The Effect of Age on Prospective Memory Performance in Adolescence: A Systematic Review

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Abstract

This systematic review has investigated the age effect on prospective memory performance in adolescence. Prospective memory (PM) is the ability to remember planned activities to perform in the future. The ability to perform future activities at the correct moment in time is an important aspect of an independent life. As PM performance is linked to the development of the prefrontal cortex, it is hence that a development in adolescence in comparison to children and into young adulthood is seen. A systematic review was performed to research if there are developmental differences on PM performance in adolescence, by looking at age differences in PM performance between children vs. adolescents and adolescents vs. young adults. Web of Science, PsycInfo and WorldCat were searched in the second week of November to find articles that matched the research questions. Eventually, eleven studies that all focused on healthy adolescents *and* either children or young adults or both and were peer-reviewed English journal articles were included. A quality of these studies was conducted by performing an AXIS risk of bias assessment. Data extraction of the eleven studies led to the conclusion that there is an age effect of prospective memory across adolescence, meaning that developmental differences can be found between children vs. adolescents and adolescents vs. young adults.

Keywords: prospective memory, adolescence, children, young adults

The Effect of Age on Prospective Memory Performance in Adolescence: A Systematic Review

An important element of human cognition that differentiates us from other species is the ability to think about the future (Atance & O'Neill, 2001). The ability to think about the future is an important aspect of a person's daily life; it has a big influence on different features, such as achievement, health improving behavior, well-being and risk-taking behavior (Kooij et al., 2018). An aspect of future thinking is prospective memory (Atance & O'Neill, 2001). Prospective memory (PM) is defined as the ability to remember planned activities to perform in the future, such as passing on a message from school to parents (Wang et al., 2011). PM can be seen as more than just 'remembering future tasks', it is a complex process that consists of the following phases: (1) forming the intention, (2) a delay between forming an intention and performing the intention, (3) period of when the intended action should be retrieved, (4) actually performing the intention (Ellis, 1996). A PM task is most often carried out while doing an attentionally demanding ongoing task (OT), which creates a challenge for a correct performance in this type of memory task (Ellis et al., 2000). In laboratory studies on PM, two types of PM tasks are being distinguished: time-based and event-based. In time-based tasks participants require to perform a specified behavior at a particular time, in event-based tasks participants are required to perform a specified behavior by an external cue (Henry et al., 2004). Event-based tasks are further divided into focal and nonfocal tasks. When processing a stimulus for the ongoing task overlaps with the processing needed for PM cue detection, a PM task is called focal, whereas this is not the case for nonfocal tasks (Zuber et al., 2016).

The ability to perform future intentions at the correct moment in time is an important aspect of whether a person can live an independent life from others, especially from childhood to adulthood when the expectation to become more and more autonomous increases (Bowman et al., 2015). For instance, the development of PM is one of the challenges children are confronted with in their cognitive development (Meacham & Colombo, 1980). When children have difficulties with PM, such as forgetting to hand in their project on time or to meet up with a friend after school, it can have a negative influence on their academic performances and social lives (Mahy et al., 2014).

Data of different studies on PM development across the lifespan, such as Zimmerman et al. (2006), show an inverted U-shape with an increase in performance from childhood to adulthood and a decrease in older adulthood. This indicates that there is a development of PM performance across childhood to young adulthood, but in what extent is yet still unclear. Studies show a start of development of PM as early as the age of three years old, which makes a fast improvement across the preschool years, and there are many differences in PM performance among preschoolers from three to six years old (Kliegel & Jäger, 2007). A reason for these variations in PM performance can be the developmental differences in cognitive monitoring and introspection over the years from three to six (Mahy & Moses, 2011). At the age of seven to 12 years old there is further improvement seen in PM performances, this improvement is rather linear and is leveled off at age 12; with a big improvement between the age of seven and eight years old (Yang et al., 2011). It is clear that there are PM increases across childhood, but whether the full PM potential has been reached at adolescence is not yet clear. As for studies that have examined PM performance between children and adolescents, and thereby showing a potential development across adolescence, show inconsistent findings. Some parts of studies show no age differences between children and adolescents (Zhao et al., 2019), other studies have suggested that PM performance in adolescents is better than that of children and thereby suggest a development of PM in adolescence (Ward et al., 2005). Similarly, the development of PM performance from adolescence to young adulthood is also yielding contrasting results. Some studies do not show an age difference between adolescents and young adults (Kretschmer-Trendowicz et al., 2016), other studies did indicate a further development of PM performance in adolescence by showing age differences between these two age-groups (Altgassen et al., 2014). As for the development of PM further in young adulthood, it is generally assumed to not develop further, as also shown by stable PM performance in young adults (Kliegel et al., 2008).

