Don’t forget to remember –
Prospective memory across the lifespan

DISSERTATIONSSCHRIFT

zur Erlangung des akademischen Grades

Doctor rerum naturalium
(Dr. rer. nat.)

vorgelegt
der Fakultät Mathematik und Naturwissenschaften
der Technischen Universität Dresden

von

Dipl.-Psych. Ingo Aberle

geboren am 26.05.1980 in Groß-Gerau

Gutachter:  Prof. Dr. Matthias Kliegel
Prof. Dr. Clemens Kirschbaum

Eingereicht am:  13.05.2009
Tag der Verteidigung: 28.10.2009
Acknowledgement

At this point, I would like to thank the people who supported me during the time of writing down this thesis. Firstly, I would like to thank Prof. Matthias Kliegel for his comprehensive support and for giving me the opportunity to work with him and learn from him over the last years. I have appreciated our collaboration on a professional and on a personal level. Furthermore, I would like to express my thankfulness to Prof. Kirschbaum for his willingness to evaluate my thesis and to Prof. Wegge for his willingness to be examiner at my viva.

In addition, I wish to thank my colleagues for their scientific support and for being more than just people working together.

Most of all, I would like to thank my parents Elfriede and Wolfgang, my brother Oliver and Ulrike, and a special thanks to Christine, for supporting me all the way and for providing the comfort of always having someone to turn to.

Finally, I am grateful to all the people in Zurich and Dresden who helped me with data collection and the participants who took part in the studies – this work would not exist without their help.
Contents

1. Abstract .............................................................................................................................................. 1

2. Introduction ....................................................................................................................................... 3
   2.1 Differences in prospective and retrospective memory (“What”).................................................. 4
   2.2 Characteristics of prospective memory ........................................................................................... 5
   2.3 Developmental perspective on prospective memory (“When, how and which mechanisms”) .... 8
      2.3.1 Age effects in prospective memory performance across the lifespan: children ................... 8
          2.3.1.1 Time-based prospective memory performance in early childhood and pre-school age ..... 10
          2.3.1.2 Time-based prospective memory performance in school age ..................................... 11
          2.3.1.3 Time-based prospective memory performance in adolescence ................................... 14
          2.3.1.4 Event-based prospective memory performance in early childhood and pre-school age .............................................................. 14
          2.3.1.5 Event-based prospective memory performance in school age ..................................... 18
          2.3.1.6 Event-based prospective memory performance in adolescence ................................... 28
          2.3.1.7 Event-based prospective memory performance across the lifespan ................................ 29
          2.3.1.8 Summary of age effects in prospective memory performance in childhood .................. 31
      2.3.2 Age effects in prospective memory performance across the lifespan: adulthood and old age ... 33
      2.3.3 Summary of age effects in prospective memory performance across the lifespan ................. 38
   2.4 Multiprocess framework of prospective memory (“Which mechanisms”) .................................. 39

3. Aims and Research Questions ........................................................................................................ 45
   3.1 Does motivation affect prospective memory performance in pre-schoolers? ............................. 45
   3.2 Are ongoing task absorption, target distinctiveness and cue focality related to prospective memory performance in school children? ........................................................................ 47
   3.3 Can task setting and motivational effects dissolve the age prospective memory paradox? ........ 48
   3.4 Summary of the research questions ............................................................................................ 49

4. Empirical Studies ............................................................................................................................ 51
   4.1 Study 1: Prospective memory development in pre-schoolers ...................................................... 51
      4.1.1 Introduction ........................................................................................................................... 51
      4.1.2 Method ................................................................................................................................. 54
      4.1.3 Results .................................................................................................................................. 56
      4.1.4 Discussion ............................................................................................................................ 58
   4.2 Study 2: Prospective memory development in school children ................................................... 62
4.2.1 Introduction ......................................................................................................................... 62
4.2.2 Experiment 1 ........................................................................................................................ 68
  4.2.2.1 Method .......................................................................................................................... 68
  4.2.2.2 Results and Discussion ................................................................................................. 72
4.2.3 Experiment 2 ........................................................................................................................ 74
  4.2.3.1 Method .......................................................................................................................... 74
  4.2.3.2 Results and Discussion ................................................................................................. 74
4.2.4 Experiment 3 ........................................................................................................................ 76
  4.2.4.1 Method .......................................................................................................................... 76
  4.2.4.2 Results and Discussion ................................................................................................. 77
4.2.5 General Discussion .............................................................................................................. 80

4.3 Study 3: Prospective memory development in adulthood ......................................................... 83
  4.3.1 Introduction ......................................................................................................................... 83
  4.3.2 Experiment 1 ........................................................................................................................ 88
    4.3.2.1 Method .......................................................................................................................... 88
    4.3.2.2 Results and Discussion ................................................................................................. 93
  4.3.3 Experiment 2 ........................................................................................................................ 95
    4.3.3.1 Method .......................................................................................................................... 96
    4.3.3.2 Results and Discussion ................................................................................................. 98
  4.3.4 General Discussion .............................................................................................................. 99

5. General Discussion ........................................................................................................................ 105
5.1 Discussion of research questions .............................................................................................. 105
  5.1.1 Motivation and prospective memory in pre-schoolers ....................................................... 105
  5.1.2 Ongoing task absorption, target distinctiveness and cue focality and prospective memory in
        school age ................................................................................................................................. 107
  5.1.3 Task setting and motivation in prospective memory in adulthood and old age ................. 110
5.2 Conceptual implications of the present findings: Prospective memory across the lifespan ..... 113
  5.2.1 Does prospective memory develop across the lifespan? .................................................... 114
  5.2.2 Is the multiprocess approach suitable to elucidate age-differences within prospective
        memory development? ............................................................................................................. 116
5.3 Outlook ..................................................................................................................................... 119
5.4 Summary ................................................................................................................................... 124

6. References ...................................................................................................................................... 126
List of Tables and Figures

Table 1. Factors of the multiprocess framework (McDaniel & Einstein, 2000)......................... 40
Table 2. Percentage of children who correctly performed the prospective memory tasks for both motivation conditions and age groups. ................................................................. 57
Table 3. Ongoing task performance (car crashes) in Experiment 1, Study 2. ............................ 72
Table 4. Ongoing task performance (car crashes) in Experiment 2, Study 2. ............................ 75
Table 5. Ongoing task performance (car crashes) in Experiment 3, Study 2. ............................ 77
Table 6. Characteristics of Participants in Experiment 1, Study 3. ......................................... 89
Table 7. Characteristics of Participants in Experiment 2, Study 3. ......................................... 97

Figure 1. Available developmental studies on prospective memory across childhood until the age of 13. .................................................................................................................... 9
Figure 2. Procedure of Study 1............................................................................................... 55
Figure 3. Screenshot of the Dresden Cruiser........................................................................ 70
Figure 4. General Procedure of Study 2 ............................................................................. 70
Figure 5. Prospective memory performance in Experiment 1, Study 2................................. 73
Figure 6. Prospective memory performance in Experiment 2, Study 2................................. 75
Figure 7. Prospective memory performance in Experiment 3, Study 2................................. 78
Figure 8. Prospective memory performance after covarying ongoing task performance in Experiment 3, Study 2.......................................................................................... 79
Figure 9. Computer screen display of German version of Virtual Week............................... 90
Figure 10. Mean proportions of correct responses on the laboratory prospective memory task by age group................................................................................................................. 94
Figure 11. Mean proportions of correct responses on the naturalistic prospective memory task by each age group for the two incentive conditions................................................. 98
Figure 12. The multiprocess framework (McDaniel & Einstein, 2000)................................. 116
1. Abstract

Prospective memory refers to the ability to remember to carry out delayed intentions, more precisely, to remember to initiate and execute an intended action at some point in the future. The development and progression of prospective memory across the lifespan is still heavily under debate. Only few studies have so far investigated prospective memory development in childhood, revealing an inconsistent pattern. In adulthood, studies in the laboratory and naturalistic studies showed paradoxical results with age deficits in the laboratory and age benefits in naturalistic tasks. Up to now, no conceptual model has been suggested to guide research on prospective memory development across the lifespan. Thus, the present work examined the effect of central factors from the multiprocess framework (McDaniel & Einstein, 2000) on the development of prospective memory in four different age-groups: pre-schoolers, school-age children, young and old adults.

The first study explored the role of task motivation in age differences in prospective memory performance across the pre-school age-range. No main effect of age or motivation in prospective memory performance was found, yet a significant interaction, indicating that for younger children motivation or task importance may help allocating the available resources to the task elements of interest.

Evidence from the second study indicated that 9-10 year old school children outperform 6-7 year old school children on a measure of prospective memory, and that retrieval-based factors (ongoing task absorption, cue salience, cue focality) systematically influenced performance. Of particular importance for possible developmental mechanisms was the finding of an age x cue focality interaction, suggesting that age effects may be modulated by cue focality.

The third study examined the effect of task setting in a laboratory procedure and the effect of motivation in a naturalistic procedure on prospective memory performance in young
and older adults. Results from the laboratory prospective memory procedure revealed significant age-related decline for irregular tasks but not for regular and focal tasks. In addition, in the naturalistic procedure, the age benefit was eliminated when young adults were motivated by incentives.

Results from the present work indicated that already pre-school age children were able to remember to perform intended actions and this ability increased across school-age. In adulthood, the results revealed a decline with age on a pure performance level. Yet, older adults may be able to compensate for basic cognitive impairments if task conditions reduce the need for controlled attention. Furthermore, the present work suggest, that factors of the multiprocess framework may indeed affect age-differences in prospective memory performance throughout the lifespan, as cue focality and task importance were related to prospective memory development in children and adults. Thus, the multiprocess approach might serve as foundation for a lifespan theory of the development of prospective memory.
2. Introduction

“If you wish to forget anything on the spot, make a note that this thing is to be remembered.”

_Edgar Allen Poe_

“I am grown old and my memory is not as active as it used to be. When I was younger, I could remember anything, [...].”

_Mark Twain_

The quotes of Poe and Twain mark the roadmap of the present thesis. Edgar Allen Poe addresses the fact that the ability to remember things one wants to do in the future is surprisingly error-prone. However, this ability is needed in daily life on many occasions. Since most of daily memory failures are due to problems in the ‘future memory’ (Kliegel & Martin, 2003), so called prospective memory, this topic recently attracted much interest, reflected by a growing body of literature (Kliegel, McDaniel, & Einstein, 2008).

Mark Twain’s quote, on the other hand, refers to developmental changes in memory performance, often assumed as a negative progression in older age (e.g. Delbecq-Derouesne & Beauvois, 1989). Most research on memory aging has focussed on remembering previously acquired information, so called retrospective memory (Einstein et al., 2005; Ellis & Kvavilashvili, 2000). Importantly, because various cognitive processes show different age-related trajectories, the assumption of a general age-related decline in cognitive performance is not confirmed (e.g. Park, 1996).

Taken together, the development and progression of prospective memory is still heavily under debate (Maylor, 2008). The present thesis aims to address this issue by applying the prototypical question of developmental psychology: "What develops when and how
because of which mechanisms?”. In this case, “what” refers to the ability of prospective memory, while “when” and “how” refer to the descriptive aspects of the development of prospective memory across the lifespan. Taking multiple possible developmental mechanisms into account, McDaniel and Einstein (2000) proposed a multiprocess framework, incorporating a series of factors that are assumed to be related to prospective memory performance. The present thesis will systematically analyze the effects of essential factors from the multiprocess approach on the development of prospective memory across the lifespan. Prospective memory performance in pre-schoolers, school children, young and older adults will be investigated in three empirical studies comprising 6 experiments. Finally, an outlook with possible future perspectives of developmental prospective memory research will be presented.

2.1 Differences in prospective and retrospective memory (“What”)

The term ‘prospective memory’ refers to the ability to remember to carry out delayed intentions, more precisely, to remember to initiate and execute an intended action at some point in the future (Brandimonte, Einstein, & McDaniel, 1996; Kliegel, McDaniel et al., 2008). Examples of everyday prospective memory tasks are to remember to do one’s homework, to take a cake out of the oven or to take medicine at a certain time. Prospective memory is contrasted with retrospective memory, which reflects the ability to remember information from the past, including processes of recall and recognition of previously acquired information (e.g. Craik, 1986). Typical everyday tasks requiring retrospective memory are to remember a phone number, to remember the name of familiar people or to recall moments from the last holiday. Therefore, externally prompted retrieval is a feature of retrospective memory tasks, while prospective memory tasks are characterized by self-initiated retrieval of delayed intentions. Without many studies available at this point, already
in his framework on age effects within the general memory domain, Craik (1986) proposed that the increasing need for self-initiated retrieval leads to more effortful memory processes. Self-initiated retrieval becomes necessary because of the absence of external cues (as in prospective memory tasks). Thus, age effects were assumed to be more distinct in prospective memory than in retrospective memory.

2.2 Characteristics of prospective memory

Ellis and Freeman (2008) referred to prospective memory as an ‘umbrella term’, describing both the type of task and the underlying cognitive processes of performing delayed intentions. In addition, the term of prospective memory implies that the key feature is a memory component. Although memory processes are part of the prospective memory process, the term may blanket the various additionally associated variables (e.g. action control, planning). Other terms were proposed to overcome this ambiguity (e.g. Ellis, 1996, suggested “realizing delayed intentions”), yet the present thesis will adopt the broad definition of prospective memory, process and task, since it is most widely accepted in the scientific community.

The process of prospective remembering can be subdivided in several sub-sequences (Ellis, 1996). Kliegel, Martin, McDaniel, and Einstein (2002) proposed a process model of prospective memory consisting of four phases: intention formation, intention retention, intention initiation and intention execution. In the first phase, intention formation, the intention to perform an action at some point in the future is formed, often accompanied by making a plan of this action. Also at this stage, the intention of performing the adequate action at the appropriate point in time is encoded. The formation of the intention is followed by a period during which the intention is retained, intention retention, while an ongoing activity is performed. Although continuous rehearsal of the intention is inhibited by the
ongoing activity, the intention must be kept in active memory. At the appropriate point in
time at which the action should be implemented, the intention needs to be initiated. At this
occasion, intention initiation, the ongoing activity has to be interrupted to realize the intended
action. At the final phase, intention execution, the intention finally needs to be carried out to
perform the prospective memory task properly. This process model can be applied to daily
activities. If for example one wants to visit a friend at the hospital in the evening (intention
formation), this intention needs to be kept in memory throughout the day at the office
(intention retention), but on the way home one has to remember this intention and take the
correct turn (intention initiation) to visit the friend at the hospital (intention execution).

Einstein and McDaniel (1990) proposed the distinction of at least two general components of
prospective memory, a retrospective component and a prospective component. The former
refers to the ability to retrieve the content of the prospective action (i.e. *what* has to be done)
and the appropriate context or point of time (i.e. *when* has it to be done) to perform the action.
The latter refers to the self-initiated retrieval of the intention of action performance (i.e. *that* it
has to be done) at the appropriate moment (Einstein, Holland, McDaniel, & Guynn, 1992;
Ellis, 1996; Smith & Bayen, 2006). In sum, the process of prospective remembering is not a
unitary operation but rather a multiprocess structure consisting of various cognitive abilities
and cognitive processes, e.g. higher order cognitive processes needed for planning,
controlling and execution of the action (Ellis, 1996; Kliegel et al., 2002).

To mirror this structure on a task level, prospective memory tasks are always
performed in a dual-task situation comprising the prospective memory task and the ongoing
activity (Ellis & Kvavilashvili, 2000). In order to execute the prospective memory task, an
absorbing ongoing activity has to be interrupted. Thus, besides being engaged in the ongoing
activity (e.g. talking to a friend on the way home), the prospective memory task has to be
carried out at an appropriate point of time (e.g. post a letter when passing a post box) while
performing the ongoing activity (Ellis & Kvavilashvili, 2000). Present laboratory tasks apply
such a dual-task situation, but in a controlled setting. In their seminal paper, Einstein and McDaniel (1990) presented a paradigm consisting of a prospective memory task and an ongoing activity, referred to as the ongoing task. While participants were busily engaged in performing the ongoing task (e.g. remembering the words that occur on a computer display), they were asked to perform the prospective task whenever a certain cue occurred (e.g. when the word “rake” occurred on the screen). Hence, participants had to interrupt working on the ongoing task in order to carry out the intended action. The ongoing task was implemented to mimic the naturalistic setting and prevent participants from rehearsing the intention of the prospective task. Today, most laboratory based studies follow this paradigm, consisting of an engaging ongoing task (e.g. rating words on their familiarity, Kliegel, Martin, McDaniel, & Einstein, 2004; compute math problems, Einstein, McDaniel, Willifort, Pagan, & Dismukes, 2003) and a prospective memory task, where a particular action (e.g. press a key, write down your name) takes place after a specific cue occurs (e.g. whenever the word “conversation” is shown, Kliegel et al., 2004; whenever the background colour changes; Park, Morrell, Hertzog, Kidder, & Mayhorn, 1997) or after a certain period of time (Einstein, McDaniel, Richardson, & Guynn, 1995).

Einstein and McDaniel (1990) further suggested a useful distinction of prospective memory tasks based on the nature of the condition that determines when to perform the task: event-based tasks and time-based tasks. In an event-based task, the performance is triggered by the occurrence of a cue. A naturalistic example would be the appearance of a bakery if one wants to remember to buy bread. In contrast, there is no event cue in time-based tasks. Here, the task must be performed at a certain point of time or after a period of time has elapsed. As an everyday example, the cake needs to be taken out of the oven after 20 minutes or an appointment is at 11:30. Due to the absence of a specific, often salient cue, time-based prospective memory is assumed to be particularly dependent on self-initiated mental activities, such as active time monitoring (d'Ydewalle, Bouckaert, & Brunfaut, 2001).
Therefore, time-based prospective memory has been assumed to be more error-prone than event-based prospective memory (e.g., Einstein et al, 1995).

As indicated above, to perform delayed intentions appropriately is an essential ability to meet everyday life challenges. Thus, the development of independence in the childhood and maintenance of independence up to the old age relies strongly on prospective memory functioning (Beal, 1985; Cockburn, 1996; Meacham, 1982). 50-80% of all everyday memory problems are, at least partly, due to prospective memory failures (e.g. Crovitz & Daniel, 1984; Terry, 1988). In childhood, everyday prospective memory tasks involve remembering to bring appropriate objects to games (e.g. the ball to a football game), to keep appointments with friends or making homework in time and bring it to school (Kvavilashvili, Kyle, & Messer, 2008). In later life, prospective memory is needed to keep business appointments, pay the bills on time or send a friend a birthday card (McDaniel, Einstein, & Rendell, 2008). Besides social and professional consequences of prospective memory failures, the decrease of prospective memory performance can be life threatening, especially in adulthood and late adulthood, because of the high demands on prospective functioning when following medical regimes and in health behaviour (e.g. remember to take the correct pills at the appropriate time of day, or to keep the administered diet; Wilson & Park, 2008).

2.3 Developmental perspective on prospective memory ("When, how and which mechanisms")

2.3.1 Age effects in prospective memory performance across the lifespan: children

This introduction will provide a background for the present studies by giving a complete review of the existing literature on prospective memory development in childhood and adolescence. In their recent review, Kvavilashvili and colleagues (2008) pointed out that
there are only few studies that have investigated prospective memory development and possible mechanisms that lead to successful prospective remembering in children and adolescents (see Figure 1 for all currently available studies on prospective memory development in childhood).

**Time-based prospective memory**

<table>
<thead>
<tr>
<th>Age</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

**Event-based prospective memory**

Figure 1. Available developmental studies on prospective memory across childhood until the age of 13. Dashed boxes indicate that no age differences were found, studies in filled boxes revealed possible underlying mechanisms. Within each domain, studies are ordered according to tested age group; horizontal arrangement is due to formal reasons.

Kvavilashvili et al. (2008) also outlined guidelines for studying prospective memory in children. These state that the task should be introduced as a game to keep children motivated. Furthermore, the task should be presented in short blocks in order to reduce boredom. At the same time, too exciting prospective memory tasks should be avoided because they might draw too much attention from the ongoing task. Moreover, ceiling-effects can be reduced by applying a prospective memory task that is a compromise between being simple enough to avoid overstrain but still challenging so variance in performance can be detected. In
addition, retrospective memory of the task instructions should be tested, especially in young children. Finally, ongoing task difficulty should be considered or adjusted across age groups, as cognitive abilities increase with age (e.g. Gathercole, Pickering, Ambridge, & Wearing, 2004) and thus the ongoing task might by more challenging for younger children than for older ones.

Guided by Einstein and McDaniel’s (1990) classification of prospective memory tasks, the following review of previous results on age differences (‘when and how’) and possible mechanisms (‘which mechanism’) of normal prospective memory development in childhood is organized according to time-based and event-based tasks.

2.3.1.1 Time-based prospective memory performance in early childhood and pre-school age

The age of onset of time-based prospective memory abilities has been examined in only one study so far. To investigate early time-based prospective memory performance, Aberle and Kliegel (in press) asked 5- to 7-year-old children to play a game of Memory (Pairs). Simultaneously, children had to monitor an hourglass situated behind them because the sand should always be running. Thus, if all the sand had run to the bottom bulb children should remember to turn the hourglass. Results indicated an age-related increase in prospective memory task performance, as older children remembered more often than younger children to turn the hourglass. However, even the youngest were able to perform the prospective memory task successfully, yet on rather low performance level. Increasing speed of processing and rising working memory capacity were suggested to affect time-based prospective remembering in kindergarten and early school age. Yet, only a crude measure of possible underling mechanisms was applied (the “substitution”-subscale of the Culture Free Intelligence Test; Cattell, 1949), blurring the differentiation between speed of processing and working memory capacity effects. In addition, only a correlative design was conducted,
limiting the explanatory power of the results. A more fine-grained analysis and an experimental design would provide further insights about related factors of the development of time-based prospective memory in early childhood.

