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Pictures as cues or as support to verbal cues at encoding and execution of prospective memories in individuals with intellectual disability

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This study focused on prospective memory in persons with intellectual disability and age-matched controls. Persons with intellectual disability have limited prospective memory function. We investigated prospective memory with words and pictures as cues at encoding and retrieval. Prospective and episodic memory was estimated from Prospective Memory Game performance. Pictures at retrieval were important for prospective memory in particular in the intellectual disability group. Prospective memory performance imposed a cost to Episodic Memory (ongoing task) performance in the intellectual disability group. This group was outperformed by the control group on working memory, time reproduction, time concepts, and Raven's coloured progressive matrices. To conclude, pictures at retrieval improve prospective memory performance compared to words as cues. This can be essential for the intellectual disability group likely due to limited episodic and working memory capacity and the ability to switch attention.

Keywords: prospective memory; intellectual disability; working memory; episodic memory

Introduction

Prospective memory (PM) refers to remembering to do things in the future at the appropriate time (e.g. at three o'clock or in one hour) or as a specific predetermined event takes place (when you walk home). PM is typically an important aspect of everyday cognition that may influence adaptive behaviour skills and the need of support in everyday life (Loveland and Tunali-Kotoski 1998, 'Mental retardation: Definition, classification, and systems of supports', 2002). Future events can be difficult to foresee due to weak time understanding in individuals with intellectual disability (ID; Sharpe et al. 2001; Janeslätt, Granlund, and Kottorp 2009; Janeslätt et al. 2010; Owen and Wilson 2006). In particular, in the real world, attention has to be switched from the ongoing activity to the intended PM task without a direct request to remember (McDaniel and Einstein 2000) which is difficult in the ID group (Meilan et al. 2009). Previous results based on performance in laboratory settings show severe limitations in PM function in individuals with ID (Levén et al. 2011; Meilan et al. 2009). Weak working memory and episodic memory are offered as explanations (Levén et al. 2008). PM performances in persons with and without ID

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converge in conditions with pictures as PM cues (Levén et al. 2008). Performance depends on type and amount of processing engaged which can explain superior performance with pictures (McBride and Dosher 2002). The present study adopts a cognitive perspective on everyday memory with a focus on remembering future actions. The present study investigates PM in individuals with ID. The difference between conditions with or without pictures as support to verbal information was in focus.

PM performance depends on memory for past events (episodic memory), capacity for memory processing and storage for a short period of time (working memory), and temporal information processing. Individuals with ID can perform on a par to individuals without ID on episodic memory tasks, although the retrieved information sometimes includes fewer details and can be more easily altered (less specific and robust, Carlin et al. 2008; Danielsson et al. 2006a, 2006b; Kebbell and Hatton 1999).

PM involves memory processing of the PM cue ('when to act'), and subsequent retrieval of the planned action ('what to do', Ellis 1996). PM performance depends to varying degrees on automatic (non-conscious) and strategic memory processing. Strategic processing is often limited in persons with ID (Bray, Huffman, and Fletcher 1999). Shifting between different (some abstract) strategies is more likely for individuals without ID than for the ID group (Bray, Huffman, and Fletcher 1999). Persons with ID usually perform better on memory tasks loading primarily on automatic rather than strategic memory processing (Wyatt and Conners 1997). Furthermore, episodic memory tends to be less limited than working memory compared to persons without ID (Levén et al. 2008).

Properties of prospective-memory cues, ongoing activity, planning, and individual differences in, e.g. memory capacity determine to what extent prospective memory load on explicit (effortful) memory processes according to the multiprocess view (McDaniel and Einstein 2000). Cue detection is more automatic if the PM cue: (1) is strongly associated with the planned action, (2) is associated with the ongoing task, (3) is salient, or (4) has relevant features that come into focus of attention while processing the ongoing task (Einstein and McDaniel 1990; McDaniel and Einstein 2000; McDaniel et al. 2004). Automatic PM retrieval is possible if the cue brings the associated intention to awareness.

The participant is typically engaged in another (ongoing) memory task in laboratory settings, e.g. a recognition task, and should temporarily shift focus and perform the PM task. PM often imposes a cost to ongoing activities (Smith, Bayen, and Martin 2010). Performance on ongoing activities is more likely to be reduced for persons with ID due to, e.g. more limited working memory capacity (ability to store and process information for a short period of time). Regular and irregular (non-recurring) PM tasks can be distinguished. In regular tasks, you are supposed to respond the same way all the time (e.g. say 'animal' each time a picture of an animal is shown). Irregular PM tasks include items with a specific link between each PM cue and task (e.g. turn on the radio when you eat dinner). Performance on irregular tasks is predicted to be more cognitively demanding compared to regular tasks, e.g. if the irregular task requires transferring information between visual and auditory modalities (Meier and Graf 2000).

