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What was I supposed to do? Effects of individual differences in age and anxiety on preschoolers' prospective memory

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Abstract

Prospective memory (PM) refers to remembering to perform a previously planned action at the appropriate time or in the appropriate context. The present study investigated the effects of individual differences in age and trait anxiety on PM performance in 3-to-5 and 5-to-7 year-olds. Two types of PM measures were used: an event-based task, requiring ongoing activity interruption across two conditions (with/without memory aid), and an activity-based task, requiring PM action implementation after the main activity was finalized. On the event-based PM task, we found that: all children benefited from the external memory aid; the 5-7 year-old group outperformed the 3-5 year-olds; and higher levels of anxiety negatively affected only the younger age group. On the activity-based PM task, we found no significant age-group differences, while higher anxiety negatively predicted children's PM performance. Findings support and extend the literature on early PM development, revealing the benefits of external cueing and the potential detrimental effects of anxiety.

Introduction

Prospective memory (PM) has been defined as remembering to perform a previously planned action at the appropriate time or in the appropriate context (Einstein & McDaniel, 1996). By definition, the realization of delayed intentions is a sequential process, relying on the interdependency between several cognitive mechanisms. Consequently, the most influential theoretical PM model, proposed by McDaniel and Einstein (2000), is a multistage, multi-process one. The authors suggest that any PM task unfolds during four stages and requires at least four corresponding cognitive processes: *intention formation,* the moment of developing a plan for a future activity (planning component), *intention retention* over a period, usually filled with other ongoing activities (memory storage), *intention initiation* – the point at which the person becomes aware that the intention should be initiated (involving monitoring) and *intention execution* in accordance with the previous plan (necessitating inhibition of other ongoing activities). Hence, prospective remembering is thought to rely on the integrity of two major neuropsychological systems: the retrospective memory (RM) system, supporting the retention stage, and the frontally-mediated executive functions system (i.e. planning, event monitoring, interruption and inhibition, and flexible initiation of responses), supporting the intention formation, initiation, and execution phases (Martin, Kliegel, & McDaniel, 2003). Successful intention initiation (and consequent execution) is suggested to employ either strategic or (more) automatic processes, depending on contextual features. Consequently, retrieving an intention can spontaneously occur when the cue is very salient or highly related to the target action (McDaniel & Einstein, 2000).

Although there is a general consensus in the literature with respect to the involvement of a retrospective memory component in PM tasks, especially in the intention retention stage, there are some key elements which differentiate PM from retrospective memory (RM). PM is usually self-referential, time-delimited, and requires appropriate planning, with no instructions about the cues available at the time of testing (Graf & Uttl, 2001). In contrast, the RM search can be self- or -other referential, is not necessarily time-delimited, nor does it entail planning, relying on cues available at the time of testing (McDaniel & Einstein, 2000). So far, most of the empirical work conducted in the field is based on two types of PM tasks (Einstein & McDaniel, 1990; 1996): *event-based*, which rely on an external target-event to cue the specific PM task which needs to be executed (e.g. remembering to send an e-mail when the internet connection gets back on) and *time-based*, in which the intended action needs to be executed at a specific point in time (e.g. remembering to send an e-mail at 11 A.M.). More recently, an *activity-based* PM task was also mentioned in the literature (Brewer et al., 2011; Einstein, McDaniel, Marsh, & West, 2008), in which ending the ongoing activity should trigger the previously planned action (e.g. remembering to send the e-mail after finishing reading the morning newspapers). The present study focuses on the early development of event-based and activity-based PM, respectively, as defined above.

Developmental aspects of PM

According to the multi-process model, age-related differences are to be expected in PM tasks requiring more executive control, rather than automatic processing. For example, age effects are expected when using nonspecific target-cues (e.g. any picture included in the "animal" category), and would be minimal when introducing salient target-cues, as they are thought to trigger spontaneous-retrieval processes, which remain relatively intact with age (Einstein &

McDaniel, 2005). Although these hypotheses have been explored in several studies comparing younger to older adults (see Kliegel, MacKinlay, & Jäger, 2008, for a review), research regarding the developmental path of children's PM is still rather limited (see Kvavilashvili, Kyle, & Messer, 2008). From early on, young children are confronted with a variety of PM tasks, ranging from remembering to deliver messages from / to educators, or bringing the appropriate objects to kindergarten activities, to packing certain items (e.g. favorite toy) when going on holidays, feeding their pet etc. The investigation of early PM development is thus of paramount importance, considering the implications that optimal PM functioning has for the child's autonomous and independent functioning in family and educational settings (Martin & Kliegel, 2003), and, not ultimately, for the development of RM strategies (Meacham & Colombo, 1980).

Moving beyond the question related to the earliest signs of PM development, which can be reliably documented around the age of 3 (Kliegel & Jäger, 2007), an important research question relates to the development of PM across the preschool years. The interest in this question can be motivated by the need to assess the child's readiness to deal with multiple educational tasks involving a PM component (see Kvavilashvili et al., 2008). As originally developed by Einstein and McDaniel (1990) for adults, the laboratory paradigm for testing event-based PM engages the participants in an ongoing task (e.g. naming pictures that appear on the screen) after previously presenting them with the PM instructions (e.g. to press the space-bar whenever they see an image of a duck). There is a growing body of evidence revealing progress in children's PM performance on this task between 3 and 13 years (see Kvavilashvili et al., 2008). In this respect, 4- to 5-year-old children were found to perform significantly better than 3-year-olds (Guajardo & Best, 2000; Kliegel, Brandenberger, & Aberle, 2010; Wang, Kliegel, Liu, & Yang, 2008), and to be outperformed by 6-to-7-year-olds (e.g. Kvavilashvilli et al., 2001; Mahy & Moses, 2011). However, other studies reveal nonsignificant improvements between the 4 to 6 years interval (e.g. Kliegel & Jäger, 2007) and the lack of a unitary methodology (e.g. requiring or non-requiring ongoing task interruption) could account for some of these age-related variations across developmental studies (Kvavilashvili et al., 2008). Age effects have also been found in some studies using more ecologically-valid, activity-based tasks for evaluating PM retrieval (Atance & Jackson, 2009; Guajardo & Best, 2000; but not in Mecham & Colombo, 1980).