With only one published study on time-based prospective memory development in early childhood, our knowledge about this ability is limited. Further studies are needed to determine the onset of time-based prospective remembering. In addition, the picture of contributing mechanisms is still unclear, thus more research on related variables would improve our understanding of early time-based prospective memory development.

2.3.1.2 Time-based prospective memory performance in school age

_Time-based prospective memory performance in school age children_ has been examined in four studies. Interest in time-based prospective memory development in this age group is just emerging, as three of the four studies were conducted at 2000 or later. Only one study reported no general age effects (Mäntylä, Carelli, & Forman, 2007). Here, children aged 8 to 12 years and young adults had to indicate the passing of time every 5 minutes while watching a video. In order to monitor the time, participants could make a clock appear on the screen by pressing a button. The results showed no age effect on the time-based prospective memory task.

In contrast, three studies revealed age-related increases in prospective memory performance in time-based tasks across school age. Furthermore, all three studies examined factors that possibly contribute to age differences in time-based prospective memory. The development of the ability to perform delayed actions in a time-based setting was initially explored in Ceci and Bronfenbrenner’s (1985) seminal study, as 10- and 14-year-old children were either asked to remember to take cupcakes out of the oven after exactly 30 minutes or to recharge a motorcycle battery for 30 minutes. In between, children were busily engaged
playing a video game. The study was conducted in varying contexts, either in the laboratory or at the child’s home. The results revealed two different time-monitoring patterns: (a) a U-shaped, strategic monitoring pattern, with a high amount of clock-checking behaviour at the beginning in order to calibrate one's psychological clock, followed by a period of reduced clock-checking activity, and finally a relative rapid burst of "last minute" clock-checks and (b) an anxious time-monitoring pattern, indicated by a constant linear increase of time-checks. Furthermore, no differences between age groups occurred when being tested in the laboratory; in contrast, in the home-condition, 10-year-olds were more likely to be late than the 14-year-olds (see Kvavilashvili et al., 2008). Different time monitoring strategies were revealed to be associated with age differences. Interestingly, older children deployed strategic time-monitoring strategies in both conditions. In contrast, young children were found to use an anxious time-monitoring pattern in the unfamiliar environment of the laboratory, while a more strategic time-pattern was applied in the familiar setting. Since most forgetting in younger children occurred in the home condition, as well as most strategic monitoring in young children was applied at home, the question arose whether strategic monitoring was indeed effective. Subsequent analyses revealed that children who forgot to remember were not engaged in strategic monitoring, but showed decreasing clock-checking behaviour over time. Yet, performance differences due to the context might also arise from varying motivation to perform the task in a familiar or unfamiliar surrounding: while motivation was rather low in the familiar setting, the anxiety provoking unfamiliar situation might have motivated young children to perform the task correctly (see Kvavilashvili et al., 2008). Even more, the distracting surrounding of their own home might constrained young children’s performance. Thus, arising inhibition abilities might underlie age differences (see Garon, Bryson, & Smith, 2008, for a review on inhibition development in children).

According to the special demands of appropriate tasks to examine prospective memory development in children (see Kvavilashvili et al., 2008), Kerns (2000) applied an
innovative computerized task, asking 7- to 12-year-old children to play a video game in which they had to drive a car without hitting other vehicles. Children received points for passing other cars and were penalized if collided with them. The goal of the game was to get as many points as possible. In addition to the main driving task, children had to take care of the fuel level, since the car was running out of gas after a certain time. Therefore, they had to monitor a fuel gauge and press a key whenever the fuel gauge showed that only ¼ of the gas was left. The fuel tank could be monitored by pressing another key that displayed the fuel gauge in the left corner of the screen and remained visible for three seconds. Whenever children forgot to refuel in time and the car ran out of gas, an alarm sounded and the tank was automatically refilled. In addition, all points were lost and the counter was reset to zero points. Prospective memory performance was assessed by the times the children forgot to refuel the car and ran out of gas. Results showed an age improvement in the prospective memory task revealed by a negative correlation between age and the number of times children ran out of gas. Differences in inhibitory control were found to be related to age effects in prospective remembering. Thus, presumably younger children were less able to disengage from the ongoing task, although they realized the need to refill the tank. Furthermore, the results showed a significant correlation of visual working memory abilities and prospective memory task performance, even after controlling for age. The virtual cruiser is a sophisticated measure to explore prospective memory performance in children. However, the driving task might be more challenging for younger children than for their older counterparts, tying more cognitive resources on the ongoing task in young children. Therefore, age-adjustment or considering ongoing task performance would prevent ongoing task age effects masking prospective memory development.

More possibly related factors were examined by Mackinlay, Kliegel, and Mäntylä (2009) using a more traditional lab-based prospective memory task. Here, 7- to 12-year old children were asked to perform an ongoing 1-back picture task in which pictures were
presented one by one on a computer screen and children were asked to judge if the current picture was the same as the preceding picture. In addition, as prospective memory task, children had to remember to press a key on the keyboard every 2 minutes while performing the 1-back task. To check the time, they could press the spacebar to access a clock that counted up the time since the task had started. Results indicated that older children carried out intended actions correctly more often than younger children did. Monitoring abilities, planning behaviour and cognitive flexibility were found to be related to age differences. Interestingly, time estimation did not contribute to time-based prospective memory development.

In sum, only four studies have investigated the development of time-based prospective memory in school age children so far. These suggest that the ability to remember intended actions improves within the addressed age range, as three studies revealed age benefits in prospective remembering. In addition, changes in time monitoring and increasing executive functions were found to be related to the development of time-based prospective memory in school age. Yet, further experimental-designed studies are needed to verify the presented results.

2.3.1.3 Time-based prospective memory performance in adolescence

To our knowledge, no studies have been conducted on the development of time-based prospective memory abilities in adolescence.

2.3.1.4 Event-based prospective memory performance in early childhood and pre-school age

So far, only four studies investigated the early development of event-based prospective memory abilities. Results on the age of onset of event-based prospective remembering are not consistent. Some studies reported age effects, whereas one study did not find age differences
in event-based prospective memory performance across very young children (Somerville, Wellman, & Cultice, 1983). In their naturalistic design, Somerville et al. asked 2-, 3- and 4-year-old children to remind their caregiver to carry out a certain action after a short or long period of time. The to-be-performed actions were either of high (i.e., buying candies at the store) or low (i.e., bringing in the washing) desirability for the children. Although varying delays were implemented (i.e. five minutes vs. four to eight hours), no general age differences were found. Importantly, even 2-year-old children performed equal to 4-year-old children in the high interest condition, while they showed reduced performance in tasks with low interest. The lack of general age effects, however, might be due to methodological problems, as activities in the delay phase were not controlled. Therefore, future studies need either to record ongoing activities or implement a controlled and standardized ongoing task design to explore possible general age effects.

In contrast to Somerville et al. (1983), three experimental studies reported age-related benefits in event-based prospective remembering. In Guajardo and Best’s (2000) study, 3- and 5-year old children were shown ten simple pictures (e.g., dog, turtle, tree, ball, eye) in a series of six blocks and were asked to recall them after each block. In addition, they should press the space bar every time they saw a target picture (i.e. duck or house). Already children at the age of 3 were able to perform the prospective memory task. Moreover, a general age effect was found showing that 5-year-old children performed significantly better than 3-year-olds. Furthermore, presence of external memory aids was varied. In the ‘cue’ condition, children could place a picture of the prospective target wherever they believed it would help them to remember to perform the prospective memory task. In contrast, the ‘non cue’ condition did not provide external memory aids. In addition, the effect of incentives was explored, as authors varied whether children received little presents for every detected target picture or not. Results revealed that the strategic use of external cues was related to older children's better performance. Yet, incentives did not influence prospective remembering and authors
concluded that motivation may not affect prospective memory performance in pre-schoolers. A methodological concern arises from the finding that at the end of the experiment 3-year-old children had more difficulties to remember prospective memory instructions relative to 5-year-olds. Furthermore, older children performed better than younger children in the ongoing task. This might indicate that the task was more difficult for younger children which in turn might have left them fewer cognitive resources to perform the prospective memory task.

Given these methodological problems, results of the study are difficult to evaluate. Thus, to overcome these shortcomings, children who do not show intact retrospective memory for the prospective memory task instructions should be excluded and ongoing task difficulty should be considered or equated.

As a result, Kliegel and Jäger (2007) controlled retrospective memory of the task instructions. Even though, they found a general age effect in event-based prospective memory performance in children aged 2 to 6 years. Here, children were asked to name objects that were presented as pictures on cards (e.g. an airplane, a chair, a clock, etc.). The occurrence of a picture of an apple was the prospective cue for the children to take this card and put it in a box. Furthermore, the box was either placed behind the child (no memory aid condition) or on the table in front of the child (memory aid condition). Importantly, results indicated no reliable prospective remembering in 2-year-olds, while children from the age of 3 onwards were able to perform delayed intentions; though older children outperformed younger children. The presentation of an external memory aid increased prospective memory performance in children. Furthermore, poor retrospective memory for the prospective memory task instructions seemed to impact prospective performance in very young children. Post-tests of the recall of prospective memory task instructions showed a substantial lack of retrospective memory of instructions in 2-year-old children. In contrast, the other age groups did not differ significantly; therefore, confirming the age trend. The same ongoing task was administered to all children. Hence, the ongoing task might have been more challenging for
2. Introduction

Younger children than for older ones and therefore might have absorbed more cognitive resources in young children, accounting for the finding that external memory aids were particularly helpful for 3-year-old children. Thus, a study with an age-equated ongoing task or considering ongoing task difficulty is needed to explore early event-based prospective memory abilities.

Also controlling for retrospective memory, but not considering or equating ongoing task difficulty either, Wang, Kliegel, Liu, and Yang (2008) examined in two experiments the effect of task interruption on prospective memory performance in 3-, 4- and 5-year-old children. In both experiments, children were asked to name objects on stickers that were attached to children-type basketballs. Whenever the picture consisted of an animal, children should refrain from picture naming and instead take the ball, turn around and throw the ball as fast as possible into a basket. While the prospective cue appeared in Experiment 1 in the middle of a sequence (task interruption), Experiment 2 required no interruption of the naming task, as the animal cue was presented at the end of the sequence. Results indicated age benefits in remembering to throw the ball in the task interruption condition. Yet, younger children performed equal to older ones if an interruption of the ongoing task was not necessary. Therefore, task interruption was revealed as an important aspect of prospective performance development in pre-schoolers. In addition, retrospective memory load was found to be related to prospective memory performance, at least if an interruption of the task was required. The findings of the study raise the question of possible underlying mechanisms. In the light of task interruption effects, examining inhibition and task switching abilities that are needed to interrupt the ongoing task, to perform the prospective memory task and later resume the ongoing task, might reveal further insights on prospective memory development.

In sum, research on the early development of event-based prospective remembering showed mixed results. Three of four studies indicated age benefits in remembering to perform a delayed intention. Varying results might be due to methodological differences and
shortcomings. For example, Somerville et al. (1983) did not control for activities performed in the delay period. Thus, the age of onset and prospective memory performance are difficult to evaluate. To keep the ongoing task comparable, Guajardo and Best (2000) applied a laboratory task, yet remembering of the prospective task instruction was not controlled. Therefore, the effect of motivation, as found in Somerville et al. (1983) and in adult literature (e.g. Kliegel, Martin, McDaniel, & Einstein, 2001), might have been masked by retrospective failures. Kliegel and Jäger (2007) and Wang et al. (2008) controlled for recall of prospective memory instructions in their lab-based tasks and results indicated an age of onset at the age of 3 years. Yet, the effect of motivation was not tested in these studies. Furthermore, ongoing task difficulty was not considered or equated, as suggested by Kvavilashvili et al. (2008).

Therefore, the first study of the present thesis (see Chapter 2.1 & Chapter 3.1) was conducted to overcome these methodological shortcomings and examine the effect of motivation on event-based prospective memory in pre-school age children.

2.3.1.5 Event-based prospective memory performance in school age

Most developmental research has been done in the field of event-based prospective memory development in school age children. So far, eleven studies have examined developmental aspects of event-based prospective memory across this age span.

Only two studies did not find age improvements of event-based prospective memory performance in school age children. Meacham and Colombo (1980) reported no age differences in 6- to 8-year-old children. Here, the experimenter had to be reminded to open a “surprise box” at the end of a session. Prior to the prospective task, children took either part in an interview or played a card game with the experimenter, each activity lasting seven minutes. The prospective memory task was regarded as performed successfully, if the child reminded the experimenter to open up the box before reaching the door in order to leave the room. The
results revealed no age effects, as older children did not remember more often to remind the experimenter to open the box.

The second study that did not find age effects in school age children was conducted by Nigro, Senese, Natullo, and Sergi (2002). Children from 7 to 11 years were asked to remember to remind the experimenter to pass on a message to his assistant as soon as the assistant would enter the room (i.e. event-based) or to remind the experimenter to make an important call at a certain point of time (i.e. time-based), while being engaged in performing ongoing tasks like mathematical additions and puzzles. While children remembered to remind the experimenter more often when seeing the other experimenter than after a period of time, no general age effect was revealed in the event-based or in the time-based prospective memory task.

In contrast, age effects were reported in nine of eleven studies. A major question of interest is to identify possible factors that might contribute to prospective memory development. While various mechanisms are proposed, only few studies did in fact test possible factors. In the following, results will be presented that showed developmental benefits in prospective memory performance, yet did not find mechanisms that could explain prospective memory development. It should be noted that some of the studies assessed possible factors, yet did not reveal significant relations to the development of prospective memory. In one study (Maylor, Darby, Logie, Della Sala, & Smith, 2002), no formal task statistics were reported, therefore no conclusions can be drawn about underlying mechanisms.

In the first study to explore event-based prospective memory development in school age, Meacham and Dumitru (1976) asked 5- and 7-year-old children to draw a picture. After completing the picture, the experimenter put the drawing in an envelope and children were told to put the envelope in a box when returning to class. Then, children were asked questions from a standardized interview which lasted seven minutes. After the interview, children could return to their classroom, passing the box on the way back. In contrast to Meacham and
Colombo (1980), a reliable age effect was obtained. Older children remembered more often to put the envelope in the box than younger children. Increasing practice in making choices, as required in formal schooling, was assumed to underlie prospective memory development. Prior to school age, children’s daily routine does not regularly require them to make choices. Thus, Meacham and Dimitru (1976) suggested that emerging autonomy in school may improve prospective memory performance. Unfortunately, in both studies (Meacham & Colombo, 1980; Meacham & Dimitru, 1976) prospective memory performance was assessed with a single response (remembered vs. not remembered), thus statistical variation and explanatory power is limited. Furthermore, discrepant findings between the two studies might arise from task differences, since the chance to open the “surprise box” is more motivating than to put an envelop in the post-box. Thus, age differences in Meacham and Colombo (1980) are possibly masked by motivation effects. Following this rationale, an experimental variation of task motivation would be suitable to explore the relation of motivation and prospective memory development in school age.

Mixed results of Meacham and colleagues (Meacham & Colombo, 1980; Meacham & Dimitru, 1976) indicated the need to further explore the development of event-based prospective memory in this age group. The study of Kurtz-Costes, Schneider, and Rupp (1995) showed similar heterogeneous findings in prospective memory performance across school age, as results revealed age-benefits for only a part of the sample; an increase of event-based prospective memory performance was obtained in later childhood. In their study, 5-, 7- and 9-year-old children had to remember to remind the experimenter at the end of the session to turn out the light, to return a chair to another classroom or to retrieve a jacket from the corner. While the oldest children outperformed the younger ones, no age differences in prospective performance were found between 5- and 7-year-old participants. Retrospective memory development was assumed to affect remembering of future intentions. Several measures were assessed that roughly tap possible underlying factors such as strategy use,
retrospective memory and working memory, but were only marginally related to prospective memory performance (retrospective memory was related to prospective memory performance in 5-year old children). As all measures were rather broad, the use of more sophisticated and theory-based measures is needed to explore mechanisms that account for prospective memory development in school age.

Kvavilashvili et al. (2008) proposed that a prospective memory task for children should be framed appropriately to appeal children. Therefore, in Kvavilashvili, Messer, and Ebdon (2001) a toy mole named “Morris” was introduced to motivate children to perform the tasks. 4-, 5- and 7-year-olds were placed in front of a stack of picture cards (e.g., carrot, pencil, guitar, spoon) and Morris asked them to name the pictures on the cards, because he could not see very well in the daylight. In addition, Morris was afraid of other animals, therefore children were asked to remember to put cards with an animal into a separate box (prospective memory task). Furthermore, as a potential developmental mechanism, task-interruption was varied. For half of the children the prospective cue appeared in the middle of the ongoing task (task-interruption condition), while the cue turned up at the end of the trial in the no-interruption condition. Results indicated an improvement in prospective remembering with age: 7-year-old children remembered more often to put animal cards in the box than 5-year-olds (but only in Experiment 1 and 2). In contrast, no age effects were obtained in Experiment 3. Here, a similar paradigm was applied, yet occurrence of the prospective cue was equated (after a certain amount of cards), therefore children in the no-interruption condition named only half the amount of cards as ongoing task compared to the interruption condition. However, no performance differences were found between 4- and 5-year-old children in all three experiments, while 7-year-olds outperformed 4-year-old children throughout. Furthermore, results revealed that task interruption affected prospective memory performance but was not able to explain development in realizing delayed intentions.

Kvavilashvili et al. accounted the inconsistent age effects (age benefits in Experiment 1 and 2,
no age effects in Experiment 3) to the developing ability to switch from one activity to another and to the just emerging abilities of prospective remembering in the examined age range. The study used an age-appropriate paradigm for children, yet further analyses of possible underlying mechanism (e.g. switching ability, see Karbach & Kray, 2007) would have been helpful to verify the assumptions of the authors. In addition, equating or considering ongoing task difficulty is needed, as the task can be rather easy for 7-year-old children, while challenging to younger children.

The relation between background and prospective cue was examined in the study of Maylor et al. (2002). As a background task, children from 6 to 11 years were asked to name teachers from photographs and, as prospective task, to remember to indicate those teachers that either were wearing glasses or had a plant in the background of the photograph. General age improvements were reported. Furthermore, age benefits increased in pictures with a plant compared to the glasses-condition. Thus, a task with a prospective cue that was not within the focus of the background task (task-appropriate processing vs. task inappropriate processing, Maylor, 1996a) seemed to be more demanding for young children than for older ones. Therefore, younger children were assumed to be less likely to constantly switch attention from stimulus processing of the ongoing task to stimulus processing of the prospective memory task. Yet, no formal task statistics were reported. Interpretation of the study is difficult due to the restricted presentation of the task, the data and the results.

A similar age-range was examined in Martin and Kliegel’s (2003) study on complex prospective memory, asking children between 6 to 11 years to play four different games (subtasks) within a limited period of time (a computerized version of the Six Elements Task; Shalice & Burgess, 1991). The prospective memory task was to remember to attempt each subtask within the time frame. Thus, children had to schedule the task efficiently and keep track of the elapsing time. Participants were requested to plan their later performance beforehand of the implementation of the task. Age improvements in prospective memory
performance were observed, as older children switched between the tasks more fluently and frequently than younger children. The development of planning abilities and self-initiated implementation of the task were suggested to account for age differences in prospective memory performance. The applied task requested abilities to inhibit the current activity in order to change to another subtask and the ability to switch between different subtasks. Thus, additional examination of these abilities would be helpful to understand the effect of executive functions on prospective memory development. As indicated above, children were requested to generate a plan, yet only half of the children actually did so, with a higher proportion in older children (30% of the youngest children vs. 68% in the oldest age group). Thus, the effect of planning abilities is difficult to interpret.

Finally, following Kerns’ (2000) approach, Rendell, Vella, Kliegel, and Terrett (in press) embedded a prospective memory task in a video game. Children of three age groups (5 years, 8 years and 11 years) were asked to play a non-competitive computer driving game. The game did not have an objective, defined end, but children were kept interested with the variety of pathways and scenes to explore within the 8-minute testing session. As prospective memory task, children were required to remember to press a button to refuel the vehicle when a red light flashed three times and when the refuelling attendant (displayed on another screen) was awake. The effect of delay on prospective memory performance was explored by varying the time between the red light flashing and the attendant waking across conditions (immediately, after 10 seconds or after 20 seconds). A general age effect was revealed, as older children outperformed 5-year-old children by remembering more often to refuel the car on time, yet 8-year-olds and 11-year-old children performed equally. In addition, results showed that a delay affected prospective memory performance but did not contribute to age differences in realizing delayed intentions. Increasing executive functions across childhood were assumed to underlie prospective memory development. In addition, as eight minutes is a rather long time to play a non-competitive game, motivational effects might have affected
prospective memory performance. Furthermore, the role of executive functions should be explored in future studies to confirm the assumption as underlying processes.

