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The Development of Prospective Memory in Children

Methodological Issues, Empirical Findings, and Future Directions

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Research on prospective memory has now reached the point at which it is no longer necessary to start a chapter with a definition of prospective memory or a discussion about its defining features and how it differs from retrospective memory. This has been done repeatedly elsewhere (e.g., see Einstein & McDaniel, 1996; Ellis, 1996; Graf & Uttl, 2001; Guajardo & Best, 2000; Kvavilashvili, 1992; Kvavilashvili & Ellis, 1996). Instead, we start the chapter by examining briefly some statistics on prospective memory research in the past 30 years, and possible reasons for the almost complete lack of research on the development of prospective memory. We then discuss methodological issues that arise in this research, review some experimental data, and outline future directions in this unduly neglected area of prospective memory.

Recently, researchers have started to express their concerns about the scarcity of developmental studies. For example, Ellis and Kvavilashvili (2000), in their editorial for a special issue on prospective memory, were hoping that "the increasing body of research on executive functions—which develop gradually throughout childhood and adolescence—may provide the spur for further research on prospective memory development" (p. S8), and cited a study by Kerns (2000) as a promising example of such research. However, in the following five years (from 2001–2005), out of more than 150 published studies on prospective memory, only 4% of studies were developmental (Kerns & Price, 2001; Kliegel, Ropeter, & Mackinlay, in press; Kvavilashvili, Messer, & Ebdon, 2001; Martin & Kliegel, 2003; Maylor, Darby, Logie, Della Sala, & Smith, 2002; McCauley & Levin, 2004; Nigro, Senese, Natullo, & Sergi, 2002).

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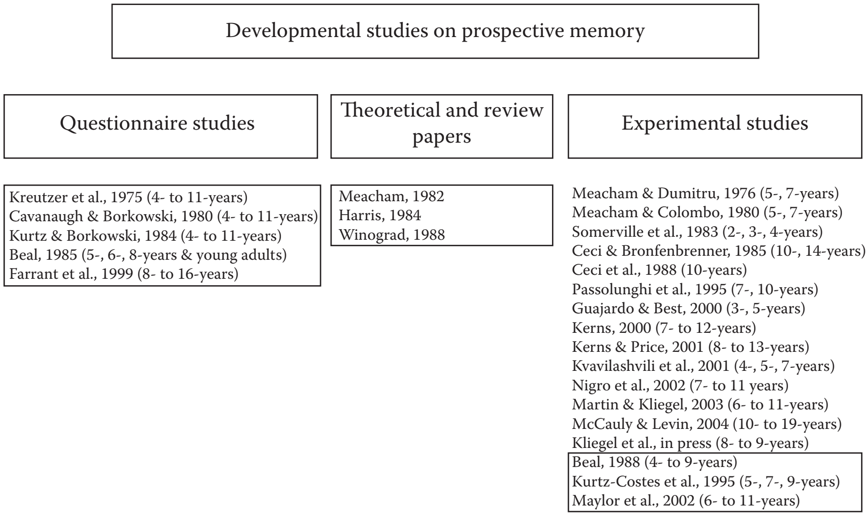
It is interesting that this was not the case in the first 15 years of prospective memory research. From 1971 to 1985, out of 10 (published) experimental studies, 4 were developmental, thus constituting 40% of the total output (Ceci & Bronfenbrenner, 1985; Meacham & Colombo, 1980; Meacham & Dumitru, 1976; Somerville, Wellman, & Cultice, 1983). This trend, however, was not preserved in the next 15 years of research. Although the number of published studies increased dramatically from 1986 to 2000 (to approximately 180), the percentage of developmental studies dropped equally dramatically from 40% to 3%, with only six developmental studies published in that period (Beal, 1988; Ceci, Baker, & Bronfenbrenner, 1988; Guajardo & Best, 2000; Kerns, 2000; Kurtz-Costes, Schneider, & Rupp, 1995; Passolunghi, Brandimonte, & Cornoldi, 1995). Moreover, as pointed out earlier, this pattern did not change in the last 5 years of prospective memory research (since 2001; see Table 6.1 for a list of developmental studies published since 1976).

The lack of interest in the development of prospective memory in children is surprising given that "remembering to do things in the future is a common everyday memory task that even young children are expected to perform" (Beal, 1985, p. 631). For preschool children, typical prospective memory tasks involve remembering "to dress properly to go outside, to bring appropriate objects to games, to deliver



messages, to carry out chores on a regular basis" (Meacham, 1982, p. 129). The list of prospective memory tasks increases even further with school-age children who may also have to remember to take routine medications, complete errands, show up for appointments in and outside of school, bring home special permission slips, call their friends or parents at work, return books to the library, bring completed homework to school, and so on (McCauley & Levin, 2004). Meacham (1982) stressed the social aspect of these tasks and that they were markedly different from the social context of retrospective memory tasks such as remembering what one did yesterday. Similarly, according to Winograd (1988), "if one remembers to perform activity one is rewarded. This is not the case with retrospective remembering by and large, until schooling begins with its demands on memorisation of arbitrary information" (p. 351). Therefore, both Meacham (1982) and Winograd (1988) believed that the early development of prospective memory skills was necessary for children to successfully cope with the everyday situations previously described. Meacham and Colombo (1980) even argued that "children's attempts at prospective remembering may be an important precursor to the development of strategies for retrospective remembering" (p. 299).

These were novel and theoretically challenging ideas. Moreover, they even received some empirical support in several early studies of prospective memory (e.g., Ceci & Bronfenbrenner, 1985; Kreutzer, Leonard, & Flavell, 1975; Meacham & Colombo, 1980; Somerville et al., 1983). Unfortunately, this initial and promising line of research was not pursued any further. In the 1990s, developmental psychologists shifted their attention to other practically relevant issues such as autobiographical memory, eyewitness suggestibility, false beliefs, and so on. On the other hand, prospective memory researchers concentrated on studying prospective memory at the other end of the developmental spectrum (i.e., in old age). This was mainly due to the publication of Einstein and McDaniel's (1990) highly influential and seminal paper on aging and prospective memory in which they developed a simple and successful paradigm for studying and measuring prospective memory in the laboratory.

However, there are at least two other possible explanations for this lack of interest and the motivation to study prospective memory development in children. First, there may be an implicit assumption that research on children cannot produce any new insights into the mechanisms of prospective memory and that it is simply an extension of research on adults. If this is the case, then it is understandable why the developmental research might be less attractive to prospective memory researchers. Second, research on children is methodologically more difficult than research on adults (Schneider & Pressley, 1997, p. 136). In addition, there is a lack of well-established methods and tasks suitable for studying prospective memory in children of wide age range.

The first explanation is not that convincing. Even with a small number of developmental studies there are plenty of examples of novel findings that are theoretically important for the general field of research on prospective memory in adults. For example, a study by Ceci and Bronfenbrenner (1985) on children's clock monitoring patterns as a function of context (home vs. lab) has been frequently cited and has had lasting influence on theorizing about time-based prospective remembering. Furthermore, research on adults has demonstrated that the remembering of event-based tasks is not affected or even improves with increased delay intervals (e.g., Hicks, Marsh, & Russell, 2000). However, in the study of Nigro et al. (2002), manipulating the delay interval from 5 to 10 minutes did not affect children's performance on event-based task, replicating previous findings with adults, but did impair their performance on the time-based task. This is a novel finding that is worth pursuing in adult studies that have not yet systematically examined the effects of delays on time-based tasks.

