the breakfast). Weaknesses in time perception is a common obstacle to 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 (for effects of delay on prospective memory performance in old age, see McDaniel & Einstein 2000; for implicit and explicit memory processes and Down's syndrome, see Vicari, Bellucci & Carlesimo 2000).

In the present study we investigate working memory and retrospective memory performances to further elucidate the relationships between these two memory systems and their effects 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, suggesting that persons with intellectual disability should be partitioned into high and low performing sub-groups. A control group of age-matched persons without intellectual disability is included with the purpose of exploring performance on the new tasks. 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 (Bayliss, Jarrold, Baddeley & Leigh 2005). Hence, the groups are compared with a focus on the relationship between performances in different tasks within the groups as well as differences between the groups.

Methods and Materials

The participants were adults with mild or moderate intellectual disability (20 female, 14 male, mean age: 35.4, SD = 9.1 years), who were employed at day activity centres and/or who by their own choice attended adult education. Participants with intellectual disability varied in language, reading proficiency and motor function. Inclusion criteria were based on adequate vision and verbal communication of at least "yes" or "no". The ability to verbally name digits presented as text was also required. However, returning specific objects to the experimenter was used to support verbal communication of actions in the prospective memory task. Furthermore, a control group with persons without intellectual disability matched on chronological age (11 female, seven male, mean age: 39.1, SD = 11.3 years) was included since they may share elements of everyday experience. The purpose was to describe and relate performance on the tasks that had not been used previously to performance on more established tasks measuring cognitive capacity.

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 were informed, and so could answer or transfer questions, and also when the researchers had left. The participants had met the researchers before giving their consent to participate and to performing the initial task. The tasks were performed at a place that was familiar to the participant (Beail 2002, Levén *et al.* in press). Two PM tasks (Picture-Based and Remind-Me), a retrospective memory task (measured through subject performed tasks, SPTs) and three working memory tasks (Listening Span, Picture Span, Digit Span), were distributed in an experimental setting (a separate room with a portable computer) at the participant's workplace (day activity centre) or at school. The procedure also included a time conception task, ratings of how the individual experienced their own memory function, and ratings made by another person, which were collected on a later occasion for individuals with intellectual disability. Furthermore, a naturalistic third PM task (Post-a-Letter) was distributed to the latter group. All tasks were distributed in a balanced order, except for the Remind-Me tasks, which were distributed first, and the Post-a-Letter task, which was distributed after the Picture-Based PM 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. As the Remind-Me and the Post-a-Letter tasks are based on everyday activities, no training tasks were used for explaining the task procedures, since they were assumed to be 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 requested 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 during which the Remind-Me task should be performed. If the Remind-Me task was performed, the participant rated the difficulty of the task most recently performed (there were three response alternatives: easy, medium or difficult). In this way ratings of different tasks were obtained. Task instructions were repeated halfway 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 PM 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). If it is a PM cue the intended PM task is to be performed before proceeding to the next picture. The task includes lures, for example with visual resemblance or no connection to the PM cues. The purpose is two-fold; (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' (the normalised distance between the distribution of hits and the distribution of false alarms in units of standard deviation). 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 (with 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 (five 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 (such as "what did you think about the hockey game last night?"). The PM task to perform (intention) was to raise a hand in the first two (2 × 5) parts, replaced by to put a plastic piece in a box on the table in the two last parts (2 × 5).

The recognition task (range 0–10) at the end of each of the four parts included 50% lures with a maximum performance of 10 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 (Meacham & Leiman 1982). The letter included questions concerning among other things how entertaining the Picture-Based PM task had been, and hence was performed as the last of the prospective memory tasks. The participant filled in the letter by marking one response alternative (sad, neutral, or happy smiley, day of the week, weather; 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), the latest accepted posting date was set to 10 days after receiving the task.

Working Memory

Working memory was examined by three different procedures: Picture Span, Listening Span and Digit Span tasks. The three span procedures all began with training tasks where the participant became familiar with the procedure. A lenient approach was used to the decision about when to abort the span tasks (recall of one out of three spans) due to considerable fluctuation in attention among participants with intellectual disability. For example, triggers included looking away from the material presented on the computer or talking 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 (see 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 were 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, so there was 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 13. The ability to read digits was checked by identification of digits on the keyboard before the training task. The digits were presented on the computer screen for a duration of 2 s, with an inter-stimulus interval of 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 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 (with an inter-stimulus interval 0.075 s; see 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 (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 81.