PM and individual differences in anxiety

One interesting research direction which remains underinvestigated regards the impact of individual differences in dispositional variables and of emotional states (e.g. trait/state anxiety) on the ability to carry out intended actions (see Kliegel & Jäger, 2006, for a review of the literature in adults). Since McDaniel and Einstein's statement in their landmark paper from 2000, concluding that "in general, there has been little research on how individual differences in personality variables are related to prospective memory" (p.S141), there have been some advances in research with adults (see Uttl, White, Gonzalez, McDouall, & Leonard, 2013), but very limited developmental work to match this challenge. One unifying framework used to account for the effects of anxiety on cognitive performance across development is the Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007). According to the ACT, anxiety-related worrisome thoughts generate cognitive interference, mainly disrupting inhibition and shifting, and to a lesser degree memory processes (from the model proposed by Miyake et al., 2000). Its consequences are mostly evident on processing efficiency (i.e. longer response times or more subjective effort invested in order to complete the task) rather than on performance effectiveness measures (i.e. response accuracy). However, when task complexity imposes greater executive demands, hence requiring less automatic processing, performance effectiveness can also be impaired by high anxiety (Eysenck et al., 2007).

An innovative way to test ACT's prediction regarding anxiety's detrimental effects on the executive functions potentially underlying PM performance (i.e. inhibition and shifting) would be via a PM task using an ongoing task interruption and switching procedure. A relevant distinction in this context is made between dual-task and task-switch paradigms, which have been used interchangeably in PM research (Bisiacchi, Schiff, Ciccola, & Kliegel, 2009), although evidence suggests that they might tap onto different cognitive processes. Dual-task procedures require the participant to execute the ongoing task and immediately perform the PM action when cued. By contrast, within the task-switching procedure, the participant must interrupt the ongoing task immediately after encountering the PM target-cue and perform only the PM action. This rather overlooked distinction has proven to be relevant in terms of behavioral (better performance in the dual-task compared to task-switching) and neural correlates (Bisiacchi et al., 2009). It is also particularly relevant for developmental research, as studies suggest that age differences are more evident in PM tasks that imply ongoing task interruption (Ford, Driscoll, Shum, & Macaulay, 2012; Wang et al., 2008; Kliegel & Jäger, 2007), as compared to tasks in which no interruption occurs (Kvavilashvili et al., 2001). Eysenck and collaborators (2007) specifically predicted that high levels of anxiety would impair PM performance when task-switching was required. The few existing studies with adults looking at the influence of anxious emotional states on PM performance, suggested a detrimental impact of anxiety, yet no consisted pattern of results has emerged (see Kliegel & Jäger, 2006, for a review).

Regarding the anxiety – PM performance relationship in children, to our knowledge, this is the first investigation testing the assumption that anxiety could disrupt children's prospective remembering. Previous developmental studies directly investigating the effects of anxiety on executive functioning provided evidence for the ACT assumptions regarding anxiety's detrimental influence. In this respect, child anxiety has been found to disrupt inhibition efficiency (see Mueller, 2011, for a review), while higher levels of trait anxiety were found to impair preschoolers' updating scores (Visu-Petra, Cheie, Benga, & Alloway, 2011), as well school-children's set-shifting performances (Mocan, Stanciu, Visu-Petra, submitted).

Directly testing ACT's prediction regarding anxiety-related effects on PM performance, in an unpublished study, Eysenck and Derakshan (2008) revealed that high trait-anxious adults performed significantly worse than low-anxious ones. However, this effect was only found when the PM cue was more general, and when the PM target was not cued in advance. The results suggest that PM could be impaired by high levels of anxiety, yet should remain unaltered when more automatic processes are involved (in the presence of salient PM cues). Aside from this unpublished study, to our knowledge, there is no research directly testing the ACT's predictions, especially in a context involving task interruption and switching demands.

Current study

The major goal of the study was to provide an evaluation of PM performance in both task-switching and non-switching contexts during the preschool years, and to explore (for the first time, to our knowledge) individual differences in trait anxiety upon children's PM performance. Thus, a first aim was to investigate individual differences in age and anxiety in preschoolers' PM performance on a task-switching event-based task. In order to be more suitable for young children, Kvavilashvili and colleagues (2001) substantially modified the adult version of the task-switching paradigm, by embedding the PM target in shorter and fewer blocks of trials, and by alternating them with a two-minute filler task, meant to prevent loss of concentration and maintain interest in the ongoing activity. We used the modified paradigm and, following procedures employing the use of an external memory aid (Guajardo & Best, 2000; Kliegel & Jäger, 2007), we divided the task into two conditions: one which included the presence of a PM memory aid (With-aid condition; to minimize processing demands), and one without such an aid (No-aid condition). An additional modification was to turn this task from a dual task procedure mentioned above, in which children performed both the ongoing task (picture naming) and the PM task (press the spacebar when encountering the PM cue) into a task-switching paradigm. In our task, children were required to inhibit the ongoing task (refrain from picture naming) and perform the PM task (press the space-bar) when encountering the PM cue. This modification was expected to increase the executive demands of the task (Bisiacchi et al., 2009) and consequently, to be more susceptible to age- and anxiety-related effects.

Several hypotheses were advanced based on this first aim and the related literature. First, regarding PM performance on the event-based task, we expected it to vary as a function of memory aid presence, age, and individual differences in trait anxiety. Specifically, we expected children's performance to be superior in the With-aid condition, compared to the one lacking a memory aid. We also expected PM performance to be better in 5- to 7-year-olds, as compared to 3- to 5-year-olds on both the With-aid, but especially on the No-aid condition. During their preschool years, children undergo massive executive functioning development (Garon, Bryson, & Smith, 2008), so it is expected that they become increasingly able to continuously update their memory contents in order to identify PM cues when no memory aid is presented (Kvavilashvili et al., 2008). However, no age differences in the ability to benefit from an external memory aid were found in PM tasks with relatively younger children (Guajardo & Best, 2000; Kliegel & Jäger, 2007). Finally, based on the ACT literature documenting anxiety-related impairments in tasks requiring inhibition and shifting, we expected PM performance on this task to be lower in high trait-anxious preschoolers. The effect of anxiety was expected to be more evident in the No-aid condition, since a more strategic memory search was needed when no salient cue was present.