Further examples of novel results include a study by Kvavilashvili et al. (2001) that demonstrated the effects of task interruption on children's performance in an event-based task, and a study by Guajardo and Best (2000) that obtained positive correlations between prospective and retrospective memory tasks in 3- but not in 5-year-old children. Findings with 5-year-olds are more in line with several other adult studies that have also failed to establish the reliable correlations between the two forms of memory (e.g., Brandimonte & Passolunghi, 1994; Einstein & McDaniel, 1990; Kvavilashvili, 1987; McDaniel, Robinson-Riegler, & Einstein, 1998). Findings with 3-year-olds, however, emphasize the possible difficulties that very young children may have with the retrospective component of the prospective memory tasks (i.e., what needs to be done and when), and show that prospective and retrospective memory scores can be correlated when the retrospective component of the prospective memory tasks is too difficult for the individual. This finding also demonstrates some inherent difficulties of studying prospective memory in children especially when studying the developmental trajectory across the wide age range.

METHODOLOGICAL ISSUES OF STUDYING PROSPECTIVE MEMORY IN CHILDREN

With the exception of the diary method, research on children has used similar methods to those used in adult studies: an interview and questionnaire method and the experiments conducted in and outside the laboratory. Because the laboratory method has become predominant in both adult and developmental research, we concentrate on the laboratory method. Consequently, important questions that need to be addressed are whether children's prospective memory can be studied with laboratory methods used with adults and what the possible difficulties with these methods are.

A Laboratory Paradigm of Studying Prospective Memory

Figure 6.1(a) shows the basic components of a standard laboratory method of studying prospective memory in adults originally developed by Einstein and McDaniel (1990). In this paradigm, participants are initially introduced to a task (mostly run on computer) that they will be performing at a later point during the experiment. This task may consist of short-term memory trials, answering general knowledge questions, rating silly sentences as true–false, rating words for pleasantness, and so on. After some practice with this main experimental task, participants

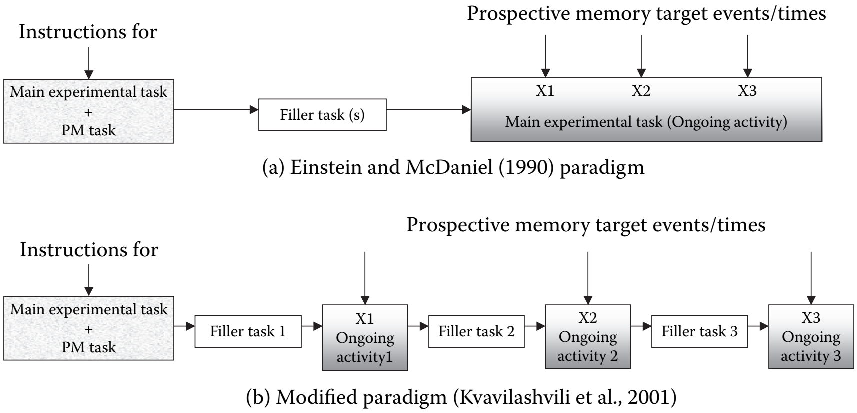


FIGURE 6.1 Caption here.

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receive instructions for a prospective memory task that usually consist of remembering to press a key in response to a target word that will occur several times in the course of the main experimental task. This corresponds to the first stage of the prospective memory task (i.e., the formation of intention to act in the future; see Ellis, 1996; Brandimonte & Passolunghi, 1994). It is followed by a delay interval that is filled with performing some unrelated (filler) tasks. This ensures that participants switch their attention from the prospective memory task to elsewhere and mimics everyday situations where after forming an intention to make a phone call later on, one switches to other ongoing tasks and concerns. When participants finish the filler tasks, they are asked to carry out the main experimental task they practiced earlier, without any mention of the prospective memory instructions. In the course of the ongoing experimental task, participants encounter the target word several times, and they have to remember to press the key without any explicit prompt from the experimenter. Prospective memory is measured as a number or proportion of cases in which participants remembered to press the key. To ensure that targets occur relatively infrequently in the course of the main experimental task, the latter usually consists of dozens or hundreds of trials that last on average between 15 and 30 minutes.

A Modified Version of the Paradigm

When we started our research on children at the end of 1990s, it was obvious to us that certain components of this basic paradigm needed modification for it to work with young children between 3 and 7 years old. With respect to an initial encoding stage, we reckoned that it would be difficult to introduce young children to the main experimental and prospective memory tasks in the manner usually done with adults (e.g., "We are additionally interested in your ability to remember to do things in the future"). Unlike adult volunteers, children might not have proper understanding of the value of doing experimental tasks for scientific research. Also, unlike psychology undergraduates who receive course credits for their participation, it is not always possible to compensate the participation of children with rewards. To keep children engaged and motivated in the procedure both tasks have to be introduced as a form of a game. For that reason in every experiment we have conducted we used (various versions of) a toy mole "Morris," who children are told cannot see very well and needs children's help in various tasks (e.g., naming pictures, drawing pictures, etc.). Prospective memory tasks consist of telling children that Morris is scared of animals, and if they happen to see a picture of any animal during the future tasks, they have to hide that picture in the box situated behind them (see Kvavilashvili et al., 2001).

We had more serious concerns about the final retrieval phase of the procedure, when participants have to perform the main ongoing experimental task with occasional prospective memory targets embedded in it. Initial piloting showed that it would not be possible to have preschool children performing the same task for dozens or hundreds of trials without them becoming bored and disinterested in the task. For this reason we slightly modified the basic paradigm so that each prospective memory target was embedded into a relatively short block of trials (e.g., naming 20 line drawings of familiar objects) that were alternated by brief 2-minute-long and engaging filler tasks such as drawing a picture for a mole. This modified paradigm for children is depicted in the lower panel of Figure 6.1(b) and was successfully used in our study on the effects of age and task interruption on young children's prospective memory (Kvavilashvili et al., 2001).

It is important to point out that the basic characteristics of the standard Einstein and McDaniel (1990) paradigm and the modified paradigm are similar. The difference between the two lies only in the ongoing activity, which, in case of the modified paradigm, consists of two different types of alternating tasks with a relatively small number of trials (or duration). This ensures that young children do not lose their concentration and interest in the ongoing activity. Moreover, several developmental studies have used the standard paradigm (e.g., Guajardo & Best, 2000; Passolunghi et al., 1995) and some adult studies have used ongoing tasks similar to those in the modified paradigm (e.g., see Cook, Marsh & Hicks, 2005).

Eliminating Possible Ceiling Effects in the Modified Paradigm

Using the modified paradigm, Kvavilashvili et al. (2001) showed that children enjoyed "helping out Morris" and were engaged in the ongoing task of naming four separate stacks of cards of line drawings. Most important, prospective memory performance was not at ceiling even in the oldest age group. However, it later turned out that the absence of ceiling effects was due to prospective memory instructions asking children to do something in response to a general target (i.e., a category of animals) without the children knowing in advance which specific exemplars of this category would occur in the ongoing task. Several studies of adults have shown reduced performance levels with such general targets (i.e., animals) compared to specific targets like, for example, tiger, leopard, and lion (Cherry et al., 2001; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Ellis & Milne, 1996).