Retrospective Memory

Retrospective memory performance theoretically ranges between zero and 48. Verbal presentation of SPTs (for instance "point at your nose", with one SPT per second) was included to tap retrospective memory (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 (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. The best performance in the time conception task was 12 correct answers, compared to six for random level performance. Time conception task performance (order of future events and time duration) was estimated from a questionnaire with 12 items, with two response alternatives each, such as "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 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 (Henry 2001, Jarrold, Baddeley & Hewes 2000). Response alternatives were presented verbally, in text and by Pictogram Ideogram Communications Symbols (Buekelman & Mirenda 1998, and see Levén *et al.* in press). 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 24.

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. The minimum scored capacity was seven, and the maximum, where persons needed least support, was 49. 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, for instance 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

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 equivalent to control group performance (for maximum and minimum scores for the two groups, see columns 6 and 11 in Table 1). The 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 have used. Therefore, 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 (for the number of participants for each task and group, see Table 1, columns 2 and 7).

An alpha level of 0.05 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

Table 1. Group performances on prospective memory, working and long-term memory tasks and conceptual knowledge and ratings.

	With intellectual disability					Without intellectual disability					
Task	*n*	*m* (SD)	Vs. min*	Vs. max**	range	*n*	*m* (SD)	Vs. min*	Vs. max**	range	*t*
Prospective Memory											
Remind-Me (number of reminders)	18	0.22 (0.55)	1.72	−52.4[†]	0–2	14	4.64 (1.95)	8.93[†]	−4.53[†]	1–7	8.25[†,‡]
Picture-Based PM	34	3.31 (1.39)	13.92[†]	−7.10[†]	0–5	14	4.93 (0.15)	120.68[†]	−1.75	4.5–5	6.70[†,‡]
Mean Recognition Picture-Based PM	33	8.61(1.86)	26.57[†]	1.15[†]	4–10	14	10 (0.00)	—[§]	—[§]	10–10	4.28[†,‡]
d′ Picture-Based PM [¶]	33	2.39 (1.25)	10.98[†]	−8.92[†]	−0.36–4.34	13	4.13 (0.31)	47.78[†]	−2.38[†]	3.48–4.34	7.41[†,‡]
Posted Letter	18	0.83 (0.38)	9.22[†]	−1.84	0–1	18	0.83 (0.38)	9.22[†]	−1.84	0–1	0.00
Working memory and retrospective memory											
Listening Span	20	17.35 (7.88)	9.85[†]	−14.00[†]	4–35	18	30.72 (3.68)	35.47[†]	−13.03[†]	24–36	6.81[†,‡]
Semantic Decisions of Listening Span	20	39.50 (2.54)	32.52[†]	−4.39[†]	35–42	17	41.88 (0.33)	259.26[†]	−1.46	41–42	4.15[†,‡]
Digit Span	22	23.41 (17.79)	6.17[†]	−25.73[†]	3–67	17	74 (18.62)	16.39[†]	−10.45[†]	50–125	8.58[†,‡]
Picture Span	23	19.26 (14.80)	6.24[†]	−20.01[†]	4–67	18	64.56 (12.78)	21.47[†]	−5.47[†]	28–80	10.32[†]
Subject performed tasks	21	10.71 (6.02)	8.16[†]	−28.39[†]	0–29	18	23.67 (5.09)	19.74[†]	−20.29[†]	18–37	7.19 [†]

Table 1 (*Continued*)

Task	With intellectual disability					Without intellectual disability					
	n	m (SD)	Vs. min*	Vs. max**	range	n	m (SD)	Vs. min*	Vs. max**	range	t
Ratings and time conception											
Time conception	22	9.64 (2.67)	$16.96^{\dagger}$ ($6.40^{\dagger,\dagger\dagger}$)	$-4.16^{\dagger}$	4–12		—				—
Self–rated PM	30	17.43 (2.96)	$17.48^{\dagger}$	$-12.17^{\dagger}$	9–22	16	18.00 (1.67)	$23.91^{\dagger}$	$-14.10^{\dagger}$	16–23	$0.83^{\ddagger}$
Self-rated retrospective memory	31	18.03 (2.93)	$19.09^{\dagger}$	$-11.35^{\dagger}$	12–23	16	19.19 (1.97)	$22.67^{\dagger}$	$-9.75^{\dagger}$	16–23	$1.42^{\ddagger}$
Staff ratings	19	30.42 (5.36)	$19.06^{\dagger}$	$-15.12^{\dagger}$	16–35		—				—