Thus, so far, only a defined number of studies have examined the development of PM in childhood and adolescence, and whether this development continues across adolescence into early adulthood. This systematic review, therefore, aims to address these uncertainties with the prediction that PM continues to develop. The rationale for this prediction is based on the indicating changes related to brain functions and cognitive processes that have been shown to be involved in PM performance as well; one of being the development of the prefrontal cortex, including executive functions, such as planning the PM task, inhibition of the OT, and organizing the execution of the intended activity (McDaniel et al., 1999). The prefrontal cortex (PFC) has one of the longest maturation periods of any brain region, taking over 20 years to attain full maturity (Diamond, 2002). This indicates that PM will also continue to develop from childhood across adolescence and into young adulthood. In addition to assessing PM, different studies additionally look at performance and/or response times in the ongoing activity, as sometimes we can observe trade-offs (e.g., age effects only in OT but not PM), and also conceptually the OT absorption (how many resources are taken by the OT) affects PM (McDaniel & Einstein, 2000) – therefore, it is recommended to look at OT in addition to PM.

To be able to properly examine this prediction, a systematic review will be performed to compare numerous scientific articles, which compare PM performances between children and adolescents, adolescents and young adults or both. Which will give answer to the following research questions: “Is there a difference in prospective memory performance between children and adolescence?” and “Is there a difference in prospective memory performance between adolescence and young adulthood?”

Method

A systematic search was executed by using the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analysis) guidelines (Liberati et al., 2009).

Literature search

An online search was conducted, in the second week of November, to select studies written in English that examined the development of prospective memory in healthy adolescents *and* either children or young adults or both. This search was performed in the following databases: Web of Science, PsycInfo and WorldCat. With the help of the PICO system (Population/Problem, Interventions/exposure, Comparison & Outcome), two search strings were developed: one for adolescents vs. children and the other for adolescents vs. young adults (Liberati et al., 2009). In this systematic review, population as well as intervention is adolescents, the comparison is children or young adults and the outcome is PM performance. This led to four keywords that expanded into four search sets (see Table 1). The search sets were linked with the Boolean operator 'AND'.

The first search set were PM-related keywords ('prospective memory' OR 'delayed intention*' OR 'intentional memory' OR 'memory for intention*' OR 'intended action' OR 'future intention' OR 'remember to remember'). The second search set were children-related keywords (child* OR schoolchild* OR 'school child*' OR school-child* OR kids OR 'school age' OR school-age OR 'pre-school child*' OR 'preschool child*' OR pre-schoolers OR preschoolers OR development OR lifespan OR life-span OR 'life span'). The third search set were adolescence-related keywords (adolescen* OR teen* OR youth). The fourth search set were young adulthood-related keywords ('young adult*' OR 'younger adult*' OR adulthood OR development OR lifespan OR life-span OR 'life span' NOT 'older adult*').

There are two types of searches conducted in each database. One containing the search sets of the children-, adolescence- and PM-related keywords, in order to find articles comparing adolescents’ and children’s PM performance. The other one, containing the search sets of the young adulthood-, adolescence- and PM-related keywords, in order to find articles that compare adolescents’ and young adults’ PM performance.

Selection criteria

During both the search strategy and the study selection process, inclusion and exclusion criteria were applied to eventually only include relevant studies. Studies that were included into this review needed the following criteria: (1) had tested healthy adolescent and child or young adult participants, (2) focused on PM performance as a dependent variable, (3) had primary data on the effects of age (defined as statistical comparison between healthy children and adolescents or between healthy adolescents and young adults or both) on PM (defined as the performance on PM tasks), and (4) were published as an English language peer-reviewed journal article. That is why, records in other languages, book chapters, theses or other systematic reviews were not included for further analysis. One other exclusion criterion was studies that included participants with clinical conditions or cognitive impairments.

To identify relevant studies, the author first screened the titles, abstracts and keywords. After this first screening, full-text of the pre-selected articles were further looked into. In case of any doubt whether an article qualified for the inclusion criteria or not, a peer consultation has taken place; any doubt has been resolved by discussion with this peer.

Data extraction

Data was extracted by the first author independently. For each article included in the systematic review, the following information was extracted: first author’s surname, year of publication, sample size, age information of the sample (e.g., age range, mean age, and standard deviation), how prospective memory was measured in relation to the OT, and main findings (e.g., age comparison, statistical test results and effect size of the overall age effect on PM and ongoing task as complementary information).