The second aim was to investigate the role that individual differences in age and anxiety play in preschoolers' PM performance on a non-switching, activity-based task. Consistent to (the limited) previous findings with activity-based PM tasks in young children (Guajardo & Best, 2000; Atance & Jackson, 2009) we expected older preschoolers (5- to 7-year-olds) to be more proficient in remembering to execute an activity after a delay. The further investigation of anxiety-related effects on this activity-based task is largely exploratory. However, considering that this task involves multiple demands including planning, memory updating over a substantial delay, resisting distractions and competing responses (Guajardo & Best, 2000), it is plausible that it will also be negatively impacted by higher levels of anxiety.

Method

Participants

From the original sample who received our invitation for the study (113 children), approximately 66% of parents agreed for their child to take part in the study. A total of 75 preschoolers were recruited and all completed the memory tasks. Children were Romanianspeaking of Romanian origin, recruited from three public urban kindergartens. They were part of middle-class families; 64% of the children's mothers held a university degree, while the remaining 36% held a high-school diploma. However, from the total sample, two preschoolers failed to recall the PM instruction at the end of the evaluation. This was considered to be a RM failure rather than a PM one (see Kvavilashvili et al., 2001), hence their data were excluded from the analysis. Hence, our sample consisted in 73 children (38 girls), with an age range of 3.09-years-old to 7.01-years-old (mean age = 65.23 months, *SD* = 10.87). The children were selected after their parents gave their written consent and completed the Spence Preschool Anxiety Scale (Spence, Rapee, McDonald, & Ingram, 2001). Parents received a written description of the study, and were asked to sign the informed consent after all their questions had been clarified. Other than the parental informed consent, the child’s verbal assent was also obtained.

Consistent with previous research using the modified paradigm for investigating event-based PM in this age population (e.g. Kvavilashvili et al., 2001), participants were divided into two groups: *Age Group 1*: 3- to 5-year-olds ($n = 31$; 16 girls; age range: 45 to 60 months) and *Age Group 2*: 5- to 7-year-olds ($n = 42$; 22 girls; age range: 63 to 85 months) (see also Table 1 for descriptives). The difference in age between the two groups was highly significant, $F(1, 71) = 131.39$, $p < .001$, $\eta_p^2 = .69$, and the two groups did not significantly differ in anxiety scores, $F(1, 71) = 2.75$, $p = .10$, or sex distribution, $\chi^2(1, N = 73) = 0.01$, $p = .95$.

Materials and procedure

In order to evaluate PM performance, two types of measures were used: an event-based computerized task, modeled after the modified paradigm for children (Kvavilashvili, et al., 2001) and an activity-based task, implying a single PM request to perform an action at the end of the testing session.

Event-based PM task. The two conditions of this task differed in terms of using an external memory aid, aimed to help children to better remember the previously planned action. In the No-aid condition, preschoolers had to name pictures as they individually appeared on the screen (i.e. ongoing task) and to remember to press the space-bar key whenever the PM target cue appeared. The pictures represented familiar images (e.g. clock, bear, carrot) taken from the Snodgrass Inventory (Snodgrass & Vanderwart, 1980) and were displayed on a laptop computer (with the resolution set to 1024 X 768 pixels) for 5s each, with a 1s interval in between. Children received the instructions for the ongoing task (picture naming) and were then engaged in a learning phase, during which they had to name 3 images individually displayed on the screen. The experimenter then introduced the No-aid PM requirement, instructing children to remember to refrain from picture naming and to press the space-bar key (covered with blue tape) whenever they saw the image of an apple. Once the preschoolers understood the instructions, the experimenter introduced them to a 2-minute block construction filler task (from the NEPSY battery; Korkman, Kirk, & Kemp, 1998). The No-aid condition consisted in 3 blocks of 10 pictures each, each block being preceded by the 2-minute filler task. The purpose of the filler task was to prevent preschoolers’ loss of concentration and maintain their interest in the ongoing activity. Therefore, it was a non-structured task, presented as a block-construction game. Specifically, for each 2-minute filler task, children were asked to use blocks in order to construct a representation similar to a block-construction model presented on the screen.