Indeed, when in subsequent projects we wanted to test 3-, 5-, and 7-year-old children with a specific prospective memory target (e.g., a picture of a dog) we had serious troubles avoiding ceiling effects even in the youngest age group. For example, in the initial pilot study children had to give a toy dog a toy bone every time they named a different picture of a dog in each of the three stacks of cards. It was apparent that this task was intrinsically too motivating. It almost seemed as if children could not wait for a moment when they could actually carry out this exciting task of "feeding the dog."

Therefore we had to make the prospective memory task less "exciting" by asking children to perform a more arbitrary activity of placing a small dog figure into a small box (that was behind the child) every time they named a picture of a dog. However, even with this modification, performance levels were still unacceptably high. To reduce performance further we had to make the ongoing picture-naming task more difficult. This was achieved by asking children to have a look at the very first picture in the booklet and tick it off with a felt pen every time it occurred in the booklet. Thus, in addition to naming the pictures, children also had to detect the (nonprospective) target picture that was different across all three picture books. Only after making these adjustments to the prospective memory task itself and the ongoing task did we manage to eliminate the ceiling effects in a prospective memory task with specific targets.

Additional Problems With Both Paradigms

Apart from ceiling effects, there are at least two additional problems facing the developmental researchers of prospective memory. The first problem involves the possibility that some younger children may forget to perform the prospective memory task because of a retrospective memory failure to remember that they had been given the prospective memory instructions in the first place. Therefore, children's retrospective memory for prospective memory instructions should be assessed at the end of the experimental session via a series of successive probes increasing in specificity. It is especially important to do so for children who forget to perform the prospective memory task on all occasions. For example, in Kvavilashvili et al. (2001), the postexperimental probing procedure consisted of asking children if, in addition to naming the pictures, they were also supposed to do something else. If the children could not answer this question, the next more specific prompt involved asking them whether they were supposed to do something when they saw certain pictures in the picture naming task. If the children were unable to answer this question as well, the final most specific prompt involved asking them what they were supposed to do when they saw a picture of an animal. All those children who are unable to answer this final question should be excluded from the analyses, as they clearly demonstrate having no memory of receiving prospective memory instructions at the beginning of the experimental session. It should be noted, however, that in all the studies that we have conducted so far, the number of such children is usually very small (but see Guajardo & Best, 2000). It is therefore unlikely that the exclusion of these children from the sample will result in the overestimation of prospective memory ability in young children.[1]

The second and more serious problem faced by developmental researchers of prospective memory concerns the necessity to adjust the difficulty and duration of the ongoing task for children in cross-sectional (and longitudinal) studies. It is obvious that naming 20 pictures will be a more difficult and resource-demanding task for 4-year-olds than it will be for 7- or 9-year-olds. For example, in a study by Kvavilashvili et al. (2001) there was a significant age effect in the time taken to name each of the four stacks of cards, with 4-year-olds being the slowest and 7-year-olds the fastest. Given that ongoing task difficulty has been shown to adversely affect prospective memory performance in adults it is possible that age effects obtained in a particular developmental study are due to deficits in processing resources for carrying out an ongoing task rather than deficits in prospective memory per se. One way to overcome this difficulty is to adjust the task duration by giving younger children fewer pictures to name than the older children. For example, in two subsequent studies Kvavilashvili, Kornbrot, and Messer (2002) and Kvavilashvili, Messer, and Kyle (2002) had 3-, 5-, 7-, and 9-year-old children process 10, 15, 20, and 25 pictures, respectively. However, even when the task duration is controlled there is still a possibility that the task is still more demanding for younger children. As shown later, if the task difficulty is not adjusted or controlled, this could significantly influence the outcomes of the study.

Another possible and perhaps more naturalistic way of equating the levels of interest in and the task difficulty of ongoing activity is to ask children to watch cartoons or play video games as part of their main ongoing activity. Playing video games is a particularly interesting possibility given that children start playing such games at a very young age and these games have become part of their everyday life.

Other Possible Methods and Tasks

Video games were initially used by Ceci and Bronfennbrenner (1985) in their famous study where children had to remember to take cupcakes out of the oven or recharge the batteries in 30 minutes and were allowed to play the video game during the delay interval. More recently, Kerns (2000) developed a simple and elegant method in which a prospective memory task is embedded in the computer game itself (see also Kerns & Price, 2001). Thus, children are introduced to a short 5-minute video game consisting of driving a car along the road. The goal is to drive as fast and as accurately as possible without hitting other vehicles on the road. For this main ongoing task children gain scores that are prominently displayed on the screen all the time. The prospective memory task consists of refueling the gas tank every time it is less than one quarter full by pressing a button on a joystick. The fuel tank can be monitored by pressing another button that brings the image of the fuel tank on the screen for 3 seconds. If the children forget to refuel the tank at an appropriate time and run out of gas, they lose all their scores accumulated at that point. Prospective memory is scored as the number of times (out of five) children run out of gas.

One remarkable aspect of this new method is that it studies time-based prospective memory in children without requiring them to have any clock-reading skills. Kerns (2000) tested children across the wide age range of 7 to 12 years. The J-shaped pattern of monitoring the fuel tank, demonstrated even by 7-year-olds, clearly indicates that the task measures time-based prospective memory (cf. Harris & Wilkins, 1982). It is obvious that this method can be used with even preschool children. Furthermore, the method can also be easily adapted to study event-based prospective memory by asking children to press the button every time they encounter a certain type of vehicle (e.g., ambulance) on their way (e.g., Wilde, 1998, cited in Kerns & Price, 2001). Clearly, this simple method opens several interesting avenues for intensive research on children's prospective memory. Another interesting and promising method developed by Martin and Kliegel (2003) involves studying children's performance in complex prospective memory tasks requiring planning, initiation, and the execution of a set of related tasks. This method is described in more detail in chapter 8 of this volume.

Having discussed methodological issues of studying prospective memory development in children we can now move on to the main findings that have emerged from published studies as well as some unpublished and current research from our laboratory.

REVIEW OF DEVELOPMENTAL RESEARCH ON PROSPECTIVE MEMORY

Research on children's prospective memory has primarily concentrated on two related and equally important questions. First, what are the effects of age on prospective memory, both in terms of the earliest age at which prospective memory skills and the development of these skills in preschool and school-age children? Second, do children possess metamemory knowledge about the best strategies for various everyday prospective memory tasks and, if yes, how effectively can they use this knowledge in their day-to-day life? We review research addressing each of these questions in turn next.