Quality assessment

The methodological quality of the studies was estimated by performing a risk of bias assessment. For the quality assessment in this systematic review the AXIS assessment tool has been used, by following eight questions looking at sample size, selection process of the participants, non-responders, clearance of the aims/objective of the studies, justification of the results, description of the method, proper use of the risk factor and outcome variables measure, and funding sources or conflicts of interest. These questions have been graded with low, unclear, or high risk of bias. All studies were independently reviewed by the author herself, in case of any doubt, the ratings for quality were discussed with a peer.

Results

Figure 1 shows the PRISMA flow diagram showing that 1378 references were identified through database searches (i.e., 170 references in Web of Science, 1013 references in PsycINFO, and 195 references in WorldCat). These references were exported to Endnote to eliminate duplicates (n = 435). Title and abstract screening led to recognition of 42 articles. The main reasons for exclusion at this stage were the inclusion of clinical condition and topics unrelated to PM. After excluding another two articles, because they could not be sought for retrieval, 40 full-text articles were assessed for eligibility. After reading the full manuscripts, eleven articles were included and 29 articles were excluded. More than half of the excluded studies did not include adolescents as a separate comparison group, others had no primary data on PM performance, one was not an English written article and one other was not a peer-reviewed journal article.

Characteristics of the studies

Out of the eleven studies that were included, seven examined the age differences in PM performance between adolescents and young adults, and the four remaining studies included children, adolescents and young adults; no studies were found that only looked at the differences between children and adolescents. The total sample size was 1,368 participants. However, individual studies varied in their sample size, ranging from 28 to 326 participants. Samples comprised healthy nonclinical participants aged between 5-10 years for children, 11-17 years for adolescents and 17-30 years for young adults. On average, out of the studies that reported gender characteristics the majority had fewer male participants than female, ranging from 18.1% to 50% male participants.

Overall, the eleven studies that were included had adopted a variety of tasks to examine the PM performance of the participants. Three studies used a picture-based task, two studies adopted a shape-based task, one a statement-based task and five studies out of the eleven included studies using a linguistic task by using words, letters and verbs (more details are summarized in Table 2).

Quality assessment

Overall, all eleven studies were of moderately good quality according the AXIS assessment tool (see Table 3). All studies were ranked with a low risk of bias on clearance of aims/objective of the study, these were all very clear in all articles. This also applies for the description of the method and proper use of the risk factor and outcome variables measure; all studies were ranked with a low risk of bias. As for justification of the results, only in Zimmerman et al. (2006) it was unclear whether there was a risk of bias, because they did not say anything specifically about adolescents and young adults when they did have the data for these age-groups. The main limitation of the eleven studies was the justification of the sample size. None of these studies were ranked with a low risk of bias on this topic, because none of these studies gave a clarification of why such small sample sizes were used. A small sample size often goes together with a low power to detect a potential effect. Altgassen et al. (2014) scored high on risk of bias for representation of the reference population. This is because, young adults were mainly psychology students, which is not a good representation of overall young adults. As for non-responders it was unclear whether there was a risk of bias in most studies, because they did not report any information about non-responders. Zhao et al. (2019) was the only study who did report about non-responders and showed that 20-30% of the people that were approached did not respond. This is a high percentage and could lead to results that does not represent the target population. Lastly, in most studies there were no reports of funding sources or conflict of interest, which makes it very unclear if there could be risk of bias in these cases.

Main results

The reviewed studies showed some variety of PM measures. All eleven studies assessed overall PM performance, of which one study did this separately for two types of event-based tasks (focal and nonfocal task) and one time-based task (Zhao et al., 2019), another study looked at two types of event-based tasks (Wang et al., 2009) and the remaining nine did this only for one type of event-based task. Additionally, two studies also investigated PM reaction times (Kretschmer-Trendowicz et al., 2016; Zöllig et al., 2007). Below a summary of the findings of the effects of age on PM performance is presented (see Table 2 for more information). These findings are divided into two categories: children vs. adolescents and adolescents vs. young adults. As studies have looked at PM performance results and the ongoing task (OT) results separately, this will be summarized separately as well.

Children vs. adolescents

PM performance. Out of the four studies that included children in their samples, all studies looked at overall PM performance, while Zhao et al. (2019) did this separately for two event-based tasks (focal- and nonfocal task) and one time-based task, the three remaining studies did this only for one type of event-based task (Kretschmer-Trendowicz et al., 2016; Ward et al., 2005; Zimmerman et al., 2006). Additionally, Kretschmer-Trendowicz et al. (2016) also looked at reaction times in PM. Out of the five findings on event-based task, three reported an age effect (Kretschmer-Trendowicz et al., 2016; Ward et al., 2005; Zimmerman et al., 2006), while two (both focal and nonfocal tasks) did not (Zhao et al., 2019). However, only Kretschmer-Trendowicz et al. (2016) reported an effect size of $\eta^2_P = .32$, which is considered as a large effect size (Durlak, J.A., 2009). This study is also the one that looked at reaction times in PM, which it did not find significant age differences between children and adolescents, but the reported effect size ($\eta^2_P = .14$), however, would potentially suggest a medium effect. This may be due to the rather low sample size of 20 participants for each age group that was used. Zhao et al. (2019) did report a significant age difference in their time-based task, in which adolescents outperformed the children. This was paired with a large effect size of $\eta^2_P = .32$.