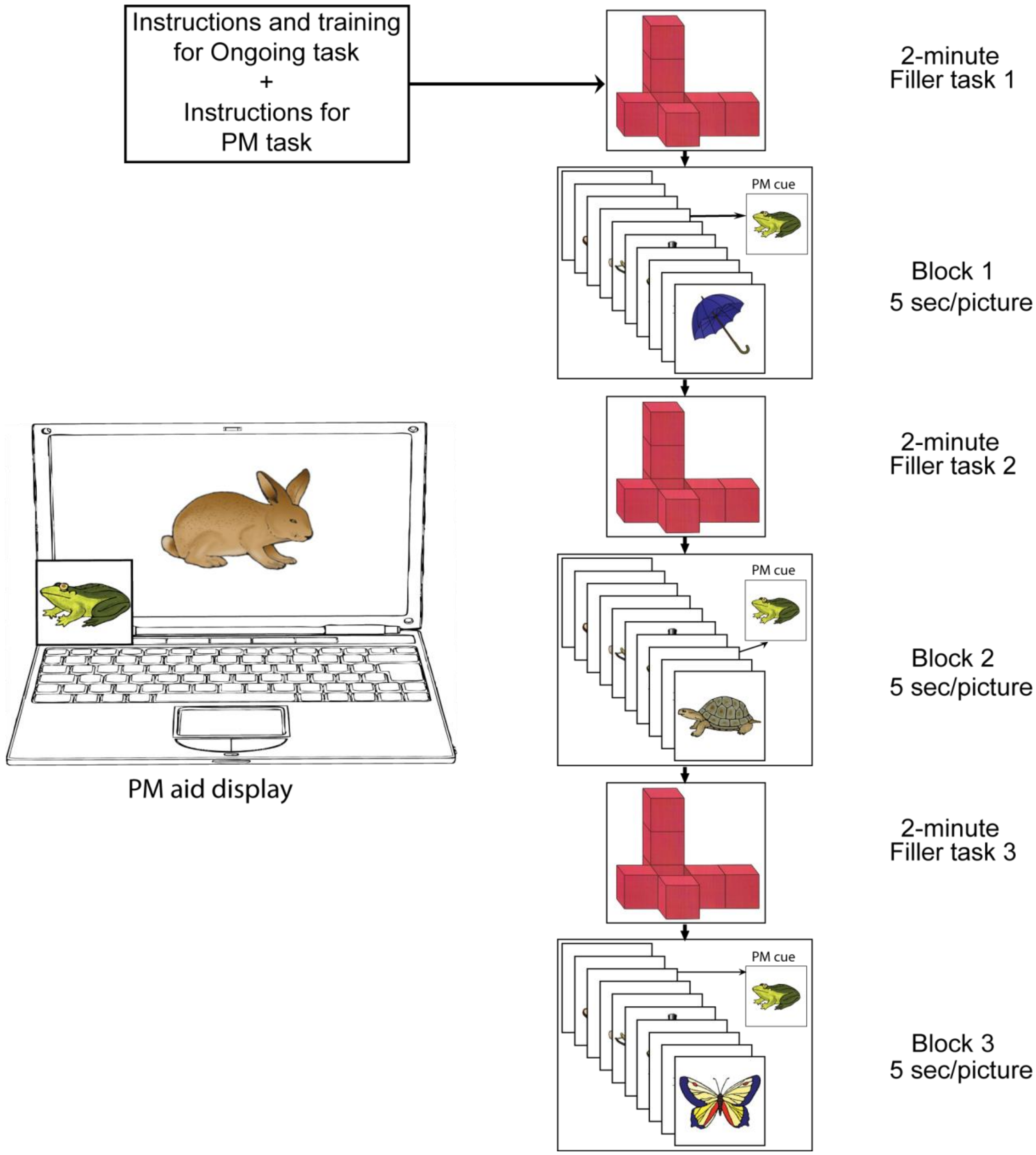

Figure 1. Diagram of the event-based PM task procedure. Children were engaged in a 6 blocks picture naming ongoing activity (10 pictures/block), each block having a PM target cue embedded within. When encountering this cue, children needed to refrain from picture naming and to press the space-bar. Three blocks were include in the No-aid condition, employing no external memory aid to trigger the PM action, while other three belonged to the With-aid condition (depicted here) which included an on-screen sticker with the PM cue (i.e. a frog). Following Kvavilashvili et al.'s (2001) modified for children paradigm, before each block, children were engaged in a filler task (i.e. block construction) meant to prevent loss of concentration.

Following Kvavilashvilli and collaborators' (2001) procedure, there was a postexperimental probe verifying whether children who had not performed the PM action on all three occasions, did actually remember the instruction, presenting a PM failure. Participants were asked three successive questions, increasing in specificity. The procedure consisted in asking children if, in addition to naming the pictures, they were also supposed to do something else. If they could not answer this question, the experimenter further prompted them by asking whether they were supposed to do something when they saw certain pictures in the picture naming task. If they could not answer this question, a third most specific prompt consisted in asking them what they were supposed to do when they saw a picture of an apple. Children who were unable to answer the final, most specific question, were excluded from the analyses, as they demonstrated having no (retrospective) memory of receiving the PM instructions.

After finishing the No-Aid blocks, participants were introduced to the With-aid condition. Following Kliegel and Jäger's (2007) procedure, children were provided with an external reminder of the target image, a 10 X 10 cm card that depicted the PM cue (i.e. a frog), which was placed on the left corner of the screen. The experimenter told participants that the frog was there to help them remember to hit the space-bar key whenever its image appeared on the screen. Aside from this particular aspect, the two aid conditions were identical. Possible differences in characteristics of the two target-cues were reduced as much as possible by selecting two Snodgrass images (i.e. of an apple, and the image of a frog respectively) matched for name agreement and familiarity in young children (5- to 6-year-olds; Cycowicz, Friedman, Rothstein, & Snodgrass, 1997). However, the presentation of the two conditions was not counterbalanced in order to preserve the secondary nature of the PM task and the primary nature of the ongoing task. The detrimental effects of anxiety are assumed to be most evident on a task perceived by the performer as being secondary to a primary ongoing activity (Eysenck et al., 2007). As opposed to the No-aid condition, the With-aid instruction emphasized the primary importance of remembering the PM task, as children were told that the external aid (i.e. card depicting the PM target) was there to "help them remember" to perform the PM action. Hence, in the current context, if the With-aid condition had been introduced before finishing all blocks of the No-aid condition, it would have stressed that the PM task is of primary importance and not the ongoing naming activity. The task procedure is illustrated in Figure 1.

Activity-based PM task. This task was adapted to our experimental context from a task used by Guajardo and Best (2000) and was administered in conjunction with the event-based PM task. Before engaging the children in the event-based filler task for the first time, the experimenter took the cube box from a nearby table, and asked children to remember to put it back on that table once the experimenter would let the child know that the 'computer game' was over and laptop lid was closed. If the preschoolers did not spontaneously perform the PM action when the experimenter gave the prompt that 'computer game' was over, then it was considered an activity-based PM failure.

Scoring. The computerized PM task was designed using the E-prime software (version 1.2; Psychology Software Tools). For the analyses in each condition, we used a total accuracy score that children received on each condition (ranging from 0 to 3). Hitting the space-bar key while also naming the PM target-cue was considered a task-switching failure. Although recorded, reaction time was not considered an outcome variable, because its measurement was only possible for trials on which the child remembered to perform the PM action (57.5% children remembered to hit the space-bar for a minimum two trials in the No-aid condition, and 79.5% in the With-aid condition).