Effects of Age on Prospective Memory in Children

So far, only two studies have examined prospective memory in very young (preschool) children (Guajardo & Best, 2000; Somerville et al., 1983). All other published studies have concentrated on the development of prospective memory primarily in school-age children covering relatively short developmental age spans of 2 to 3 years and using a cross-sectional methodology. Some studies have compared prospective memory performance in either preschool to school-age children from 4 to 7 years (Kvavilashvili et al., 2001) or early school-age children from 5 to 7 years (Meacham & Colombo, 1980; Meacham & Dumitru, 1976). Other studies have used older school children comparing prospective memory performance in 7- and 10-year-olds (Passolunghi et al., 1995) or in 10- and 14-year-olds (Ceci et al., 1988; Ceci & Bronfenbrenner, 1985). Finally, only a few published papers have studied the development of prospective memory across wider age ranges of 4 to 5 years. For example, Nigro et al. (2002) studied children between 7 and 11 years, and Kerns (2000) studied children between 7 and 12 years old (see also Maylor et al., 2002). All these studies have reported variable results. We briefly review these findings before we discuss possible reasons for obtaining discrepant results across the studies.

Prospective Memory in 2- to 5-Year-Old Children The question about the earliest age at which prospective memory skills can be observed has so far been addressed only in a naturalistic study of Somerville et al. (1983). In this study, 2-, 3-, and 4-year-old children were assigned to eight different reminding tasks by their usual caregivers (mothers) over a period of 2 weeks. These tasks varied in the level of motivation, like "Remind me to buy candy at the store tomorrow morning" (high interest) or "Remind me to bring in washing after the nap" (low interest), and in the length of delay between receiving these instructions and the opportunity to carry them out (5–10 minutes vs. several hours).

The results that were obtained about the motivation and delay manipulation were highly interesting and novel at the time, and were later replicated in several adult studies on prospective memory. There was a highly significant effect of motivation explaining up to 25% of variance in children's prospective memory performance (cf. Kliegel, Martin, McDaniel, & Einstein, 2001, 2004; Kvavilashvili, 1987). There was also a significant effect of delay in that performance was better with short delays of several minutes than long delays of several hours. However, this effect was much smaller and explained only 5% of the variance in performance. This finding is in line with adult studies showing only a small or no reliable effects of delays on prospective memory performance (e.g., Einstein, Holland, McDaniel, & Guynn, 1992; Harris & Wilkins, 1982; Nigro & Cicogna, 2000). However, the most important results that emerged from this study concern the absence of any age effects on children's prospective memory. Thus, 2-year-olds were as good as 4-year-olds, with 80% success in remembering tasks with high interest and short delays (the success rate was still 50% with high interest and long delay intervals of several hours).

It was this remarkable finding that prompted researchers like Meacham (1982) and Winograd (1988) to suggest that prospective memory skills may develop particularly early for a child to cope successfully in everyday social contexts. Unfortunately, no attempt has been made to replicate this finding using similar age groups. The only other published study that has compared preschool children belongs to Guajardo and Best (2000) who studied 3- and 5-year-old children's prospective memory with a laboratory task using the Einstein and McDaniel (1990) paradigm depicted in Figure 6.1(a). The ongoing task was introduced to the children as a computer game in which they received six blocks of 10 pictures of familiar objects (5 sec per picture) and at the end of the block they had to recall as many pictures as possible. The prospective memory task consisted of pressing a key on the keyboard every time they saw a picture of a house (or a duck) as part of this "computer game."

Unlike Somerville et al. (1983), Guajardo and Best (2000) obtained a significant effect of age: 5-year-olds were reliably better at remembering to press the key than the 3-year-olds. However, postexperimental probing of children showed that 52% of 3-year-olds had difficulty remembering prospective memory instructions, as they were unable to answer the question about what it was that they were asked to do when they saw the picture of a house or duck. In addition, the ongoing free recall task was undoubtedly more difficult to 3-year-olds, who recalled significantly fewer pictures than 5-year-olds. Given these problems with methodology, it is difficult to draw firm conclusions about the nature of prospective memory development between the ages of 3 and 5 years. However, what is remarkable in this study is that 5-year-old children performed near ceiling in this computerized prospective memory task, with 50% of children remembering on all six occasions and mean prospective scores ranging between 5.05 and 5.58 across different conditions.

Prospective Memory in 5- to 7-Year-Old Children Discrepant findings have been obtained in studies covering late preschool and early school years. For example, in Meacham and Dumitru (1976), 7-year-old children were reliably better at remembering to post their drawing at the end of the session than 5-year-olds. However, no age effects were obtained in a study by Meacham and Colombo (1980) in which children had to remind the experimenter, at the end of the session, to open the surprise box. One possible explanation for discrepant findings across these two studies could be that the task of opening the surprise box was more interesting or motivating than posting the drawing and that this high level of motivation eliminated age effects.

Somewhat discrepant results for 5- and 7-year-olds were also obtained by Kvavilashvili et al. (2001), who used a modified paradigm presented in Figure 6.1(b), and described earlier. Whereas 7-year-olds performed reliably better than 5-year-olds in Experiments 1 and 2, no age effect was obtained in Experiment 3 between these age groups even though broadly similar tasks and materials were used in all three studies. Interestingly, in this study no age effects were obtained between 4- and 5-year-old children but, in both experiments, 7-year-olds were reliably better than 4-year-olds.

Prospective Memory in 7- to 14-Year-Old Children Two other studies that investigated prospective memory in older school children both found reliable age effects that, however, were qualified by interactions with some other independent variables manipulated by the researchers. For example, in Passolunghi et al. (1995), 7- and 10-year-old children were tested with a standard Einstein and McDaniel (1990) paradigm where the ongoing task consisted of 40 trials of five two-syllable words presented simultaneously on the screen for 6 seconds, which children had to read as quickly and as accurately as they could. The prospective memory tasks consisted of pressing a key on the computer keyboard whenever the word *boat* appeared on the screen as part of the ongoing word reading task. The encoding modality of prospective memory instructions was manipulated by showing children either a picture of the boat (pictorial encoding), the written word *boat* (verbal encoding), or asking them to enact the prospective memory task by actually pressing the designated key on the keyboard (motoric encoding). The results showed that age effects were present only in motoric encoding conditions, but not in pictorial and verbal encoding conditions. If anything, 7-year-olds had reliably higher scores than 10-year-olds in pictorial encoding condition in Experiment 1, and the difference between the means in Experiment 2 was in the same direction.

Furthermore, in a study by Ceci and Bronfenbrenner (1985) on 10- and 14-year-old children, the prospective memory task was remembering to take cupcakes out of the oven (or recharge the batteries) in exactly 30 minutes while being busily engaged in an ongoing task of playing a computer game in two different contexts (laboratory vs. home). Although the primary emphasis of this study was on children's time-monitoring strategies (discussed in the next section), the results concerning prospective memory performance are equally important even though they are less well known and almost never discussed in the literature. In the laboratory, prospective memory performance was at ceiling as all but 1 child remembered to remove the cupcakes or recharge the batteries on time (i.e., within the first 60 seconds of the critical time). An age effect was only present when children were tested in their own homes, with 10-year-olds being more likely to be late than 14-year-olds (58% vs. 25%). One possible explanation of this age by context interaction could be differences in motivation across the two contexts in younger children. Thus, it is possible that 10-year-olds took the prospective memory task less seriously in their own homes than in the anxiety-provoking laboratory situation.