Three studies reported effects of possible mechanisms on prospective memory development. These mechanisms were either tested experimentally within the prospective memory task or by analyzing their relation to prospective memory performance. Using an experimental approach, Passolunghi, Brandimonte, and Cornoldi (1995) asked younger (7 to 8 years) and older children (10 to 11 years) to perform a revised version of the Einstein and McDaniel paradigm. They had to read out loud words that appeared on a computer screen as the ongoing task and press a key whenever a target-word (i.e. boat) occurred as prospective memory task. Yet, instructions varied in terms of different encoding processes: the prospective cue was either presented as a picture (pictoral encoding), as a word (verbal encoding) or the prospective action was practiced (motoric encoding). Older children only outperformed younger children in the motoric encoding condition but not if the cue was encoded as picture or verbally. Thus encoding processes and encoding condition appeared to affect prospective memory performance in school age children. The authors assumed that the lower performance of young children in the motoric enactment condition was based on not fully developed integrative processes that are necessary to link the prospective cue and the to-be-performed action. In addition, the attempt to link motoric information with the cue and later action was suggested to overload young children’s attentional resources, and thus affecting the prospective performance negatively instead of improving it (for results on the enactment effect, see e.g. Cohen & Stewart, 1982; Helstrup, 1986). To classify the results of the study, further exploration of underlying processes (e.g. executive functions and attention) would be helpful. Moreover, a reading task is possibly more challenging for younger children than for older children, with more reading experience. Thus, a non-verbal ongoing task might be more appropriate in research with children.
Another possibility to adjust a lexical task in terms of task difficulty is to use age-equated material, as applied by Ward, Shum, McKinlay, Baker-Tweney, and Wallace (2005). Here, children (7 to 10 years), adolescents (13 to 16 years) and young adults (18 to 21 years) were engaged in a lexical decision task comprising letter strings with one letter presented at a time. As ongoing task, they had to decide if the letters form a proper word. Number of letter strings depended on the age of the participants. The prospective memory task required respondents to remember to press a key whenever an italic letter appeared. Furthermore, the contribution of ongoing task demands and task importance to prospective memory development was investigated. Ongoing task demands were varied by the length of the letter strings/words (three and four letters for children, four and six to seven letters in both older age groups). Only the last letter of the nonwords was altered (e.g. “both” to “bota”), thus lexical decisions could not be made until the last letter appeared which meant that attention had to be maintained on every letter string. In the importance condition, the prospective memory task was highlighted in the instructions, whereas the prospective task was only presented marginally in the instructions of the importance-unstressed condition. Children remembered less often to press the target key after the occurrence of an italic letter than adolescences and young adults did, while no differences were found between the latter two age groups. Furthermore, children’s proportional decrease in prospective remembering from the low to the high ongoing task demands conditions was significantly greater than either adolescents’ or adults’, and adolescents’ reductions were equivalent to adults’. Interestingly, importance did not alter prospective memory performance in any age group (see Kliegel et al., 2001; Kliegel et al., 2004, for different findings). Furthermore, relationships were found between the prospective tasks with high ongoing task demands and executive-functions tests (working memory: self-ordered pointing-task, and inhibition: Stroop test; but not planning ability: the tower of London-task), but not between the low-demands condition and executive functions. Thus, authors attributed age differences in prospective remembering between
childhood and adolescence to the maturity of the prefrontal lobes, which is reflected in age improvements in executive functioning. The effect of task importance might be more distinct if the intention to perform a task is intrinsically motivated. In order to induce a high intrinsic motivation some sort of incentive can be provided (e.g. a little present when remembering all prospective tasks). Furthermore, following Miyake et al.’s (2000) model of executive functions, additional task-switching tests might provide further insights on the role of executive functions on prospective memory development.

Resting upon Kvavilashvili et al. (2001), Shum, Cross, Ford, and Ownsworth (2008) examined the effect of task interruption on prospective memory performance in younger (8 to 9 years) and older school children (12 to 13 years). Children were asked to read an age-adjusted text aloud. Whenever a certain word appeared (i.e. “Henry” in the younger age group or “Lower” in the older age group), participants should remember to substitute it with another word (i.e. “Tom” in the younger age group or “Upper” in the older age group). Both narratives were 10 pages long and two prospective targets occurred on each page from page 3 to page 10. In addition, half of the participants read the text without interruption, while the other half were interrupted after finished reading page 2, 5 and 8. The interruptions required children to respond to a questionnaire or attempt to solve a tangram or an anagram puzzle. A general age effect was obtained, as older children remembered more often to appropriately change the target word. In addition, interruption of the ongoing task only affected younger children, while performance in the older age group remained at the same level in both interruption conditions. Furthermore, executive function measures were not related to prospective memory performance in the “no interruption” condition. In contrast, measures of executive function significantly added to the prediction of prospective memory performance in the interrupted condition. Thus, differences in prospective memory performance in childhood were attributed to prefrontal maturation and functioning, which is related to task interruption. The results are in line with Wang et al. (2008) on pre-schoolers, as in both
studies task interruption revealed age benefits in prospective memory performance, in early and in later childhood. Although the tasks were age-equated, reading ten pages of text might have been more exhausting to young, unskilled readers than to older and more skilled readers. Thus, a non-verbal ongoing task might be more sensitive.

Taken together, results on prospective memory development in school age children are mixed. While most studies reported age improvements across this age-span, some studies did not find age differences. In most cases, ongoing task difficulty was not equated or considered which presumably leads to higher cognitive load in young children and may thus disadvantage them (see Kvavilashvili et al., 2008). Though, some studies found age benefits despite age-equated ongoing tasks (Martin & Kliegel, 2003; Shum et al., 2008; Ward et al., 2005). Thus, age effects in prospective memory performance seemed to result not solely from age differences in cognitive load due to the ongoing task. Furthermore, only three studies reported factors that were related to event-based prospective memory development, all requiring alphabetical knowledge for performing the ongoing task (Passolunghi et al., 1995; Shum et al., 2008; Ward et al., 2005): encoding condition, ongoing task demands, task interruption and executive functions contributed to the development of prospective remembering. One of the greatest conceptual lacks that emerges from this review is, that, so far, possible underlying factors were explored unsystematically and were not integrated in a broader framework. *Thus, the second study of the present thesis (see Chapter 2.2 & Chapter 3.2) systematically examined possible underlying mechanisms of prospective memory development, grounded on a theoretical framework (multiprocess framework, McDaniel & Einstein, 2000) using a paradigm according to Kvavilashvili et al.’s (2008) suggestions.*
2.3.1.6 Event-based prospective memory performance in adolescence

Only one study examined the development of event-based prospective memory in adolescence. Wang, Kliegel, Yang, and Liu (2006) explored the relation of perceived task importance and prospective memory performance. Therefore, teenagers and young adults (13-22 years) were asked to listen to an auditory questionnaire task and pick a choice on a numbered sheet. Task importance was varied by stressing the importance of the ongoing task in the instructions and in addition, six arithmetic problems were implemented that should be carried out with special attention. As prospective memory task, participants were asked to make two marks behind their chosen answer on the sheet, if the statement they were listing included any negative word (e.g. not). In the prospective memory emphasis condition, participants were required to tick three marks behind their choice if a negative word as included in the statement and the importance of the prospective memory task was stressed in the instructions. Results indicated that young adults correctly carried out intended actions more often than teenagers. Furthermore, the benefit of prospective memory task emphasis was more pronounced in teenagers than in young adults. Age differences were attributed to developing working memory abilities and executive functions resources. Results revealed an effect of the dual-task situation on prospective memory task development. Yet, no ongoing task performance was recorded, thus we do not know if lower prospective memory task performance was due to a resource allocation in favour of the ongoing task. Furthermore, the applied task clearly demanded the ability to hold information in mind and manipulate it (i.e. working memory), yet no test on working memory capacity or executive functions was administered. Examining these abilities might shed further light on prospective memory development in adolescence.

The fact that only one study on event-based prospective memory development in adolescence is published so far, demonstrates the need for more research in this age-range.
Executive functions are assumed to affect prospective development, yet the knowledge about underlying mechanisms is limited. Thus, more research on related variables would improve our understanding of event-based prospective memory development in adolescence.

2.3.1.7 Event-based prospective memory performance across the lifespan

So far three studies have been conducted on the development of prospective memory across the lifespan. These studies examined children and/or adolescents, as well as younger and older adults. All studies reported age differences between age groups, with an increase of prospective memory performance in childhood and a decline in late adulthood.

In a study of Zimmerman and Meier (2006), participants of five different age groups (4-6 years, 13-14 years, 19-26 years, 55-65 years and 65-75 years) had to perform a picture comparison task. As prospective memory task, participants were asked to press a key whenever a picture of an animal appeared. Results showed age improvements between 4-6 year old children and 13-14 year olds. Retrospective memory showed a similar trajectory, yet results suggested that different processes might underlie performance in the prospective and retrospective component. Age differences in prospective memory were attributed to the rise of processing resources and the ability to identify prospective memory targets. However, authors did not elaborate on specific processes for retrospective memory development. Interestingly, an adaptive ongoing task approach was applied which equates task difficulty across all age groups. Unfortunately, no additional factors that are assumed to be related to prospective memory development were assessed (e.g. executive functions).

The relation of prospective memory and retrospective memory was also examined in the study of Zöllig and colleagues (2007), yet results were different compared to Zimmerman and Meier (2006). In Zöllig et al. (2007), 12- to 13-year-old adolescents, young (21-24 years) and older adults (65-76) years were asked to perform a semantic categorization task.
Participants’ task was to decide whether two presented words belonged to the same (e.g., cat and dog) or to a different (e.g., table and car) semantic category. Word pairs were presented in six different colours. If in lieu of a word pair one of two possible letter strings (‘cccc’ or ‘vvvv’) was presented, participants were instructed to remember to press the target key (‘c’ or ‘v’) the second time a word pair in the same colour as the cue appeared. Correct responses increased from adolescents to younger adults and decreased from younger to older adults. Results indicated further, that the retrospective component (assessed by number of confusion errors for prospective execute trials and false alarms for prospective inhibit trials) of prospective memory was more efficient in younger adults than in adolescents and older adults. Therefore, processes underlying the retrospective component of prospective memory were assumed to be not fully developed in adolescence; event-related potentials-data confirmed this conclusion. To test this assumption, a test of retrospective memory should be applied. In addition, further measures of underlying mechanisms could add additional information to our knowledge of event-based prospective memory development.

Complex prospective memory development across the lifespan was investigated in the study of Kliegel, Mackinlay, and Jäger (2008). To test prospective memory performance, a modified computerized version of the Six Elements Task (Shalice & Burgess, 1991) was applied. The sample consisted of 7- and 10-year-old children, younger adults (21-26 years) and older adults (62-72 years). The participants were asked to plan how to execute the six subtasks and after a delay to attempt each of the subtasks within a given time limit. Furthermore, task interruption was varied: in the interruption condition, the next item of the subtask automatically appeared, therefore switching to another subtask required the active interruption of the current subtask. In contrast, in the no interruption condition, a blank screen appeared after a response was made, thus changing to another task did not demand interrupting the current task. The prospective memory task consisted of intention initiation (to remember to start the tasks at the appropriate point of time) and intention execution
(remember to attempt each of the subtasks). Results revealed that younger children forgot more often to initiate the task and switched between tasks less fluently and frequently than older children, while younger adults outperformed older children. Interestingly, older children remembered their plans as often as younger adults did, yet did not execute the plans appropriately. Furthermore, task interruption was suggested to be related to prospective memory development as age differences in prospective memory were substantially greater when active task interruption was necessary. Developing executive abilities and children’s ability to plan a complex intention were thought to determine the development of performance in complex prospective memory tasks. Yet, performance in the no interruption condition was at ceiling for older children and both adult groups. Therefore, possible differences between these groups might have been masked.

In sum, present results on prospective memory development across the lifespan indicate an increase in prospective remembering in childhood with a peak in early adulthood and a decline in later age. Interestingly, results on the effect of retrospective memory components on prospective memory development differ across studies (Zimmerman & Meier, 2006, unrelated; Zöllig et al., 2007, relation between prospective and retrospective performance). This might be driven by different operationalisation of retrospective memory performance. By now, no measures of possible contributing factors have been applied in studies on lifespan prospective memory development. Thus, there is a clear need for more studies explicitly testing possible underlying mechanisms.

2.3.1.8 Summary of age effects in prospective memory performance in childhood

Taken together, research on prospective memory development is still restricted to a rather small number of studies and revealed a heterogeneous picture. However, a general trend becomes obvious: already young children remember to perform delayed intentions. This
ability develops across pre-school- and school age until adolescence. Results from lifespan approaches indicate that prospective memory development peaks in early adulthood. One possible explanation for mixed results is the methodological diversity of applied paradigms. Research in children demands special requirements, as the task must be easy enough not to overstraining young children, yet challenging enough to keep them motivated. Thus, a variety of approaches have been chosen to meet these requirements, with varying sensitivity. Furthermore, adjusting and considering of ongoing task difficulty is an important issue, especially in childhood with emerging cognitive abilities (see Kvavilashvili et al., 2008). Possible age effects can be masked by tasks that are more challenging for younger children than for older ones.

In addition, various factors and processes have been proposed to contribute to prospective memory development. The development of time-based prospective memory performance seems to be affected by time monitoring and executive functions. To examine the development of event-based prospective memory, some studies manipulated the prospective memory task (Kliegel & Jäger, 2007; Guajardo & Best, 2000; Passolunghi et al., 1995; Shum et al., 2008; Wang et al., 2008; Wang et al., 2006). Here, memory aids, task interruption, task importance, ongoing task demands and encoding condition were related to the development of performing delayed intentions. In addition, executive functions and retrospective memory abilities were found to be associated with prospective memory development (Shum et al., 2008; Ward et al., 2005; Zöllig et al., 2007). Again, results are mixed, as some studies found potential mechanisms while other studies did not confirm those factors. This heterogeneous picture might arise from a broad variety of measures that were applied to assess potential mechanisms.

Study 1 (Chapter 3.1) and study 2 (Chapter 3.2) of the present thesis aimed at systematically exploring the development of prospective memory performance across pre-school age and school age. According to Kvavilashvili et al. (2008), age appropriate tasks
were conducted. The multiprocess approach of McDaniel and Einstein (2000) served as the theoretical framework, which suggests several task-related mechanisms and individual factors (e.g. task motivation) that might underlie age differences in prospective performance. Therefore, selected components of the multiprocess framework were tested in the present studies.

2.3.2 Age effects in prospective memory performance across the lifespan: adulthood and old age

Over the recent years, the focus in research of prospective memory development has been on the development of the ability to remember delayed intended actions in adulthood and late adulthood. Thus, a thorough review of the existing literature on prospective memory development in adulthood is beyond the scope of this thesis. A comprehensive overview of the present literature is provided by the meta-analyses by Henry, MacLeod, Phillips, and Crawford (2004) and Kliegel, Jäger, and Phillips (2008), as well as by McDaniel et al. (2008) and Phillips, Henry, and Martin (2008). In the following, only the grand pattern of developmental trends and possible mechanisms will be presented to give an overview of discussed issues of prospective memory development in adulthood.

Since the multidirectional and multidimensional development of cognitive performance in adults and older adults became apparent (e.g. Craik, 1977), there has been a need for explanatory mechanisms for the observed age effects. According to Craik’s framework (1986), “remembering is to recapitulate some previous mental state” (p. 411). While context information provides supportive signals to regain the previous state, a lack of context information obliges to self-initiated activities in order to endow remembering. As presented in Chapter 1.1, Craik proposed a hierarchy of memory tasks, based on the amount of environmental support and self-initiated activity. Here, “procedural memory (priming
2. Introduction

tasks)” involves highly supportive environmental structures and few self-initiated activities, while the amount of self-initiation increases and context support declines in “Relearning”, in “Recognition”, in “Cued Recall”, and in “Free Recall”, finally culminating in “Remembering to remember” (i.e. prospective memory), which consists of uttermost self-initiated activities and scarce environmental support. It is assumed that tasks require more processing resources if they rely mostly on self-initiated operations (Hasher & Zacks, 1979). Craik and Byrd (1982) suggested a decrease of processing resources in older adults (see also Salthouse, 1991), which might underlie the decline of performance in tasks with high self-initiation in older age. Thus, because prospective memory tasks are considered to be very resource-demanding, they have been assumed to be more error prone to age effects in adulthood than retrospective memory tasks.

In their seminal study, Einstein and McDaniel (1990) suggested a distinction between age effects for event-based and time-based prospective memory task, as results did not support the assumption of unitary age decrements in prospective memory either (e.g. West, 1988). In their study, participants (17 to 24 years and 60 to 78 years) were asked to perform a short-term memory test as ongoing task, while the embedded prospective memory task comprised to press a button whenever a certain target word (i.e. “rake” or “method” or “sone” or “monad”) appeared on the screen. Interestingly, results indicated no age-related decline of performance in event-based prospective memory tasks. A key feature of event-based prospective memory tasks is the presence of a cue that can serve to facilitate retrieval, therefore reducing self-initiating requirements. Hence, Einstein and McDaniel (1990) argued that “event-based prospective memory tasks […] might not produce large age-related effects” (p.724). In contrast, time-based prospective memory tasks feature no supportive external cue and therefore participants have to rely on internal processes in order to monitor and initiate the delayed intention correctly. Harris and Wilkins’ (1982) Test-Wait-Test-Exit model proposed that subjects encode the time-based task, and then wait for a period of time until a
test of memory seems appropriate. The test-wait cycles are repeated until the critical point of
time is reached and the action is executed. Thus, successful prospective memory performance
in a time-based setting is largely dependent on self-initiated processes. Following this
rationale, time-based tasks should reveal an age-related decline in prospective memory
performance as decreasing cognitive resources in older adults (e.g. Salthouse, 1991) do not
meet the requirements of time-based prospective memory tasks. In contrast, event-based tasks
should not show any age effects as they are less resource-demanding due to the supportive
color of external cues.

As next important milestone, the results of a study by Park et al. (1997) qualified
Einstein and McDaniel’s (1990) assumption of different age effects in event- and time-based
prospective memory tasks (see also Einstein et al., 1992; Mäntylä, 1994). Here, younger
(mean age 19 years) and older (mean age 69 years) participants had to perform a working
memory task, in which common seven-letter words were presented for 3 seconds in two 12
minutes intervals. In addition, the words were presented against one of six abstract black and
white background patterns. The instructions stated to keep the last three words in memory and
participants were asked to say aloud these words whenever the word RECALL appeared on
the screen. While the working memory task served as ongoing procedure, an additional
prospective memory task was embedded. In Experiment 1, one of the six background patterns
was used as prospective cue and participants had to press the zero key whenever the specific
target background was presented. Therefore, this task was conceptualized as an event-based
prospective memory task. In contrast, Experiment 2 consisted of a time-based prospective
memory task. While being engaged in the ongoing task, participants had to monitor a time
device that was attached to the monitor and pull a lever every 1 minute (or every 2 minutes).
As proposed by Einstein and McDaniel (1990), time-based prospective memory performance
did decline with age, as older adults were outperformed by younger adults in the presence of
an on-line working memory task. However, in contrast to the hypothesis posited by Einstein
and McDaniel (1990), event-based prospective memory performance was also affected by age, as younger adults did remember more often than older adults to press the key when the target background pattern appeared. Therefore, the results of Park and colleagues (1997) did not confirm the notion that age differences in prospective memory performance can be explained by differences in age sensitivity of event- and time-based tasks.

Hence, age differences in prospective memory performance need to be reframed to reveal possible mechanisms. Maylor (1996b) pointed out that the elderly perform at least equal to younger adults in naturalistic settings, while often being outperformed in laboratory tasks. Findings of Rendell and colleagues confirmed the effect of task setting on age differences in prospective memory (Rendell & Craik, 2000; Rendell & Thomson, 1999). In laboratory-based studies, participants perform the task in the laboratory in a controlled and standardized setting (e.g. d'Ydewalle, Luwel, & Brunfaut, 1999; Vogels, Dekker, Brouwer, & de Jong, 2002; West, Jakubek, & Wymbs, 2002), while naturalistic tasks are carried out in the everyday environment of the participant (e.g. Devolder, Brigham, & Pressley, 1990; Rendell & Thomson, 1993). In the study of Rendell and Craik (2000), young adults (19 to 24 years), young-old adults (61 to 73 years) and old-old adults (75 to 84 years) took part in a laboratory paradigm and in a naturalistic task. As laboratory task, Rendell and Craik applied a board game called “Virtual Week”, simulating everyday life across a number of days. One round on the board represented one virtual day; the times of the virtual day were marked on the board. Participants moved a token around the board with a roll of dice and had to make virtual daily decisions. In addition, prospective memory tasks were embedded in virtual daily activities. The laboratory task was followed by a naturalistic paradigm (“Actual Week”). Participants were asked to perform ten prospective memory tasks on each of seven consecutive days. Like in Virtual Week, the tasks were not actually carried out but were recorded on a portable micro-recorder which had a time-stamp function. The study revealed intriguing insights, as the patterns of age differences in performance varied across task setting conditions. The
results of the laboratory task mirrored previous findings and indicated an age-related decline of prospective memory performance. Interestingly, the naturalistic task showed a reversed pattern as results indicated a superior performance of older adults in prospective memory tasks outside of the laboratory. Rendell and Craik (2000) referred to this finding of different directed age effects as the *age prospective memory paradox*.