OT performance. Out of the four studies that included children in their samples, three looked at overall OT performance, one did not report any findings (Ward et al., 2005). Out of these three, two found significant age differences of more accurate OT responses in their event-based tasks in adolescents (Kretschmer-Trendowicz et al., 2016; Zhao et al., 2019), one did not (Zimmerman et al., 2006). Zhao et al. (2019) found large effect sizes in both their event-based OT focal- and nonfocal tasks; an effect size of $\eta^2_P = .41$ in the OT focal task and an effect size of $\eta^2_P = .27$ in the OT nonfocal task. Kretschmer-Trendowicz et al. (2016) also reported a large effect size of $\eta^2_P = .37$. In this study the reaction times were also further looked into, in which the study shows no significant effect, but the effect size ($\eta^2_P = .66$) is rather large. As previous stated, this could be due to the small sample size that is used for each age-group. Zhao et al. (2019) did also report an age effect in their OT time-based task, with also a large effect size of $\eta^2_P = .46$. One thing that should be noted about the effect sizes of both the event-based tasks and time-based task in Zhao et al. (2019) is that these effect sizes refer to the overall age effect.

Adolescents vs. young adults

PM performance. All eleven studies that included young adults in their sample looked at overall PM performance, while Zhao et al. (2019) did this separately for two event-based tasks (focal- and nonfocal task) and a time-based task, the ten remaining did this only for an event-based task. Additionally, two studies also looked at PM reaction times (Kretschmer-Trendowicz et al., 2016; Zöllig et al., 2007). Out of the eleven studies, three did not find significant age differences between adolescents and young adults (Ward et al., 2005; Kretschmer-Trendowicz et al., 2016; Zimmerman et al., 2006), of which one still reported an effect size of $\eta^2_P = .32$ (Kretschmer-Trendowicz et al., 2016). As previous stated, this could indicate an effect, but due to the small sample size of 20 participants in each age group there is no sufficient power to detect a potential effect. As for the eight remaining studies, all studies show significant age differences between adolescents and young adults; with young adults outperforming adolescents in all studies. Wang et al. (2006) is the only study that does not report an effect size of these eight studies. Effect sizes range from a medium to large effect. Altgassen et al. (2017) provided a large effect size of $\eta^2_P = .12$, Altgassen et al. (2014) showed a large effect size of $d = .70$, Hering et al. (2020) also showed a large effect of $\eta^2_P = .25$, and lastly Zöllig et al. (2007) showed a large effect size of $d = 1.05$. As for Magis-Weinberg et al. (2020), who showed a medium effect of $\eta^2_G = .06$, it should be noted that this effect size referred to both PM and OT performance. Wang et al. (2011) showed no significant differences and also did not provide an effect size in the focal task, but did in the nonfocal task, with a large effect size of $\eta^2_P = .22$. This is in contrast with the results of Zhao et al. (2019), who showed significant age differences in both the focal- and nonfocal task; with a large effect size of $\eta^2_P = .25$ in the focal task and a medium effect size of $\eta^2_P = .09$ in the nonfocal task. This study also showed a large age effect in their time-based task, with an effect size of $\eta^2_P = .32$. As for the two studies that also investigated PM reaction times, only one showed a significant effect of age (Zöllig et al., 2007), with a large effect of $\eta^2_P = .28$. Kretschmer-Trendowicz et al. (2016) does not show a significant effect of age for PM reaction times, but still reports a rather large effect size (η^2_P

= .14), which could indicate that there is an effect, but the small sample size is not enough to be able to back up this claim.