Finally, as pointed out earlier, there are very few published studies that have examined the development of prospective memory across larger age ranges of 4 to 5 years, and these studies have also produced mixed results. For example, in Nigro et al. (2002), children whose age ranged from 7 to 11 years were busily engaged in an ongoing activity of solving problems (mathematical additions and puzzles) for 15 minutes and, in addition, had to remember to remind the experimenter to do something either at a particular time (time-based task) or when seeing another experimenter (event-based condition). Although children were more likely to remind the experimenter in the event-based than in the time-based condition, there was no effect of age ($F < 1$). On the other hand, Kerns (2000), who tested 7- to 12-year-old children using her novel computerized Cyber Cruiser task for studying time-based prospective memory (described earlier), did report a reliable age effect in a form of negative correlation between the chronological age and prospective memory performance assessed by the number of times children ran out of gas ($r = -.29$; see also Martin & Kliegel, 2003; Maylor et al., 2002).

Possible Reasons for Discrepant Findings and Conclusions

What can be concluded from this brief review of findings concerning the development of prospective memory in children? At first sight this diverse set of data may seem confusing and contradictory. We would argue that there are at least two major points that need to be taken into account when trying to interpret the variable pattern of findings. The first point is methodological, and concerns the importance of equating the difficulty of ongoing tasks across the age groups in the laboratory experiments. The second point concerns the size of age effects that have been reported. These issues are now discussed in more detail.

With two exceptions (Martin & Kliegel, 2003; Nigro et al., 2002), none of the published studies has made an attempt to equate the difficulty of ongoing tasks across the age groups used. It is obvious, for example, that in Passolunghi et al. (1995), reading sets of five words in 6 seconds would have been a much more difficult task for 7-year-olds than for 10-year-olds. Similarly, in Guajardo and Best

(2000), studying lists of 10 pictures was a substantially more demanding task for 3-year-olds than for 5-year-olds. Furthermore, Kvavilashvili et al. (2001) also reported that 4- and 5-year-old children took significantly longer to name 20 pictures in each of the four stacks of cards than 7-year-olds.

In most studies, however, age effects in the performance of ongoing tasks are not even reported. On the other hand, Kerns (2000) stressed that the ongoing task of playing Cyber Cruiser was equally engaging to children of various ages who took part in her study. Even if the game was equally interesting to children aged 7 to 12 years, this still does not eliminate the possibility that the game was more difficult to 7-year-olds than to 12-year-old children. Unfortunately, Kerns did not analyze children's performance on the Cyber Cruiser to see if there were any age effects on this ongoing computer task. It is interesting that Nigro et al. (2002), who covered a similar age range (7–11 years), but at the same time adjusted the level of difficulty of problems and puzzles that children were solving as part of their ongoing activity, did not report any age effects in event-based or time-based prospective memory. Moreover, when we reanalyzed the data of Kvavilashvili et al. (2001) and entered the time spent on naming the pictures as a covariate, the effects of age reported in this paper disappeared.

This issue is obviously less important for naturalistic studies as participants would be engaged in their habitual everyday (and mostly age-appropriate) tasks. For example, naturalistic studies on aging and prospective memory have consistently failed to obtain any significant age effects between young and old (Moscovitch, 1982; Rendell & Thompson, 1999; West, 1988, Study 1). Similarly, in the only existing naturalistic study conducted by Somerville et al. (1983) on 2- to 4-year-old children, no age effect was obtained. Taken together, the evidence seems to support the idea that in many cases significant age effects may be attenuated or even disappear when children of various ages are engaged in ongoing activities that are matched in their difficulty across the age groups.

On the other hand, it would be incorrect to conclude that prospective memory is largely age invariant and that adjusting task difficulty in the developmental studies of prospective memory will always eliminate the age effects. For example, in two unpublished studies we modified the method developed by Kvavilashvili et al. (2001) so that younger children had to process a smaller number of pictures during an ongoing activity than older children (with 3-, 5-, and 7-year-olds processing 10, 15, and 20 pictures, respectively). Nevertheless, in a study by Kvavilashvili, Kornbrot, and Messer (2002, Experiment 2) a significant age effect was found in children's prospective memory so that 7-year-olds were significantly better than 5- and 3-year-olds, who did not differ from each other. In another study using an identical ongoing activity, but a different prospective memory task (i.e., instead of putting a dog figure into a box, children had to remember to say something to the toy mole when seeing a particular picture), Kvavilashvili, Messer, and Kyle (2002) also found a significant age effect. Thus, 3-year-olds were significantly worse than 5-year-olds who did not differ from 7-year-olds, who, in turn, did not differ from 9-year-olds.

Given that age effects can be obtained even when the length and the difficulty of ongoing activities have been controlled for, an important issue that needs to be examined is the size of these age effects. Unfortunately, very few studies have reported effect sizes and often insufficient information is provided to calculate the effect sizes in these studies. However, the examination of existing studies and available data shows that effect sizes are relatively modest, especially in comparison to often dramatic developmental changes in a variety of retrospective memory tasks covering the same age range (e.g., Gathercole, 1998; Schneider & Pressley, 1997).

For example, in two experiments reported by Kvavilashvili et al. (2001), age explained a relatively small percentage of variance in 4-, 5-, and 7-year-old children's prospective memory performance (with $\eta = .08$ and .07, respectively). Moreover, in Experiment 3, the effect size was twice as large for a free recall task ($\eta^2 = .15$) than for the prospective memory task ($\eta^2 = .07$). Similarly, in the published study that has used the largest age range (7–12 years), Kerns (2000) reported a relatively small negative correlation between chronological age and the performance on the prospective memory task embedded in the Cyber Cruiser game ($r = –.29$), indicating that age explained only 8% of variance in children's prospective memory performance.

Interestingly, when the length or the difficulty of ongoing tasks is controlled, the effect sizes can become even smaller. For example, although Kvavilashvili, Kornbrot, and Messer (2002) did find an age effect in 3-, 5-, and 7-year-old children, as described earlier, this effect explained only 3% of variance in children's prospective memory of remembering to put a dog figure in the box. In contrast, very large age effects were obtained in the same study on children's performance on standard retrospective memory tasks such as digit span ($\eta^2 = .45$), picture recognition ($\eta^2 = .44$), and immediate and delayed free recall ($\eta^2 = .20$ and $\eta^2 = .16$, respectively; for the latter two tasks only the data of 5- and 7-year-olds were available).

Similar results were also obtained by Kvavilashvili, Messer, and Kyle (2002) in a study conducted on 3-, 5-, 7-, and 9-year-old children in which difficulty of an ongoing task was controlled and the prospective memory task involved a verbal response instead of an overt action of putting a dog figure in the box. Initial analyses showed a large effect size ($\eta^2 = .16$). However, this turned out to be entirely due to 3-year-olds' difficulty in remembering this verbal prospective memory task (saying something to the mole when seeing a particular picture). Indeed, when 3-year-olds were excluded from the analyses the effect of age explained only 3% of the variance in 5-, 7-, and 9-year-olds' prospective memory performance. Incidentally, the data of 3-year-olds in these two experiments seem to provide some support for the idea that "prospective memory may be superior for intentions requiring motor response than for those requiring verbal … response" (Freeman & Ellis, 2003, p. 990). This is clearly an issue that merits further investigation in adults and especially in young children.

