**Episodic Future Thinking Improves Children’s Prospective Memory Performance in a Complex Task Setting with Real Life Task Demands**

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Abstract

Research on children’s prospective memory (PM) shows an increase of performance across childhood and provides first evidence that encoding strategies such as episodic future thinking (EFT; i.e., engaging in a vivid prospection of oneself performing future tasks) may improve performance. The present study aimed at testing whether the beneficial effects of EFT extend from typical lab-based tasks to more complex tasks with real life demands. Further, it was tested whether children’s ability to project themselves into different perspectives (i.e., self-projection) moderates the effects of EFT encoding on PM. Overall, 56 children (mean age: *M* = 10.73 years) were included in this study who were randomly assigned to either an EFT or control condition. Children participated in a ‘sightseeing tour’ (ongoing activity) inside the lab with various socially relevant and neutral PM tasks embedded. Results showed significantly higher PM performance in the EFT compared to the control group. There was no difference between neutral and social PM tasks and no interaction between type of PM tasks with encoding condition. Further, self-projection did not moderate the effects of EFT encoding on PM. Results suggest that EFT is an effective strategy to improve children’s everyday PM. These beneficial effects seem to occur independent from children’s general ability to change perspectives and for different types of PM tasks.

Key words: Prospective memory, future thinking, encoding strategies, memory improvement

Remembering to perform delayed intentions at an appropriate time in the future (time-based) or upon the occurrence of an external cue (event-based), so-called *prospective memory* (PM), plays a crucial role in developing independence in childhood and adolescence (Altgassen, Kretschmer, & Schnitzspahn, 2017). Thus, it is not surprising that during the last years a growing number of studies has focused on the development of PM in these age groups (e.g., Altgassen, Vetter, Phillips, Akgün, & Kliegel, 2014; Ford, Driscoll, Shum, & Macaulay, 2012; Guajardo & Best, 2000; Kerns, 2000; Kretschmer, Voigt, Friedrich, Pfeiffer, & Kliegel, 2014; Wang et al., 2011). Overall, empirical evidence points to a developmental increase of PM performance across childhood and adolescence (see, e.g., Aberle & Kliegel, 2010 for time-based PM; e.g., Kliegel & Jäger, 2007 for event-based PM; Mahy, Moses, & Kliegel, 2014a for a review). Examples of everyday PM mistakes are to forget to pick up the younger sibling from sports or to leave the sports bag at home which is needed at school. Given the importance of PM in school-aged children on the one hand, and their apparent performance deficits on the other hand, highlights the clear need for interventions supporting children in the fulfillment of their PM tasks. It was therefore the primary aim of the present study to examine the effects of an encoding strategy aiming to improve PM in children.

In order to develop helpful interventions, it is important to understand the cognitive mechanisms underlying PM development across childhood. Only recently research has begun to focus on these mechanisms. Conceptually, PM has been described as a complex process relying on different cognitive abilities across different PM phases (*process model*, Kliegel, Martin, McDaniel, & Einstein, 2002; see also Ellis, 1996). Within the first phase of prospective remembering, the prospective intention needs to be formed and encoded and it is planned when and how the intention will be initiated. Thus, efficient intention encoding and planning play a crucial role. In the second phase, the individual is busily engaged in other ongoing activities, while the intention needs to be stored in retrospective memory. When the PM cue is detected (event-based PM) or the target time approaches (time-based PM), the intended action needs to be retrieved and the individual has to inhibit other ongoing activities and to switch to the PM task (last two phases: intention initiation and execution). Overall, retrospective memory and cognitive control processes (such as monitoring, inhibition, updating, task switching) are crucial for successful PM performance (see, e.g., Ford et al., 2012; Kerns, 2000; Shum, Cross, Ford, & Ownsworth, 2008 for correlational evidence on children). Importantly, different PM tasks differ in the amount to which they require cognitive control processes; a notion that has been suggested by the *multiprocess framework* by McDaniel and Einstein (2000). According to this model, the ongoing activity and the PM task compete for the limited amount of cognitive resources. Depending on task characteristics, PM tasks can either be initiated rather spontaneously or with the need of cognitively controlled processes. For instance, if PM cues are perceptually salient as compared to ongoing task stimuli, they are assumed to automatically attract attention and prompt retrieval of the intention (see, e.g., Kliegel et al., 2013 for evidence on children; Kretschmer-Trendowicz & Altgassen, 2016 for results in a lifespan sample). Given that PM tasks are dual tasks, the difficulty of the competing ongoing task may also influence the availability of cognitive resources to simultaneously monitor for the PM cue, inhibit the ongoing task and switch to the PM task (see, e.g., Kliegel et al., 2013; Mahy, Moses, & Kliegel, 2014b for results on children). In line with these assumptions, previous studies reported larger age differences when PM tasks required more cognitive control resources to be completed or when only few cognitive resources were available to work on the PM task (see, e.g., Einstein, Smith, McDaniel, & Shaw, 1997 for evidence in older adults; Ward, Shum, McKinlay, Baker-Tweney, & Wallace, 2005 for evidence in children).