Regardless of retrieval condition, picture encoding improved PM performance in an ongoing sentence verification task (McDaniel, Robinson-Riegler, and Einstein 1998). Performance was better with matched encoding and retrieval formats (picture–picture and word–word). Reduced load on working memory capacity may be essential for adequate strategic PM behaviour in persons with ID (Levén et al.

2008). Demands for linguistic proficiency may limit performance for individuals with ID (Bebko and Luhaorg 1998).

McDaniel et al. (2004) distinguish between PM views that focus on PM cues or on processes involved in PM performance. PM retrieval has been suggested to follow from noticing the PM cue due to either familiarity or a discrepancy between the actual and the predicted processing of the cue (Einstein and McDaniel 1996; Einstein et al. 2005; McDaniel et al. 2004). Retrieval results from the subsequent directed search in memory.

An overlap in cognitive processing of the ongoing task and the intended action improved performance in a general population (e.g. Marsh, Hicks, and Hancock 2000). Interaction between (preparatory attentional) processes preparing for PM performance and processing of memory for the past is essential for successful PM performance according to the Preparatory Attention and Memory (PAM) theory (Smith and Byan 2004). Working memory capacity affects the likelihood of engaging in preparatory processing. Automatic recognition of the PM cue is more likely in case of focal cues, i.e. when attention is directed to the cue as the ongoing task is performed.

Superior recall of pictures compared to words follows from interacting encoding-retrieval demands (McBride and Dosher 2002). According to transfer appropriate processing theory, performance relates to the amount of processing overlap at encoding and retrieval (Weldon, Roediger, and Challis 1989). Pictures have also been suggested to be dually encoded as an image and a verbal code (Paivio 1991, 1995) and perceptually distinct with a direct access to meaning (Nelson, Reed, and Walling 1976; Weldon and Coyote 1996) which favours retrieval.

A relationship between recall of pictures and working memory has been found in persons with ID (Cherry, Applegate, and Reese 2002). Recognition of encoded sentences can benefit from verbal elaborations as cues for adults with ID (Cherry, Njardvik, and Dawson 2000). Similarly, semantic setting at encoding and recognition of the PM cue (McDaniel, Robinson-Riegler, and Einstein 1998) improve PM performance.

An understanding of the time concept enables us to predict future events. It gives us a sense for when retrieval is close in time (e.g. time monitoring in children, Ceci and Bronfenbrenner 1985). Temporal information processing varies profoundly in individuals with ID (Owen and Wilson 2006).

The present study is focused on PM in individuals with ID. This was investigated by comparing performance in four conditions using words and pictures as cues.

Method and material

Participants

Eleven participants (6 female, 5 male; mean age = 30.55, *SD* = 8.08) with mild or moderate ID were recruited from the municipal upper secondary special programme for pupils with intellectual disabilities and from day activity centres in Sweden. Their placement meant that they had already been diagnosed with ID. ID is a multi-dimensional state of human functioning with significant limitations in intellectual functioning and adaptive behaviour (Schalock 2011). The control group was composed of 13 individuals with similar chronological age (5 female, 8 male; mean age = 25.07, SD = 4.34). As expected, the groups differed in non-verbal conceptual ability (see Table 1; Coloured Progressive Matrices; Raven, Court, and Raven 1995).

Table 1. Group performances on prospective memory, working and long-term memory and time tasks.

	With intellectual disability					Without intellectual disability					
Task	*n*	m	SD	min	max	*n*	m	SD	min	max	t
Prospective Memory Game											
Start[a]	11	0.41	0.29	0.11	0.89	13	0.96	0.07	0.78	1.00	6.16[c]*
Start with cue[a]	11	0.16	0.17	0.00	0.50	13	0.02	0.07	0.00	0.25	– 2.57[c]*
Regular[a,b]	11	0.94	0.06	0.90	1.00	13	0.99	0.03	0.90	1.00	2.63[c]*
Irregular											
Picture – Picture	11	3.27	1.00	2	5	13	4.77	0.44	4	5	4.57[c]*
Picture – Word	11	1.09	0.94	0	3	13	3.85	0.80	2	5	7.74*
Word – Picture	11	2.55	1.57	0	4	13	4.77	0.44	4	5	4.54[c]*
Word – Word	11	1.18	1.25	0	4	13	3.54	0.88	2	5	5.41*
Episodic Memory											
Without Prospective Memory Tasks	11	4.45	0.93	2	5	13	5	0.00	5	5	1.94[c]
With Cue	11	0.27	0.47	0	1	13	0.00	0.00	0	0	1.94[c]
Card	11	4.18	1.17	2	5	13	4.92	0.28	4	5	2.06[c]
Episodic Memory; Picture – Picture	11	4.27	1.01	2	5	13	5.00	0.00	4	5	2.39[c]*
Episodic Memory; Picture – Word	11	3.73	1.35	1	5	13	5.00	0.00	4	5	3.13[c]*
Episodic Memory; Word – Picture	11	3.55	1.21	2	5	13	4.77	0.44	4	5	3.17[c]*
Episodic Memory; Word – Word	11	2.82	1.66	1	5	13	4.62	0.87	2	5	3.23[c]*
Episodic Memory With Cue											
Cued Episodic Memory; Picture – Picture	11	0.73	1.01	0	3	13	0.00	0.00	0	0	2.39[c]*
Cued Episodic Memory; Picture – Word	11	1.09	1.22	0	4	13	0.00	0.00	0	0	2.96[c]*
Cued Episodic Memory; Word – Picture	11	1.27	1.10	0	3	13	0.21	0.23	0	1	2.94[c]*
Cued Episodic Memory; Word – Word	11	2.00	1.67	0	4	13	0.36	0.38	0	3	2.89[c]*
Working Memory											
Easy Picture Position Span	11	21.73	14.52	5	49	13	53.77	6.78	32	58	6.72[c]*
Hard Picture Position Span	11	17.00	11.05	5	41	13	52.62	5.33	43	60	9.77[c]*