One final example of dramatic changes that may occur in effect sizes due to experimental manipulations was recently reported by McGann, Defeyter, Ellis, and Reid (2005). They conducted two experiments on 4-, 5-, and 7-year-old children using a modified paradigm presented in Figure 6.1(b). In Experiment 1, children had to name each of the four blocks of 20 pictures presented on the computer screen (the ongoing task), with each block being preceded by drawing a picture for Rosie the rag doll. The prospective memory task involved remembering to press a key on the computer keyboard every time they saw a food picture that Rosie "could collect for her picnic" (the prospective memory task). In Experiment 2, children had to name and manually sort the four stacks of 20 cards into categories. Moreover, the length of the ongoing task was controlled by allowing each child to engage in this task for only 1 minute. Finally, the prospective memory task consisted of taking a picture with a food item and putting it into Rosie's lunch box. Significant age effects were obtained in both experiments. However, whereas age explained 20% of variance in Experiment 1, it explained only 7% of variance in Experiment 2, in which children were engaged in a more meaningful prospective memory task and in which the length and possibly the difficulty of the ongoing card naming and sorting task was controlled. In addition, in Experiment 2, there was an interesting age by target salience interaction so that the effect of age was present only when prospective memory targets were the same size as the nontarget pictures. When prospective memory targets were slightly larger in size than most of the nontarget pictures, there were no age effects in 4-, 5- and 7-year-old children.

Taken together, the existing evidence appears to suggest that although prospective memory does develop with age, the developmental changes are modest at best and can be reduced even further by testing children with meaningful and interesting prospective memory tasks (e.g., McGann et al., 2005) or by adjusting the difficulty of ongoing activities (Kvavilashvili, Kornbrot, & Messer, 2002). Is this relatively good ability of remembering to carry out prospective memory tasks accompanied by equally good metamemory for processes and strategies involved in successful prospective remembering?

Effects of Age on Metamemory for Prospective Memory Tasks in Children

As pointed out earlier, this question consists of two related issues. The first concerns children's knowledge of processes and strategies that can enhance performance in everyday prospective memory tasks. This issue has been examined by Kreutzer et al. (1975) and Beal (1985) by using an interview and questionnaire method. The second issue concerns children's actual ability to utilize these strategies in prospective memory tasks that they have to carry out in everyday life. This question has so far been addressed in a study by Ceci and Bronfenbrenner (1985; see also Ceci et al., 1985) and Kerns (2000), who studied children's monitoring behavior in time-based tasks.

Children's Knowledge of Strategies for Prospective Memory Tasks Kreutzer et al. (1975) conducted the first and seminal study on children's strategic knowledge of several everyday (primarily retrospective) memory tasks such as remembering where one could have left one's jacket at school, remembering Christmas when a particular present was given, or how to memorize a categorical set of nine pictures (three pictures from three different categories). The most famous and often cited question concerned children's strategic knowledge of a typical prospective memory task. Specifically, children were asked to list every possible strategy they could think of to ensure that they would remember to take their skates to school the next morning. Four age groups were tested: kindergarten (4–5 years), first grade (6–7 years), third grade (8–9 years), and fifth grade

(10–11 years) children. Children's answers to the skates question fell into four categories, three of which referred to external strategies and one to internal strategy (i.e., periodic rehearsal of the task in one's mind). The external strategies involved the physical manipulation of skates (e.g., putting them near the door), the use of external reminder cues other than the skates (e.g., writing a note), or soliciting help from others (e.g., asking a parent to provide a reminder).

The results showed that there were no marked age effects in the tendency to list one versus another of these four strategies. Even the kindergarteners were able to come up with at least one strategy each. There was also a clear preference for external strategies, as only 16% of children suggested using the internal rehearsal strategy. It is interesting that in a naturalistic study, when college undergraduates had to remember to send postcards to the experimenter on prearranged dates, a similar small percentage of students (i.e., 20%) reported having actually used the internal strategy of rehearsing the task in their mind (Meacham & Singer, 1977). Overall, however, older children (the third and fifth graders) listed more strategies than younger children (kindergarteners and first graders) and the strategies that they described were more explicitly planful and means–ends-oriented than those reported by younger children. Similar results were obtained for another prospective item from the Kreutzer et al. (1975) questionnaire that asked children what they needed to do to ensure that they would not forget an upcoming event (e.g., a friend's birthday). Here again, even the youngest children could come up with a strategy or two, with more and increasingly planful strategies reported by older children.

In contrast, marked age effects were obtained in the same study with several retrospective items, such as how to remember an event from a previous Christmas or how to memorize a categorical list of nine pictures. For example, in relation to the Christmas question, 5-year-olds could hardly understand the task, whereas 7- and 9-year-olds said they would solicit help from adults. Only 11-year-olds produced more varied strategies, but even with this age group there was plenty of scope for further improvement. This contrasting pattern of findings concerning prospective and retrospective items was subsequently replicated in several other studies using similar questions (e.g., Cavanaugh & Borkowski, 1980; Kurtz & Borkowski, 1984; see also Farrant, Boucher, & Blades, 1999, for using the prospective questions in children with autism).

Another well-known study on children's metamemory of prospective memory tasks, using a similar interview method, was conducted by Beal (1985, Study 1). Unlike Kreutzer et al. (1975), Beal tested children's knowledge of the effectiveness of different types of cues in everyday prospective memory tasks. Moreover, in addition to children, she also tested a group of college undergraduates. Children (5-, 6-, and 8-year-olds) and young adults were given the descriptions of six different prospective memory task scenarios together with two alternative reminder cues that the protagonist could use to help him or her successfully remember the task (e.g., remembering to take out trash or calling a friend after school, etc.). Participants had to choose the effective reminder out of two and provide justification for their choice. The three scenarios concerned the cue informativeness (e.g., that the cue should be nonambiguous or sufficiently detailed to act as an effective reminder, etc.), and the other three, the cue placement (e.g., that the cue should be easily noticeable or that it should be encountered at the right time, etc.).

The results showed that there were no statistically reliable differences in the number of correct responses in 5-, 6-, and 8-year-old children. However, whereas 5- and 6-year-olds were significantly less accurate than adults, 8-year-olds were as good as adults in four out of six target scenarios. It is also important to note that, in comparison to adults and 8-year-olds, young children were somewhat disadvantaged by having to provide verbal justification for their choices. In addition, both 8-year-olds and especially adults performed at ceiling in several of the six target scenarios. Despite these difficulties in interpreting the results, on the whole, the results seem to be in line with the findings of Kreutzer et al. (1975) and indicate that young children, and especially 8-year-olds, may have a fairly good understanding of the basic nature and functions of reminders in prospective memory tasks.

One problem that these studies share is that they assess children's metamemory knowledge of memory situations (i.e., declarative metamemory) rather than their actual strategic behavior in everyday prospective memory tasks (i.e., procedural metamemory). There is evidence in the literature showing that although children may have an adequate knowledge of a strategy suitable for a particular retrospective memory task, they might not use it in an actual memory test situation (e.g., Fabricius & Wellman, 1983; Schneider & Pressley, 1997). None of the developmental studies has examined children's spontaneous use of external strategies in prospective memory tasks such as remembering to take skates to school. This is an interesting topic that awaits future investigation. There are, however, three published studies that have examined children's strategic monitoring behavior in time-based prospective memory tasks.