For the Ongoing task performance, the maximum score that the children could accumulate was 27 points for each condition. However, children's scores on this task reached ceiling levels: ongoing scores ranged between 25-27 for the No-aid condition (*Mdn* = 26), and between 23-27 for the With-aid condition, (*Mdn* = 25). Hence, ongoing task performance was eliminated from subsequent analyses. As for the activity-based task, we used a pass–fail assessment type.

Trait anxiety was assessed via parental report on the Spence Preschool Anxiety Scale (Spence et al., 2001). The scale consists in 28 trait anxiety items, 5 nonscored posttraumatic stress disorder items, and another open-ended (nonscored) item. Each parent rated the concordance between the child's behavior and the one described in each item on a 5 point scale, and an overall measure of trait anxiety was generated. The Romanian version of the test (Benga, Ţincaş, & Visu-Petra, 2010) has good internal consistency (Cronbach's alpha = .87 for mother reports and Cronbach's alpha = .89 for father reports). The total anxiety score (that could vary between 0-132) was used as the measure of each child's trait anxiety level. Mean levels of anxiety for each age group in our sample (20.45 for the 3-5 year-olds and 25.04 for the 5-7 year-olds) were slightly higher than those reported in the original sample (14.12 for 4-year-olds and 15.65 for 5-year olds, Spence et al., 2001), but still lower than those obtained on a larger Romanian sample (31.57 for 4-year-olds and 32.55 for 6-year-olds, Benga et al., 2010).

Table 1. Descriptive statistics (age, trait anxiety, and prospective memory performances) for 3- to 5-year-olds and 5- to 7-year-olds, respectively.

	Age Group			
	3- to 5-year-olds (*n* = 31)		5-to 7-year-olds (*n* = 42)	
Measures	Mean	SD	Mean	SD
Spence Anxiety Score	20.45	9.76	25.04	12.93
Age (in months)	54.65	4.28	73.05	6.86
Event-based PM accuracy				
No-Aid Condition	1.55	1.4	2.12	1.36
With-Aid Condition	2.26	1.21	2.67	.87
Activity-based PM success frequency (%)	14 (45.2)		18 (42.9)	

Note: PM = total score on the prospective memory task. No-Aid = PM condition with no external memory aid; With-Aid = PM condition with an external memory aid; Trait anxiety score = total trait anxiety score on the Spence Preschool Anxiety Scale (Spence et al., 2001).

Results

Preliminary analyses

Descriptive data presenting children's mean trait anxiety scores, age, and PM performances for each age group are presented in Table 1. Preliminary analyses of gender effects revealed non-significant results in the case of both event-based (No-aid condition: F (1,71) = .01, p = .96; With-aid condition: F (1,71) = .15, p = .70) and activity-based PM tasks (χ^2(1, N = 73) = 1.22, p = .27). Consequently, gender was eliminated from subsequent analyses. Five children occasionally hit the space-bar and also named the PM target cue and this was scored as an error. Also, related samples Cochran's Q tests revealed that children's frequency of PM hits did not vary across the three blocks within each event-based condition (Q^2(2) = .86, p = .65 for No-aid, and $Q^2(2) = 1.14$, $p = .57$, for the With-aid condition, respectively), suggesting that PM performance did not improve (across blocks) with practice.

Pearson correlations showed that age was not significantly related to trait anxiety scores, $r(71) = .19$, $p = .11$, but was significantly associated to the event-based PM performance, $r(71) = .24$, $p = .038$. Investigating whether age was also related to performance on the activity-based PM task, a univariate analysis revealed that children failing on this task (M = 64.97 months, SD = 11.88) did not differ in age from those who succeeded (M = 65.56 months, SD = 9.61), $t(71) = -.23$, $p = .82$. Analyzing inter-task associations, a partial correlation (controlling for age) revealed a positive relationship between PM scores on the With-aid and No-aid conditions, partial $r(71) = .32$, $p < .001$. While success on the activity-based task was found to significantly predict PM performance on the No-aid condition, $b = .83$, $SE = .32$, $t(71) = 2.61$, $p = .011$, it failed to predict performance on the With-aid condition, $b = .40$, $SE = .24$, $t(71) = 1.65$, $p = .10$.

Table 2. Repeated measures mixed models and estimates of fixed effects on children's event-based prospective memory performance

Parameter	***b***	***SE***	***t***	***Sig.***
Model 1				
Intercept	2.70	.17	15.86	**<.001**
PM Condition (No-Aid)	-.62	.17	-3.57	**.001**
Age Group (Group 1)	-.49	.23	-2.17	**.033**
Model 2				
Intercept	3.08	.29	10.59	**<.001**
PM Condition (No-Aid)	-.62	.17	-3.57	**.001**
Age Group (Group 1)	-.56	.22	-2.48	**.015**
Trait Anxiety	-.02	.01	-1.60	.11
Model 3				
Intercept	2.79	.32	8.68	**<.001**
PM Condition (No-Aid)	-.62	.17	-3.57	**.001**
Age Group (Group 1)	.31	.49	.63	.53
Trait Anxiety	-.01	.01	-.31	.76
Trait Anxiety*Age Group	-.04	.02	-1.97	**.052**

Note: PM = prospective memory. No-Aid = PM task condition employing no external memory aid. No-aid was the reference condition and Group 1 was the reference age group.