Since low PM performance in children seems to be caused by lower levels of cognitive control resources compared to adolescents and young adults, interventions resulting in rather spontaneous than cognitively controlled initiation and execution of the delayed intention should be especially helpful to improve performance. Thorough *planning* of the intended action may represent such an intervention as it has been suggested to strengthen the PM cue – action link, leading to rather spontaneous than cognitively controlled PM execution when the target moment arises (see, e.g., Guynn, McDaniel, & Einstein, 1998; McDaniel & Einstein, 2000). However, studies testing this prediction by exploring possible beneficial effects of thorough intention encoding on children’s PM are scarce. One specific encoding strategy that has received some attention recently will be outlined below.

Instructing participants to engage in *episodic future thinking*1 (EFT) while encoding the prospective intention has been found to improve PM performance. EFT refers to the mental projection of the self into the future to pre-experience a certain future situation (Atance & O’Neill, 2001). It has been proposed that PM and EFT are closely related (Addis, Wong, & Schacter, 2008) and that the brain regions being recruited when mentally engaging in a future situation are similar to those involved in PM (i.e., frontal and medial temporal-parietal regions; Spreng, Mar, & Kim, 2009; West, 2011). Thus, EFT may be involved within the PM phase of intention formation as individuals may mentally engage in the prospective situation and imagine themselves performing the PM task at the appropriate future moment (Schacter, Addis, & Buckner, 2008). Consistent with this notion, previous correlational studies found significant relations between PM and EFT performance in children (see Atance & Jackson, 2009 for results on 3- to 5-year-olds; Nigro, Brandimonte, Cicogna, & Cosenza, 2014 for results on 4- to 7-year-olds). However, encoding of an intended action is not automatically accompanied by a mental simulation of its future fulfillment (Szpunar, 2010). Instructing EFT during intention encoding has been suggested to lead to deeper encoding of the intention in retrospective memory (thus, stronger memory traces) and the formation of a stronger cue-context or cue-action association which may facilitate (rather) automatic retrieval of the intention during the delayed performance interval (Paraskevaides et al., 2010). Further, research has shown that the ability of EFT is not fully developed in children, yet and continues to improve until adolescence (Gott & Lah, 2014). Thus, it seems unlikely that children spontaneously use EFT during encoding, but they should benefit from the explicit instruction to do so.

In fact, Altgassen et al. (2017) investigated the effects of EFT encoding on PM in adolescents and found significant PM improvements when instructing EFT compared to a standard PM condition. Whether those beneficial effects also extend to children was in the focus of a second study. Specifically, Kretschmer-Trendowicz, Ellis and Altgassen (2016) tested 5- and 7-year-old children with an event-based PM task. Half of the participants received EFT instructions during intention encoding, while the other half received standard PM instructions. Results revealed beneficial effects of EFT, particularly in the group of 7-year-olds. These initial findings are very promising and suggest that EFT is an effective encoding strategy to improve PM in children and adolescents.

One critical issue that remains open when reviewing the literature on the effects of EFT on PM is whether the beneficial EFT effects described above are strong enough to extend to rather complex tasks with real life task demands. Both former studies on EFT encoding and PM in children and adolescents (Altgassen et al., 2017; Kretschmer-Trendowicz et al., 2016) applied typical lab-based PM paradigms that were rather simple in nature, such as pressing a pre-defined key upon PM cue appearance on a computer screen or saying the word ‘juice’ when seeing fruits or vegetables on a presented card. From an applied perspective, it is crucial to test if beneficial strategy effects can be replicated using tasks more closely mirroring everyday PM challenges in children. In one previous study testing young and older adults, Altgassen et al. (2015) tested the effects of EFT encoding on PM performance in a complex and rather familiar task. Specifically, participants worked on a computerized task in which they had to prepare a breakfast (Dresden Breakfast task, Altgassen, Koban, & Kliegel, 2012). The task required participants to adhere to certain rules and time restrictions. Before preparing the breakfast, individuals were asked to develop a plan on how to initiate the single steps of task execution. Younger and older adults significantly benefited from EFT instructions. Moreover, individuals of the EFT group adhered to their previously formed plans more closely than individuals who received standard PM instructions. However, whether this effect also occurs in individuals at the other end of the lifespan remains unknown. Therefore, the present study set out to investigate the effects of EFT on children’s PM when using a complex PM paradigm simulating a real life situation.