Children's Use of Strategies in Prospective Memory Tasks In their cupcake and battery recharging study, Ceci and Bronfenbrenner (1985) were primarily interested in 10- and 14-year-old children's strategic clock monitoring behavior during the 30-minute delay interval filled with playing a computer game. An earlier study by Harris and Wilkins (1982) had shown that when young adults had to remember to carry out a time-based task at 3- or 9-minute intervals while watching a film, their clock checking prior to each critical time resembled the J-shaped pattern: Participants checked the clock initially a few times, then the clock checking dropped for some time until it dramatically increased in the period immediately preceding the critical time. Ceci and Bronfenbrenner wanted to see if 10- and 14-year-olds would also engage in this strategic clock monitoring displayed by adults and whether this behavior would vary as a function of context. Thus, an interesting aspect of this study was that half of the children were tested in the laboratory by the trained psychology undergraduate who was unknown to them and the other half were tested at home by their older siblings (also psychology undergraduates).

The results showed entirely different clock monitoring patterns in these two contexts. In the more anxiety-provoking environment of the psychology laboratory, in which the prospective memory task was probably perceived as quite important, the number of clock checks linearly increased, with the highest number being made in the last 5 minutes of the delay interval. Although this strategy was not most parsimonious, given the large number of clock checks that children had to make, it paid off in that all but 1 child remembered to take out the cupcakes (or recharge the batteries) on time. In contrast, in the more relaxing and familiar environment (i.e., at home), those children who remembered to take out the cupcakes on time demonstrated strategic monitoring that resembled the U-shaped pattern. Thus, children checked the clock quite frequently in the first 10 minutes of the delay interval as if trying to synchronize or calibrate their internal clock with the elapsed time shown by the external clock. After this, the number of clock checks dropped markedly for some time until it again sharply increased in the last 5 minutes of the delay period. Interestingly, there were no marked age effects in clock monitoring. Although overall younger children made more clock checks than older children, the pattern of clock checks was similar across age groups in both contexts.

These findings are remarkable for two reasons. First, they show that children can use different clock monitoring strategies as a function of context. In the laboratory, where the consequences of forgetting the prospective memory task were probably perceived as less acceptable, children chose to use the less parsimonious but safer strategy of linearly increasing monitoring. At home, however, where children were more relaxed and probably deemed the forgetting of the prospective memory task as more acceptable, they chose to use a completely different U-shaped pattern of monitoring. Second, this U-shaped pattern of monitoring indicates that 10- and 14-year-old children, if necessary, can engage in fairly complex strategic behavior that involves temporal calibration of internal clocks at the beginning of the delay interval. As a result of this calibration, the overall number of clock checks is substantially reduced, allowing children to deploy their attentional resources elsewhere (in this case on playing the computer game).

To study this temporal calibration strategy in more detail Ceci et al. (1988) conducted a follow-up study in which 10-year-old children had to carry out the same prospective memory task at home as before, but the speed of clocks was manipulated (accelerated or decelerated by 10%, 33%, or 50%). The results showed that 10-year-olds managed to successfully use the temporal calibration strategy (reflected in the U-shaped pattern of monitoring) in conditions in which the time on the external clocks was accelerated or decelerated by 10% and 33%. However, when the time was accelerated or decelerated by as much as 50%, children chose a linearly increasing pattern of monitoring instead, as if realizing that they could no more trust their internal estimation of time that did not seem to match the one shown by the external clock.

The findings of Ceci and his colleagues were recently replicated by Kerns (2000) in 7- to 12-year-old children who, in the course of the computer game Cyber Cruiser, had to periodically check the levels of a gas tank and refuel it whenever it reached a certain critical level. The gas tank ran out of the fuel five times in the course of this computer game (approximately once every 60 seconds). The findings showed that there was no age effect in the pattern of strategic monitoring. All children, irrespective of age, displayed the J-shaped pattern of monitoring originally reported by Harris and Wilkins (1982) on young adult participants. Mäntylä and Carelli (2005) also reported the J-shaped pattern when they studied time monitoring and time estimation across the life span in children (8–12-year-olds), young adults, and older adults. Moreover, children were as good as young adults at a time estimation task in which they had to reproduce short time intervals of 4 to 32 seconds.[2]

Conclusions Taken together, the results of Ceci and colleagues and Kerns (2000) show that young children can use fairly complex monitoring strategies in time-based prospective memory tasks. However, an intriguing aspect of these findings is that children may be using these strategies fairly automatically without much conscious knowledge of what they are doing. For example, when Ceci and Bronfenbrenner (1985) probed their participants at the end of the session, children seemed to be unaware or unable to verbally formulate the temporal calibration strategy that they were exhibiting in their behavior (i.e., they seemed to be unaware of the fact that they checked the clock more frequently at the beginning than in the middle of the delay period). Ceci and Bronfenbrenner (1985) argued that if the temporal calibration strategy is indeed deployed automatically then "this would help explain why young children appear to be adept at its use, as automatic processing has been shown to be age-invariant" (p. 162).[3]

CONCLUSIONS AND FUTURE DIRECTIONS

The research on prospective memory development in children is surprisingly small and still in an embryonic stage, even after almost three decades of prospective memory research. Moreover, the few studies conducted in this area have varied considerably in their choice of age range, research questions, manipulated variables, and the research methodology. This diversity is also reflected in the highly variable and often inconsistent patterns of results obtained in these studies. However, despite these problems, an overriding theme that is starting to emerge from the studies reviewed in this chapter is that the age effects are often weak and highly dependent on experimental manipulations (e.g., target event salience, modality, etc.) and changes in methodology (e.g., equating the difficulty or the length of the ongoing activity, task interest, etc.).

Thus, even 2- to 4-year-old children seem to be able to remember high-interest tasks over short delays 80% of the time (Somerville et al., 1983) and in the past, in our own work, we have experienced difficulties eliminating ceiling effects in the performance of preschool children with such meaningful (and interesting) tasks as remembering to feed a toy dog with a bone (see also Guajardo & Best, 2000, for near-ceiling performance obtained in 5-year-olds). Moreover, in those studies that do obtain reliable age effects, the effects are relatively small (e.g., Kerns, 2000; Kvavilashvili et al., 2001), and they can disappear altogether when the difficulty of the ongoing activity is adjusted across the age groups (e.g., Nigro et al., 2002). In addition, the age effects seem to be highly sensitive to different experimental manipulations reflected by interactions of age with several different independent variables such as experimental context (Ceci & Bronfenbrenner, 1985), target salience (McGann et al., 2005, Experiment 2), and target modality (Passolunghi et al., 1995).

Taken together, these initial findings and observations seem to suggest that prospective memory may be relatively well developed in preschoolers as originally proposed by Meacham (1982) and Winograd (1988). Moreover, the developmental trajectory from preschool to early and later school years might not be as sharp as in the case of some retrospective memory tasks (but see Maylor et al., 2002). Additional support for this idea comes from the studies on metamemory and strategy use in children showing that even children as young as 7 years old can use a fairly complex temporal calibration strategy in time-based prospective memory tasks (e.g., Kerns, 2000; see also Ceci et al., 1988; Ceci & Bronfenbrenner, 1985). Somewhat surprisingly, Ceci and Bronfenbrenner (1985) found that 10- and 14-year-old children were unable to verbalize the key aspects of the temporal calibration strategy, suggesting that it was probably used automatically without much effort or conscious awareness on their part.