Main analyses

In order to investigate children's performance on the computerized PM task as a function of aid condition and age group, a repeated measures mixed-model analysis of covariance (ANCOVA) was conducted, with intercept as the random factor, Age Group as the fixed between factor, and PM Condition as the repeated measures (No-aid and With-aid conditions) fixed factor. The main effects model revealed a significant Condition effect, $F(1,72) = 12.54$, $p = .001$, as children displayed superior performances in the With-aid condition, $b = .62$, $SE = .17$, $t(72) = 3.54$, $p = .001$. The model also revealed a significant Age Group effect, $F(1,71) = 4.43$, $p = .039$, 5- to 7-year-olds displaying better overall PM performances compared to the younger group, $b = .49$, $SE = .23$, $t(71) = 2.15$, $p = .035$. Adding the Condition X Age Group interaction as a fixed factor to the model, did not change the previously-found effects and revealed a nonsignificant interaction effect, $F(1,71) = .21$, $p = .65$.

Next, in order to analyze children's event-based PM performance according to individual differences in trait anxiety, several repeated measures mixed-model ANCOVAs were conducted. Two intermediate models, as well as the final one, are presented in Table 2. The final model employed PM Condition (No-aid and With-aid conditions), Trait Anxiety, Age Group, and Trait Anxiety X Age Group interaction as fixed factors, and the intercept as the random factor. Adding interactions between Condition X Age group, or Condition X Trait Anxiety did not significantly improve the model, F (1,70) = .37, p = .55, and F (1,70) = .69, p = .41, respectively. Also, there was no significant improvement of the model when introducing the three-way interaction between Condition, Age group, and Trait anxiety, F (1,69) = .30, p = .54.

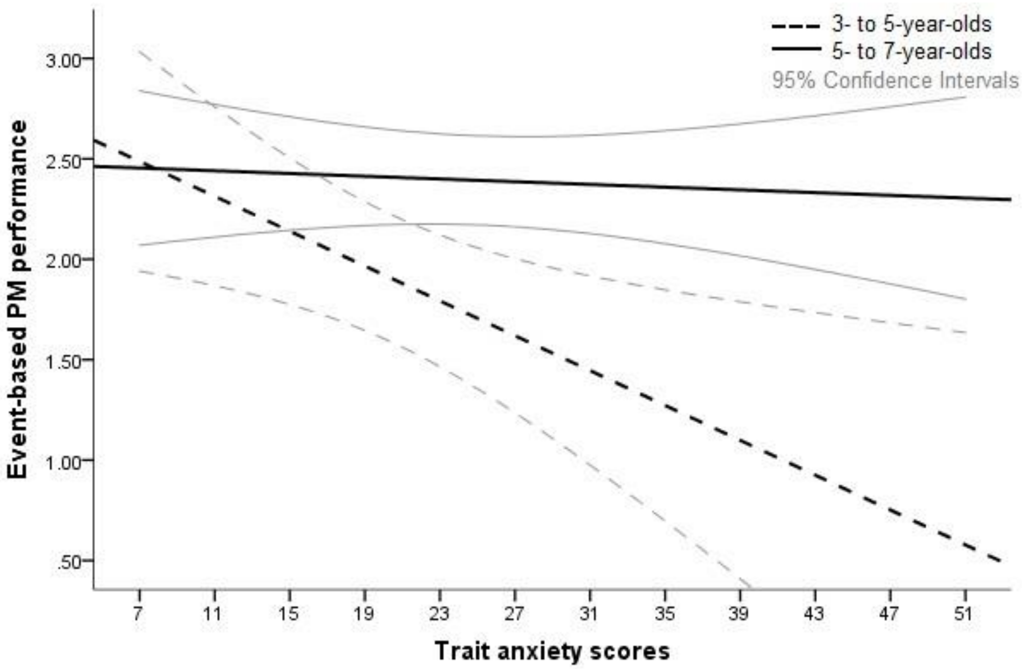

Figure 2. Children's mean event-based PM scores varying as a function of their trait anxiety scores and age group.

The analyses in the final model indicated that the main effect of age group was further accounted by a Trait Anxiety x Age Group interaction, $F(1,69) = 3.89$, $p = .052$. Subsequent repeated measures ANCOVAs computed for each age group, revealed that trait anxiety's detrimental effect was only present in the case of 3-5 year-olds, $F(1, 29) = 4.99$, $p = .033$, $\eta_p^2 = .15$, and not in the case of 5-7 year-olds, $F(1, 40) = 0.11$, $p = .74$, $\eta_p^2 = .01$. Figure 2 illustrates children's event-based PM performance as a function of age group and trait anxiety scores.

A total of 32 preschoolers (43.8%) succeeded in remembering to perform the PM action of the activity-based task. Binary logistic regression analyses were employed to predict the probability that a preschooler would succeed on the task. The predictor variables were: Trait anxiety, Age group, and Age group X Trait anxiety. The first model employing trait anxiety as the predictor of PM success was significant, $\chi^2(1) = 5.02$, $p = .025$, and revealed that higher levels of anxiety negatively predicted children's PM success, $b = -.05$, $SE = .02$, $p = .034$, the odds of success on the task decreasing by a factor of .95 with every 1 unit increase in anxiety.

Adding Age Group did not significantly improve the model, $\chi^2(2) = 5.07$, $p = .08$, and neither did the addition of Age Group X Trait Anxiety interaction, $\chi^2(2) = 5.02$, $p = .07$. The probability of success on the task as a function of children's trait anxiety scores is illustrated in Figure 3.