In addition, the present study set out to explore whether PM performance may differ when presenting various types of PM tasks that may be crucial in real life task settings (i.e., social vs. neutral PM tasks). Importantly, in everyday life, the social context in which a PM task has to be executed plays a crucial role. Typical examples of children’s everyday PM tasks are to remember to meet a friend after school or to pass a message to their parents. Given that failures in ‘social’ PM tasks may result in negative consequences in their relationships to other people, social PM tasks may be perceived as being more important than neutral PM tasks without any social relevance (see also Penningroth, Scott, & Freuen, 2011 who found social intentions to be rated as being of particular importance). In a previous study, Altgassen, Kliegel, Brandimonte and Filippello (2010) compared PM performance in a social importance condition with performance in a standard PM condition. Only older (around 68 years old) adults’, that as a group are associated with reduced executive functioning and memory, but not younger adults’ (around 24 years old) time-based PM was improved when the PM task was of high social importance. Thus, older adults and possibly also children may particularly benefit from social manipulations as they might help them to allocate their limited cognitive resources to the rather important task. Surprisingly, no study has explicitly tested the effects of social importance on children’s PM, yet. The present study therefore set out to explore the effects of the social relevance of PM tasks in children by asking them to perform either rather social versus neutral PM tasks and compare performance between the two task types.

Importantly, first papers have identified mechanisms that may be directly related to the ability of EFT and may thus also impact the efficiency of using EFT as a strategy. Specifically, self-projection (i.e., the ability of projecting oneself into different perspectives like another person (Theory of Mind) or another time (e.g., episodic memory)) has been suggested as possibly underlying EFT given that EFT requires the individual to shift from the current to another (future) perspective (e.g., Buckner & Carroll, 2007). The underlying assumption is that individuals with better developed self-projection abilities can rather easily project themselves into the future situation which allows them to form a particular vivid image of themselves performing a certain task in the future. This may result in stronger memory traces or stronger cue-action links which in turn may result in a higher efficiency of EFT (see, e.g., Kretschmer-Trendowicz et al., 2016 for first preliminary evidence on relations between EFT encoding and self-projection with regards to PM). Given that research targeting the impact of self-projection for successful EFT is scarce, the present study also included Theory of Mind tasks as measures of self-projection.

Taken together, this study examined the effects of EFT during intention encoding on PM in a complex task simulating real life task demands. A group of children, aged 10 to 12 years, was tested. Children at this age are increasingly required to initiate certain PM tasks without being reminded by parents or teachers (e.g., remembering to attend a football training in the afternoon, meeting friends after school). However, PM during this age range is still developing (e.g., Yang, Chan, & Shum, 2011), which may result in difficulties in children’s everyday life if delayed attentions are being forgotten. Thus, instructing a strategy that facilitates spontaneous PM task retrieval may be particularly important in this age group. It was further explored whether children’s PM performance differed when presenting social as compared to neutral PM tasks. Finally, this study tested whether self-projection serves as mechanism underlying EFT and possibly moderates the effects of EFT encoding on PM.

As for our hypotheses, we proposed EFT instructions to significantly improve children’s PM performance. Moreover, it was assumed that overall children would perform better in social as compared to neutral tasks. Theory of Mind as an indicator of children’s self-projection abilities was suggested to moderate the effects of EFT encoding on PM performance. Specifically, children with more developed abilities to put themselves into different perspectives were predicted to particularly benefit from EFT instructions, as they may also rather easily take a future perspective.

**Method**

*Participants*

Overall, 56 children aged 10 to 12 years (*M* = 10.73, *SD* = 0.77) were included in this study. Children were recruited through the department’s participant pool and through advertisements. All children spoke German as their first language, were in good health and had no psychiatric or neurological disorders as assessed by a parent’s questionnaire. Children were randomly assigned to one of the two encoding conditions. Importantly, both encoding groups did not differ significantly in age, gender, verbal abilities and Theory of Mind performance (for details see Table 1). The study was conducted in accord with the Declaration of Helsinki and was approved by the local ethics committee. Only children whose parents had given written informed consent were allowed to participate.

(Table 1 about here)

*Materials*

*PM assessment*. To simulate a real life task setting, while making sure to have an appropriate amount of experimental control, we developed a new task for the present study. Specifically, children were told that they will do a ‘sightseeing tour’ (cover story). The walls of the room in which the tour took place showed various tourist attractions of the city that the children lived in. At each attraction, the children had to stop and work on a certain task. These tasks represented the ongoing activity. To ensure an appropriate difficulty level of the tasks and to avoid ceiling effects, tasks were thoroughly piloted. According to results obtained in the pilot phase, the time limit for each task was set to 5 minutes. At the first attraction children stood on a bridge and had to throw as many marbles as possible into a small bucket. Each marble in the bucket was counted as one point for the ongoing task. If children had 10 marbles in the bucket, the distance between the bridge and the bucket was doubled to keep children’s attention and motivation. At the second attraction, children had to stack small wooden sticks on the back of a wooden camel to build a tower as high as possible. For each layer on the back of the camel children received one point. If the tower collapsed, three points were subtracted. At the third attraction, children had to copy one of the wall paintings (showing a rainbow, landscape and houses) as accurate as possible. The painting was scored (criteria: rainbow with colors in the right order, every further element correctly painted under the rainbow resulted in one additional point). At the last stop, children were asked to solve riddles using matches. For instance, children were shown a figure that included various triangles and they had to find out the overall number of triangles shown in the figure. Further, there were two equations and children had to move one match in each task so that the equation was correct. The final task at this stop showed three triangles and children were asked to move two matches to receive four equilateral triangles (for details on the riddles see Appendix A). While unlimited points could be gained at stops one to three, the maximum score at the last stop was four (i.e., one for each correctly solved riddle or equation, respectively).