Table 1 (*Continued*)

Task	With intellectual disability					Without intellectual disability					t
	n	m	SD	min	max	*n*	m	SD	min	max	
Time Tasks											
Time Conception[e]	9	4.00	1.22	2	5	13	–	–	–	–	
Time Reproduction, of short durations[d]	9	1.46	1.53	0.11	4.87	13	0.23	0.12	0.11	0.49	2.40[c]*
Time Reproduction, of medium durations[d]	11	0.87	1.33	0.07	4.62	12	0.09	0.09	0.02	0.40	1.92[c]*
Time Reproduction, of long durations[d]	11	0.52	0.58	0.03	2.03	12	0.07	0.08	0.02	0.30	2.52[c]*
Non-verbal intelligence											
Raven's	11	20.50	5.87	14	34	13	34.85	1.41	31	36	7.56*[c]

[a]Percent.
[b]Collapsed over four sections due to few omissions.
[c]Equal variance not assumed (significant result on Levene's test for equality in variance).
[d]Mean deviance (s) per reproduced second.
[e]Performed only in the intellectual disability group.
*$p < 0.05$.

Individuals with visual impairment that interfered with interpretation of the computer interface were excluded from the present study.

This project has been approved by municipal officials and by the regional ethical committee of Linköping University. One of the researchers presented the project and ethical guidelines verbally to participants, relatives, and to staff, in larger groups. Information was also available in writing (based on guidelines for 'Swedish that is easy-to-read', 'Lättläst svenska', 'Lättläst - vad är det?' 2003, and in a more comprehensive letter). Consent was obtained from participants/guardians.

Prospective and episodic memory tasks

PM was investigated by means of a computer-based PM Game. This game resembles the laboratory board game task '*virtual week*' (Rendell and Craik 2000) that mimics features of daily living. The new PM Game included a Start Task, an Irregular PM Task, a Regular PM Task, and an Episodic Memory Task, which was the main ongoing task in the PM Game.

The prospective memory game

How to play. The participant collects points by performing Start, Regular and Irregular PM Tasks. The participant starts the game by clicking the mouse whereby a dice is displayed on the screen. Help was offered, if a participant was not confident in pressing a key or clicking the mouse. Participation did not require computer literacy. Before the participant is able to advance in the game, the Start Task has to be completed. A 'trace' (red spots) is left behind as the participant follows the trail. Each lap ends with an Episodic Memory Task. Each participant made 1 lap with no Irregular PM Task, and 1 trial and 1 lap per condition.

Game procedure. The game instructions were organized in paragraphs and presented in association with trials (cf., Swanson and Hoskyn 2001). Extra demonstrations of the game procedure, and repetition of verbal instructions were provided in case trial performance indicated that the instructions had been misinterpreted (i.e. no performance at all or erroneous response). Help was provided in the trials and did not change the points gained in the actual game. Points were gained by performing an item in any of the three PM tasks in the game.

The 'virtual week' (Rendell and Craik 2000) method was altered to suit the participants. For instance, the participant did not have to role a dice as a computer version was implemented (SuperLabPro programme). The PM Game includes PM tasks that the participant is likely to be familiar with from daily life experiences as in The Virtual Week. Both tasks include regular (Event-Card) tasks and Irregular, non-reoccurring, PM Tasks. The PM Game uses one day (lap) for each condition and a fifth lap for the Episodic Memory Task. If the participant forgets to request an Event-Card, two Event-Cards are presented together later in the PM Game. The PM Game does not include time-based PM tasks which the Virtual week does. Time was shown using pictures of meals (breakfast, coffee, lunch, ice cream, dinner, and coffee) in the PM Game. Task modifications aimed at: (1) reducing the influence from limitations in motor (e.g. Dunst 1998), spatial working memory (e.g. Vicari, Bellucci, and Carlesimo 2003), counting and reading skills (Conners et al. 2001). Verbal responses to the Irregular PM Task could be replaced by the participant handing an object (related to the task associated with the PM cue) to the experimenter for participants with limited speech.