OT performance. Out of all eleven studies that included young adults in their sample, three studies did not report any findings on overall OT performance (Magis-Weinberg et al. 2020; Wang et al., 2006; Ward et al., 2005). Out of the remaining eight studies, two studies did not find a significant age-effect between adolescents and young adults (Zimmerman et al., 2006; Kretschmer-Trendowicz et al., 2016). Kretschmer-Trendowicz did still report large effect sizes for both the overall OT performance (η^2_P = .37) and OT reaction times (η^2_P = .66), which can indicate that there is an effect, but due to the small sample sizes for each age-group (n = 20) in this study there is no sufficient power to detect a potential effect. The other six studies all showed a significant age difference between adolescents and young adults in OT performance; all showed that young adults outperformed adolescents. These effects sizes range between a medium to large effect. Altgassen et al. (2017) showed a medium effect size of η^2_P = .09, Altgassen et al. (2014) reported a large effect size of η^2_P = .29, Hering et al. (2020) showed a large effect of η^2_P = .46, and Zöllig et al. (2007) also showed a large effect size of d = 1.34. Wang et al. (2011) showed significant age differences in OT performance in the focal task with a medium effect size of η^2_P = .02, but no significant age differences in the nonfocal task. The study still reported a small effect size of η^2_P = .03 in OT performance in the nonfocal task, which could indicate that there is an effect. This is in contrast whit Zhao et al. (2019) who did show a significant age effect in the nonfocal task, with a large effect of η^2_P = .27. This study also reported a significant age effect for the focal task, with a large effect of η^2_P = .41. As for the time-based task, it also showed a large significant age-effect of η^2_P = .46. As for OT reaction times, Wang et al. (2011) showed only a significant age effect in the nonfocal task and not for the focal task, this significant age effect was paired with a large effect size of η^2_P = .14. The study does report a small effect size of $\eta^2_P = .02$ of OT reaction times in the focal task, which can still indicate an effect of age in this condition.

Discussion

This systematic review examined the effects of age on PM in non-clinical adolescents. This has been done by looking at the age differences between children vs. adolescents and adolescents vs. young adults. Despite it being acknowledged that PM is important for an autonomic daily life in adolescence, research on the development of PM in this age-group is rather limited. This is displayed by the limited number of studies identified for inclusion. Only eleven studies met the inclusion criteria. Of which all eleven studies investigated the age differences between adolescents and young adults, and four studies examined the age differences in both children and young adults in comparison with adolescents. Thus, no studies were found that only looked at the differences between children and adolescents.

At first glance, the results indicate an age effect in PM performance from childhood, across adolescence, into young adulthood; which was also hypothesized at the start of this systematic review. These results are in line with the findings of development of PM that shows an inverted U-shape across the lifespan, with an increase in performance from childhood to adulthood and a decrease in older adulthood. Which indicates there is a high development of PM in children, adolescence and young adulthood (Zimmerman et al., 2006). This review provided a more detailed view of this development, as it shows that between 4-to 6-year-old children and 13- to 14-year-old adolescents the PM development makes a rapid improvement, this growth continues between adolescents and 19-to 26-year-old young adults but somewhat more slowly. In addition to this finding, the previous rationale linked to PFC development is something that is also shown by the results. PM, which is thought to depend on PFC maturity, is continuing to develop from childhood to adolescence, and also from adolescence to young adulthood – which can be explained with the ongoing PFC maturation past the age of 20 (Diamond, 2002).

As for the age differences between children and adolescents, there were three out of four studies that did show a significant difference in their event-based PM task (Kretschmer-Trendowicz et al., 2016; Ward et al., 2005; Zimmerman et al., 2006), and one study (Zhao et al., 2019) that did not show a significant difference in their event-based PM task. Looking at OT performance, this study does show large age effects in OT performance. Considering that children have limited resources, and they really want to do well, they might reach the same PM performance as the adolescents, but they do this at the cost of the OT – where age differences are shown (McDaniel et al., 2000). Taking PM and OT together in consideration, this still strongly suggests developmental differences. Therefore, it is possibly still safe to say that there is an age difference shown in PM performance between children and adolescents and, therefore, a case of development in PM between children and adolescence.

As for the age differences between adolescents and young adults, there were eight of eleven studies that did show a medium to large age effect, and three that did not find significant age differences (Ward et al., 2005; Kretschmer-Trendowicz et al., 2016; Zimmerman et al., 2006). Kretschmer-Trendowicz et al. (2016) did report a large effect size which could indicate there is an effect of age, but due to a small sample size it is plausible that there is a low power, which causes a neglect of effect. As for Ward et al. (2005) and Zimmerman et al. (2006) it is not clear why they did not find results, as they also do not find significant differences in OT performance. Despite these contrasting findings between the three studies that did not find a significant effect and the eight who did, of which found medium to large effect sizes, it still could be assumed that there is an effect of age between adolescents and young adults in PM performance and, therefore, a case of development in PM between adolescence and young adulthood.