While working on the tasks of the ongoing activity, children were asked to additionally remember and perform six PM tasks. Three of these tasks were social tasks, i.e., required interaction with the experimenter. The first social PM task (*S1*) was to give the experimenter a tissue when she sneezed. To ensure that the tissues were not in the direct focus of the children’s attention and thereby could serve as a constant reminder for the PM task, they were stored in a belt pouch which was given to each child. The second social task (*S2*) was to fill up the experimenter’s glass with water as soon as she had emptied it. Finally, the experimenter told the children that she will lend them her pen, so that he/she will be able to work on the riddles. The pen was also stored in the belt pouch. Children were told to immediately give the pen back to the experimenter at the end of the ‘sightseeing tour’ (*S3*). The other three PM tasks were neutral, i.e., required the manipulation of objects and no interaction with the experimenter. The first neutral PM task (*N1*) was to put a ticket in a box when arriving at stop 3 of the tour. Children received the admission ticket for the ‘sightseeing tour’ directly at the beginning of the testing session and had to put it in the belt pouch. The box was placed outside the room to ensure that it did not serve as a highly salient cue. The second neutral task (*N2*) was to pin a picture on a pin board when the experimenter put her own picture on a red chair. The third neutral task (*N3*) was to put on a jacket when the experimenter opened the window. Again, the jacket was placed outside the room to increase task difficulty. For the neutral PM tasks N1 and N3 and for the social tasks S1 and S3 performance was scored as correct if the children initiated the appropriate action within 10 seconds after cue appearance. The time windows for the neutral task N2 and the social task S2 were extended to 20 seconds as the PM cues were not in the direct focus of attention and children had to actively move their heads to the side (task S2) or even look behind themselves (task N2) to monitor for the cue. The maximum number of PM hits was 6 (3 neutral, 3 social), which served as the dependent measure of PM performance. The overall number of points that the children gained at the various stops served as dependent measure for ongoing task performance.

*Theory of Mind.* Two tasks were applied to test Theory of Mind: The bake-sale-story (Hollebrandse, van Hout, & Hendriks, 2014) and the ice-cream-truck-task (Perner & Wimmer, 1985). Both tasks assess second-order Theory of Mind, i.e. the ability to reason about what another person thinks about a third person (e.g., Baron-Cohen, 2001). The bake-sale-story additionally includes one first-order Theory of Mind question (i.e., reasoning about another persons thoughts, Baron-Cohen, 2001). For both tasks maps and figures were used to illustrate the stories. Across both tasks, a maximum of 8 Theory of Mind hits could be achieved.

*Verbal abilities.* To investigate children’s verbal abilities the vocabulary subtest of the German version of the Wechsler Intelligence Scale for Children fourth version (WISC-IV; Petermann & Petermann, 2008) was applied. In this test children had to explain words of increasing difficulty, and depending on the complexity of their answer achieved 2, 1 or 0 points. The maximum number of points was 68. Testing was stopped, if children consecutively gave six 0-point answers.

*Procedure*

Figure 1 provides an overview of the entire procedure and also shows which PM task had to be solved at which station.

(Figure 1 about here)

After welcoming the children, the ongoing activity was explained. The experimenter showed every attraction and explained each task children had to work on. Thereafter, the PM tasks were instructed and children received the belt pouch, the pen and the tissues. After explaining the PM tasks, children’s understanding of both, the PM tasks and the ongoing activity, was tested. Children were asked to explain every single task and the experimenter noted whether they named the crucial points of the task. The general questions about the tasks were followed by more specific questions or hints if children missed one or several points. For instance, if children missed to explain PM task S1, the first question the experimenter was asking was: ‘What do you need to do when I have emptied my glass of water?’. If the child gave the right answer and replied that he/she needed to take the bottle of water and to refill the glass, the experimenter stopped asking for more details. If the child did not give the right answer, the experimenter gave the hint that it had something to do with water. If the children still failed to describe the right action, the experimenter repeated the instructions of the specific PM task. This approach was applied to all PM *and* ongoing tasks. After the explanation phase, children of both encoding conditions were led into another room to receive the EFT or control instructions, respectively.