The Episodic Memory Task in the PM Game (1) familiarize the participant with the board, (2) present one part at a time of the PM Game instructions (with the risk of creating a difficulty when more tasks were added), (3) show the influence of the Irregular PM Task on Episodic Memory performance, and (4) increase the delay and complexity of the ongoing task in the game.

The game parts. The PM Game included three PM tasks: 'Start', 'Regular', and 'Irregular', and one Episodic Memory Task.

The board: The board included a 'one day' trail that is made up by empty squares (69) and squares with different pictures. Each picture belongs to one of three picture categories, i.e. meals, locations, and running feet. The pictures of meals indicates time of the day; breakfast, lunch, ice cream, dinner, and coffee (5 meals). The pictures of locations in the PM Game were: home (a house), bakery, supermarket, barber, shoe shop, library, ice-cream booth, post office, lamp, sofa, and stereo (11 locations). Different pictures were used as traps and targets in different conditions. Identical running feet pictures (6) marked when the participant should demand an event-card. All in all, the trail included 91 squares.

The start task. The participant should 'throw a six' with a click (cf. Rendell and Craik 2000). If the participant forgot to perform the Start Task, the experimenter said: 'Waking up is tough, what were you supposed to do?' Thus, throwing a six made up a PM task. In case a cue was provided, the task measures the retrospective aspect of PM (memory for the intended action). The Start Task was scored as percent correct performed tasks with or without cue.

The regular prospective memory task: The Regular PM Task was based on the number of times that the participant requested an Event-Card as the marker either ended up at or passed by a running feet picture in the trail. The experimenter read the written message on an Event-Card out aloud. The Regular PM Task was scored as percent demanded cards collapsed over the four Irregular Task conditions (4 * 5 cards).

The irregular prospective memory task: The Irregular PM Task comprised four conditions with 5 items: picture – picture, picture – word, word – picture, or word – word. In the Irregular PM Task, word refers to verbal messages. Picture refers to pictures as support to verbal instructions on Event-Cards or as part of the trail. Items (verbal messages or pictures) such as 'buy bread when you pass the bakery' and verbal lures were presented on Event-Cards. The items were encoded verbally (word – picture or word – word conditions) or with picture support (picture – picture or picture – word conditions). The experimenter showed those Event-Cards that included pictures (e.g. the bakery) to the participant. Retrieval cues (targets) were either pictures included in the trail (picture – picture or word – picture conditions), or verbal cues on Event-Cards (picture – word or word – word conditions). Event-Cards could also include verbal lures that were not cues, such as, 'The sun is shining.'. The Irregular PM Task items were 'performed' by verbal reports to the experimenter. Performance was scored as correct if the verbal report preceded moving along the trail once the cue had been presented.

Pictures were named verbally at encoding allowing for both visual and verbal processing.

The Irregular PM Task yielded one result per condition (4*(0–5)). Complete omissions were either not to perform anything, or to perform an incorrect task in response to an incorrect event.

The episodic memory task. The Episodic Memory Task included questions with three response alternatives, e.g. 'You have a loan from the library. Is it a book, a CD or a film?'. Event-cards included questions (5 questions per Irregular PM Task condition). The participant chose a response (N.B. At this stage, all responses were correct.). From this point forward, this response was the participant's correct answer in the Episodic Memory Task.

The Episodic Memory Task (5 questions) was first performed without the Irregular PM Task. Recall of the correct answers was tested at the end of each lap. The questions (5) were presented one by one in text on the screen, and read aloud by the experimenter as cues. If the participant failed to recall the correct answer, the three response alternatives were used as cues. Episodic memory performance was rated as total number of correct answers with or without cues (0–5 per condition of the Irregular PM Task, and 0–5 without the Irregular PM Task).

Time tasks

Time tasks were chosen with respect to the ability in the ID group and to the relevance for PM performance, temporal maintenance and updating (Mäntylä, Carelli, and Forman 2007). One task focused on concepts and experience, and a second task tapped time reproduction of short time spans.

Time Conception was tapped by questions (5) with two response alternatives, e.g. 'What takes the longest time, to shut a window or to be on holiday?'. Apart from duration, the order of everyday procedures and time concepts were included. The questions were presented on the computer and read aloud by the experimenter. Performance was scored as total number of correct responses (0–5, the order of correct response and lure varied between the tasks). The control group was predicted to perform without error.

Time Reproduction included short (3, 5, 6 s), medium (12, 13, 14 s), and long (26, 27, 30 s) durations. Performance was scored as average deviance per second, for short, medium, and long durations, respectively. A picture of a lit light bulb on the computer screen indicated the time to reproduce (Kerns and Price 2001). The participant reproduced the duration by clicking the mouse. The first click turned the lamp on and the second turned it off.