The results of Rendell and Craik (2000) were supported by a first meta-analysis by Henry and colleagues (2004). The review of twenty-six prospective memory studies confirmed that older adults did not only compensate for age-related decline but substantially outperformed younger adults in naturalistic studies. Therefore, the question arises which task-related factors systematically affect performance of younger and older adults in laboratory and in naturalistic tasks. Phillips et al. (2008; see also Klügel, Rendell, & Altgassen, 2008) proposed several factors that might underlie the age prospective memory paradox. In a naturalistic setting, younger and older adults may differ in their motivation to perform a prospective memory task (Patton & Meit, 1993; Rendell & Craik, 2000). Possible mechanisms for this suggestion are non-compliance with instructions in younger adults (Dobbs & Reeves, 1996), personality factors such as politeness or conscientiousness (Cuttler & Graf, 2007; Maylor, 1993a), a more structured lifestyle in late adulthood (Henry et al., 2004; Rabbitt, 1996) or that higher social salience of naturalistic tasks might boost performance in the elderly (Ellis & Kvavilashvili, 2000). Furthermore, older adults might be more likely to employ reminders in naturalistic prospective memory tasks as they are used to rely on memory aids (e.g. Dobbs & Reeves, 1996; Hertzog, Park, & Morrell, 2000; Logie, Maylor, Della Sala, & Smith, 2004). Potential factors in laboratory tasks are the amount of processing resources needed due to variations in task setting (McDaniel et al., 2008) or the level of abstractness of the task (Ellis & Kvavilashvili, 2000). McDaniel et al. (2008) suggested that the focality of the prospective cue seems to be especially critical for age effects in laboratory-based studies, resulting in lower performance of older adults in nonfocal
prospective memory tasks. This notion is in line with results from the meta-analysis by Kliegel, Jäger et al. (2008) that showed an attenuated age-related decline of prospective remembering in focal tasks and larger age deficits in nonfocal prospective memory tasks.

In sum, the development of prospective memory abilities in adulthood and old age still needs clarification. One of the most surprising findings in prospective memory research of older age is the age prospective memory paradox (Maylor, 2008). Thus, it remains a major task for applied cognitive aging research to solve this paradoxical finding. Therefore, the third study of the present thesis (see Chapter 2.3 & Chapter 3.3) investigated the age prospective memory paradox by exploring possible related factors in a laboratory and a naturalistic task.

2.3.3 Summary of age effects in prospective memory performance across the lifespan

Research on prospective memory has revealed developmental trends from early childhood up to old age. Yet, no comprehensive developmental theoretical framework has been proposed that could help to explain age benefits in childhood and the puzzling findings of the age prospective memory paradox in adulthood. According to previous findings, motivation and task related factors, such as task focality, seem to affect prospective remembering in childhood (see Chapter 1.3.1.4 and 1.3.1.5) and might be related to the age paradox (see Chapter 1.3.2). In the present thesis, the effects of the proposed factors on prospective memory performance were examined. The multiprocess framework of McDaniel and Einstein (2000) is used as a theoretical structure that contains the mentioned factors, suggesting mechanisms that are assumed to be related to age differences in prospective memory performance. Thus, in the following chapter a brief overview of the multiprocess approach will be provided.
2.4 Multiprocess framework of prospective memory ("Which mechanisms")

In their seminal framework, McDaniel and Einstein (2000) proposed a set of critical factors that account for the use of spontaneous and automatic or strategic and attention-demanding processes within the prospective memory retrieval process. Even though this is currently one of the most influential theoretical models of event-based prospective memory (see, e.g., Henry et al., 2004; Maylor, 2008), it has not been used to guide developmental studies so far. The framework is primarily obliged to event-based memory, yet implications might also be drawn for time-based prospective memory.

Two antithetic approaches were aligned to explain the retrieval of an intended action: one theoretical approach suggested that retrieval of a delayed intention is a voluntary, strategic process, mediated by some sort of supervisory attention system (Shallice & Burgess, 1991). While being engaged in the ongoing activity, the environment is monitored for a target cue to indicate the appropriateness of performing the intended action (Ellis, 1996). This monitoring process requires attentional resources which are therefore voluntarily applied to scan for environmental events (Smith, 2003). Thus, following this rationale, prospective remembering is dependent on available cognitive resources. In contrast, an alternative theoretical approach assumed that an involuntary associative memory system enables relative automatic retrieval of the intended action (Guynn, McDaniel, & Einstein, 2001). If a memory trace in the associative system is activated by a cue, then an obligatory response will deliver the appropriate information for the intended intention to consciousness (Moscovitch, 1994). Therefore, no strategic monitoring for the cue is necessary as the intended action is automatically brought to mind, establishing a low cognitive resource-demanding pathway.

The multiprocess framework of McDaniel and Einstein (2000) integrated both approaches as prospective memory retrieval is suggested to be either strategic or automatic. Several factors were proposed to determine the extent to which prospective remembering depends on each of
the two processes respectively (see Table 1). In detail, the multiprocess framework suggests two specific ongoing task-related and two specific cue-related aspects that were thought to determine the amount of automatic versus controlled processes being recruited when performing a prospective memory task. As ongoing task characteristic, cue focality and ongoing task absorption are proposed; with regard to cue-related aspects, distinctiveness of the target cue and associativity between target cue and intended action are assumed to affect prospective remembering. Furthermore, the motivation to perform the prospective memory task, planning of the prospective task and individual differences are suggested to modulate retrieval processes. From a developmental perspective, greater age differences should occur if strategic retrieval is necessary as cognitive resources are needed to monitor for the appropriate situation to perform the prospective task. Thus, persons with less cognitive resources (e.g. younger children, Gathercole, 1998; e.g. older adults, Salthouse, 1991) should be more likely to forget to perform the prospective task. In contrast, age differences are assumed to be attenuated in tasks with automatic prospective memory retrieval, as, in that case, remembering the intended action does not strongly depend on cognitive resources.

**Table 1.**
Factors of the multiprocess framework (McDaniel & Einstein, 2000)

<table>
<thead>
<tr>
<th>Proposed factors of the multiprocess framework</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ongoing task-related</strong></td>
</tr>
<tr>
<td>Focal processing</td>
</tr>
<tr>
<td>Ongoing task absorption</td>
</tr>
<tr>
<td><strong>Cue-related</strong></td>
</tr>
<tr>
<td>Target distinctiveness</td>
</tr>
<tr>
<td>Associativity of target with the intended action</td>
</tr>
<tr>
<td>Importance of the prospective memory task</td>
</tr>
<tr>
<td>Planning of the prospective task</td>
</tr>
<tr>
<td>Individual differences</td>
</tr>
</tbody>
</table>
With regard to ongoing task-related characteristics, cue focality refers to the integration of the prospective cue within the processing of the ongoing task. In focal prospective memory tasks the prospective cue is part of the information that is extracted to perform the ongoing task. An everyday example would be that one has to remember to buy a loaf of bread while being engaged in shopping in a mall (see Einstein & McDaniel, 1990, for a laboratory task). McDaniel and Einstein (2000) suggested that in a focal condition, the cue is sufficiently processed to enable automatic, non-resource-demanding retrieval of the delayed intention. In contrast, in nonfocal prospective memory tasks the cue is present in the environment but does not overlap with the information constellation that is relevant for performing the ongoing task. As an everyday example one has to remember to buy a loaf of bread while being immersed in a conversation with a friend on the way home (see Park et al., 1997, for a laboratory task). In nonfocal tasks, prospective remembering is assumed to require strategic resources in order to carry out extra monitoring for the cue to perform an intended action (Kliegel, Jäger et al., 2008; McDaniel et al., 2008). Therefore, age effects are proposed for prospective memory tasks with nonfocal target cues as a result of more effortful, strategic monitoring processes while age differences are assumed to be attenuated or even non-existent in focal tasks requiring mainly automatic processes.

Ongoing task absorption is the amount of how engaging, demanding or absorbing the ongoing task is. The level of absorption is determined by various factors, such as the speed of presentation of the ongoing task, item difficulty, number of simultaneous tasks, and individual interests. Thus, McDaniel and Einstein (2000) proposed that a highly absorbing ongoing task would require numerous cognitive resources, therefore restraining the availability of resource-demanding, strategic monitoring processes to retrieve an intended action. Hence, to perform a prospective memory task while being engaged in an absorbing ongoing task, one has to rely mainly on automatic, less resource-demanding retrieval processes, which might be critical if further circumstances necessitate strategic processing. An everyday example would be that it
is more difficult to remember to buy a loaf of bread on the way home while being immersed in conversation with a friend than when walking without company. Kvavilashvili (1987) reported a decline of intended-action-related thoughts when performing absorbing ongoing tasks compared to less absorbing tasks (8% when performing an interesting task vs. 42% when performing no task). Age differences are assumed to emerge in prospective memory tasks with a high absorbing ongoing task, due to the cognitive resource allocation in favour of the ongoing task.

With regard to cue-related aspects, the distinctiveness of the target cue refers to the salience of the target event. If the prospective cue is perceived as unusual relative to the context or distinct relative to prior knowledge than it might capture attention more easily. Therefore, a distinct cue is assumed to produce attentional switching from the ongoing task to the target cue, thus accelerating the recognition of the significance of the prospective cue (McDaniel & Einstein, 2000). Therefore, salient prospective cues are expected to support prospective memory performance by eliciting an automatic orienting response. Recent studies indicated the superiority effect of tasks with salient prospective memory cues (Cohen, Dixon, Lindsay, & Masson, 2003; Einstein, McDaniel, Manzi, Cochran, & Baker, 2000). An everyday example would be that it should be easier to remember to buy a loaf of bread on the way home if the shop-window of the bakery is decorated with illuminated advertisement. The availability of a salient cue should reduce the appliance of resources-demanding strategic monitoring and therefore result in attenuated or no age effects.

The associativity between target cue and intended action specifies the relation of cue and to-be-performed action. A low association between the prospective cue and the intended action is proposed to facilitate resource-demanding strategic processes. In turn, a high associativity between target cue and target action should increase the involvement of automatic associative memory-based processes (McDaniel & Einstein, 2000). As an everyday example, it should be easier to remember to buy a loaf of bread if a bakery is on the way than
2. Introduction

if one passes a gas station on the way home. Results of McDaniel, Guynn, Einstein, and Breneiser (2004) revealed that prospective memory performance was significantly better if target cue and target action were related (e.g., participants were instructed to write down the word “sauce”, whenever the word “spaghetti” was presented) than when prospective cue and intended action were unrelated (e.g. “needle” and “spaghetti”). A high associativity between target cue and intended action is assumed to attenuate age differences, due to automatic retrieval processes.

Furthermore, the importance of the prospective memory task is suggested to have implications on prospective memory processes. If a prospective task is perceived as being important, then a successful realisation of the action is desired and therefore more strategic monitoring is applied to ensure a positive outcome, even if cognitive resources need to be shifted from other domains. Furthermore, perceived importance increases the motivation to perform the intended action adequately. An everyday example would be that it is easier to remember to buy a loaf of bread on the way home if one is really hungry and the fridge at home is empty. Kliegel and colleagues showed a positive relation between perceived task importance and prospective memory performance (Kliegel et al, 2001; Kliegel et al., 2004). Prospective memory tasks that are perceived as important to the individual should attenuate or even eliminate age effects (Kliegel, Phillips, & Jäger, 2008).

In addition, the type and the degree of planning of a to-be-performed prospective memory task are proposed to affect the later performance by determining the reliability on automatic processes (McDaniel & Einstein, 2000). To plan an intended action increases the representation of the target event, and therefore enhances the sensitivity of the occurrence of the appropriate event (Mäntylä, 1993). Thus, planning seems to be most effective when the association between the target event and the action is strengthened (Guynn, McDaniel, & Einstein, 1998). As an everyday example, it should be easier to remember to buy a loaf of bread on the way home if one made a plan beforehand, maybe even applying reminders. The
The allocation of strategic or automatic retrieval processes in prospective remembering is finally suggested to depend on various individual difference factors (McDaniel & Einstein, 2000). Cognitive resources (e.g. working-memory capacity) apparently affect prospective memory performance (e.g. Marsh & Hicks, 1998; Logie et al., 2004). In addition, other non-cognitive variables are assumed to vary the degree of strategic vs. automatic processes. Goschke and Kuhl (1993) proposed that individuals with a certain personality profile (state orientation vs. action orientation) tend to favour one of the two processing approaches. In one study, conscientiousness was found to be related to prospective memory performance (Cuttler & Graf, 2007). Yet, there has only been little research on the relation between individual differences and prospective memory performance.

In sum, the multiprocess approach of McDaniel and Einstein (2000) provides a useful framework to further explore the mechanisms of prospective memory development. The suggested factors might explain age effects found in prospective memory development. Thus, if a task facilitates spontaneous, automatic retrieval of the intended intention, age effects should be attenuated. In contrast, the need of strategic and resource-demanding monitoring processes due to the proposed factors should increase age effects based on developing cognitive resources in childhood (e.g. Gathercole, 1998) and limited processing resources in later adulthood (e.g. Salthouse, 1991). Therefore, the multiprocess approach might be useful to reveal mechanisms explaining age effects in prospective memory performance across the lifespan.
3. Aims and Research Questions

Based on the presented review, the present thesis comprises three studies to further explore the development of event-based prospective memory abilities across the lifespan. Therefore, participants of four different age groups took part in the studies, covering a great part of the ontogenesis: pre-school children, school children, young adults and older adults. The overall theoretical framework is provided by the multiprocess approach of McDaniel and Einstein (2000), pervading all three studies. For the first time, central factors from the multiprocess framework are tested systematically across the lifespan.

In detail, three research questions will be discussed. The first research question concerns the effect of task importance on event-based prospective remembering in pre-school children, implemented by a motivation manipulation. The second research question will pertain to the influence of distinctiveness of the target cue, ongoing task absorption and cue focality on event-based prospective memory performance in school children by using an innovative paradigm. Finally, the third research question aims at improving the understanding of the age prospective memory paradox (see Chapter 1.3.2) by investigating the impact of task setting and motivation/ importance of the task on prospective memory performance in younger and older adults.

3.1 Does motivation affect prospective memory performance in pre-schoolers?

While several studies have examined prospective memory in adulthood, there are only few studies investigating the early development of prospective memory abilities (see Kvavilashvili et al., 2008). This is especially true for pre-school age children (see Chapter 1.3.1). Previous results showed that already at the age of 3 years, children are able to successfully perform event-based prospective memory tasks (e.g. Kliegel & Jäger, 2007), yet
possible developmental mechanisms are still discussed. The multiprocess approach (McDaniel & Einstein, 2000) proposed the perceived importance of the task as a critical factor in prospective remembering, resulting in a higher motivation to perform the prospective task successfully. In the adult literature, the results of a laboratory-based study by Kliegel and colleagues (2001) revealed the impact of task importance on prospective memory performance in young adults. In childhood, the findings of Somerville et al. (1984) indicated that already in young children motivation does affect prospective memory performance. Yet, the study was conducted in the course of everyday life, and therefore results are difficult to evaluate due to methodological limitations, like the lack of control over the activities performed in the delay phase. In contrast, incentives did not affect prospective remembering in Guajardo and Best’s (2000) laboratory study. Here, the retrospective memory for task instructions was not controlled. Thus, results on the relation of prospective remembering and motivation in young children are heterogeneous and suffer from methodological limitations. Moreover, ongoing task difficulty might mask possible motivation effects. Kvavilashvili et al. (2008) pointed out that the difficulty of the ongoing task can differently affect performance of younger and older children. The same ongoing task might be more difficult for younger children than for older children and thus requiring more cognitive resources in younger children, which might lead to lower prospective performance. Hence, ongoing task difficulty needs to be considered or equated across the age groups.

Therefore, the first study aimed for the first time to explore the role of motivation on prospective remembering in pre-school age children using a standardized ongoing task (Kaufman Assessment Battery for Children, Kaufman & Kamphaus, 1984; Melchers & Preuss, 1991). Children performed an ongoing task that equated ongoing task difficulty across age groups by applying age-standardized task material. The study was conducted in the laboratory and retrospective memory of task instructions was controlled. In addition, a motivation manipulation was induced by applying one task that was designed to generate high
motivation, while another task should generate low motivation. In the low motivation condition, children were asked to remind the experimenter to write down their name on the front of documents after finishing one part of the task. In contrast, in the high motivation condition, children were told that they would get a present, if they remembered to remind the experimenter later on.

3.2 Are ongoing task absorption, target distinctiveness and cue focality related to prospective memory performance in school children?

Mixed results emerged from previous research on event-based prospective memory development in school age children (see Chapter 1.3.1). The incoherent picture of previous results on the development of prospective memory underlines the need for research on possible mechanisms and factors that might contribute to the process of prospective memory development. As delineated, McDaniel and Einstein’s (2000) multiprocess approach provides a broad theoretical framework. Though most research on the proposed factors has been done in the area of adult and older adults (see Chapter 1.4), similar mechanisms might affect prospective memory performance in children, and even more, might help to understand the development of prospective memory abilities in childhood. Thus, a systematically exploration of the effects of the mentioned factors on prospective memory performance in children would provide further insights in prospective memory development. Yet, appropriate paradigms in research of children have to meet special requirements to produce reliable results (see Kvavilashvili et al., 2008).

Thus, the purpose of the second study was to systematically test the effects of cue focality, ongoing task absorption and target distinctiveness on prospective memory performance in school age children. By embedding the prospective memory task in a videogame, a motivating and challenging ongoing task for children was developed.
Participants had to drive a vehicle down the road without hitting other cars on the track. Every passed vehicle was awarded with points. The main goal of the game was to reach a high score. As additional prospective memory task, children had to remember to refuel the car. Within this overall setting, in three separated experiments three factors of the multiprocess framework were implemented. The game varied in the number of other cars on the street (ongoing task absorption), the conspicuousness of the prospective cue (i.e. number of yellow flowers at the roadside: target distinctiveness) or the style of the target cue (i.e. a red car vs. yellow flowers at the roadside: cue focality).

3.3 Can task setting and motivational effects dissolve the age prospective memory paradox?

Previous studies on prospective memory performance in younger adults and older adults revealed heterogeneous results (see Chapter 1.3.2). The age prospective memory paradox perhaps stands out as the most puzzling finding (Rendell & Craik, 2000). Here, older adults are outperformed by younger adults in laboratory based tasks, while the performance of the elderly in naturalistic prospective memory tasks is equal or even better than of their younger counterparts (Henry et al., 2004). Phillips and colleagues (2008) proposed several possible factors that might hold responsible for the age paradox. Among them, motivation and some aspects of task setting are discussed as two central components. The suggested factors are in line with the proposed parameters of the multiprocess approach by McDaniel and Einstein (2000), i.e. perceived task importance (Kliegel et al., 2004) and task focality (McDaniel et al., 2008) In addition, a novel aspect of task setting was explored in the present study: task regularity (Kliegel, Rendell et al., 2008).

A more focal processing of a task is assumed to attenuate age benefits in laboratory tasks. Likewise, age deficits are proposed to decline in regular tasks, while irregular tasks
3. Aims and Research Questions

should increase age differences. Yet, only few studies explicitly tested the influence of these factors (e.g. Kliegel, Jäger et al., 2008), with virtually only one study examining the effect of task regularity (Rendell & Craik, 2000). So far, the relation of motivation and prospective memory performance was only tested in laboratory settings. Here, the performance of older adults in prospective memory tasks can be facilitated by increasing the perceived importance of the task (e.g. Kliegel, Phillips et al., 2008). Though, if an enhancement of importance can also boost prospective memory performance in a naturalistic prospective memory task still awaits confirmation. In addition, a lack of motivation is assumed to be critical in particular for the performance of younger adults (Maylor, 2008).

Following upon the outlined issues, the third study aimed at further exploring the age prospective memory paradox and therefore tested the influence of task setting and motivation on prospective memory performance in younger and older adults. In the laboratory, an established paradigm was used: the Virtual Week task by Rendell and Craik (2000). Younger and older adults played a board game that simulated the course of an ordinary week. On each virtual day in the game, virtual daily decisions had to be made. Besides the decision task, daily prospective memory tasks were embedded within each day. Furthermore, a naturalistic task was applied, as participants had to send text messages to the experimenter on five consecutive days at two given times of the day. In order to excite a high motivation level a monetary incentive was provided to half of the sample. Thus, for the first time, the effect of motivation was directly tested in a naturalistic setting, by inducing a motivation manipulation.

3.4 Summary of the research questions

To summarize, the aim of the present thesis is to investigate potential cognitive mechanisms and processes underlying event-based prospective memory development across the lifespan. To this end, the influence of central factors from the multiprocess framework
3. Aims and Research Questions

(McDaniel and Einstein, 2000) on prospective memory performance will be explored in three age groups. The three research questions focus on the impact of (1) motivation in pre-school age children; (2) task absorption, target distinctiveness and cue focality in school age children; and (3) task setting and motivation in younger and older adults on performing delayed intentions.
4. Empirical Studies

4.1 Study 1: Prospective memory development in pre-schoolers

4.1.1 Introduction

One of the most frequent everyday memory failures is to forget to carry out a delayed intention, e.g., to hand over a message to a friend. The ability of remembering to initiate and execute an intended action at some time in the future is called prospective memory and is contrasted to retrospective memory which reflects remembering information from past situations. A particular challenge for succeeding in this type of memory task is that an intended action often has to be carried out in the midst of performing an ongoing task, which renders prospective memory tasks highly susceptible to failures and constitutes the dual-task nature of prospective memory paradigms (Brandimonte et al., 1996; Kliegel, McDaniel et al., 2008).

While several studies have examined prospective memory in young and older adults (see Henry et al., 2004, for a meta-analytic review), there are only a few studies investigating mechanisms and processes that lead to successful prospective memory performance in children, especially in pre-schoolers (see Kvavilashvili et al., 2008, for an overview).