Children were randomly assigned to one of the two encoding conditions (EFT vs. control). To familiarize children in the *EFT condition* with the method of mentally simulating future events, they firstly had to simulate an unrelated task (i.e., imagine to come home and to ask the mother for ice-cream). After finishing this exercise, children were asked to mentally simulate the tasks that they had to perform during the ‘sightseeing tour’ later on. To develop a vivid picture of the upcoming situation children were asked to close their eyes (see, e.g., Altgassen et al., 2015, in press for a similar approach). Before the children started to mentally simulate the PM tasks, they were asked to imagine the room with all its attractions in as much detail as possible. Importantly, to ensure that the children were *mentally engaging* in the prospective situation and were not simply describing their environment, the imagination was conducted in a different room. For each PM task, the experimenter named the cue and asked the children to imagine what to do upon cue appearance. Moreover, children were asked to imagine the task in as much detail as possible and to verbalize what they were seeing (e.g., “The first task had something to do with water. What do you have to do? Imagine how you are executing the task and describe what you see.”). The experimenter checked whether the central points of each PM task (e.g., water glass is empty, going to the bottle, opening the bottle, going to the glass and refilling it) were named. If details were missing, the experimenter added them and asked the child to also include these details in his/her image of the prospective situation. This approach was applied to every PM task. After finishing the imagination, children were asked to rate its vividness on a scale from 1 (no vivid mental image) to 10 (very vivid mental image).

Following the instructions for the PM and the ongoing task activities, children in the *control group* were given the same amount of time as children in the EFT group (i.e. five minutes) to reflect on the PM and the ongoing task, and to take some notes if they wanted to. They did not receive any EFT instructions. Afterwards, they were asked what they did during the five minutes. Their answers were classified in the following categories: Writing down the tasks, rehearsal, doing something unrelated to the tasks. Children left the piece of paper they used to take some notes in the room, in which they had to encode the PM tasks.

After the EFT instructions or the control instructions, respectively, the filled delay with both Theory of Mind tasks followed (bake-sale-story first, then the ice-cream-truck-task). Then, children changed the room again, got the ticket for the ‘sightseeing tour’, put it in their belt pouch and walked to the first attraction. After finishing the sightseeing tour, children’s retrospective memory for the PM tasks was tested following Kvavilashvili et al.’s (2001) approach. Specifically, a consecutive number of questions with increasing specificity were asked to find out whether errors in retrospective remembering might have caused PM errors. Then, the children were asked whether they think that they did something that helped to improve PM performance during the 5-minute delay (control group). If the children answered the question with ‘yes’, they were asked to explain their strategy. Children in the EFT group were asked whether imagining the future situation and the PM tasks at the beginning helped them to better remember the PM task execution later on. Finally, the children worked on the vocabulary test. Overall, testing took between 60 to 75 minutes. Children were tested individually and received 5 Euro for their participation.

**Results**

*PM performance.* A 2 x 2 mixed measures analysis of variance (ANOVA) was applied on PM hits. Encoding group (EFT, control) served as between-subject factor, type of PM task (neutral, social) as within-subject factor. Results revealed a significant main effect of encoding group (*F*(1,54) = 8.58, *p* = .01, η2p = .14) with better PM performance in the EFT than in the control group (see Figure 2). The main effect for type of PM task (*F*(1,54) = 1.28, *p* = .26, η2p = .02) and the interaction between encoding group and type of PM task (*F*(1,54) = 0.40, *p* = .53, η2p = .01) were not significant.

(Figure 2 about here)

*Analysis of strategy application.* Descriptively, analyzing strategies that children of the control group applied during the 5-minute delay showed that around 61 percent of the children wrote down the tasks to ensure better encoding, 7 percent used a rehearsal strategy and 32 percent did something that was not related to the task (e.g., drawing a picture). Around 60 percent of the children in the control group indicated that they did something which helped them to achieve better PM performance. In the EFT group around 85 percent of the children believed that the encoding strategy helped them to improve their PM performance. Moreover, the vividness rating of the mental image in the EFT group revealed a mean rating value of *M* = 8.26, *SD* = 1.28 suggesting strong vividness on average. A correlational analysis showed that vividness was not related to EFT group’s PM performance (*r* = 0.11, *p* = .56).

When excluding those control participants from the PM analysis who did something unrelated to the task, results did not change significantly (significant effect of encoding group with overall better performance in the EFT compared to the control group: *F*(1,45) = 7.58, *p* = .01, η2p = .14; no significant main effect of type of PM task and no significant interaction: *F*s ≤ 2.04, *p*s ≥ .16).

*Moderator analysis.* To explore whether Theory of Mind as an indicator of self-projection moderated the effects of EFT encoding on children’s PM performance, a moderator analysis with encoding group as the predictor, PM performance as the outcome and Theory of Mind performance as moderator was conducted. The approach suggested by Hayes and Matthes (2009) was used. Before including the variables in the analyses, their values were standardized using z-transformation. Results of the moderator analysis revealed a significant effect of encoding group on PM performance (*p* < .01). The effect of Theory of Mind on PM performance approached significance (*p* = .06). However, the interaction between encoding group and Theory of Mind did not significantly contribute to PM performance (*p* = .29) indicating that Theory of Mind did not moderate the effect of encoding group on PM performance (see also Table 2; regression summary of the model: *F*(3,52) = 4.49, *p* = .01, *R2* = 0.21).

(Table 2 about here)

*Ongoing task performance.* The univariate ANOVA with encoding group (EFT, control) as independent and overall number of correct ongoing task items as the dependent measure revealed no significant group difference between the encoding groups (EFT: *M* = 55.14, *SD* = 18.07; control: *M* = 50.02, *SD* = 16.33; *F*(1,54) = 1.24, *p* = .27, η2p = .02).