There is currently much debate and research about the underlying mechanisms of prospective memory. Several contrasting theoretical models have been developed and tested with some models suggesting that prospective remembering entirely relies on automatic retrieval processes (Guynn, McDaniel, & Einstein, 2001; McDaniel et al., 1998) and others that it is due to self-initiated rehearsal and strategic monitoring (Shallice & Burgess, 1991; Smith, 2003). However, McDaniel and Einstein (2000) proposed that the retrieval of prospective memory tasks can be mediated by either of these processes. According to their multiprocess account, although prospective remembering relies predominantly on automatic processes, under particular conditions (e.g., when the target event is not salient) it is necessary to adopt a more strategic mode of operation like periodic rehearsal of an intention or monitoring the time or environment. Direct empirical evidence in support of this new framework comes from several recent experiments conducted by McDaniel and Einstein and their colleagues (e.g., Einstein et al., 2005; McDaniel & Einstein, 2000).

Interestingly, the pattern of findings emerging from developmental research appears to provide additional support for this model. Thus, the findings that young children display fairly good prospective memory performance under some conditions (e.g., high motivation, salient target event), and that they can employ a temporal calibration strategy without being consciously aware of it indicate that prospective remembering is indeed (at least partly) mediated by automatic processes. On the other hand, the significant age effects obtained in several studies indicate that prospective memory can also be mediated by more conscious strategic processes. Thus, the future developmental research on prospective memory may turn out to be a particularly useful testing ground for the multiprocess framework. Of particular importance would be to investigate the interactions of age with several variables such as motivation, target salience, and cue action association to find the conditions that are more conducive for automatic or strategic processing.

There are at least two other lines of research that can further inform and contribute to the debate about the nature of underlying mechanisms of prospective memory. The first line would be to study prospective memory performance in very young children. Currently there is only one published study on

2- to 4-year-olds (Somerville et al., 1983) with encouraging results, and it will be necessary to replicate and extend these initial findings. Second, it will be necessary to conduct studies in which children's prospective memory performance will be compared to adults' performance. Making the ongoing activities and experimental situation comparable across such a wide age range is quite challenging methodologically but not entirely impossible, as shown by the results of a recent study conducted in our laboratory (Kvavilashvili & Taylor, 2004).

In this study, 5-year-olds and young undergraduates with a mean age of 21 years ($SD = 6.76$) had to remember to say something when they encountered a picture of a horse (specific instruction) or a picture of an animal (general instruction) in a later picture naming task containing either 10 or 30 line drawings, depending on the age group (children and adults, respectively). The participants had to also make a prediction of whether they thought they would remember to carry out this task or not. After a short 10- to 15-minute delay interval filled with listening to a story from a picture book (children) or a taped story by Edgar Allan Poe (adults), participants had to name the line drawings presented either on the computer screen (adults) or manually on picture cards (children). The target picture of a horse occurred only once in the 7th or 21st position for children and adults, respectively.

The results showed that 5-year-olds were much more accurate in predicting their prospective memory performance than adults. In addition, although there were no differences across age groups in the general instruction condition, 5-year-olds were significantly better than adults in the specific instruction condition. Although these results are both interesting and encouraging, they need to be interpreted with caution as experimental tasks and instructions were not identical in the two age groups. For example, children were introduced to the toy mole Morris, who was absent in the adult group, and children and adults were exposed to different storybooks in the delay period. Most important, due to experimenter error, the children's storybook contained several animals (but no prospective memory target, the horse), which could have served as inadvertent reminders and enhanced children's performance (see, e.g., Taylor, Marsh, Hicks, & Hancock, 2004). We are currently conducting a follow-up experiment in which the tasks and instructions are more comparable across the two age groups.

Another very useful avenue for future research is studying the developmental trajectories of prospective memory tasks and comparing them to those of retrospective memory tasks (e.g., Kvavilashvili, Kornbrot, & Messer 2002; Kvavilashvili et al., 2001, Experiment 3; Maylor et al., 2002). The question about the relationship between prospective and retrospective memory is an important one and has been examined since the beginning of prospective memory research in the 1970s. However, the results of correlational studies have proved to be disappointing due to the difficulty of obtaining significant correlations between the two tasks. An alternative way of addressing this issue, suggested by McDaniel (1995), is to examine the effects of important variables, such as age, motivation, delay interval, and so on, on both prospective and retrospective memory tasks to see if different patterns emerge under these two conditions. The best example of such study is the one conducted by Hicks et al. (2000) in which the contrasting effects of delay intervals

(2.5 minutes vs. 5 minutes vs. 15 minutes) were obtained for an event-based prospective memory task and the retrospective memory tasks of free and cued recall that were closely matched with the event-based task on several task dimensions. It is obvious that directly comparing the age effects on a variety of closely matched prospective and retrospective memory tasks in future developmental studies can provide invaluable insights into the question about the similarities and differences that may exist between these two types of tasks.

One additional and fruitful avenue for research on this question would be to compare children's (as well as adults') metamemory predictions in simple prospective and retrospective tasks. For example, in Kvavilashvili and Taylor (2004), described earlier, 5-year-old children were quite good at predicting their performance on a prospective memory task but grossly overestimated their performance on a simple retrospective memory task (i.e., recalling 10 line drawings). Findings concerning retrospective prediction accuracy are in line with the results of several early metamemory studies on retrospective remembering (e.g., Levine, Yussen, DeRose, & Pressley, 1977; Yussen & Berman, 1981). Interestingly, young adults seemed to perform at chance level for both prospective and retrospective memory tasks.

In conclusion, we believe that the developmental studies have a lot to offer to the general research on prospective memory as shown by this discussion and the review of the relevant literature. Moreover, there are already promising signs of renewed interest into this unduly neglected area, with several papers presented at the 2nd International Conference on Prospective Memory in July 2005 being developmental. If this trend continues, we may witness particularly important and rapid developments in the research on children's prospective memory in the future.

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ENDNOTES

[1] We are grateful to Matthias Kliegel for pointing out this possibility to us.

[2] You may have noticed some discrepancy in the findings of Ceci and Bronfenbrenner (1985), who found the U-shaped curve, and all the other studies reviewed in this chapter that reported the J-shaped curve. According to Kerns (2000), this slight discrepancy could be entirely due to the repeated nature of prospective memory task in her (and the other) studies. Thus, with each consecutive delay interval, the calibration of the internal clock would be less and less necessary resulting in the J-shaped rather than the U-shaped pattern when averaged over several delay intervals.

[3] However, if children use temporal calibration strategy automatically, as suggested by Ceci and Bronfenbrenner (1985), this raises an issue about the definition of strategy. Is an automatically deployed strategy a strategy in its traditional sense used in the developmental research? We are grateful to Matthias Kliegel for pointing this out to us. However, the discussion of this important question is outside the scope of this chapter.