In a first study, Somerville et al. (1983) examined 2-, 3- and 4-year-old children who were asked to remind their caregivers to carry out a specific action after a short or long delay. The action, that had to be performed, was either of high (i.e., buying candies at the store) or low (i.e., bringing in the washing) interest for the children. Even with a long delay (four to eight hours) no general age differences were found. Importantly, in the high interest condition, 2-year-old children performed as well as 4-year-olds on the task while performance of the youngest was reduced in the low interest condition (and only with long delays).
Because the study was conducted in the course of everyday life, however, results may be difficult to evaluate due to the lack of control over the activities performed in the delay phase.

Consequently, Guajardo and Best (2000) tested the effect of motivation on pre-schoolers’ prospective memory performance in a controlled laboratory study. Specifically, they compared prospective memory of 3- and 5-year-old children in a computerized prospective memory task and varied whether incentives to enhance motivation were given to the children. As ongoing activity, the children had to perform a memory task, in which pictures were presented that the children should learn for later retrieval. In addition, they were told to remember to press a specific button, whenever they saw one of two possible target pictures (i.e., a house or a duck). Incentives were little presents given to the children as reward for every detected target picture. Results showed a general age effect, as more 5-year-olds than 3-year-olds remembered to perform the prospective memory task (see also Wang et al., 2008, for a similar age effect studying 3-, 4- and 5-year olds). Yet, there was no effect of incentives and the authors concluded that motivation may not affect prospective memory performance in pre-schoolers. A potential critical aspect with this study (which also holds for the Wang et al., 2008, study), however, may be that the difficulty of the ongoing memory task appeared to be different for young and old pre-schoolers as younger children showed lower performance in the ongoing memory task (see Kvavilashvili et al., 2008, for a discussion of these limitations). Consequently, the observed age effect in prospective memory performance might have been caused by the differential ongoing task absorption across the two pre-school age groups; similarly, a possible motivational effect might have been masked by differential ongoing task difficulty. So far, only Zimmerman and Meier (2006) examined prospective memory performance across the lifespan using an experimental design that aims at equating task difficulty. In this study, they also included two groups of pre-schoolers; however, unfortunately, in their analyses, all pre-schoolers were merged in one children group; therefore no intra-group comparison of pre-schoolers was reported. Moreover, the potential
effects of motivational incentives were not targeted in this study. Thus, it remains unclear whether the age and motivation effects initially discussed within the pre-school age range hold for tasks that equate ongoing task difficulty across age groups.

Regarding the age effect, recently Kliegel and Jäger (2007) examined the effect of cue-action reminders on prospective memory performance in pre-schoolers (2-6 years). Results showed a reliable age effect in prospective memory performance, as older children outperformed the younger children even when statistically taking differential ongoing task performance in account. Moreover, they found a beneficial effect of cue-action reminders in performance, especially in 3-year-olds. This seems to corroborate the conclusion that prospective memory indeed develops across the pre-school age range. Still, the question of the potential effects of motivational incentives on pre-schoolers’ prospective memory performance remains.

Following up on the effects of task motivation on prospective memory performance in pre-schoolers obtained in the Somerville et al. (1983) study and initial findings from the adult literature showing an impact of task importance on prospective memory performance in young adults (Kliegel et al., 2001), the aim of the present study was to further explore the role of task motivation on age differences in pre-schoolers. For the first time, we examined the role of motivation in a controlled and standardized ongoing task design using an ongoing task that equates ongoing task difficulty by applying age-standardized task material. Specifically, we tested the following hypotheses. First, we expected an age effect in prospective memory performance between 3- and 5-year-old children in the direction of older children outperforming the younger children. Second, we expected an effect of motivation on prospective memory performance, as higher task motivation should lead to better performance. Third, in the light of prior studies indicating that facilitating task characteristics such as reminders appear to help younger children in particular (Kliegel & Jäger, 2007), we also examined a potential age x motivation interaction.
4. Study 1: Prospective memory development in pre-schoolers

4.1.2 Method

Participants and Design

Forty children were recruited from local day care centres and kindergartens. Half of the children were 3 years old (mean age of 43.65 month, $SD \pm 4.08$) and half were 5 years old (mean age of 69.45 month, $SD \pm 9.38$). In the younger group, 60% were girls, in the older group 65%. The task employed a 2 (age) x 2 (motivation) mixed factorial design, in which age as a between-person (3 years vs. 5 years) and motivation as a within-person (low motivation vs. high motivation) factor were varied.

Material and Procedure

Ongoing Task. To secure comparability of task difficulty and cognitive load in both age groups, the German version of the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kamphaus, 1984; Melchers & Preuss, 1991) was applied. The K-ABC is an instrument for assessing cognitive development in children providing age appropriate task versions. To equate ongoing task difficulty, we applied the 3-year-old task material to the 3-year-old children and the 5-year-old task material to the 5-year-olds. The children performed the ongoing task in three consecutive blocks, each consisting of 10 exercises out of four subscales of the K-ABC. Subscales for the 3-year-olds were Magic Window, Hand Movements, Gestalt Closure and Number Recall; for the 5-year-old children, Triangles, Hand Movements, Gestalt Closure and Number Recall were used. The Magic Window task requires children to identify a picture through a slit, so only one part of the picture is visible at the same time. In the Hand Movement task, children have to replicate a series of hand movements. The Gestalt Closure task consists of incomplete blot-drawings, which have to be named correctly. In the Number Recall task, children have to verbally replicate series of numbers that are read to them. The Triangles task requires children to manually replicate an abstract figure using small rubber triangles. Each task has age-appropriate versions that were
standardized on 3098 children. To give an example on the different versions, in the Hand Movement task, 3;0 to 4;11-year old children have to replicate series of three to four movements, while 5;0 to 5;11-year olds have to replicate series of four to five movements. In a similar way, all age-appropriate subscales differ in task difficulty.

Between each block, a prospective memory task was instructed to the children and was supposed to be executed after the block. See Figure 2 for an overview of the procedure.

*Figure 2. Procedure of Study 1. All children received both motivation conditions. The order of administration was counterbalanced. PM = Prospective Memory. K-ABC = Kaufman Assessment Battery for Children.*

*Prospective Memory Task.* Two prospective memory tasks were applied with one designed to generate a high motivation to perform the task later on and the other task designed to generate low motivation in task performance. In the high motivation condition, the children were told to remind the experimenter to give them a present out of a “magic box” after finishing the next task (see Meacham & Colombo, 1980). In the low motivation condition, children were asked to remind the experimenter to write down their name on the front of the documents of the next task after finishing that task.

*Procedure.* Children were tested individually in a room in their day care centre or kindergarten. They were asked to sit next to the experimenter. First, children were told, that they would work on three folders with little games in them. After accomplishing the first block as a warm-up phase, children were either instructed on the high or low motivation
prospective memory task, respectively. Half of the children in each age group received the high-motivation prospective memory task first, the other half vice-a-versa. Then, children were given the items from the second folder, after which they were supposed to remember the prospective memory task. Specifically, after completing the second folder of the ongoing activity, the experimenter explicitly stated that this part is now finished and put the folder away. Before the children started the third block, the experimenter instructed the children on the remaining prospective memory task. After completing the third folder, again, the experimenter stated that this part is now finished and put the folder away. To ensure appropriate comprehension of task instructions after instructing each prospective memory task children’s understanding of the task instructions was tested by the experimenter and misunderstandings were corrected. In addition, at the end of the test session, if a child forgot one of the prospective memory tasks, the experimenter asked the child if he/she could remember the instruction to perform the prospective memory task. When the child could remember that he/she should perform an additional task, the child was asked to recall the details of the instruction to the experimenter. There were no significant age differences in post-task recall of instruction details with 5 and 4 children in the younger and older age group, respectively, not recalling task instructions appropriately. At the end of the session also those children who had forgotten the high motivating task were given the opportunity to choose a present out of the magic box.

4.1.3 Results

Ongoing task. Comparing ongoing task performance (i.e., number of correctly completed K-ABC items) of 3-year-old children \((M = 13.05, SD = 1.03)\) with ongoing task performance of 5-year-olds \((M = 13.10, SD = 1.06)\) showed no performance difference, \(t(38) = -0.34\).
4. Study 1: Prospective memory development in pre-schoolers

Prosp ective memory task. Because motivational incentives were varied as a within-person factor and each prospective memory task was coded as a dichotomic variable (0 = not remembered; 1 = remembered), we employed the following analytic strategy to test our predictions. To determine main effects of age and motivation, performance was collapsed across both motivation and age conditions, respectively and a Mann-Whitney-U-Test or a Wilcoxon-Z-Test were applied, respectively. In order to determine a possible interaction effect of age and motivation, two separate Chi-Square-Tests were applied analysing the age effect separately for both motivation conditions. The results are presented in Table 2, as percentage of correct prospective memory performance across the two age groups and the two motivation conditions.

Table 2.
Percentage of children who correctly performed the prospective memory tasks for both motivation conditions and age groups.

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>High Motivation</th>
<th>Low Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>25%</td>
<td>5%</td>
</tr>
<tr>
<td>5</td>
<td>30%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Comparing the two age groups collapsed across both motivation conditions revealed no main effect of age ($U = 161.50, p > 0.30$). Overall, 5-year-old children did not perform significantly better in the prospective memory tasks than the 3-year-olds. Comparing prospective memory performance in the two motivation conditions collapsed across both age groups, revealed no significant main effect of motivational incentives in prospective memory.
performance \((Z = -1.13, p > 0.25)\). Overall, pre-schoolers did not remember the high
motivation task more often than the low motivation task.

However, importantly, testing the age effect for the two motivation conditions
separately, revealed a significant interaction. While in the high motivation condition there was
no difference between the 3- and the 5-year-olds \((\chi^2(1, N = 40) = .125, p = .72,\) effect size phi
coefficient \(\phi = .056)\), in the low motivation condition, the two age groups differed
significantly (Fisher’s Exact Test \((N = 40)\): \(p < .05,\) effect size phi coefficient \(\phi = .375)\). Here,
performance of 3-year-old children was lower compared to the performance of the 5-year-
olds.

4.1.4 Discussion

For the first time, the present study explored age differences in prospective memory
performance across the pre-school age-range in an age-standardized task procedure that
explicitly equates ongoing task difficulty as suggested by Kvavilashvili et al. (2008).
Moreover, the effect of motivation on pre-schoolers’ prospective memory performance under
laboratory control and given equal ongoing task difficulty was tested. The findings have
several conceptual and methodological implications.

A first important finding was that indeed ongoing task performance was comparable
across both age groups. This is in contrast to previous studies on prospective memory
performance in pre-schoolers which either found worse performance in at least main parts of
ongoing task performance in the younger group compared to the older group (e.g., Guajardo
& Best, 2000; Kliegel & Jäger, 2007; Wang et al., 2008) or did not report ongoing task
performance at all (e.g., Somerville et al., 1983). So far, as indicated by Kvavilashvili et al.
(2008) this pattern had constituted a general caveat to the existing literature on prospective
memory performance in pre-schoolers, even though some studies presented initial
circumstantial evidence that performance differences in the ongoing tasks likely had not
caused the obtained age differences in prospective memory. For example, Wang et al. (2008) have argued that the same age effect on prospective memory performance appeared across several ongoing task conditions that placed more or less demands on ongoing task activities, and Kliegel and Jäger (2007) found age differences to remain even after partialling out individual differences in ongoing task performance. While these approaches deal with the problem of differential ongoing task difficulty and performance across age groups, the present study suggests one methodological approach that – at least in the present experiment – succeeded in a-priori equating ongoing task difficulty. Extending early adult aging studies that have chosen a somewhat similar approach by generally allowing older adults more time or presenting them with less items (e.g., Einstein & McDaniel, 1990), the present approach utilizes the well-standardized and age-scaled diagnostic materials available for children. This allows for much more precise and fine-grained designing of age-appropriate ongoing task material in the study of prospective memory in children (see Zimmermann & Meier, 2006, for an alternative approach).

That comparable ongoing task performance may indeed be an important requirement for studying prospective memory performance in pre-schoolers is suggested by the finding of no general age effect in prospective memory performance in the present study. Across both motivational conditions younger pre-schoolers did not statistically differ from the older pre-schoolers. This is in contrast to at least part of the literature as, e.g., Guajardo and Best (2000) as well as Kliegel and Jäger (2007) have reported reliable age differences for the two age groups studied in the present experiment. A potential explanation for the lack of a main effect of age comes from Kvavilashvili et al. (2001) and Wang et al. (2008). Those studies have demonstrated that task interruption seems to be an important factor influencing prospective memory performance in young children. Examining similar age groups as the present study, Wang et al. (2008) found that prospective memory was only reduced in younger pre-schoolers compared to older ones if the prospective response required active task interruption of the
ongoing task; in contrast, if the prospective response did not require active task interruption there was no age effect. The present study applied a task that did not require active task interruption of the ongoing activity and consistent with these previous two studies did not find a main effect of age. In this context, it has to be noted that although the prospective memory task itself can be considered as relatively low demanding, the children in the present study showed only medium to low performance levels. This might be due to the age-appropriate task material chosen for the ongoing activity phase that was originally constructed and standardized for a test to assess age-appropriate maximum performance levels in general ability. However, as ongoing task difficulty was not systematically varied but explicitly equated in the present study, this as to remain speculative at this point and awaits direct empirical testing.

Regarding the age effect, the present results, hence, largely dovetail with the previous studies on pre-schoolers’ prospective memory performance. However, they do not only replicate Wang et al.’s (2008) no interruption findings. Specifically, the observed age x motivation interaction revealed that – under specific conditions such as low motivation – younger pre-schoolers may indeed show severely reduced prospective memory performance even in a task that equates ongoing task difficulty. Or in other words, only in tasks that are sufficiently motivating may even young pre-schoolers perform as well as older pre-schoolers. This finding is largely consistent to Somerville et al. (1983), where 2-year-old children performed in the high interest condition as well as 4-year-olds while the performance of the youngest was reduced in the low interest (long delay) condition. From a conceptual perspective, the results may reflect that especially in younger children, where the cognitive resources required for successful prospective memory performance (such as attention and retrospective memory) are still developing, motivating or important tasks may help allocating the available resources to the task elements of interest.
However, the data also revealed a lack of an overall effect of motivational incentives. This was mainly due to older pre-schoolers’ performance and could be seen as being in line with Guajardo and Best (2000) who found no significant effects of reinforcements given for accurate performance. However, Guajardo and Best reported this to occur for both age groups. One possible explanation for this inconsistency could be the way of manipulating motivation. Guajardo and Best externally rewarded correct performance in a computer-based task that itself may be seen as rather neutral. In contrast, in the present study, we directly asked the children to remember to execute an action that itself was internally more or less motivating. Alternatively, the presents children could get out of the magic box might have been of differential interest for the two age groups; although post-experimental observations of children and their presents argue against this. Furthermore, the statistical procedure used in the study might also be a factor contributing of missing overall effects of motivation and/or age, since nonparametrical procedures have relatively limited statistical power compared to parametric tests. Yet, due to the coding of the results, no parametric tests could be applied. Nevertheless, future studies will have to empirically address these alternatives.
4. Study 2: Prospective memory development in school children

4.2.1 Introduction

The processes associated with the task of carrying out delayed intentions are referred to as prospective memory (see Kliegel, McDaniel et al., 2008, for an overview). Examples of prospective memory tasks in everyday life are remembering to pass a message to a teacher when you next see them, or to call the football coach at 12 o’clock. Methodologically, prospective memory tasks have been classified as event-based tasks, time-based tasks and activity-based tasks (Kvavilashvili & Ellis, 1996). Event-based prospective memory tasks require the individual to initiate the intended action after the occurrence of an external event signaling the appropriate context for the execution (e.g., “remember to take the cake out of the oven, when the timer rings”), whereas time-based tasks require remembering to perform the intended action at a specific point in time or after a specified period of time has elapsed (e.g., “remember to feed the dog around 6pm”). In activity-based tasks the individual must remember to do something at the end of a specific activity (e.g., “remember to fetch the coat after the tennis training”).

The focus of the present study is on the development of event-based prospective memory, and specifically, on the developmental changes that occur across primary school age. Interestingly, while there is a vast body of research on prospective memory development across late adulthood (see Henry et al., 2004; Kliegel, Jäger et al., 2008, for meta-analytic overviews), only few studies investigated the development of prospective memory in childhood (see Kvavilashvili et al., 2008, for a recent review). This lack of research on prospective memory development is particularly surprising since several researchers have suggested that the development of independence and autonomy in childhood is heavily dependent on prospective memory functioning (e.g. Kvavilashvili et al., 2001; Meacham, 1982), and even in early school years, “children are often responsible for remembering to
transport their schoolwork, to perform chores at home, and to call parents at particular times” (Beal, 1985, p. 631). Thus, prospective memory is a necessary skill to cope with central demands in school children’s everyday life (Meacham, 1982; Winograd, 1988). To date only three studies have examined event-based prospective memory across early school age children and the few available findings are mixed.

The first study on event-based prospective memory in school age children was reported by Passolunghi et al. (1995). Besides examining possible age differences comparing 7/8-year-old with 10/11-year-old children, they tested the effect of encoding mode on prospective memory performance. Children had to read out words that appeared on a computer screen as the ongoing task. As the prospective task, they had to remember to press a specific key whenever a target-word (i.e. boat) occurred amongst the words in the ongoing activity. Encoding information was either presented visually (children saw a picture of a boat), verbally (children read the cue word) or motorically (children heard the cue word and performed the prospective action). Only in the motoric encoding condition did older children outperform the younger ones. The authors suggested that the necessity to link motoric information of the later prospective action with the processes of cue detection may have overloaded young children’s attentional resources.

The second study targeting age differences in event-based prospective memory across early school age examined factors specifically affecting prospective cue detection (Kvavilashvili et al., 2001). In three experiments, 4-, 5- and 7-year-old children were placed in front of a stack of cards with pictures (e.g., carrot, pencil, guitar, spoon) and asked to name them. While being busily engaged naming the pictures on the cards, they had to remember to put cards with an animal picture into a box. As a potential developmental mechanism, the need of ongoing task interruption was varied, as for half of the children the prospective cue appeared in the middle of the ongoing task (task interruption condition), while the cue was placed at the end of the card deck in the no interruption condition. Results generally indicated
Study 2: Prospective memory development in school children

A task interruption effect (no interruption being easier than interruption) along with small age benefits, as 7-year-old children remembered slightly more often to sort out animal cards than 4- and 5-year-olds, but no interaction. The authors attributed the (small) age effects to the developing ability to switch from one activity to another and to the just emerging abilities of prospective remembering in the examined age range.

In contrast to these results, a clear pattern of age invariance emerged in the third study by Nigro et al. (2002), again examining children aged from 7 to 11 years. Here, while engaged in a demanding ongoing task such as mathematical additions, children had to remember to remind the experimenter to pass a message on to an assistant as soon as the assistant entered the room. One possibility is that the very salient and (socially) relevant (human) cue might have resulted in overall high performance in this task. However, since no factor relevant for cue event-detection was manipulated, the role of cue saliency remains to be directly tested.

Although not directly targeting event-based prospective memory development across primary school age, two other recent studies examined possible age differences across early and later childhood / adolescence. Ward et al. (2005) tested the effects of ongoing task demands comparing 7- to 10-year-old children, adolescents (13 to 16 years) and young adults (18 to 21 years). The prospective memory task involved pressing a key whenever an italic letter appeared in an ongoing task (a lexical decision task) with ongoing task demands manipulated by varying stimulus string length. The results indicated that children performed less well than adolescents and young adults, while no differences were found between the latter two groups. Furthermore, an interaction, between age and ongoing task condition was identified, which indicated larger decreases of prospective memory task performance in the high demanding ongoing-task condition for children compared to both adolescents and adults.

Finally, following on from Kvavilashvili et al. (2001), Shum et al. (2008) examined the effect of task interruption on prospective memory performance in an older group
comparing 8/9-year-old children with 12/13-year-olds. As the ongoing activity, children were asked to read a text. Whenever a specific word appeared in the narrative, children had to remember to substitute it with another word. Half of the participants read the text without interruption, while the other half was interrupted on three occasions. A general age effect was obtained, as older children remembered more often to change the target word appropriately. In addition, interruption of the ongoing task only affected younger children, while performance in the older age group was equal in both interruption conditions. These findings were attributed to the ongoing maturation of prefrontal brain networks underlying the inhibitory control processes required for task interruption.

Taken together, the few available studies on event-based prospective memory development across early school age have targeted different age ranges and have failed to consistently identify age differences. In contrast to age invariance from 7 to 11 years in Nigro et al.’s (2002) study, heterogeneous results were obtained by Passolunghi et al. (1995) targeting a comparable age range. Examining younger children, Kvavilashvili et al. (2001) reported better performance of 7-year-olds compared to 4-year olds, yet 7-year-olds outperformed 5-year-olds in only two of three experiments. Besides this mixed descriptive pattern, no clear picture on possible developmental mechanisms has emerged, either. Passolunghi et al.’s (1995) results suggested possible effects of encoding condition on prospective remembering. Kvavilashvili et al. (2001) as well as the two studies on older children (Ward et al., 2005, and Shum et al., 2008) demonstrated that the relation of the ongoing task and the prospective memory task at prospective memory retrieval may be a key factor (Kvavilashvili et al., 2001, and Shum et al., 2008: need for ongoing task interruption; Ward et al. 2005: overall ongoing task demands).