*Retrospective memory analysis*. A 2 x 2 univariate ANOVA with encoding group (EFT, control) as between and type of PM task (neutral, social) as within-subject factor was conducted to test for possible differences with regards to correctly recalled PM tasks after completing the PM paradigm. Results revealed no significant main effect for encoding group (*F*(1,54) = 2.03, *p* = .16, η2p = .04) and no main effect for type of PM task (*F*(1,54) = 1.09, *p* = .30, η2p = .02). The interaction between encoding group and type of PM task was also not significant (*F*(1,54) = 1.09, *p* = .30, η2p = .02). Overall, the children remembered the PM tasks very well (*M* = 5.16, *SD* = 1.04).

**Discussion**

Within the last years a growing number of studies has focused on PM development across childhood and adolescence and has started to delineate mechanisms that may underlie the rise of PM in early development. The present study extended existing research by focusing on the effects of intention encoding via EFT on children’s PM performance in a complex task with real life task demands. Further, it was explored whether performance may differ between neutral and social PM tasks, a differentiation which has rarely been addressed by previous studies, but which is clearly important with regard to everyday PM tasks. Finally, the present study tested whether children’s self-projection abilities may moderate possible EFT effects on PM.

We assumed that children who received EFT instructions during intention encoding would outperform children in the control group. PM performance in social tasks was predicted to be higher than in neutral tasks. Further, we expected that children with more developed self-projection skills benefit more from EFT instructions than those with less developed self-projection skills.

Addressing the first research question of the present study, instructing EFT as an encoding strategy resulted in significantly better PM performance compared to the control condition. These beneficial effects of EFT are in line with our prediction and with previous studies investigating this effect in various age groups (children: Kretschmer-Trendowicz et al., 2016; adolescents: Altgassen et al., 2017, younger and older adults: Altgassen et al., 2015). Thus, encoding the prospective intention using EFT seems to be an effective strategy to enhance PM across the entire lifespan. Importantly, the results of this study extend previous findings by showing that EFT instructions do not only improve PM in typical lab-based tasks, but also in a complex task setting simulating real life task demands. This is of particular interest as PM is an important challenge in everyday life (e.g., Ellis & Freeman, 2008). Our results suggest that EFT encoding represents an effective strategy that should be used in our daily lives to successfully master these challenges. Future studies should follow this line of research and test the effects of EFT in children’s everyday environment (i.e., with regard to PM tasks at home or at school).

The EFT effects in the present study occurred independent of the type of PM task (neutral vs. social). Together with previous studies, results suggest a strong beneficial effect of EFT on PM performance. Importantly, these beneficial effects could be observed in comparison with a strict control condition. Former studies compared EFT with standard PM instructions (e.g., Kretschmer-Trendowicz et al., 2016) which explained the PM task and then continued directly with the delay task. As a result, children in the control group spent less time familiarizing themselves with the PM task compared to children in the EFT group and it is not clear if EFT effects in such a design are truly caused by the strategy or by the enhanced time spent on learning and repeating the task rules. In contrast, the control group in the present study had additional time after the PM tasks instructions to repeatedly engage in the PM tasks without the instruction to mentally simulate the prospective situation (see Altgassen et al., 2017 for a similar approach). Even though children of the control group had the same amount of time to encode the PM tasks as children in the EFT group, they did not reach a similar performance level. Thus, EFT improved PM beyond the effects of additional encoding time. This result is in contrast to the results of Altgassen et al. (2017) who did not find performance differences between a similar, enhanced encoding control group and an EFT group in adolescents, while performance in both conditions was better than a standard PM instruction condition (giving the participants less encoding time). Thus, while in adolescents a repeated PM cue exposure seems to be sufficient to enhance PM performance, younger age groups may only benefit from additional time during intention formation, when they are explicitly instructed to use an effective encoding strategy such as mentally engaging in the prospective situation. Research on the development of strategy utilization may help to explain these contrasting findings.