Working memory task

A Picture Position Span Task (Levén et al. 2011) was used to tap working memory capacity (Just and Carpenter 1992: range: 0–60 pictures recalled in the correct position—for details, see Levén et al. 2011). Photos of persons (difficult to verbalise; Smyth et al. 2005) were presented one by one (1 s, inter-stimuli interval 0.075 s). The participant should recall the order of presentation of the photos in each span (2–6 pictures). The Picture Position Span Task was used in two versions that differed in demand for concurrent mental processing (henceforth denoted Hard and Easy). The Hard version demanded the participant to say if the person on the picture was a 'he' or a 'she'. Picture lists were balanced over the two versions.

Non-verbal conceptual ability

Raven's coloured progressive matrices (Raven, Court, and Raven 1995) was used to estimate non-verbal conceptual ability. This task has been suggested to primarily tap a fluid component of intelligence (cf. Fry and Hale 2000), which can be assumed to differ between persons with and without ID.

Procedure

The board and the basic procedure of the PM Game were introduced in the Episodic Memory Task. The order of the Irregular conditions was varied to reduce the effects of order (not significant). The order of the Time Reproduction, the Time Conception, the Picture Position Span and Raven's Coloured Progressive Matrices Tasks was also changed between participants, apart from always performing the Easy Picture Position Span condition before the Hard condition. The number of tasks performed (per occasion and in total) differed for participants with ID, due to variation in mental processing and motor speed (e.g. Merrill et al. 1987) as well as the opportunity to participate.

Results and discussion

The results are reported in three sections: group performance levels, PM performance, skilled and less skilled performance levels, and a correlation analysis. The data analysis was performed with consideration to a limited number of participants and major differences in performance level. Only participants who performed all four conditions of the PM Game are included in the reported results (Table 1). Group performances are reported as it may reveal issues for further inquiry. An alpha level of .05 was adopted for all statistical tests unless otherwise reported. The Sidak method was used for investigations of ANOVA results.

Group comparisons

The results for this section will be presented in the following order: PM Game, Episodic Memory, Picture Position Span, Time Conception and Time Reproduction Tasks.

Prospective memory performance

The ID group performed significantly lower than the control group in all conditions of the PM and working memory tasks (Table 1). The ID group required more cues than the control group on the Start Task (Table 1), but both groups performed the majority of these items without cues (ID group $t(10) = 2.65$; control group: $t(13) = 27.77$).

Regular PM Task performance was almost without error in the control group, and above 90% correct also in the ID group (Table 1). Irregular PM Task performance was also higher in the control group than the ID group (Table 1). The number of PM mistakes where the correct task was performed on the wrong occasion or vice versa, did not differ between the ID and the control group.

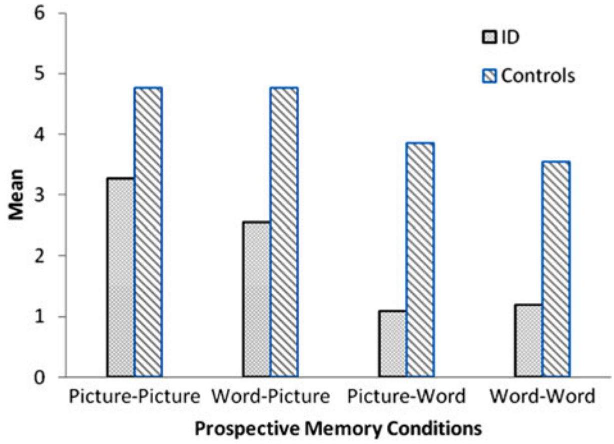

Figure 1. Irregular prospective memory performance.

PM cue (within: encoding and retrieval modality) and group (between) revealed a significant main effect of group (F(1, 22) = 74.19, MSE = .39), of retrieval (F(1, 22) = 84.45 MSE = .57), and an interaction between retrieval modality and group (F(1, 22) = 5.04, MSE = .57). This result was due to superior performance in conditions with pictures at retrieval (Figure 1). There was a tendency for a three-way interaction (F(1, 22) = 3.17, MSE = . 59).

The interaction between retrieval and group was due to superior performance for pictures compared to words at retrieval (word – word vs. word – picture, ID group t(1, 10) = 4.40; control group (1, 12) = 4.79; picture – word vs. picture – picture, ID group t(1, 10) = 5.16; control group (1, 12) = 3.49).

Episodic Memory performance differed between the groups only as an ongoing task in relation to the Irregular PM Task (Table 1). The Episodic Memory performance in the control group was at ceiling level for the Episodic Memory Task without Irregular PM, and for the picture – picture and the picture – word conditions. The Episodic Memory Task performance (in the word – word condition) in the ID group was performed equally as often with without the response alternatives as cues (t(10) = .82, n.s.). Episodic Memory performance as an ongoing task in two of the Irregular PM conditions for the ID group declined compared to performance without interference from the PM task (picture – word: t(10) = 2.39; word – word: t(10) = 3.61), whereas there was no difference in the ongoing task in picture – picture nor word – picture PM conditions.