The aim of the present study was to help clarify this literature by providing a systematic examination of the role of retrieval-based factors in understanding age differences in event-based prospective memory in early school age children. This approach is informed
by the multiprocess framework of event-based prospective memory proposed by McDaniel and Einstein (2000) which identifies specific factors that contribute to successful prospective memory retrieval. In the present study the multiprocess framework will be used to systematically test possible developmental mechanisms associated with age effects across early childhood.

The basic assumption of the multiprocess framework is that prospective memory performance involves both automatic and strategic processes, and that their relative prominence varies systematically as a function of specific variables. Importantly for the present study, it is well-documented that controlled processing resources such as executive control are subject to marked developmental changes across the early school years (see, e.g., Anderson, 1998; Anderson, Anderson & Lajoie, 1996; Gathercole et al., 2004; Levin, Culhane, Hartmann, Evankovich & Mattson, 1991; Schneider & Pressley, 1997; Welsh, Pennington & Grossier, 1991). In particular, working memory span is known to increase (e.g., Schneider & Björklund, 1998), and inhibitory control as well as task switching become more efficient (see Goswami, 2008, for an overview). Consequently, any manipulation that reduces the demands placed on strategic rather than automatic processes may be expected to attenuate or even eliminate age differences across early school age. Three main retrieval-associated factors are proposed by the multiprocess framework to predict strategic processing demands: (a) ongoing task absorption, (b) cue distinctiveness and (c) cue focality.

With respect to ongoing task absorption, the model suggests that the more demanding, engaging, or absorbing the ongoing task, the more controlled resources will be required to detect the prospective cue (e.g., while being immersed in conversation with a friend, higher strategic monitoring may be necessary to maintain the intention to buy bread for dinner upon passing a bakery than when walking without company). Thus, higher task absorption should lead to larger age-related differences. This prediction was tested in Experiment 1.
With respect to cue distinctiveness, distinct or salient prospective cues are predicted to support prospective memory performance by eliciting a rather automatic orienting response (e.g., while passing a post box, a large yellow box should be a more salient cue to post the mail on the way home than a small box in the colours of the surrounding buildings). Thus, the more salient the prospective memory task cue, the less controlled monitoring may be required, which again, should result in attenuated age effects. This prediction was tested in Experiment 2.

Finally, cue focality refers to the focality of prospective memory cue processing relative to the processing required for the ongoing task (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000; McDaniel et al., 2008). Consequently, focal prospective memory tasks are those in which the ongoing task involves processing the defining features of the prospective memory cue (e.g., keeping words in working memory while remembering to press a button whenever a specific word appears; Einstein & McDaniel, 1990). In this case, it is assumed that the prospective memory cues are sufficiently processed during the ongoing task to enable rather automatic retrieval of the intended action. By contrast, nonfocal prospective memory tasks are those in which the prospective memory cue is not part of the information being extracted in service of the ongoing activity (e.g., keeping words in working memory while remembering to press a button whenever the background of the screen shows a particular pattern; Park et al., 1997). In nonfocal tasks, prospective remembering is thought to require controlled resources in order to carry out extra monitoring for the cue to perform an intended action. Because age differences should be attenuated or even non-existent in tasks requiring less controlled processes age effects should be greatest for prospective memory tasks with nonfocal target cues. This prediction was tested in Experiment 3.

Taken together, in three experiments, the present study for the first time systematically examined conceptual predictions derived from the multiprocess framework for possible age differences across early school age, as well as associated developmental mechanisms.
potentially underlying those age differences. Importantly, across all three experiments the same general experimental procedure was applied adhering to the general guidelines for research on prospective memory in children recently outlined by Kvavilashvili et al. (2008): (i) applying an age-appropriate task that is of general interest for children in terms of task motivation, task duration and task difficulty (ideally to be presented in the context of a game setting), (ii) eliminating possible ceiling effects in the older group, (iii) considering age differences in ongoing task performance in which the prospective memory task is embedded, (iv) ensuring retrospective memory for task instructions.

4.2.2 Experiment 1

In Experiment 1, the effect of ongoing task absorption on age differences in event-based prospective memory performance across primary school age was examined.

4.2.2.1 Method

Participants. Sixty-six children were recruited from local primary schools. The younger group consisted of 33 children between 6-7 years (mean age = 6.88 ± 0.33 years) with 54.4% being female, whereas the 33 children of the older age group were 9-10 years old (mean age = 9.67 ± 0.54 years; 42.4% female; no significant gender differences emerged between age groups). All children scored within ±1SD on standardized measures of fluid and crystallized intelligence (detailed below).

Materials and procedure

General ability. To assess crystallized intelligence, the “Information” subscale of the German Version of the Wechsler Adult Intelligence Scale WAIS (Wechsler, 1981) was used. Participants were asked general knowledge questions (e.g. Who was Christopher Columbus?), of increasing difficulty.
4. Study 2: Prospective memory development in school children

The “Block Design” subscale of the German Version of the Wechsler Adult Intelligence Scale WAIS (Wechsler, 1981) was used to assess fluid intelligence. Here, participants had to manually replicate abstract figures using small plastic cubes.

*Prospective memory task.* Following up on recommendations by Kvavilashvili et al. (2008), the experimental procedure used in this study (*The Dresden Cruiser*) was based on a driving game scenario initially suggested by Kerns (2000; see also Kerns & Price, 2001). In this game, the ongoing task was to drive a vehicle and the prospective memory task was to remember to refuel before the vehicle runs out of gas. Specifically, children were engaged in driving a car on a dimensional road, which was displayed vertically on the monitor. The road consisted of three parallel lanes, with the speed of other vehicles driving on the road in the same direction increasing from left to right (see Figure 3 for screenshot). The car was controlled by gamepad (Thrustmaster FireStorm Digital 3 Gamepad). Children were able to manoeuvre on the horizontal axis (left-right), but not on the vertical axis (forward-backward). The aim of the ongoing task was to gain as many points as possible by avoiding hitting other cars. A prospective memory task was embedded in this ongoing driving task: children had to remember to refuel the car. It was only possible to refuel when ¼ or less fuel was left in the tank. In all three experiments, children were cued by specific events that the tank was ¼ full and were instructed to remember to press a button on the gamepad to refuel whenever the specific event occurred. After pressing the button, a fuel gauge appeared for four seconds in the left lower corner of the screen, indicating that refuelling was successful. The tank was refilled automatically when the car ran out of gas, but no fuel gauge appeared. Whenever participants performed the prospective memory task successfully, extra points were added to the score. Without refilling, the car ran out of gas after one minute, after 45 seconds the tank could be filled within 15 seconds. The duration of the game was 4 minutes.
Procedure. The general procedure followed Kvavilashvili et al.’s (2008) suggestion of separating the prospective memory procedure in several short sub-components. Two blocks of four minutes were administered in which the experimental factor was varied in counterbalanced order (see Figure 4).
First, children were told about the ongoing task. When children could repeat the instructions for this task accurately, they played a 30 seconds practice trial to familiarise themselves with the game. In the practice trial, no refuelling was required. If children hit cars on purpose, they were asked to repeat the instructions and emphasized that they would lose points by hitting other vehicles. Then, children were provided with the prospective memory task instructions. The prospective cue in Experiment 1 was a change in the colour of flowers passing by at the side of the road. While flowers were usually displayed in a soft pink, one flowerpot on each side of the road occurred with yellow flowers as a cue to refuel the car. Pilot work had revealed that an over-learned single event (such as a gas station) produced ceiling effects even amongst the younger children and that children readily accepted the flowerpot cue as a normal part of the game instructions. Again, children were required to show understanding of task requirements by verbal recall of instructions. However, to introduce a delay between task instructions and subsequent execution of the prospective memory task (see Ellis & Kvavilashvili, 2000), this time children were told that they would first play another game, the Information scale of the WAIS. After completing the Information task, children were asked to play the first round of the cruiser, without further mentioning the need to refuel. To manipulate ongoing task absorption, in Experiment 1 half of the children played a less demanding version with 15 other cars per minute appearing on the road, while the other group played a more demanding version with 35 cars per minute. Thereafter, another delay was implemented, as children completed the Block Design task of the WAIS. When finished with the Block Design task, children played the second (alternative) round of the cruiser game and completed the second prospective memory task. Afterwards, retrospective memory for task instruction was tested; all children (in all three experiments reported) were able to recall the instructions for the prospective memory task. Finally, children received a 5 Euro-voucher of a
local toy store. The overall procedure lasted about 40 minutes. Children were tested individually.

4.2.2.2 Results and Discussion

*Ongoing task performance (manipulation check).* The number of car crashes with other cars was used as indicator of ongoing task performance. A 2 x 2 ANOVA with the within-subject factor *ongoing task absorption* (high, low) and with the between-subject factor *age* (younger children, older children) was conducted. The analysis revealed a main effect of ongoing task absorption indicating more car crashes in the high absorption condition than in the low absorption condition, $F(1, 64) = 925.65$, $MSE = 88.85$, $p \leq .001$, $\eta^2 = .935$. In addition, there was a main effect of age group indicating more car crashes in the younger age group than in the older age group, $F(1, 64) = 18.96$, $MSE = 262.75$, $p \leq .001$, $\eta^2 = .229$. Moreover, an interaction effect emerged, $F(1, 64) = 4.79$, $MSE = 88.85$, $p \leq .05$, $\eta^2 = .07$. Planned comparisons indicated larger age differences in ongoing task performance when being highly engaged in a demanding ongoing task compared to age differences in the low absorbing task condition (see Table 3).

<table>
<thead>
<tr>
<th></th>
<th>Young Children</th>
<th>Older Children</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M (SD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Absorption</td>
<td>20.3 (10.1)</td>
<td>11.6 (6.9)</td>
</tr>
<tr>
<td>High Absorption</td>
<td>73.8 (17.5)</td>
<td>57.9 (15.7)</td>
</tr>
</tbody>
</table>

*Prospective memory performance.* A mixed 2 x 2 analysis of variance (ANOVA) was conducted with the within-subject factor *ongoing task absorption* (high, low) and the
4. Study 2: Prospective memory development in school children

between-subject factor age (younger children, older children). The analysis revealed a main
effect of ongoing task absorption, $F(1, 64) = 14.82, MSE = 0.05, p \leq 0.001, \eta^2 = .188$, as well
as a main effect of age group, $F(1, 64) = 11.59, MSE = 0.17, p = .001, \eta^2 = .153$, but no
interaction effect, $F \leq 1$ (see Figure 5): Older children remembered to refill the car more often
than younger children and the car was refuelled more often in tasks with low ongoing task
absorption.

*Figure 5.* Prospective memory performance in Experiment 1, Study 2. (Error bars represent
one standard error of the mean.)

Taken together, results clearly showed age differences in prospective memory across early
school age and hence are in contrast with earlier studies demonstrating age invariance for this
age range (Nigro et al., 2002). In addition, findings revealed that ongoing task absorption
affects children’s prospective memory performance. However, in terms of a possible
developmental mechanism underlying this effect, Experiment 1 revealed no support for the
prediction that ongoing task absorption may be driving this effect. In fact, ongoing task
difficulty affected both younger and older children’s prospective memory equally; therefore
task absorption did not contribute to the developmental differences observed.
4.2.3 Experiment 2

In Experiment 2, a second factor suggested by the multiprocess framework was examined. Specifically, the effect of cue distinctiveness on age differences in event-based prospective memory performance across primary school age was tested.

4.2.3.1 Method

Participants. Seventy-six children were recruited from local primary schools. The younger group consisted of 37 children between 6-7 years (mean age = 7.25 ± 0.49) with 37.8% being girls, whereas the 39 children of the older age group were 9-10 years old (mean age = 9.73 ± 0.51) with 46.2% being girls (no significant gender differences emerged between age groups). All children scored within ±1SD on standardized measures of fluid and crystallized intelligence.

Materials and procedure. Materials were identical to Experiment 1 except for the within-person variation of cue distinctiveness in the driving task. In the low distinction condition, one flowerpot on each side of the road occurred with yellow flowers in contrast to standard pink flowers. In the high distinction condition, several yellow flowerpots occurred. Ongoing task difficulty was held constant at high difficulty (i.e., 35 cars per minute).

4.2.3.2 Results and Discussion

Ongoing task performance. Ongoing performance was analyzed using a 2 x 2 mixed-factorial ANOVA that included the within-subjects factor cue distinctiveness (high, low), and the between-subjects factor age (younger children, older children). Younger children hit other cars more often than older children, $F(1, 74) = 17.87, MSE = 614.72, p \leq .001, \eta^2 = .195$, but there was no difference between the two cue salience conditions, $F(1, 74) = 3.35, MSE = 126.92, p > .05, \eta^2 = .043$, nor an interaction, $F \leq 1$ (see Table 4).
Table 4.
Ongoing task performance (car crashes) in Experiment 2, Study 2.

<table>
<thead>
<tr>
<th></th>
<th>Young Children</th>
<th>Older Children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Low Salience</td>
<td>72.5 (17.4)</td>
<td>57.1 (16.9)</td>
</tr>
<tr>
<td>High Salience</td>
<td>77.5 (19.3)</td>
<td>58.8 (22.8)</td>
</tr>
</tbody>
</table>

Prospective memory performance. Prospective memory performance was analyzed using a 2 x 2 mixed-factorial ANOVA that included the within-subjects factor cue distinctiveness (high, low), and the between-subjects factor age (younger children, older children). Prospective memory performance was higher when a more distinctive cue was presented, $F(1, 73) = 9.63, MSE = 0.06, p \leq .01, \eta^2 = .117$. In addition, performance improved with age, $F(1, 73) = 13.91, MSE = 0.16, p \leq .001, \eta^2 = .160$. Yet, no interaction between age and cue salience emerged $F(1, 73) = 1.36, MSE = 0.06, p > .05, \eta^2 = .018$ (see Figure 6).

Following up on suggestions by Kvavilashvili et al. (2008), as ongoing task difficulty was not directly manipulated in this experiment, age differences in ongoing task performance were then considered. In order to test the influence of ongoing task performance on the age...
In Experiment 3, cue focality, the third factor suggested by the multiprocess framework that may affect cue detection and prospective memory retrieval, was examined for its potential to explain age differences in event-based prospective memory across early school years.

4.2.4.1 Method

Participants. Eighty children were recruited from local primary schools. The younger group consisted of 40 children between 6-7 years (mean age = 6.68 ± 0.47) with 30% being girls, whereas the 40 children of the older age group were 9-10 years old (mean age = 9.50 ± 0.51) with 52.5% being girls (no significant gender differences emerged between age groups;
however, as gender distribution was relatively uneven we tested for gender effects in the variables of interest, but none of the variables analysed below were affected by gender. All children scored within $\pm 1SD$ in a test of fluid and crystallized intelligence.

*Materials and procedure.* Materials were identical to Experiment 1 and 2 except for the within-person variation of cue focality in the driving task. For the *nonfocal* condition, the cue was the yellow flowerpot outside of the road (as in Experiments 1 and 2, low distinctiveness). For the *focal* condition, the cue was presented in the focus of the attention required for the ongoing task (i.e., trying to avoid hitting other cars). Here, the prospective memory cue was a yellow car that had to be overtaken in the process of the driving activity (no other cars were yellow). Ongoing task difficulty was held constant at high difficulty (i.e., 35 cars per minute).

### 4.2.4.2 Results and Discussion

*Ongoing task performance.* Ongoing performance was analyzed using a 2 x 2 mixed-factorial ANOVA that included the within-subjects factor of *cue focality* (focal, nonfocal), and the between-subjects factor *age* (younger children, older children). Younger children hit other cars more often than older children, $F(1, 76) = 29.03$, $MSE = 508.18$, $p \leq .001$, $\eta^2 = .276$, but there was no difference between the two cue focality conditions, $F \leq 1$, nor an interaction, $F(1, 76) = 2.45$, $MSE = 146.77$, $p > .05$, $\eta^2 = .031$ (see Table 5).

*Table 5.*

<table>
<thead>
<tr>
<th>Ongoing task performance (car crashes) in Experiment 3, Study 2.</th>
<th>Young Children</th>
<th>Older Children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ ($SD$)</td>
<td>$M$ ($SD$)</td>
</tr>
<tr>
<td>Focal Cue</td>
<td>83.3 (21.2)</td>
<td>60.8 (15.8)</td>
</tr>
<tr>
<td>Nonfocal Cue</td>
<td>81.9 (17.7)</td>
<td>65.5 (17.3)</td>
</tr>
</tbody>
</table>
Prospective memory performance. Prospective memory performance was analyzed using a 2 x 2 mixed-factorial ANOVA that included the within-subjects factor cue focality (focal, nonfocal), and the between-subjects factor age (younger children, older children).

Prospective memory performance was higher with a focal cue than with a nonfocal cue, $F(1, 76) = 26.91, MSE = 771.9, p \leq .001, \eta^2 = .261$. In addition, performance improved with age, $F(1, 76) = 12.12, MSE = 1564.6, p \leq .01, \eta^2 = .138$. Moreover, an interaction between age and cue salience emerged $F(1, 76) = 3.84, MSE = 771.9, p \leq .05, \eta^2 = .048$ (see Figure 7). Planned comparisons revealed that this interaction was due to age differences being significant for the nonfocal ($p \leq .001, \eta^2 = .168$), but not for the focal cue condition ($p > .05, \eta^2 = .039$). Strikingly, the age difference was more than four times larger in the nonfocal condition than in the focal condition as indexed by effect size.

Figure 7. Prospective memory performance in Experiment 3, Study 2. (Error bars represent one standard error of the mean.)

As ongoing task performance differed between age groups, age differences in ongoing task performance were then considered. In order to test the influence of ongoing task performance on the age effect in prospective remembering, an ANCOVA was applied. The results still revealed an effect of cue focality, $F(1, 75) = 6.60, MSE = 759.5, p \leq .05, \eta^2 = .081$, but no age effect anymore ($F(1, 75) = 3.59, MSE = 1492.6, p \leq .06, \eta^2 = .046$). However, an
(even stronger) interaction effect was revealed, $F(1, 75) = 6.10$, $MSE = 759.5$, $p \leq .05$, $\eta^2 = .075$. Planned comparisons covarying ongoing task performance showed that this interaction was again due to reliable age differences in the nonfocal ($p \leq .01$, $\eta^2 = .127$), but not in the focal condition ($p \leq .75$, $\eta^2 = .001$) (see Figure 8 for estimated means).

![Figure 8. Prospective memory performance after covarying ongoing task performance in Experiment 3, Study 2. (Error bars represent one standard error of the mean.)](image)

Three main findings emerged from Experiment 3. First, data replicated the general age difference found in Experiments 1 and 2 (again with a comparable effect size of $\eta^2 = .14$). Second, cue focality was clearly identified as a variable affecting children’s prospective memory performance. This main effect was approximately twice as large as the age effect identified, and supports the claim of the multiprocess framework that cue focality is a key factor determining prospective memory retrieval (McDaniel & Einstein, 2000). Third, and most importantly, an age x cue focality interaction was revealed, indicating that younger children were disproportionately affected from having to respond to nonfocal cues than older children. In fact, planned comparisons further exploring the interaction showed that the age effect emerged only in the nonfocal (but not the focal) condition. This finding is in clear accordance with more recent predictions by McDaniel and Einstein (2005) suggesting that age
effects may be modulated by cue focality. The present study is the first to empirically demonstrate this pattern for child development of prospective memory.

4.2.5 General Discussion

The present study provided the first evaluation of retrieval-based factors that potentially contribute to age differences in event-based prospective memory function in young school age children. The first finding of note was that, in contrast to prior studies that have failed to consistently identify age differences in prospective memory function in this age group (see e.g., Nigro et al., 2002), across all three experiments age differences were identified. Importantly, in each of these studies the general guidelines for research on prospective memory in children outlined by Kvavilashvili et al. (2008) were adhered to. Thus, an age-appropriate task of general interest for children was used, possible ceiling effects in the older group were eliminated, age differences in ongoing task performance were considered, and retrospective memory for task instructions was demonstrated. With each of these key methodological considerations in place, the present study therefore provides the strongest evidence to date that 9-10 year old children remember to execute delayed intentions reliably better than 6-7 year old children, and thus identifies a systematic developmental shift in prospective memory function in early school age children.

However, of particular interest were the manipulations of retrieval-based factors. As noted, the rationale for these manipulations was predicated on the multiprocess framework (McDaniel & Einstein, 2000). This model predicts that event-based prospective remembering can be supported by either strategically monitoring the environment for the presence of the prospective cue or by relying on the prospective cue to automatically prompt the target action. Consistent with this model, the provision of a less complex ongoing task (Experiment 1), higher cue salience (Experiment 2) and higher cue focality (Experiment 3) were each
associated with better prospective memory performance in both age groups. These data therefore have important practical implications, in identifying specific ways by which prospective memory function may be optimised in school age children. However, neither the complexity of the ongoing task, nor cue salience interacted with age, and consequently did not contribute to the developmental differences observed. Instead, cue focality emerged as a potential developmental mechanism, with age effects in Experiment 3 restricted to the nonfocal (but not the focal) cue condition. Indeed, the absolute magnitude of the age effect in the nonfocal condition was four times larger than in the focal condition, implying that age effects in early childhood may be modulated by cue focality.