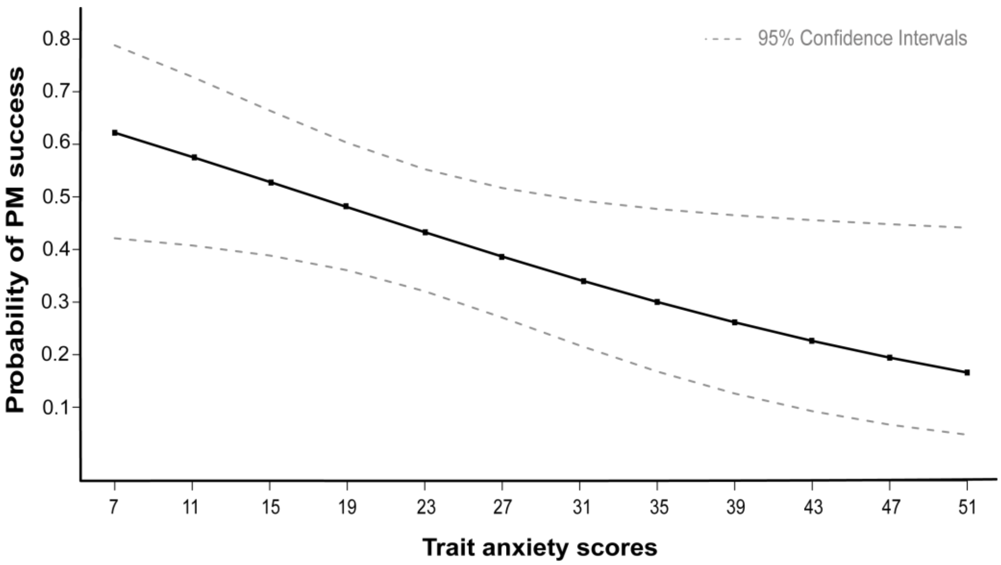

Figure 3. Probability of success on the activity-based PM task as a function of children's trait anxiety scores.

Discussion

Prospective memory represents an umbrella term used to denote multiple cognitive processes (executive, mnemonic) involved in the realization of delayed intentions (McDaniel & Einstein, 2000). The current study set out to investigate PM performance development in 3-to 7-year-old children across two types of PM tasks: an event-based task, requiring ongoing activity interruption across two conditions (with/without memory aid), and an activity-based task, requiring the child to remember to perform a specific action when the other activity was terminated. Besides the developmental research question, we were interested – for the first time in such a young population – in the role played by individual differences in trait anxiety across the two PM tasks.

Our findings partially confirmed our initial hypotheses. First, regarding the event-based PM task, we found that all children benefited from the introduction of the memory aid and had a better PM performance in this condition. There was an age-related improvement in PM performance, irrespective of aid condition. Results also indicated that higher levels of trait anxiety had a selective negative impact, affecting only younger children, again irrespective of aid condition. Second, in the activity-based PM task, although there was no age-related improvement, higher levels of anxiety predicted poorer performance. Performance on the two PM tasks was moderately related, with a stronger relationship being observed between the No-aid condition of the event-based PM task and the activity-based PM task. Each of these findings will be discussed and integrated in the existing literature.

Developmental aspects of PM

Identifying an overall superior performance when a memory aid was present confirms the multi-process model's assumption that successful PM highly depends on contextual features, such as the salience of the target-cue (McDaniel & Einstein, 2000). As such, results revealed that children’s performance was superior in the presence of the aid, suggesting that the engagement of strategic monitoring processes was much diminished, triggering a (more) spontaneous PM retrieval. This finding also confirms previous studies with preschoolers (e.g. Kliegel & Jäger, 2007) in which aids signaling both the cue and the PM action were found to enhance PM performance. It was encouraging to note that this effect was present in our case, even when only the PM cue (and not the corresponding action) was explicitly emphasized. Although preschoolers have been shown to benefit from the presence of memory cues in RM tasks (Gordon & Flavell, 1977; Ritter, 1978), Guajardo and Best (2000) found no effect of using an external memory aid upon 3- to 5-year-olds' PM performance. However, in our case, the fact that the space-bar which needed to be pressed when encountering the PM cue was covered with blue tape could have acted as an external memory aid for the PM action across both conditions, reminding participants of the PM action which needed to be performed. The combination of this action reminder with the on-screen sticker reminding them of the PM target cue might have substantially diminished the amount of attentional and memory resources usually required by a PM task, and boosted the total accuracy in the With-aid condition, as compared to performance in the No-aid condition, and to the substantially lower (44%) accuracy in the activity-based task, in which no specific memory cue was present.

Analyzing age effects on the event-based PM performance, we found that accuracy in the task-switching procedure increased with age, suggesting that PM abilities substantially improve during this developmental period. These findings are consistent with previous studies of PM performance in young children which used a task interruption procedure (Ford et al., 2012; Kliegel, Mackinlay, & Jäger, 2008; Wang et. al., 2008). This age-related progress could be accounted for by the fact that executive functions in general, and inhibitory/shifting skills in particular, are found to develop considerably during this period (e.g. Garon et al., 2008) and represent critical ingredients which facilitate PM performance (Ford et al, 2012; Wang et al., 2008). Based on the multi-process model's assumptions (McDaniel & Einstein, 2000) according to which age differences are expected when the PM task requires more processing demands, we expected age effects to be more evident on the No-aid condition, as it would have requested a more executive-demanding intention initiation in search of the target cue. However, both Guajardo and Best (2000) and Kliegel and Jäger (2007) also failed to find a significant interaction between memory aid condition and age group. It is possible that although the presence of the memory aid enhanced overall PM performance, it might have done so by facilitating the intention retention stage, which might not be very sensitive to age-related effects (Kliegel, McDaniel, & Einstein, 2000).

Our second objective was to investigate potential age effects in preschoolers' performance on the activity-based PM task. Since previous data regarding age-related variations on this task is minimal, our investigation was rather exploratory. No age-related improvement was found, and this is inconsistent with findings of Guajardo and Best (2000), suggesting that activity-based PM improved from 3 to 5 years of age. However, this discrepancy could be explained by the fact that PM skills are only beginning to develop around the age of 3 (see Kliegel & Jäger, 2007). Hence, it is more plausible to find substantial PM improvement when decomposing this developmental window (i.e. 3–5 years, as done by Guajardo & Best, 2000) than when contrasting it to later preschool years (as in the present study). However, the fact that the number of children remembering to perform this action was rather small (less than 50%) makes it evident that such skills are still developing during this developmental window. It is interesting to note that performance on the activity-based task was significantly related to the No-aid component of the event-based PM task, both having in common the lack of a salient cue to trigger the PM response.