Additionally, the results also provide interesting findings that could be important to look at in future research on age effects on prospective memory. As for the results between children and adolescents, a medium effect size was reported for the age effect in PM reaction times, while no significant effect was found (Kretschmer-Trendowicz et al., 2016). This could indicate that there is an effect, not only in accuracy as previous seen in this study, but also in speed; faster in responding to the target trials. Due to the small sample size of 20 participants per age group that was used in this study, the power is too low to speak of a potential effect. Thus, it is still an open question if adolescents are indeed faster in responding to the target trials than children. Another interesting finding is from the study that looked at both event-based PM and time-based PM (Zhao et al., 2019). This shows no age differences in event-based PM tasks, but it did in the time-based PM task. Studies, such as Mills et al. (2020), show that children perform better on event-based PM tasks than on time-based PM tasks. This indicates that there might be some event-based tasks in which children already perform as well as adolescents, hence why there is no age-effect in the event-based PM task. For future research on development in PM it could be important to consider looking at the difference between these types of tasks between different age-groups.

As for the results between adolescents and young adults, these showed contrary findings on focal and nonfocal tasks. Wang et al. (2011) and Zhao et al. (2019) were the only studies that distinguished between these different tasks. Both studies agree on age differences for nonfocal tasks. The difference is that one did find age differences for focal tasks (Zhao et al., 2019), the other did not find significant age differences for this task type (Wang et al., 2011). Looking at OT performance, Wang et al. (2011) does show a medium age effect in the OT focal task. For whatever reason, this shows a trade-off; adolescents might reach the same PM performance in the focal task as the young adults, but they do this at the cost of the OT.

Thus, it seems likely that adolescents can perform as well as young adults in case of a focal task. Future studies are required that directly test this assumption.

Looking at the data that is available in this systematic review, a limitation of this review is that the sample sizes in the studies that are included are rather small. As a result, it happens that a finding in age difference is not significant, but a rather large effect size is found. So, there probably is an effect, but it cannot be taken into account due to low power. Another limitation is that some studies did not report their findings in OT performance. When a study does not show age differences in a PM task, it could be that these differences are shown in the OT. When these findings are not reported, an age development in PM is still an open question.

Altogether, with the limitations of this systematic review and somewhat contrasting results it seems very likely that there is an age effect of prospective memory across adolescence, meaning that developmental differences can be found between children vs. adolescents and adolescents vs. young adults. In terms of practical relevance, it is important for parents, caregivers and teachers to keep in mind that PM is still developing. Therefore, one has to take into account that this age-group may still have difficulties in performing certain expected future tasks, despite the expectation that adolescents will become more independent.

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Table 1

Search String Expanded in Four Search Sets

Keywords	Web of Science	PsycInfo	WorldCat
Prospective memory	'Prospective memory' OR 'Delayed intention*' OR 'Intentional memory' OR 'Memory for intention' OR 'Intended action*' OR 'Future intention*' OR 'Remember to remember'	'Prospective memory' OR 'Delayed intention*' OR 'Intentional memory' OR 'Memory for intention' OR 'Intended action*' OR 'Future intention*' OR 'Remember to remember'	'Prospective memory' OR 'Delayed intention*' OR 'Intentional memory' OR 'Memory for intention' OR 'Intended action*' OR 'Future intention*' OR 'Remember to remember'
Adolescence	Adolescen* OR Teen* OR Youth OR	Adolescen* OR Teen* OR Youth OR	Adolescen* OR Teen* OR Youth OR
Children	Child* OR Schoolchild* OR 'School child*' OR Kids OR 'School age' OR School-age OR 'pre-school child*' OR 'Preschool child* OR Pre-schoolers OR Preschoolers OR Development OR Lifespan OR Life-span OR 'Life span'	Child* OR Schoolchild* OR 'School child*' OR Kids OR 'School age' OR School-age OR 'pre-school child*' OR 'Preschool child* OR Pre-schoolers OR Preschoolers OR Development OR Lifespan OR Life-span OR 'Life span'	Child* OR Schoolchild* OR 'School child*' OR Kids OR 'School age' OR School-age OR 'pre-school child*' OR 'Preschool child* OR Pre-schoolers OR Preschoolers OR Development OR Lifespan OR Life-span OR 'Life span'
Young adulthood	'Young adult*' OR 'Younger adult*' OR Adulthood OR Development OR Lifespan OR Life-span OR 'Life span' OR NOT 'Older adult*'	'Young adult*' OR 'Younger adult*' OR Adulthood OR Development OR Lifespan OR Life-span OR 'Life span' OR NOT 'Older adult*'	'Young adult*' OR 'Younger adult*' OR Adulthood OR Development OR Lifespan OR Life-span OR 'Life span' OR NOT 'Older adult*'