ANOVA of Episodic Memory performance during the Irregular PM Tasks revealed a main effect of group (F(1, 22) = 831.17, MSE = .51), and a significant main effect of encoding modality (F(1, 22) = 13.29, MSE = . 59). A tendency for a main effect of retrieval modality was found (F(1, 22) = 4.18, MSE = .70).

In other words, Episodic Memory performance was significantly higher in conditions with pictures as PM cues.

Easy and Hard manipulation had no effect on level of Picture Position Span performance in either of the groups (Table 1). The ID group, as predicted, performed at a lower level and with more extensive variation than the control group (cf., Levén et al. 2008).

Time Concept performance was close to perfect (one mistake) for the control group, but rendered variability in the ID group (Table 1). ANOVA of duration (short, medium and long) and group, revealed a main effect of group. This effect was due to a more accurate performance in the control group than in the ID group for short ($F(1, 19) = 8.68$, $MSE = 1.65$) and for long durations ($F(1, 19) = 4.88$, $MSE = 1.65$). The effect of time was due to improved Time Reproduction for long compared to short durations in the ID group ($t(8) = 2, 69$). ID group performance spans from absence of sense for time passing to performance levels on par with the control group.

In summary, PM, Episodic Memory, Working Memory, Time Concept and Time Reproduction Tasks generated inferior performance for the ID than the control group. However, there was no significant group difference for Episodic Memory encoded without load from any Irregular PM Tasks. Pictures proved to be a support to Irregular PM performance at retrieval.

Level of performance. Performance of the control group resulted in flawless performance (SD = 0) for certain tasks (Regular PM, time concepts and episodic memory without integrated PM tasks; Table 1). Thus, deviance from perfect performance implies a limited capacity. However, this perspective does not imply that floor performance should reflect a complete lack of a specific ability, since performance can improve in changed conditions. Performance at floor level on the PM Game was made only by persons with ID (Table 1). Performance without error was present only in the picture – picture condition in the ID group. PM performance without error was most frequent for the Regular Task. This task was based on pictures ('running feet') as PM cues and identical task to perform for all cues. Time concept performance was without error for 45.5% of the ID group.

Correlations

PM, working memory, Episodic Memory, Time Conception and Time Reproduction performances correlated more often for the ID group than the control group (Table 2; cf. children with learning difficulties, Bayliss et al. 2005; adults with ID, Levén et al. 2008). The differences in how task performances are related in the two groups cannot be attributed solely to a tendency to ceiling effects in some tasks (Table 1).

The ID group performed at a lower level than the control group but the groups performed equally on Episodic Memory without Irregular PM Task at encoding.

Discussion

Pictures as PM cues and as support to verbal cues at encoding and retrieval of PM items will be discussed in relation to cognitive capacity. Empirical findings will be considered in relation to working memory, episodic memory, Time Reproduction and Time Concept capacity.

Persons with ID were outperformed by persons without ID on a group level on all tasks, except for the Episodic Memory Task. Performance in the ID group showed major differences both between individuals and different tasks. Correlation between PM, episodic memory and working memory were found for the ID group. This could