*One-tailed *t*-test versus the theoretical minimum performance.
**One-tailed *t*-test versus the theoretical maximum performance.
$^{\dagger}p < 0.05$.
‡Equal variance not assumed (significant result on Levene's test for equality in variance).
§Not computed (0 variance).
¶0 in a cell adjusted to 0.5.
††One-tailed *t*-test versus the theoretical mean performance.

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 $2 \times$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, for example, by excluding written instructions. Furthermore, the tasks were scored in accordance with the cognitive characteristics of the persons with intellectual disability. As cognitively demanding tasks increase the risk of acquiescence for persons with intellectual disability (Beail 2002; for central executive functioning see Conners, Carr & Willis 1998; for working memory sub-systems see Gyselinck, Cornoldi, Dubois, De Beni & Ehrlich 2002; see also Levén *et al*. in press) d', which 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 function, requiring support from the experimenter; (b) experience with the computer; and (c) communication skills.

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 the values of t in the right-hand column in Table 1). Group-wise performances are also compared to minimum and maximum performance levels (columns 4, 5, 9 and 10 in Table 1). The Picture-Based PM task detected 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 detected PM performance in the control group but performance of individuals with intellectual disability was virtually 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, such as The Digit Span task (columns 6 and 11 in Table 1). Of the individuals with intellectual disability, the performance of 90% was below the mean of the control group on the Picture-Based PM task and the recognition task based on PM cues.

Prospective Memory. Statistically significant group differences in performance were found for the Remind-Me and for the Picture-Based PM tasks (Table 1). However, in the Post-a-Letter task there was equal group performance. False alarms (responding to lures) on the picture-based PM were almost exclusively made by persons with intellectual disability ($t(32) = 2.56$, $p < 0.05$) 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 58% for the persons with intellectual disability. Tasks to perform in response to PM cues (raising 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 in Table 1).

In summary, 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, Gyselinck *et al*. 2002, Levén *et al*. in press). That is, the Picture-Based PM task performance reflected inter-individual differences primarily in 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 the Listening Span, Digit Span and Picture Span tasks in Table 1; for effect of memory rehearsal in children see Hutton & Towse 2001). Three individuals with intellectual disability were excluded from the Listening Span task, due to problems following the instructions for the task. The sensibility judgements of the Listening Span sentences were performed without error by 13 persons with intellectual disability. Individuals with intellectual disability were generally prone to repeat words from former sections of the task when they failed to remember. At least one individual with intellectual disability used in part a 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 11 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 (influence of cue distinctiveness, see McDaniel & Einstein 1993).

Retrospective Memory. Individuals with intellectual disability recalled fewer SPTs than the control participants ($t(37) = 7.19$, $p < 0.05$; see Table 1), i.e. not equal to the control group as found by Cohen & Bean (1983); for central executive functioning see Conners *et al.* 1998, and for category learning in children with mental retardation see Hayes & Taplin 1993). Individual variation in performance on the retrospective tasks was high for both groups, both in terms of scored performance and in other aspects of observed behaviour during the test session. Strategies such as performing the tasks immediately, looking in another direction or rehearsing (moving lips or hands), and commenting on performance strategies that could be used were observed within both groups during encoding of the task.

Both working memory and retrospective memory performance mirrored 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 (for memory strategies in children with mental retardation see 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: $r(29) = 0.59$, control group: $r(16) = 0.65$). 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 (for comparisons of PM performance levels see Table 1 and for correlations in each group see Table 2). However, retrospective memory was rated as better than PM for the control group ($t(15) = 3.15$, $p < 0.05$), but not for persons with intellectual disability ($t(28) = 1.57$, $p < 0.15$).

The time conception questionnaire was associated with considerable differences (a) in performance level (in column 6, Table 1Table 60% performed above chance level, and 30% without error) that in part corresponded to the observed PM performance level, and (b) in observed behaviour (such as reading and easily filling in the form yourself, or guessing). 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 ($r(17) = 0.65$, $p < 0.01$).