PM and individual differences in anxiety

Regarding the role of individual differences in PM performance, our findings revealed that anxiety had a selective effect on younger children's performance, as revealed by the interaction between trait anxiety and age group. As younger children also displayed lower overall PM performance, it is reasonable to hypothesize that the task was experienced as more difficult for them, compared to the older children. Previous studies which found age effects on event-based tasks similar to ours offered a similar explanation, mostly related to younger children experiencing the PM task as more memory (Guajardo & Best, 2000) or executive-demanding (Ford et al., 2012). Older children's better memory/executive skills might explain their increased PM performance and might act as a buffer against the negative effects of anxiety on PM task performance. However, according to the ACT (Eysenck et al., 2007), less visible costs of anxiety than those related to performance accuracy might still be found in older high-anxious children's response times. Unfortunately, the design of task precludes us from making valid assumptions regarding response time – this is a variable which needs to be considered by future studies relating individual differences in anxiety to PM performance in older children, in which a larger number of trials can be used. Contrary to our hypotheses, the effect of anxiety did not interact with the presence/absence of a memory aid. As previously mentioned when discussing the lack of age effects on children's ability to benefit from the use of a memory aid, it is possible for this cue to have facilitated the maintenance of the PM intention over time (the memory storage component), which is not an executive-demanding dimension of PM (Kliegel et al., 2008), and is also found to be less impacted by trait anxiety in preschoolers (Visu-Petra et al., 2011).

An important finding is the negative effect of anxiety upon children's activity-based PM performance. Results showed that low-anxious preschoolers were significantly more accurate in remembering to perform the previously planned action after a delay. This finding is consistent with previously found disruptive effects of anxious states on PM activity-based performance in adults (Cockburn & Smith, 1994). It also confirms one of the ACT’s predictions, according to which the negative effects of anxiety should be evident on tasks perceived as secondary (Eysenck et al., 2007) – in our case, on the PM task, compared to the primary ongoing task. However, one could wonder why anxiety selectively affected younger children in the event-based PM task, while in the activity-based PM task it had a non-discriminative impact across the whole age range. Activity-based PM tasks impose a mixture of demands related to planning, memory updating over a delay, and resisting competing distractors (Guajardo & Best, 2000), all key functions which have been shown to be impacted by anxiety. Thus, while the event-based PM task was less demanding for older children (as reflected in their increased accuracy and their lack of anxiety-related effects), the activity-based PM task might have been equally challenging for both younger and older children (as reflected by the lack of age effects, and an accuracy of less than 50% in our investigation, as well as in the Guajardo and Best, 2000 study).

Limitations and future directions

There are several limitations of the current study that could be taken into account in future investigations. First, as previously described, in order to preserve the secondary nature of the PM task, the presentation order of aid conditions was not counterbalanced. Hence, as the No-aid blocks always preceded the With-aid condition, this could have boosted children's performance on the second part of the event-based task, as a consequence of practice. Nevertheless, there was no performance progress within each condition from the first block to the last to suggest the possibility of a practice effect that would account for children's superior performance when the memory aid was present.

There are also other limitations which make us cautious about directly incorporating the results of this investigation in the ACT framework. First, the absence of a direct state anxiety measure precludes us from making conclusions regarding the extent to which elevated anxiety levels might be responsible for the results. However, obtaining a valid measure of state anxiety in preschoolers is difficult, since both self-report measures of the worry component and physiological markers of state anxiety are difficult to obtain in a reliable manner in this young age population (Campbell & Rapee, 1996). Second, the lack of a response timing measure makes the results difficult to reconcile with the ACT, which proposes a specific anxiety-related impairment in the amount of resources that individuals invest in solving a task. Although the simplified version of the event-based PM task developed by Kvavilashili et al. (2001) does not allow for a thorough analysis of response time measures, other indexes such as subjective reports of increased effort might offer indirect measures of reduced efficiency in high anxious children.

Conclusions and implications

These limitations notwithstanding, the present findings offer a glimpse into the early development of event-based and activity-based PM skills in preschoolers and relate them for the first time with individual differences in anxiety, reflecting its negative impact on performance across both tasks. From a conceptual perspective, findings are partially consistent with the PM multi-process model (McDaniel & Einstein, 2000). In line with its assumptions, results showed that preschoolers benefited from having specific PM target-cues, thought to redirect attention and spontaneously trigger prospective remembering. However, contrasting the model, younger children were not impaired to a higher degree as compared to 5- to 7-year-olds when more strategic processing was required (in the absence of a specific PM aid). Still, it is possible for the memory aid to have enhanced children's PM by facilitating a less sensitive to age-effects stage (i.e. intention retention; Kliegel et al., 2000). For the most part, it seems highly probable that the level of executive demands imposed by the tasks play a crucial role in both the uncovering of age effects, and of anxiety-related performance impairments. This idea could be investigated systematically in an investigation directly contrasting various levels of executive functioning demands in PM tasks by emphasizing one or another of the multi-processes involved at various information processing stages (Kliegel et al., 2008), or by identifying the role that individual differences in executive functioning skills play in children's PM performance (Ford et al., 2012).

From an applied perspective, the study suggests ways to improve PM performance for both typical and high-anxious preschoolers. It has been shown that all preschoolers could benefit from having an external PM aid that would trigger the previously planned action. Thus, children can be aided to achieve PM success at home or in educational settings just by using external cues which remind them to carry out their intentions (e.g. putting a card /sticker depicting an apple on their lunch box so they could remember putting one in before heading for kindergarten). Also, cognitive-behavioral interventions designed to reduce anxiety levels in young children have started to question whether this type of intervention is developmentally appropriate for this age group (Grave & Blissett, 2004). In this respect, besides factors already included in the analysis of cognitive demands imposed by CBT techniques (e.g. on working memory, inhibition), therapists should also take into account that PM demands (e.g. to continuously monitor one's thinking and to generate alternatives when encountering automatic thoughts; to remember to implement alternative behaviors when encountering specific situations) are affected by anxiety, especially in younger children. Furthermore, the use of external memory cues (e.g. visible cards depicting the alternative thought/behavior) could also alleviate some of the difficulties that these young children might experience during challenging tasks imposed by both educational and therapeutic environments.

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