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

N = 11	N = 13																		
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1. Start[a]	1.00	−0.81**	0.34	−0.25	−0.02	0.23	0.23	.(c)	.(c)	.(c)	0.04	−0.21	−0.13	0,21	0,01	−0,19	0,23	−0.38	−0.26
2. Start with cue[c]	**0.11**	**1.00**	0.08	0.14	−0.22	0.18	−0.13	.(c)	.(c)	.(c)	0.14	0.12	0.08	−0,20	0,06	0,33	0,17	0.42	0.26
3. Routine[c,b]	**0.39**	**−0.14**	**1.00**	−0.14	−0.09	0.44	−0.18	.(c)	.(c)	.(c)	−0.14	−0.12	−0.08	−0,02	0,06	0,14	−0,08	−0.31	−0.05
4. Picture – Picture	**0.33**	**0.45**	**0.23**	**1.00**	−0.17	0.06	−0.52	.(c)	.(c)	.(c)	−0.27	−0.23	−0.14	−0,64*	0,22	−0,46	0,03	0.21	0.44
5. Picture – Word	**0.54***	**−0.26**	**0.20**	**−0.03**	**1.00**	0.15	0.06	.(c)	.(c)	.(c)	−0.37	0.16	0.22	−0,21	0,03	−0,12	−0,47	−0.06	0.07
6. Word – Picture	**0.09**	**0.02**	**−0.45**	**0.40**	**0.30**	**1.00**	0.30	.(c)	.(c)	.(c)	0.06	−0.28	−0.18	−0,57 *	0,13	0,15	0,57*	0.39	0.50*
7. Word – Word	**0.17**	**0.56***	**−0.43**	**0.43**	**0.15**	**0.76****	**1.00**	.(c)	.(c)	.(c)	0.25	0.01	−0.18	0,10	0,07	0,03	0,29	0.22	0.02
8. Episodic Memory	**0.47**	**0.29**	**−0.24**	**0.07**	**0.40**	**0.09**	**0.09**	**1.00**	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)
9. Episodic Memory Picture – Picture	**0.07**	**0.01**	**0.07**	**0.41**	**0.29**	**0.21**	**0.12**	**0.07**	**1.00**	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)
10. Episodic Memory Picture – Word	**0.52***	**0.10**	**0.07**	**0.43**	**0.73****	**0.45**	**0.27**	**0.66****	**0.35**	**1.00**	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)	.(c)
11. Episodic Memory Word – Picture	**0.56***	**−0.47**	**0.46**	**0.11**	**0.65****	**−0.01**	**−0.27**	**0.11**	**0.52***	**0.47**	**1.00**	−0.02	−0.14	0,19	−0,50	0,27	0,60*	0.56**	0.18
12. Episodic Memory Word – Word	**0.31**	**−0.15**	**0.07**	**0.33**	**0.33**	**0.04**	**−0.22**	**0.44**	**0.27**	**0.60****	**0.60****	**1.00**	−0.12	0,38	−0,22	0,05	−0,09	−0.04	−0.27
13. Time Conception[e f]	**−0.04**	**0.19**	**0.25**	**0.00**	**0.10**	**−0.20**	**−0.11**	**−0.10**	**0.46**	**0.00**	**0.42**	**0.12**	**1.00**	0,06	0,22	0,13	0,00	−0.04	−0.26
14. Time Reproduction, short[d]	**0,08**	**0,09**	**0,33**	**−0,22**	**−0,22**	**−0,34**	**−0,31**	**0,17**	**−0,16**	**−0,21**	**−0,21**	**−0,45**	**0,27**	**1**	−0,27	−0,31	0,00	−0,46	−0,71 **
15. Time Reproduction, medium[d]	**−0,36**	**0,25**	**−0,23**	**0,15**	**−0,36**	**0,04**	**−0,04**	**0,28**	**0,26**	**0,00**	**−0,46**	**−0,22**	**−0,12**	**0,51**	**1**	−0,08	0,21	−0,15	0,02
16. Time Reproduction, long[d]	**−0,26**	**0,15**	**−0,25**	**0,27**	**−0,27**	**0,12**	**−0,01**	**0,27**	**0,47**	**0,03**	**−0,27**	**−0,07**	**−0,16**	**0,31**	**0,92 ****	**1**	0,08	0,19	0,09
17. Picture Span Easy	**−0,03**	**0,08**	**−0,14**	**−0,37**	**0,23**	**0,01**	**0,14**	**0,01**	**−0,27**	**0,18**	**0,04**	**−0,01**	**0,22**	**−0,27**	**−0,48**	**−0,69 ***	**1**	0,35	0,03
18. Picture Span Hard	**−0.29**	**−0.19**	**−0.36**	**−0.44**	**0.04**	**0.02**	**0.01**	**−0.19**	**−0.04**	**−0.03**	**0.05**	**−0.03**	**−0.04**	**−0,53**	**−0,34**	**−0,40**	**0,78 ****	**1**	0.78**
19. Raven[g]	**0.05**	**−0.34**	**−0.14**	**−0.51**	**0.20**	**−0.17**	**−0.36**	**0.11**	**−0.15**	**0.14**	**0.38**	**0.29**	**0.26**	**−0,25**	**−0,49**	**−0,62 ***	**0,97 ****	**0.82***	**1**

Correlations for the intellectual group in bold text, for the control group in regular text.
[a]Percent.
[b]Collapsed over four sections due to few omissions.
[c]Cannot be computed because at least one of the variables is constant.
[d]Mean duration per reproduced second.
[e]Performed only in the intellectual disability group.
[f]$N = 9$ in the intellectual disability group.
[g]$N = 10$ in the intellectual disability group.

reflect a limitation that affects multiple cognitive processes (e.g. processing speed), similar to changes related to development over the lifespan.

Pictures and verbal prospective memory cues

PM performance was better with pictures compared to words as PM cues at retrieval. Performance near floor level in conditions with verbal cues at retrieval in the ID group and near perfect performance in the condition with pictures at retrieval in the control group possibly prevented a three-way interaction from reaching standard levels of significance. Previous PM studies have shown picture superiority effects as in explicit memory tasks (McDaniel, Robinson-Riegler, and Einstein 1998). The result in the present study may be due to picture superiority at PM retrieval. Pictures at encoding did not improve PM performance compared to condition with words, despite an overlap in verbal processing between encoding and retrieval according to dual encoding theory (Paivio 1995). A robust picture superiority effect emerged although pictures as support to words at encoding did not improve performance significantly. Pictures were important for performance in the word – picture condition. That is, in case of less elaborative encoding.