It is of note that although Einstein & McDaniel (2000) have proposed several specific variables that determine the relative prominence of controlled, strategic relative to more automatic demands, it has been suggested that cue focality may be the most important determinant. Thus, it was noted that, “whether or not there are age differences will depend on whether the PM task uses nonfocal or focal target events” (Einstein & McDaniel, 2005, p. 289). The present data is consistent with this prediction, in showing that only in conditions where nonfocal cues are presented are age differences in school age children identified. Further, since in the context of healthy adult ageing, age effects are reliably greater for nonfocal compared with focal prospective memory tasks (for a meta-analytic review, see; Kliegel, Jäger et al., 2008), the present study provides important evidence that there may be common developmental mechanisms that contribute to age differences in prospective memory across childhood and older adulthood.

The precise cognitive mechanisms that underpin these age differences however, warrant further consideration. As noted previously, there are marked developmental shifts in controlled processing resources in early school age children, including working memory and inhibitory control (see, e.g., Anderson, 1998; Anderson et al., 1996; Gathercole et al., 2004; Levin et al., 1991; Schneider & Pressley, 1997; Welsh et al., 1991). It would therefore be of
considerable interest in future research to more directly assess whether age-related differences in the integrity of executive control operations mediate age-related differences in prospective memory performance.

To conclude, using a methodologically rigorous approach the present study indicates that there are developmental shifts in prospective memory function in early school age children. Further, the degree of difficulty experienced by children in this age group is systematically related to retrieval-based factors. The finding that cue focality emerged as a potential developmental mechanism is also consistent with theoretical models that attribute age differences in prospective memory function to developmental shifts in controlled processing resources.
4.3 Study 3: Prospective memory development in adulthood

4.3.1 Introduction

Prospective memory is referred to as the ability to remember delayed intentions (e.g., taking medication at prescribed times, keeping an appointment at 3 pm or passing a message when meeting a friend; McDaniel & Einstein, 2000). Conceptually, prospective memory is contrasted with retrospective memory, which is defined as remembering information from the past (e.g., recalling a word list, remembering what one did last summer or where one put the keys; Einstein & McDaniel, 1990). Prospective memory is an essential ability to meet everyday life challenges across the lifespan and is especially important in old age with increasing health-related prospective memory demands. Therefore, understanding mechanisms underlying prospective memory in old age has become a major effort in applied cognitive aging research (e.g., Kliegel, Rendell et al., 2008; McDaniel & Einstein, 2007).

So far, research on prospective memory in old age reveals an intriguing age-related pattern: on average, younger adults tend to outperform older adults in laboratory-based prospective memory tasks (defined as studies carried out in the laboratory, e.g., d’Ydewalle et al., 1999; Maylor, 1993b, 1996a; Vogels et al., 2002), while older adults perform on a superior level to younger adults in naturalistic tasks (defined as studies carried out in the everyday environment of the participant; e.g., Devolder et al., 1990; Rendell & Thomson, 1993, 1999). These results have been confirmed in a meta-analysis on twenty-six prospective memory studies by Henry et al. (2004), as it was shown that older adults did not only compensate for age-related decline but substantially outperformed younger adults in naturalistic studies. Moreover, age-related deficits of older adults in laboratory-based prospective memory tasks seemed equivalent in magnitude to the age-related benefits observed in naturalistic prospective memory tasks. Together, these findings have been referred as the *age prospective memory paradox* (Rendell & Craik, 2000), and it remains a
major task for applied cognitive aging research to solve this puzzle (Phillips et al., 2008; Rendell, McDaniel, Forbes, & Einstein, 2007).

Interestingly, on a single study level, findings are not as consistent as suggested by Henry et al.’s (2004) meta-analysis. In fact, age effects vary considerably across studies. Although many laboratory prospective memory studies have shown an age deficit, in several laboratory studies only small or no age differences were found (e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Reese & Cherry, 2002). In addition, performance of older adults in naturalistic tasks did not constantly result in an age advantage (West, 1988). In further exploring the paradox, recent reviews have identified a handful of factors that may be associated with this pattern (Kliegel, Rendell et al., 2008; McDaniel et al., 2008; Phillips et al., 2008) and the present study examines two of the key conceptual predictions: task setting and motivation.

In laboratory-based studies, McDaniel et al. (2008) have argued that task setting may affect the amount of processing resources required by the task which, in turn, will result in a larger, smaller or even non-significant age deficit. Following up on their multiprocess framework (see also McDaniel & Einstein, 2000) they argued that variations in age effects may be a function of whether the prospective memory tasks depend on strategic, attention-demanding processes, which would lead to an age deficit, or in contrast on more automatic processes sparing age-related performance decrements. Two task features have been highlighted that may particularly determine the amount of strategic processing resources involved: task focality (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000) and task regularity (Kliegel, Rendell et al., 2008).

Task focality is one of the key dimensions proposed by the multiprocess framework and represents the extent to which the prospective memory task involves overlapping processing with the ongoing task. Therefore, a task is referred to as focal if the cue of the prospective memory task is directly processed while performing the ongoing task. While only
few studies have explicitly tested this assumption, a recent meta-analysis by Kliegel, Jäger et al. (2008) that post-hoc classified available paradigms as rather focal versus rather nonfocal suggested that indeed prospective memory tasks using rather nonfocal cues showed significantly greater age deficits than tasks using rather focal cues.

The second task feature targeted in the present study, task regularity, concerns the pattern of cue presentations in a prospective memory task and has been suggested by Rendell and Craik (2000) to affect age-related prospective memory performance. In regular tasks, the cues are presented in a consistent routine. Thus, the appearance of a prospective memory cue is more predictable, since preceding situational cues can be used to ‘get ready’ for the appropriate moment. In contrast, as in most laboratory studies, irregular tasks show no consistent pattern and occur somewhat arbitrarily. In consequence, this should result in higher monitoring load. Rendell and Craik (2000) were the first and so far only to directly test this assumption. In their Virtual Week paradigm simulating everyday life across a number of days, younger and older adults had to perform regular tasks as well as irregular tasks. The regular tasks were the same tasks, simulating for example, taking medication at breakfast each day, while irregular tasks were different tasks, and simulated one off tasks such as return a library book when being at the library next. Results with various clinical populations have shown that participants are much more accurate on the regular tasks compared to irregular tasks in Virtual Week (Henry, Rendell, Kliegel, & Altgassen, 2007; Kardiasmenos, Clawson, Wilken, & Wallin, 2008; Rendell, Gray, Henry, & Tolan, 2007; Rendell, Jensen, & Henry, 2007). Importantly, in the one published study reporting Virtual Week with young and older participants, task regularity was the one feature to interact with age, with age-related deficits being substantially attenuated on regular tasks compared to irregular tasks.

Considering both task features, in Experiment 1, the present study aimed at confirming and extending those previous results. Specifically, using a new computer version of the Virtual Week paradigm we directly compared young and older adults’ performance in regular
and irregular tasks. The prediction was that an age deficit should only emerge in irregular tasks while regular task should show no or reduced age differences. Moreover, the new computer version also allowed for examining the focality assumption. Besides regular and irregular daily activities embedded in the original board game Virtual Week, Rendell and Craik (2000) also reported substantial age deficits in a third task type, in which participants had to monitor a continuous external timer to perform regular time-check tasks. In the original board game, this timer was placed next to the board outside of participants’ focal awareness. To test the focality assumption, in the present version, we have increased the focality of this task by placing the timer prominently in the middle of the virtual board, directly in focal awareness. Following up on the multiprocess framework, the prediction was that increasing the focality of this task should reduce the previously reported age deficit on time-check task.

As a second factor, motivation has been assumed to underlie age differences in prospective memory performance. In the laboratory, Kliegel, Phillips et al. (2008) demonstrated that performance of older adults in prospective memory tasks can be facilitated if successful prospective remembering is perceived as highly important to the individual. Even when applying a very demanding ongoing task, older adults performed equal to younger adults when the prospective memory component was perceived as more relevant than ongoing task performance, while younger adults outperformed older adults only if the ongoing task was seen as more relevant. This holds true if task importance was directly manipulated by instruction. Besides reducing the laboratory-based age deficit, an alternative hypothesis regarding motivational effects in the naturalistic age benefit is also possible. Task motivation may also underlie older adults’ superior performance outside of the lab. Here, a potential mechanism might be that either older adults are more motivated to perform a prospective memory task in their everyday life or younger participants may show a suboptimal performance level in naturalistic tasks due to a lower level of motivation to complete prospective memory tasks in their everyday life. The latter might be due to prospective
memory instructions competing with current concerns and “real” everyday tasks. This might be particularly true when the incentive to perform the prospective memory task consists of course credits in academic studies, which is the case in most studies where undergraduate students take part as young participants group (Maylor, 1993a). Importantly, course credits do not necessarily provide an incentive as they typically are not dependent on the level of performance. So far, no study has directly examined the potentially beneficial effect of task motivation on younger and older adults’ performance in naturalistic prospective memory. Thus, in Experiment 2, the present study examined the effects of motivation on age-related performance in a naturalistic prospective memory paradigm. Using a typical naturalistic task (contacting the experimenter at target times, e.g., Devolder et al., 1990; Kvavilashvili & Fisher, 2007; Maylor, 1990) in order to induce a high motivation level a monetary incentive was provided to half of the sample (see Touron, Swaim & Hertzog, 2007). A decrease of the age benefit was expected with motivation especially benefiting younger participants.

In sum, the role of task setting (in the laboratory) and motivation (in a naturalistic task) on the age prospective memory paradox were examined. Specifically, in the present project, an established lab-based task (Experiment 1; the virtual week task, e.g., Rendell & Craik, 2000; Rendell, Jensen et al., 2007) as well as a typical naturalistic task (Experiment 2; contacting the experimenter at target times, e.g., Devolder et al., 1990; Kvavilashvili & Fisher, 2007; Maylor, 1990) were presented to young versus old adults. In Experiment 1, regular and irregular tasks were presented, as well as a focal presentation of a regular time-check tasks. Reductions of age deficits were expected in regular tasks and in focal time-check tasks. In Experiment 2, in the naturalistic task, in order to induce a high motivation level a monetary incentive was provided to half of the sample and a decrease of the age benefit was expected with motivation especially benefiting younger participants.
4.3.2 Experiment 1

4.3.2.1 Method

Participants. Forty participants took part in the study: 20 young and 20 old (see Table 6 for participants’ characteristics). Young participants were undergraduate students at the University of Zurich, Switzerland, and received course credits or 20 Swiss Francs for their participation in the study. The older adults were recruited from local senior citizen groups and received 20 Swiss Francs for their participation. All participants were asked to rate their current health as well as their health over the previous month on a five-point Likert scale, ranging from 1 (excellent) to 5 (poor). The young and old participants did not differ in current health \(t(37) = 0.73, p > .05\) or in previous health \(t(37) = 1.27, p > .05\), but more old adults took medication than younger adults \(\chi^2 (1) = 4.67, p < .05\). Furthermore, the two age groups did not differ significantly in years of education \(t(37) = 0.56, p > .05\). Older adults had significantly higher MWT vocabulary scores than younger adults (a German word vocabulary test; Lehrl, 2005) \(t(37) = 2.71, p < .01\). In contrast, younger adults outperformed older adults on the digit substitution test (German Version of the Wechsler Adult Intelligence Scale WAIS; Wechsler, 1981) \(t(37) = 6.41, p < .001\), the digit span test of the WAIS \(t(37) = 2.11, p < .05\), and the Stroop test (Stroop, 1935) \(t(37) = 11.41, p < .001\). No age differences were found in the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford, Smith, Maylor, Della Sala, & Logie, 2003), neither on prospective errors \(t(37) = 0.85, p > .05\) nor on retrospective errors \(t(37) = 0.35, p > .05\).
### Table 6.
Characteristics of Participants in Experiment 1, Study 3.

<table>
<thead>
<tr>
<th></th>
<th>Young Adults</th>
<th>Old Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 20</td>
<td>n = 20</td>
</tr>
<tr>
<td>Sex (Women %)</td>
<td>80</td>
<td>65</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>26.25 ± 8.27</td>
<td>63.26 ± 5.09</td>
</tr>
<tr>
<td>Self-rated-health&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day of test</td>
<td>4.15 ± 0.67</td>
<td>4.32 ± 0.75</td>
</tr>
<tr>
<td>Over last 2 month</td>
<td>3.85 ± 0.81</td>
<td>4.16 ± 0.67</td>
</tr>
<tr>
<td>Percent taking medication</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Education (in years)</td>
<td>14.05 ± 2.61</td>
<td>14.11 ± 3.48</td>
</tr>
<tr>
<td>Word vocabulary test (MWT)</td>
<td>29.85 ± 4.16</td>
<td>32.80 ± 2.55</td>
</tr>
<tr>
<td>Digit substitution</td>
<td>65.10 ± 9.72</td>
<td>46.30 ± 8.80</td>
</tr>
<tr>
<td>Digit span</td>
<td>14.20 ± 3.90</td>
<td>12.05 ± 2.35</td>
</tr>
<tr>
<td>Stroop (in seconds)</td>
<td>18.10 ± 3.74</td>
<td>39.30 ± 7.42</td>
</tr>
<tr>
<td>PRMQ&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>prospective</td>
<td>18.20 ± 3.97</td>
<td>17.25 ± 3.02</td>
</tr>
<tr>
<td>retrospective</td>
<td>18.65 ± 4.34</td>
<td>18.25 ± 2.69</td>
</tr>
</tbody>
</table>

*Note. Unless specified otherwise, data are given in M ± 1 SD*

<sup>a</sup>Self-rated health responses varied from 1 (excellent) to 5 (poor).

<sup>b</sup>PRMQ-Subscales ranged from 8 (no memory errors) to 40 (very often memory errors).

**Materials.** A computer version of the board game Virtual Week was used as the laboratory measure of prospective memory. Virtual Week has revealed robust prospective memory deficits both in the context of normal adult aging (Rendell & Craik, 2000) as well as
in relation to various different clinical groups (Henry et al., 2007; Rendell, Gray et al., 2007; Rendell, Jensen et al., 2007). This computer version closely followed the original manual version outlined in Rendell and Craik (2000) and was developed to provide a more efficient and flexible measure. The computer version did not change the essential elements of the activity. Figure 9 shows the Virtual Week board as it was displayed on the computer screen, except for that the screen display was in colour. In addition, in this study, all the text was in German.

![Figure 9. Computer screen display of German version of Virtual Week.](image)

The general feature of Virtual Week is that it simulates a course of a week in everyday life. The times of the day people are typically awake are marked on the board and one round on the board represents one virtual day. As participants move around the board they are required to make choices about plausible daily activities and remember to carry out life
activities (i.e., prospective memory tasks). Participants have to roll a six on the dice, before starting to move on the board, simulating waking up from sleep. The choices about daily activities occur, whenever passing or moving on an event square on the board (squares labelled E). When passing such an event square, participants have to select the event-card button, whereon a window appears with the information of a daily activity and participants have to choose between three options. Choosing an option determines the roll of dice that is required to move on (e.g., roll an even/odd number, or a set number, or any number). These three types of possible dice rolls were randomly allocated to the three activity choices on each event card. The activities on the event card are coherent to the virtual time of day.

Furthermore, three meals everyday at the same time of the day establish some sort of structure on the virtual day. Therefore, these tasks serve as backdrop for the prospective memory tasks, by creating the structure of a typical daily routine.

Similarly, the prospective memory tasks used in Virtual Week are also coherent daily activities. Each “day” (circuit) of Virtual Week includes 10 prospective memory tasks (four regular, four irregular, and two time-check tasks) and in this study, participants completed five virtual days. The four regular PM tasks simulate the kinds of regular tasks that occur as one undertakes normal duties, two of which are time-based (i.e., triggered by passing a particular time on the board), and two of which are event-based (i.e., triggered by some information shown on an event card). The tasks are “take asthma medication at 11 a.m. and 9 p.m.” and “take antibiotics at breakfast and dinner” (triggered by event cards featuring breakfast and dinner). The two time-check tasks require the participant to break set from the board game activity and monitor real time on the stop-clock that was displayed prominently. The stop-clock starts every virtual day and participants are asked “to do a lung test” at two occasions, at 2 minutes 30 seconds, and at 4 minutes 15 seconds. Together, the critical feature of the regular tasks and the time-check tasks are that they are the same every day of the game and participants are informed about the tasks before the start of the game. The stop-clock
4. Study 3: Prospective memory development in adulthood

Times are not connected to the events or the virtual time of day in Virtual Week while the targets for the regular events are either events or virtual times of day in Virtual Week.

The four irregular prospective memory tasks represent unforeseen tasks that occur while doing normal daily activity (e.g., returning library book for a friend when at library or phoning plumber at 4 p.m.). Here, the critical features of irregular tasks are that the participants are informed during the game and the tasks are all different. The instructions of those tasks occur either at the beginning of each circuit on the start card that has to be displayed at the beginning of each day, or is displayed during a virtual day on an event card. Like regular tasks, the irregular tasks consist of two time-based and two event-based prospective memory tasks.

At the beginning of each virtual day, one time-based task and one event-based task were presented on the start card, while one time-based task and one event-based task occurred during the game. As in the original version, participants completed a trial day that included four irregular prospective memory tasks, but were not informed about the regular tasks and the time-check tasks until after they had completed the trial day. This was to avoid overwhelming participants with information prior to the trial day. Participants were able to become familiar with Virtual Week during the trial game and before learning the four regular tasks and two time-check tasks. They were instructed to carry out the prospective memory task by telling the experiment about the tasks at the set times. An experimenter sat behind the participant as they played the game at the computer.

Procedure. Participants were tested individually in a session lasting up to two hours. At the beginning of the session, participants were informed about the following procedure and informed consent was obtained. Afterwards, the board game was introduced. In the introduction, the purpose of Virtual Week was described to the participants. They were told that we were interested in their ability to remember to do things later and in the choices they will make during the game. Then, the game was explained in detail. Regarding the
prospective memory tasks, participants were told that tasks had to be performed at prescribed events or at a specific time-square. The participants were instructed to carry out these tasks by telling the experimenter what they wanted to do. They were asked to try to remember to carry out the tasks on-time but to still carry out these tasks even if they were late. In order to become engaged to the game, participants were told to read aloud the information on every event and start card. After the introduction, participants completed a practice day where the experimenter explained the procedures, checked that participants had understood the procedure, and during which participants could ask questions. After completing the practice day, the experimenter introduced regular and time-checking tasks, which were not included in the practice day. Before starting the regular game, participants were asked to recite three times verbatim the regular and time-check prospective memory tasks detailed. During the game, the researcher sat quietly behind the participants, who sat at a desk and played the game on their own. Following virtual week, participants completed the questionnaires and cognitive abilities tests (for further information see participants section).

4.3.2.2 Results and Discussion

A mixed 2 x 3 analysis of variance (ANOVA) was conducted with the within-subject variable of prospective memory task type (regular, time-check, irregular) and with the between-subject variable age (young, old). The analysis revealed a significant main effect of task type, $F(2, 76) = 43.61, MSE = 0.03, p < .001, \eta^2 = .534$, as well as an interaction effect, $F(2, 76) = 5.71, MSE = 0.03, p = .005, \eta^2 = .131$, but no significant main effect of age group, $F(2, 38) = 1.21, MSE = 0.05, p > .05, \eta^2 = .031$ (see Figure 10). Tests of simple effects were conducted to analyse the significant interaction effect. As predicted, there were no age differences on the regular prospective memory task, as well as on time-check tasks, $F$'s < 1, but younger adults outperformed older adults on the irregular prospective memory tasks, $F(1,38) = 8.32, p = .006, \eta^2 = .180$. 
One main finding that emerged from Experiment 1 was that task regularity affected age-related prospective memory performance in a laboratory based study. Concerning task regularity, predictions were clearly confirmed as age differences were eliminated in regular tasks while an age deficit emerged in irregular tasks. These results are in line with the initial findings of Rendell and Craik (2000), and directly show task regularity to be a potent factor in modulating age-related differences in prospective memory performance (see also Einstein, McDaniel, Smith, & Shaw, 1998).

A second, perhaps even more important finding was that presenting the stop-clock within focal awareness also eliminated the previously reported age differences on the time-check task. This finding is further in accord with the theoretical perspective provided by the multiprocess model (McDaniel & Einstein, 2000). Moving the stop-clock into focal attention of participants presumably led to more automatic processing of the time-check task, resulting

Figure 10. Mean proportions of correct responses on the laboratory prospective memory task by age group. (Error bars represent one standard error of the mean.)
in a decrement of age-related differences as less attention-demanding processes were needed. Interestingly, from a broader conceptual perspective, the time-check task contains various features that could be seen as constituting a traditional time-based prospective memory task. Importantly, the previous literature on time-based tasks mostly reported age deficits in older adults when presented in a laboratory setting (d’Ydewalle et al., 2001; Park et al., 1997). Present results indicate that also in time-based prospective memory tasks the feature of task focality may affect age-related task performance. This pattern suggests that if presentation of a clock (used to monitor time) intrudes in focal awareness, the typically reported age decrement in time-based prospective memory performance can be attenuated.

As Experiment 1 has demonstrated, task setting seems to affect the deficit in prospective memory performance in laboratory based studies. Yet, this is only one half of the age prospective memory paradox. In the present lab based tasks, older adults at best performed no worse than younger adults. When a naturalistic prospective memory task is used, however, older adults significantly outperform younger adults (Henry et al., 2004; Rendell & Thomson 1999). In an attempt to isolate a factor that might account for the superior performance of older adults in such tasks, Experiment 2 investigated age-differences in a naturalistic task when motivation was varied (via incentives).