Table 2

Summary of Studies on Prospective Memory Performance in Adolescence

Study	Sample *N* & Age Information	Prospective Memory Measures		Main Findings	
		OT	PM	PM Performance	OT Performance
Altgassen et al. (2017)	*N* = 109 AD: *n* = 49 (21♂) *M* = 14.43 *SD* = 0.71 YA: *n* = 60 (18 ♂) *M* = 21.18 *SD* = 2.38	*N*-back task (pictures).	Press a highlighted button whenever one of four specific pictures appeared.	AD < YA $p = .001$, $\eta^2_p = .12$	AD < YA $p = .002$, $\eta^2_p = .09$
Altgassen et al. (2014)	*N* = 83 AD: *n* = 42 (10 ♂) *M* = 13.55 *SD* = 0.50 Range: 13-14 YA: *n* = 41 (5 ♂) *M* = 19.44 *SD* = 0.50 Range: 19-20	Press left or right arrow key, depending on which of the noun pairs had more vowels.	Press space bar as quickly as possible whenever one of the two words was a verb.	AD < YA $p = .003$, $d = .70$	AD < YA $p = .001$, $\eta^2_p = .29$
Hering et al. (2020)	*N* = 45 AD: *n* = 25 (9 ♂) *M* = 13.50 *SD* = 0.82 Range: 12-15 YA: *n* = 20 (10 ♂) *M* = 25.50 *SD* = 2.70 Range: 21-30	Semantic judgment task.	Adapted version of an established encoding/retrieval paradigm (color-related).	AD < YA $P_{adj} < .01$, $\eta^2_p = .246$	AD < YA $P_{adj} < .001$, $\eta^2_p = .456$

Study	Sample N & Age Information	Prospective Memory Measures		Main Findings	
		OT	PM	PM Performance	OT Performance
Kretschmer-Trendowicz et al. (2016)	N = 60 CH: n = 20 (10 ♂) M = 5.00 Range: 5 AD: n = 20 (7 ♂) M = 13.60 SD = 1.05 Range: 12-15 YA: n = 20 (13 ♂) M = 22.60 SD = 1.19 Range: 21-25	Computer-based picture categorization task.	Press a predefined key whenever one of the specific PM targets (e.g., a crown) was presented.	CH < AD = YA $ps < .01$, $\eta^2_p = .32$ *PM reaction times* CH = AD = YA $ps > .09$, $\eta^2_p = .14$	CH < AD = YA $p < .01$, $\eta^2_p = .37$ *OT reaction times* CH = AD = YA $p = 1$, $\eta^2_p = .66$
Magis-Weinberg et al. (2020)	N = 47 AD: n = 28 (13 ♂) M = 14.60 SD = 1.4 Range: 12-17 YA: n = 19 (10 ♂) M = 27.10 SD = 1.9 Range: 22-30	Indicate whether the triangle shape was located to the left or the right of the other shape.	Press a third key if the shapes were the same color or were one chess knight's move away.	AD < YA $p = .005$, $\eta^2_G = .06$	n.a.
Wang et al. (2006)	N = 341 AD: n = 122 (53 ♂) M = 14.47 SD = 0.58 Range: 13-16 YA: n = 219 (54 ♂) M = 20.54 SD = 0.63	Ticking a √ behind the statement that would fit their personality or emotional states best their current situation.	Remember to make two √ marks behind their chosen answer if the statement to which they were listening included any negative word.	AD < YA $p = .001$	n.a.

Study	Sample *N* & Age Information	Prospective Memory Measures		Main Findings	
		OT	PM	PM Performance	OT Performance
	Range: 19-22				
Wang et al. (2011)	*N* = 119 AD: *n* = 60 (23 ♂) *M* = 13.26 *SD* = 0.50 Range: 11-14 YA: *n* = 59 (19 ♂) *M* = 19.70 *SD* = 0.87 Range: 17-21	Spatial working memory task (shapes).	Remember to press a target key whenever a specific target stimulus appeared in the working memory task (*focal condition*). Remember to press the target key whenever the background color of the working memory trials changed to yellow (*nonfocal condition*).	*PM performance Focal* AD = YA *PM performance Nonfocal* AD < YA $p < .01$, $\eta^2_p = .22$	*OT performance Focal* AD > YA $p < .05$, $\eta^2_p = .07$ *OT performance Nonfocal* AD = YA $p > .17$, $\eta^2_p = .03$ *OT reaction times Focal* AD = YA $p > .25$, $\eta^2_p = .02$ *OT reaction times Nonfocal* AD < YA $p < .01$, $\eta^2_p = .14$
Ward et al. (2005)	*N* = 90 (43 ♂) CH: *n* = 30 *M* = 8.6 *SD* = 1.19 Range: 7-10 AD: *n* = 30 *M* = 14.57 *SD* = 1.30 Range: 13-16 YA: *n* = 30 *M* = 19.07 *SD* = 1.14	Lexical decision task.	Press a specific key when the letter string appeared in italic.	CH < AD $p < .01$ AD = YA	n.a.