Superior performance in the word–picture compared to the picture–word condition, could follow from familiarity with the retrieval context as the pictures were part of the trail. Opportunity to form on-going associations between context and the future and the PM task (cf. Nowinski and Dismukes 2005) at encoding could have contributed to performance in the conditions with pictures at retrieval.

Overlapping processing at encoding and retrieval in the matched condition and in the picture–word condition (cf. Weldon and Roediger 1987) was assumed essential for successful PM performance in the ID group due to reduced load on limited working memory capacity, language and strategic skills (Bray, Huffman, and Fletcher 1999). Instead, pictures were essential at retrieval. In a general population, words result in more typical associations than pictures (Saffran, Coslett, and Keener 2003). Thus, it may have been less demanding to match a word with a picture compared to vice versa.

Episodic memory

Episodic memory performance as an ongoing task was worse for the ID group than the control group. It is probable that the PM task performance interfered with the ongoing Episodic Memory Task in the ID group. Hicks, Marsh, and Cook (2005) offer an explanation based on near-term intentions usurping cognitive capacity away from ongoing task performance. Participants with ID may have been unable to adopt a resource allocation policy that allowing completing both the ongoing and the PM task without error. It has been argues that PM retrieval requires cognitive capacity (Smith and Bryan 2004).

Encoding and retrieval affected episodic memory performance, which suggest less influence on episodic memory performance from PM conditions with pictures. That is distinct cues with direct access to meaning (Nelson, Reed, and Walling 1976; Weldon and Coyote 1996), encoded both as a picture and a verbal code (Paivio 1995). Picture recognition is to a large extent automatic. The prospective aspect of the Irregular PM Task relied primarily on picture recognition in two conditions. This could spare capacity for memory processes such as retrieval of the intended task to perform (retrospective aspect of PM).

Distinctiveness

Pictures may be more distinct than words and provide more overlap in memory processes supporting PM performance. This may be important in case of limited verbal skill as in persons with ID (Bebko and Luhaorg 1998). PM performance highlights that distinctiveness is an outcome of the interaction between cue and the individual's cognitive capacity in a context. That is, the interaction between encoding and retrieval conditions. Performance in the word–word and picture–word sections points to a plausible group difference in demand for contextual support Pictures at retrieval improved PM performance in the ID group who performed near floor level with verbal retrieval cues. As in previous research, cue distinctiveness at retrieval and familiarity with the retrieval context are important for PM performance.

Strategic behaviour

Abstract cues (words) can be associated with more distinct cues (e.g. with a picture or position on the board; cf. Sellen et al. 1997). This would be similar to PM performance on time-based tasks (at three o'clock), which improves if the cue is associated with a concrete event (the post arrives). Thus, this strategy reduces effects of the original cue distinctiveness that are assumed to be higher for pictures than words (Nelson, Reed, and Walling 1976; Weldon and Coyote 1996). Hence, the results of this study are in line with previous research that has found that cue distinctiveness at retrieval and familiarity with the retrieval context are important for PM performance.

Temporal maintenance and updating

Inaccurate time reproduction suggests weak temporal maintenance and updating (Mäntylä, Carelli, and Forman 2007) due to, e.g. fluctuating attention in persons with ID. Performance in PM, working memory, and Time Concept Tasks was lower and displayed a high degree of heterogeneity in the ID compared to the control group. Furthermore, task performances were interrelated to a higher extent in the ID group. This variation between individuals with ID, suggest tailor-made training approaches to improve prospective memory (Kliegel et al., in press). In particular, training based on requirements in everyday life, and that account for individuals cognitive resources.

The prospective memory game

The PM Game can be changed for studying different aspects of PM. Previous PM studies (Meilan et al. 2009), suggest further investigation of, e.g. executive functions involved in goal directed behaviour. By adapting the game to the person's everyday life, the game could be used for training in order to improve performance in specific situations.

Despite major performance differences, there are similarities that suggest that performance of the control group would be more similar to that of the ID group on a more complex task. This could be confirmed if the task difficulty was adjusted to the participants' performance level, and by improving the resolution by adding more PM tasks. However, the task should not be too time-consuming or boring to perform. Taken together, the PM Game requires further testing in order to achieve a more reliable and valid test of PM.

In summary, as previously noted, performance was better with pictures than words as PM cues (Levén et al. 2008; McDaniel, Robinson-Riegler, and Einstein 1998). PM performance in the ID group relied on visually distinct cues at retrieval. This is likely due to limited episodic memory, working memory and non-verbal conceptual function. Pictures at encoding did not improve PM performance. The PM Game is a useful method when studying PM in individuals with ID. This study suggests that the PM game offers a complement to real-world measurements when investigating the potential of interventions such as memory training to promote change.

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