Here, the evidence showed that elaborated knowledge about strategies is one factor influencing their effectiveness (Schneider & Sodian, 1997). Thus, when getting additional time adolescents may spontaneously apply strategies that ensure good performance, while children may still lack this knowledge. Another aspect that has been shown to influence the effectiveness of memory strategies is the so-called *utilization deficiency*, i.e. even though a memory strategy is spontaneously produced, it does not always result in enhanced memory performance (e.g., Miller, Seier, Barron, & Probert, 1994). Thus, even though children of the control group might have applied PM strategies, these strategies did not result in improved PM performance (at least not as much as with EFT instructions). This might be because children do not have enough experience in using these strategies. Consistent with this notion Bjorklund and Harnishfeger (1987) showed that limitations in cognitive capacity led to reduced benefits from memory strategies. The authors explained this with mental effort: children already need to produce the strategy which is then not available for other mental activities needed to improve performance. Thus, the gains of the memory strategy are limited (Bjorklund & Harnishfeger, 1987). Previous studies have shown that the age at which the utilization deficiency can be observed, ranges between 3 and 14 years (Miller & Seier, 1994) depending on the specific task and the difficulty of the strategy (Miller et al., 1994). In the present study, children of the control group were asked to report what they did during the additional time they received. Sixty-one percent of the children reported that they wrote down the task instructions and 7 percent that they continuously rehearsed the instruction. Moreover, after finishing the PM task, children were asked whether they believed that the strategy they used was helpful to ensure good task performance during the ‘sightseeing tour’. Overall, 60 percent of the children of the control group indicated that they thought that the strategy helped them to improve performance. Thus, even though most of the participants in the control group produced a memory strategy and trusted in its utility, PM performance did not increase to the level of the EFT encoding group. The present study is the first to show that the utility deficiency with regards to memory strategies seems to occur not only in retrospective, but also in prospective remembering. This has important consequences for instructing strategies that may improve PM performance. Whereas older children and adolescents might be able to successfully produce and apply a PM strategy autonomously (for evidence see, e.g., Altgassen et al., 2017), younger children may rather need guided strategy instructions (as e.g., EFT encoding) to be able to successfully initiate delayed intentions. The age from which children are able to autonomously produce and apply PM strategies remains an open issue that needs to be addressed in future studies.

The second aim of the present study was to explore possible performance differences between neutral and social PM tasks. Results did not show any significant differences between neutral and social delayed intentions and are thus not in line with our expectation of increased performance in social PM tasks. Moreover, retrospective memory for the PM cues did not differ between the two task types, suggesting that social PM tasks were not deeper encoded than neutral PM tasks. Our results contrast with previous studies that reported beneficial effects of social importance on PM performance (e.g., Altgassen et al., 2010; Brandimonte, Ferrante, Bianco, & Villani, 2010; Kvavilashvili, 1987, Exp. 2; see Walter & Meier, 2014 for a review on PM importance effects). Importantly, in all of these studies, social importance was directly emphasized by the experimenter, i.e., participants were told that executing the task appropriately had important consequences for a third person (e.g., Kvavilashvili, 1987 told participants that the experimenter is waiting for an important phone call, thus it would be of particular importance to hang up the telephone receiver after finishing the experiment). In the present study, social importance was not directly emphasized and was rather manipulated implicitly. Specifically, the tasks required individuals to do something for a third person (e.g., giving the experimenter a tissue when she sneezed), but children were not explicitly told that these tasks are of particular importance. Findings may also indicate that children are not as sensitive to manipulations of the social dimension of PM tasks as, for instance, older adults (Altgassen et al., 2010). Consistently, there is evidence that social information processing skills and social cognition are still developing until and across adolescence (e.g., Choudhury, Blakemore, & Charman, 2006; Vetter, Leipold, Kliegel, Phillips, & Altgassen, 2013). A methodological issue that may explain the missing effects of social importance could be the highly motivating game-like task character of the task, in which children could earn points. The possibility to receive incentives for all tasks, independent of task type, may have overridden potential effects of pro-social tasks. The possible interaction between motivation and pro-social gains in PM performance might be an interesting issue for future studies.

The last research aim of this study was to gain further insights into the mechanisms possibly underlying EFT and its efficiency as encoding strategy. One variable that is assumed to possibly influence EFT, and in turn its efficiency as encoding strategy, is the ability of self-projection measured through Theory of Mind in the present study. Our results showed that even though Theory of Mind influenced PM on a trend level, it did not moderate the effects of EFT encoding on PM performance. This contrasts with our hypothesis but is in line with Kretschmer-Trendowicz et al.’s (2016) finding, who also found EFT effects to occur independent of children’s self-projection abilities (indicated by the results of an ANCOVA). Further, the vividness of the mental image, as another aspect suggested to influence the efficiency of EFT encoding, did not correlate with PM performance and thus can rather be excluded as a factor influencing EFT effects. Overall, the exact mechanisms that underlie the effects of EFT encoding on PM need to be disentangled in future studies. In addition to behavioral assessment, neural measures using magnetic resonance imaging (MRI) and event-related potentials might provide important insights into the (neural) underpinnings of EFT.

Taken together, the present study gives new insights into the development of children’s PM and the effects of intention encoding for the performance of delayed intentions. Hereby, we extend existing evidence in showing that EFT does not only improve children’s lab-based PM performance, but also performance in complex task settings comprising real life task demands. With regards to the underlying mechanisms of the positive EFT effect, results indicate that the mental simulation of the prospective situation and not the simple repeated exposure with the PM cues seems to be critically important. However, self-projection was not found to impact the beneficial effects of EFT encoding. Moreover, performance did not differ between neutral and social PM tasks; indicating that children’s PM performance might not be influenced by manipulations of the social dimension of PM.

Even though the present study represents a first step in testing the effects of elaborated intention encoding on PM in a rather real life task setting, future studies need to explicitly test whether these effects also extend to children’s everyday PM performance.