Study	Sample *N* & Age Information	Prospective Memory Measures		Main Findings	
		OT	PM	PM Performance	OT Performance
	Range: 18-21				
Zhao et al. (2019)	N = 326 CH: *n* = 108 (46 ♂) *M* = 8.07 *SD* = 0.59 Range: 7-9 AD: *n* = 112 (49 ♂) *M* = 13.35 *SD* = 0.75 Range: 12-14 YA: *n* = 106 (51 ♂) *M* = 19.66 *SD* = 1.17 Range: 17-23	Decide whether the current letter was the same as the letter presented two trials back (*EBPM OT*). Decide whether the letters on the second and fourth position in the letter string were identical or not (*TBPM OT*).	Press the space bar rather than to respond according to the OT (*EBPM focal trial*). Pressing the space bar upon seeing a letter that was surrounded by either a red or yellow frame (*EBPM nonfocal trial*). Press a specific key when the participant thought the target time had passed (*TBPM*).	*EBPM focal trial* CH = AD AD < YA $p < .001$, $\eta^2 = .25$* *EBPM nonfocal trial* CH = AD AD < YA $p < .001$, $\eta^2 = .09$* *TBPM* CH < AD $p = .02$, $\eta^2 = .32$* AD < YA *ps* = .001, $\eta^2 = .32$*	CH < AD AD < YA *EBPM OT focal trial* $p < .001$, $\eta^2 = .41$* *EBPM OT nonfocal trial* $p < .001$, $\eta^2 = .27$* *TBPM OT* $p < .001$, $\eta^2 = .46$*
Zimmerman et al. (2006)	*N* = 120 CH: *n* = 40 *M* = 5.5 *SD* = 0.56 Range: 4-6 AD: *n* = 40 *M* = 13.3 *SD* = 0.46 Range: 13-14 YA: *n* = 40 *M* = 21.2 *SD* = 1.75	Indicate for each pair whether the pictures were identical or not by pressing 'b'-key or the 'm'-key with the index finger of the right hand. + The shift-key had to be pressed continuously with the index finger of the left hand.	Press the 'y'-key on the keyboard with the left index finger every time they saw a picture of an animal.	CH < AD = YA *ps* < .05	CH = AD AD = YA

Study	Sample *N* & Age Information	Prospective Memory Measures		Main Findings	
		OT	PM	PM Performance	OT Performance
	Range: 19-26				
Zöllig et al. (2007)	*N* = 28 AD: *n* = 14 (7 ♂) *M* = 12.80 *SD* = 0.6 YA: *n* = 14 (7 ♂) *M* = 22.5 *SD* = 1.4	Semantic relatedness judgement task.	Press a target key when a word pair was presented in the target color.	AD < YA $p < .01$, $d = 1.05$ *PM reaction times* AD < YA $p < .01$, $\eta^2 = .28$	AD < YA $p < .01$, $d = 1.34$

Vote. CH = children, AD = adolescents, YA = young adults, PM = prospective memory, OT = ongoing task, EBPM = event-based prospective memory,

[BPM = time-based prospective memory, n.a. = not available or not applicable.

ᵃ Overall age effects, no effect sizes for each age pair comparison.

Table 3

AXIS Risk of Bias Assessment

+ = low risk of bias - = high risk of bias ? = unclear risk of bias	Sample size justification	Selection process of participants	Non-responders	Clearance of aims/objective of the	Justification of the results	Description of the method	Proper use of the risk factor and outcome	Funding sources or conflicts of interest
Altgassen et al. (2017)	-	+	?	+	+	+	+	+
Altgassen et al. (2014)	-	-	?	+	+	+	+	?
Hering et al. (2020)	-	+	?	+	+	+	+	?
Kretschmer-Trendowicz et al. (2016)	-	+	?	+	+	+	+	?
Magis-Weinberg et al. (2020)	-	+	?	+	+	+	+	?
Wang et al. (2006)	-	?	?	+	+	+	+	?
Wang et al. (2011)	-	?	?	+	+	+	+	?
Ward et al. (2005)	-	+	?	+	+	+	+	?
Zhao et al. (2019)	-	+	-	+	+	+	+	+
Zimmerman et al. (2006)	-	?	?	+	?	+	+	?
Zöllig et al. (2007)	-	+	?	+	+	+	+	?

Figure 1

PRISMA Flow Diagram