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

Table 2. Correlations* in bold text for the intellectual disability group and plain text for the control group.

Tasks	Tasks 1 r_S (n)	2 r_S (n)	3 r_S (n)	4 r_S (n)	5 r_S (n)	6 r_S (n)	7 r_S (n)	8 r_S (n)	9 r_S (n)
1. Remind-Me (number of reminders)	**1.00 (18)**	0.14	(13)	0.43 (14)	0.10 (14)	−0.16 (13)	−0.38 (14)	0.15 (13)	−0.12 (14)
2. Picture-Based PM**	**0.15 (18)**	**1.00 (33)**	(13)	0.35 (13)	0.41 (13)	0.01 (12)	0.07 (13)	−0.21 (12)	−0.20 (13)
3. Recognition of PM cues	**0.20 (18)**	**0.37† (33)**	**1.00 (33)**						
4. Post-a-Letter	**(10)**	**0.13 (18)**	**0.22 (18)**	**1.00 (18)**	−0.19 (18)	−0.06 (17)	0.09 (18)	0.31 (17)	0.07 (18)
5. Listening Span	**0.06 (12)**	**0.54† (20)**	**0.14 (20)**	**0.00 (14)**	**1.00 (20)**	0.10 (18)	0.44 (18)	−0.13 (17)	−0.24 (18)
6. Digit Span	**0.07 (14)**	**0.51† (22)**	**0.59‡ (22)**	**0.23 (15)**	**0.57† (17)**	**1.00 (22)**	−0.07 (17)	−0.45 (16)	0.34 (17)
7. Picture Span	**−0.14 (14)**	**0.53‡ (23)**	**0.30 (23)**	**0.00 (14)**	**0.40 (17)**	**0.69‡ (20)**	**1.00 (23)**	0.13 (17)	0.11 (18)
8. Semantic decisions of Listening Span	**−0.08 (12)**	**0.32 (20)**	**0.12 (20)**	**0.46 (14)**	**0.33 (20)**	**0.57† (17)**	**0.34 (17)**	**1.00 (20)**	0.00 (17)
9. Subject performed tasks	**0.11 (13)**	**0.34 (21)**	**0.37 (21)**	**0.16 (15)**	**0.48† (17)**	**0.56† (20)**	**0.32 (19)**	**0.06 (17)**	**1.00 (21)**

*Spearman's rho.
**d'.
†Correlation is significant at the 0.05 level (2-tailed).
‡Correlation is significant at the 0.01 level (2-tailed).

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, Picture Span and SPT performances. This revealed significant correlations only for individuals with intellectual disability (Table 2).

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 (West *et al.* 2006).

The pattern of correlations suggests that the tasks in this study tap cognitive processes that are coupled, especially for individuals with intellectual disability, as may be predicted for children and for persons of old age (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 *high-performing* and *low-performing* subgroups 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 above mean value, or less than two standard deviations below mean performance of the control group (see Table 1, cut-off value 3.49, 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 lower than 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 summary, the PM performance of the persons with intellectual disability does not change 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 (Marsh, Hancock & Hicks 2002), though not to self-rated memory (for memory strategies in children with mental retardation see Kamioka & Matsumura 2000).

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 the same level as the control group (often different persons for different tasks; see Table 1). The high-performing subgroup of persons with intellectual disability (who performed on the same level as the control group on the Picture-Based PM task) furthermore outperformed the remaining 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 demands in everyday life.

The impact of task characteristics on performance was prominent for individuals with intellectual disability. PM tasks with visual cues (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 may reflect the fact that processing of pictures demands 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 (that is, decline in PM, but not retrospective memory in old age – see Kliegel, McDaniel & Einstein 2000; for children see 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; see Gavens & Barrouillet 2004), to execute strategies for task performance (see the study of Salthouse, Berish & Siedlecki 2004 with adults) or fluctuations in attention (Sterr 2004). Previous research has demonstrated that retrospective and PM performance are sometimes unrelated in 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 due to weaknesses in attention (Sterr 2004) that is less restricted in the control group, for example, noticing cues, which either indicate time of execution or support recollection of PM content in relation to prospective memory (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 (The American Association on Mental Retardation 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 summary, 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.

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