**Footnotes**

1 With the growing number of studies on individuals’ abilities to mentally simulate future events, various terms have been developed to describe one and the same ability. Other terms for episodic future thinking are: future thinking, episodic foresight, prospection, mental time travel, memory for the future, pre-experiencing, proscopic chronesthesia, imagination (see also Buckner & Carroll, 2007).

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**Compliance with Ethical Standards**

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Conflict of Interest: Author Anett Kretschmer-Trendowicz declares that she has no conflict of interest. Author Katharina M. Schnitzspahn declares that she has no conflict of interest. Author Lydia Reuter declares that she has no conflict of interest. Author Mareike Altgassen declares that she has no conflict of interest.

Ethical approval: All procedures performed in in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study and also from their parents.

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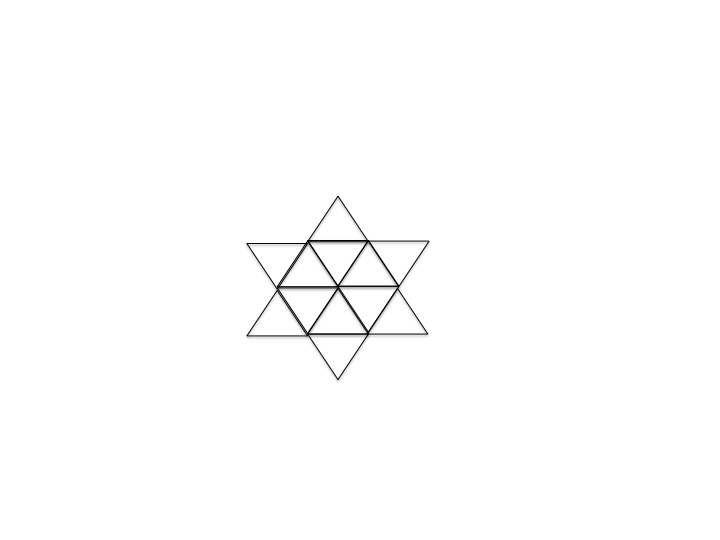
Yang, T., Chan, R. C. K., & Shum, D. (2011). The development of prospective memory in typically developing children. *Neuropsychology*, *25*(3), 342–52. https://doi.org/10.1037/a0022239

**Appendix**

Appendix A

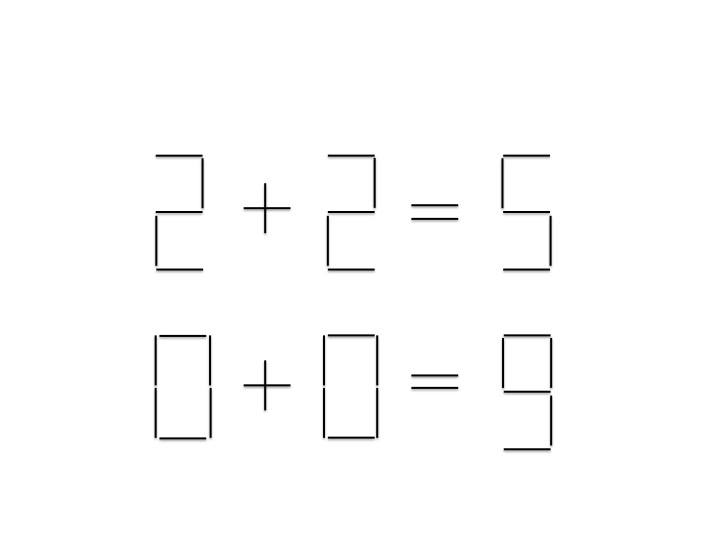
Riddle with matches

1. How many triangles are included in this star?

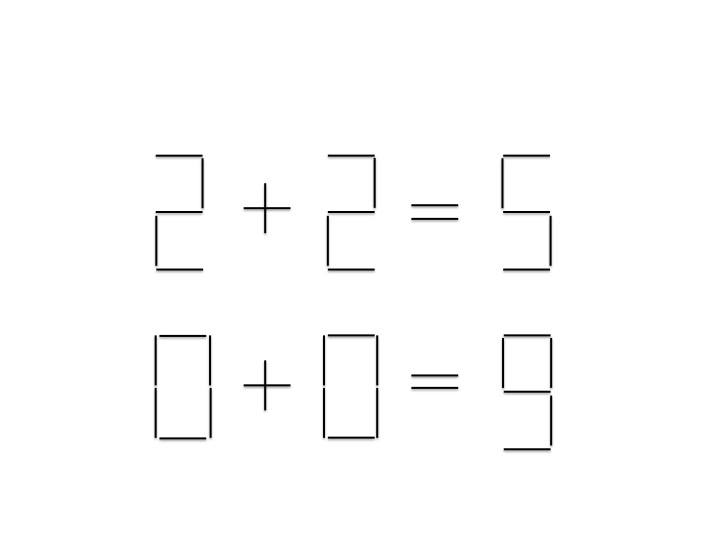


2. Which match needs to be rearranged to receive a correct equation?

a)



b)



3. Rearrange two matches to receive two equilateral triangles.