4.3.3 Experiment 2

The second experiment was conducted to test possible effects of motivation for the age benefit in a naturalistic prospective memory task. Motivation is assumed as one of the key factors to be associated with age differences in naturalistic prospective memory performance in younger and older adults (Phillips et al., 2008). The role of motivation was examined by inducing high motivation to half of the sample via monetary incentives that were directly related to the level of performance.
4.3.3.1 Method

Participants. There were 80 participants (for participants’ characteristics see Table 7). Young and old adults reported regular use of mobile phone. Both age groups received 5 Swiss Francs as compensation for sending text messages to the experimenter as well as course credits or 20 Swiss Francs for their participation in the study. The young and old participants did not differ in current health ($t(78) = 0.47, p > 0.05$) or in previous health ($t(78) = 0.58, p > 0.05$), but more old adults took medication than younger adults ($\chi^2(1) = 7.53, p < .01$). Furthermore, the two age groups did not differ significantly in years of education ($t(78) = 1.32, p > .05$). Older adults outperformed the younger adults on the MWT vocabulary test (Lehrl, 2005) ($t(78) = 2.43, p < .05$). Younger adults outperformed older adults in the digit substitution test of the WAIS (Wechsler, 1981) ($t(78) = 8.44, p < .001$), the digit span test of the WAIS ($t(78) = 2.59, p < .05$), and the Stroop test (Stroop, 1935) ($t(78) = 6.89, p < .001$). No age differences were found in the PRMQ (Crawford et al., 2003), either on prospective errors ($t(78) = 1.59, p > .05$) or on retrospective errors ($t(78) = 0.03, p > .05$).

Materials. For the naturalistic phone task, participants were asked to send a text message with their mobile phone to the experimenter twice a day for a period of five consecutive days. The text message consisted of the initials of the participants as well as a one-digit ID number. As receiving device of the text messages, a Motorola V360 was used, which provides exact time stamps for received text messages. Participants were told to send the 3 character text messages with their mobile phone at two set times, 11 a.m. and 9 p.m. These times matched the virtual times of day for the regular task in the board game (Experiment 1). Participants were asked to remember to send the message on-time but if not able then they should the send message when they remembered or have the chance. They were told that in this study, on-time was to be five minutes either side of set time (e.g., 10:55 to 11:05) and late was being later than five minutes but before the next set time. Furthermore,
they were advised to try to avoid switching off their mobile phone but if mobile phone use
would be restricted to consider switching to vibrate or mute.

Table 7.
Characteristics of Participants in Experiment 2, Study 3.

<table>
<thead>
<tr>
<th></th>
<th>Young Adults</th>
<th>Old Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 40$</td>
<td>$n = 40$</td>
</tr>
<tr>
<td>Sex (Women %)</td>
<td>82.5</td>
<td>50</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>24.58 ± 7.03</td>
<td>62.46 ± 4.64</td>
</tr>
<tr>
<td>Self-rated-health$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day of test</td>
<td>4.10 ± 0.63</td>
<td>4.03 ± 0.78</td>
</tr>
<tr>
<td>Over last 2 month</td>
<td>3.83 ± 0.78</td>
<td>3.90 ± 0.82</td>
</tr>
<tr>
<td>Percent taking medication</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Education (in years)</td>
<td>13.60 ± 2.13</td>
<td>14.41 ± 3.23</td>
</tr>
<tr>
<td>Word vocabulary test (MWT)</td>
<td>30.33 ± 3.31</td>
<td>32.10 ± 3.32</td>
</tr>
<tr>
<td>Digit substitution</td>
<td>65.98 ± 10.25</td>
<td>46.28 ± 10.61</td>
</tr>
<tr>
<td>Digit span</td>
<td>14.40 ± 3.68</td>
<td>12.50 ± 2.84</td>
</tr>
<tr>
<td>Stroop (in seconds)</td>
<td>18.08 ± 3.82</td>
<td>30.50 ± 10.74</td>
</tr>
<tr>
<td>PRMQ$^b$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>prospective</td>
<td>18.65 ± 3.70</td>
<td>17.35 ± 3.55</td>
</tr>
<tr>
<td>retrospective</td>
<td>19.05 ± 3.96</td>
<td>19.03 ± 3.83</td>
</tr>
</tbody>
</table>

Note. Unless specified otherwise, data are given in $M ± 1 SD$

$^a$ Self-rated health responses varied from 1 (excellent) to 5 (poor).
$^b$ PRMQ-Subscales ranged from 8 (no memory errors) to 40 (very often memory errors).
Motivational manipulation. Half of the participants in each age group (the incentive groups) were told that they and 19 other participants taking part in this task had a chance to win a lottery prize of 100 Swiss Francs. Specifically, they were instructed that their chance to win depended on how many “entries” they had in the lottery: each on-time text message would get them three entries and each late response one entry. Sending no message would result in no entry at all. Thus, a maximum of 30 entries could be reached, a minimum of zero. The other half of the participants (no incentive groups) was entered into a similar lottery, but was not informed about the lottery at the outset of the experiment.

4.3.3.2 Results and Discussion

The proportion of correct prospective memory responses was analyzed by a 2 x 2 ANOVA with between-groups variables age (young, old) and incentive (no incentive, incentive). This analysis revealed no significant main effects of age group, $F < 1$, and incentive group, $F(1, 76) = 2.46$, $MSE = 0.07$, $p > .05$, $\eta^2 = .030$, but there was a significant interaction effect, $F(1, 76) = 4.11$, $MSE = 0.07$, $p = .046$, $\eta^2 = .051$ (see Figure 11).

Figure 11. Mean proportions of correct responses on the naturalistic prospective memory task by each age group for the two incentive conditions. (Error bars represent one standard error of the mean.)
The interaction effect was further investigated with tests of simple effects. Younger adults were significantly more accurate at sending the short message in the incentive group than in the no incentive group, $F(1, 38) = 5.79, p = .021, \eta^2 = .132$. In contrast, for older adults there was no significant effect of incentive on prospective memory performance, $F < 1$.

Further analyses examined simple main effects for age within each incentive group. Age differences were not significant for the incentive group, $F < 1$, but for the no incentive group, the age difference approached significance, $F(1, 38) = 3.79, p = .059, \eta^2 = .091$.

The results of Experiment 2 indicated that participants’ motivation affected prospective memory performance in a naturalistic environment. Specifically, only young adults’ prospective memory performance was affected by motivational incentives, while there were no differences between the two incentive conditions in the older adult group. This is in line with previous assumptions, that in real life tasks older adults exhibit a greater level of intrinsic motivation (Rendell & Craik, 2000), whereas the level of motivation to complete study-based prospective memory tasks in a naturalistic setting might be reduced for younger adults (Maylor, 1993a).

4.3.4 General Discussion

Various factors have been proposed to contribute to paradoxical results of previous studies regarding age-related differences in laboratory versus naturalistic prospective memory tasks. Therefore, the aim of the present study was to explore this paradox applying both a laboratory based task and a naturalistic task. Using the virtual week game, participants performed irregular as well regular tasks and additionally a focal time-check task. Outside of the lab, the impact of motivation on prospective memory performance in a naturalistic setting was examined.
Our findings clearly indicated that age effects in laboratory tasks are affected by task regularity, as age deficits emerged in irregular tasks but disappeared in regular tasks. Furthermore, moving the time-check task in focal awareness eliminated the age deficits previously reported. This finding supports theoretical proposals that assume focal presentation of prospective memory cues leads to more automatic and less resource-demanding processing of the task, thereby resulting in reduced deficits in old age (McDaniel & Einstein, 2000). In addition, Experiment 2 showed that in a naturalistic task increasing motivation does affect younger but not older participants’ performance. This finding supports previous conceptual proposals that suggest that younger adults may have lower motivation in naturalistic prospective memory tasks than older participants (Maylor, 2008; Phillips et al., 2008). Results obtained have important conceptual and methodological implications.

First, the present results indicated the importance of task setting for prospective memory task performance within laboratory conditions: Remarkably, although embedded in a complex multi-intention laboratory-setting, a more regular task enabled older participants to perform on an equal level with young adults, attenuating age-related deficits in prospective memory performance. Conceptually, a critical feature of regular tasks might be the predictability of the occurring tasks. This possibly enables participants to make plans on the future performance of these tasks, either explicit or implicit. As McDaniel and Einstein (2000) proposed, planning to perform a prospective memory task can affect the extent to which prospective memory performance is supported by relatively automatic, low resource demanding processes. Therefore, regular presentation of a prospective memory task might lead to more automatic processing of relevant information, which in turn facilitates prospective performance. Particular older adults might benefit from the change to more automatic processing as age-related decreases in cognitive resources are attenuated (see Kliegel et al., 2007, for evidence showing beneficial effects of intention planning on prospective memory performance in older adults).
Second, moving the stop-clock into focal awareness eliminated the age differences in the time-check task. In general, this result is in line with the rationale of the multiprocess framework (McDaniel & Einstein, 2000), suggesting that focal cue presentation stimulates automatic processing of a prospective cue in event-based tasks. However, this finding is the first to show that focality is also relevant for time-based tasks and that even *time-based* prospective memory performance of older adults who are outperformed in cognitive ability tests may be equal to young adults when being focal.

Interestingly, the interaction of age and task type in this paradigm, such that age differences were attenuated in regular tasks, contrasts with consistent deficits on all types of prospective memory tasks in several studies comparing clinical and control groups (Henry et al., 2007; Kardiasmenos et al., 2008; Rendell, Gray et al., 2007; Rendell, Jensen et al., 2007). These studies with diverse clinical samples, multiple sclerosis, schizophrenia, and substance abusers, all reported that participants had greater difficulty on regular tasks compared to irregular tasks but the magnitude of differences between clinical and control groups was consistent across the different tasks. Therefore, the present differences on task types appear to be exclusively between age groups, indicating different mechanisms impacting on the normal age-related pattern compared to the impact of clinical conditions on prospective memory.

Third, the present study revealed motivational differences in age groups for a naturalistic prospective memory task, with highly motivated younger but not older adults outperforming their normal motivated counterparts (Experiment 2). It is important to recognize that the young “no-incentive” group represented the average motivated students who normally participate in prospective memory studies and not an especially low-motivated condition. Therefore, age benefits found in previous studies might be overestimated when student populations comprise the young adults group, and these young student groups have been used for most prospective memory and aging studies (Rendell & Thomson, 1999; Rendell & Craik, 2000; Kvavilashvili & Fisher, 2007). This might especially be the case
when young adults are given course credits for experimental participation. In general, age benefits in naturalistic prospective tasks might not be exclusively due to better performance of older adults, which is assumed to be mediated, for example, by the use of reminders (Dobbs & Reeves, 1996, Logie et al., 2004).

Instead, the present results suggest that young adults’ inferior performance (due to generally lower motivation) is an important factor underlying previously reported age benefits (Henry et al., 2004). For instance, Rendell and Thomson’s (1999) younger adults were possibly more likely to have difficulties keeping an organizer with them the whole day, resulting in poorer prospective memory performance. In line with present results, older adults in the study of Kvavilashvili and Fisher (2007) reported higher intrinsic motivation to complete the task than their younger counterparts. Similar, the older participants of Patton and Meit (1993) reported a higher importance of the prospective memory task than the younger adults. In addition, comments of participants from Rendell and Craik (2000) imply that older participants took the prospective tasks more seriously than young participants. Interestingly, normally motivated younger adults in the present study (no incentive group in Experiment 2) performed better than the younger age groups in Rendell and Thomson’s study (1999). In the present study, the recording device (their personal mobile phone) presumably favoured the young adults (relative to Rendell & Thomson), still without extra motivation, the young participants performed at a lower level than older participants in Experiment 2. In contrast, the proportion of correct responses of older adults was relatively similar in Rendell and Thomson compared to this study.

While younger adults increased their performance when an incentive was provided, older adults’ prospective performance was not affected. One possible reason for this finding might be the nature of the incentives. In the present study, the possibility to win money was used to increase motivation. Perhaps, presenting a monetary incentive was not sufficient to boost motivation in older adults. However, Touron et al. (2007) recently showed that
performance of older adults on a retrieval task was enhanced when monetary incentives were provided, but not when doing well was emphasized by instructions alone. Another possible reason for failing to find incentive effects in the older age group might be that older adults were already highly motivated (e.g. see Maylor, 2008), and therefore incentives did not affect performance. Following this rationale, older adults might perform already at their maximum level in naturalistic tasks due to a high intrinsic motivation.

Finally, a few methodological issues need to be considered. With regard to Experiment 1, although a board game should be familiar to most participants, attentional resources that are needed to perform the ongoing task might vary between and within age groups. In addition, using a computer version of the board might be more demanding to older people than for younger participants. If so, then the differential resource demands of the ongoing task across age groups could lead to decreased prospective task performance in the group for whom the task was more demanding (i.e., the older adult group). Yet, this would hold for the entire paradigm and can not explain the differential task setting effects obtained. Nevertheless, future studies should be aware of ongoing task costs by controlling for performance in the ongoing task. With regard to the naturalistic task (Experiment 2), participants had to send messages at two given times. Previous research has indicated that younger adults tend to have a less structured, less predictable and busier lifestyle (e.g. Henry et al., 2004; Rendell & Thomson, 1999). Because the naturalistic part of the present study required carrying out tasks at a fixed time, a structured lifestyle could facilitate successful performance. Therefore, the two groups of participants in the present study might not match adequately regarding structure of the lifestyle. Yet, age differences in lifestyle might in fact be one of the constituting factors underlying the age benefit previously observed in naturalistic prospective memory performance. An option to directly address this issue in future research would be to examine young employees and old employees, ideally within an equivalent occupation.
In sum, our findings add to the prospective memory paradox literature showing that age differences in prospective memory may be less pronounced and paradoxical than assumed in the literature (cf. Henry et al., 2004). It seems to be too simplistic to suggest that age differences invariably occur in laboratory prospective memory tasks, as performance is related to the applied task type. As proposed by the multiprocess framework (McDaniel & Einstein, 2000, 2007), age differences are attenuated in regular tasks and at focal presentation. Furthermore, in naturalistic tasks the age superiority appears to reflect, at least partly, motivational differences within age groups, as age differences can be eliminated by increasing motivation in young adults.
5. General Discussion

The aim of the work presented in this thesis was to investigate event-based prospective development and to explore possible mechanisms associated with developmental differences across the lifespan. Thus, three research questions were proposed: (1) the relation of prospective memory and motivation in pre-schoolers; (2) the effect of task absorption, target distinctiveness and cue focality on prospective memory performance in school children; and (3) task setting effects and motivational effects on prospective memory performance in adulthood. In the following, the results of the three empirical studies according to the research questions will be summarized and discussed, and implications for future research will be outlined. The results of this thesis will then be integrated into the concept of lifespan psychology of prospective memory development. Finally, an outlook suggesting key issues for further research will be provided.

5.1 Discussion of research questions

5.1.1 Motivation and prospective memory in pre-schoolers

Does motivation affect prospective performance in pre-schoolers? This research question can be answered with “yes”. Previous research on the effect of motivation on event-based prospective memory in pre-school age children showed mixed results (see Chapter 1.3.1.1), yet methodological limitations became apparent. Therefore, Study 1 applied an age-equated ongoing task in a laboratory setting to overcome these shortcomings. The results of Study 1 (see Chapter 3.1) indicate that already in pre-school age motivation did affect prospective remembering. Thus, a task that was perceived as highly important yielded better retrieval and execution of an intended action. This finding is in line with results from Somerville and colleagues (1984), who revealed that the importance of task motivation was
already evident in very young children. As Somerville’s study was conducted in the course of everyday life the activities performed in the delay phase could not be controlled. Thus, due to the lack of control some children might have chosen more engaging ongoing activities, while other children performed undemanding tasks. The variation of commitment to the ongoing task may have influenced the effect of motivation manipulation on the prospective memory task by detracting cognitive resources. Therefore, Study 1 was conducted in the laboratory, in contrast to Somerville’s naturalistic design, confirming results under more rigorous methodological control. Unlike Somerville et al. (1984) and the present results, Guajardo and Best (2000) did not find increased prospective remembering by providing incentives to pre-school age children (3-year olds vs. 5-year olds) in their laboratory-based study. Although the ongoing task was controlled in their study, the same procedure was applied to the whole sample; therefore, the difficulty of the ongoing task was not equivalent regarding the cognitive abilities of the two age groups (see Kvavilashvili et al., 2008). In addition, retrospective memory for prospective memory task instructions was not controlled. Thus, to overcome these shortcomings, the present Study 1 implemented age-standardized ongoing task material in order to equate ongoing task difficulty and also controlled for retrospective memory of task instructions. Results revealed that even in the controlled environment of a laboratory with an age-standardized task procedure task-importance did affect prospective remembering in pre-schoolers. Together with results from the adult literature (see Chapter 3.3; Kliegel et al., 2001), findings from Study 1 confirm the impact perceived task-importance has on prospective memory performance across the lifespan, even in very young children. From this point of view, research on prospective memory will have to take the motivation of the participants into account. A highly important task might facilitate performance in groups with limited cognitive resources (e.g. young children, older adults) or in participants with low motivation to perform the task, while low importance of the prospective task might increase age differences.
As possible cognitive resources, executive functions are assumed to affect the development of prospective memory abilities (see Chapter 1.3.1). Executive functions are adaptive, goal-directed behaviours that enable individuals to deal with situations when automatic or established thoughts and responses would lead one astray (Mesulam, 2002). In detail, working memory is assumed to be related to prospective memory performance.

Working memory refers to the ability to hold information in mind and manipulate it (Baddeley, 1986, 2002). Results of cross-sectional studies have indicated that working memory capacity increases from 3 to 5 years of age. This holds true for digit or word span tasks (Bull, Espy, & Senn, 2004; Espy & Bull, 2005; Gathercole, 1998, 1999) or object or spatial span tasks (Ewing-Cobbs, Prasad, Landry, & Kramer, 2004; Luciana, 2003). Hence, on a descriptive level, the development of working memory abilities dovetails with the developmental trend of prospective remembering within pre-school age groups. Yet, this also might become apparent on a task level in order to actually remember a delayed intention, i.e., to keep in mind information that something has to be done and also what it is that has to be done over a period of time.

Further studies are needed to validate the impact of motivation on prospective memory performance in pre-schoolers. Furthermore, the effect of motivation on prospective remembering in older children could easily be examined by expanding the age range. In addition, future research should explore the relationship of working memory development in early childhood and emerging abilities of performing delayed intentions.

5.1.2 Ongoing task absorption, target distinctiveness and cue focality and prospective memory in school age

Are ongoing task absorption, target distinctiveness and cue focality related to prospective memory performance in school children? All three factors affected prospective
remembering in school age children, yet only task focality was related to the development of prospective memory. Previous studies on event-based prospective memory development in school age children showed mixed results (see Chapter 1.3.1.2) therefore Study 2 was carried out to systematically explore the effects of factors from the multiprocess framework (McDaniel & Einstein, 2000) on realizing delayed intentions. The results of Study 2 (see Chapter 3.2) indicated that particularly young children can benefit from a focal presentation of the prospective task. The findings are in line with results from the adult literature on task focality (Kliegel, Jäger et al., 2008; McDaniel et al., 2008), showing increased age deficits in nonfocal prospective memory tasks, while age differences were attenuated in tasks with focal processing. Furthermore, for the first time, a systematic, theory-based exploration of possible factors of prospective memory development in school children was conducted. Development of event-based prospective memory in school age has been examined in only few studies and has revealed mixed results (see Chapter 16). While Meacham and Colombo (1980) and Nigro et al. (2002) did not find age effects, results of other studies have indicated better performance of older children on prospective memory tasks (Kurtz-Costes et al., 1995; Kvavilashvili et al., 2001; Martin & Kliegel, 2003; Maylor et al., 2008; Meacham & Dumitru, 1976; Passolunghi et al., 1995; Shum et al., 2008; Ward et al., 2005). Yet, only three studies revealed possible underlying mechanisms (Passolunghi et al., 1995; Shum et al., 2008; Ward et al., 2005). So far, a theoretical framework to integrate existing results and guide research on prospective memory development has not been applied. The present thesis therefore used the multiprocess framework by McDaniel and Einstein (2000), which suggests factors that might be related to age effects in adulthood (see Chapter 1.4). For the first time, this theory was assigned to childhood development of prospective remembering and central factors of the model were tested, in detail ongoing task absorption, target distinctiveness and cue focality. To meet the criteria for age-appropriate measures in childhood (see Kvavilashvili et al., 2008), an innovative computerized task was developed that embedded a prospective memory task in a
video game. To ensure comparability between age groups, the impact of ongoing task
difficulty was controlled statistically. Results indicated that all factors tested affected
prospective memory performance in school children, though a significant interaction between
age and factor was only revealed for cue focality. Here, younger children performed equal to
older children in the focal condition, while older children remembered more often to perform
the prospective task than younger children if a nonfocal cue was presented. Thus, younger
children were able to perform on a rather high level, if a focal target was provided, but
performance dropped, if the cue was presented nonfocally. In contrast, older children could
sustain their performance even in the nonfocal condition, although at a slightly lower level
than with a focal cue. Development of several cognitive variables can be assumed to underlie
these age differences:

A nonfocal prospective memory task requires monitoring abilities to constantly
control for the prospective cue while performing the ongoing task. In contrast, a focal task
reduces monitoring demands, as the prospective task is integrated in the processing of the
ongoing task. Thus, participants do not have to constantly switch between the ongoing and the
prospective memory task in order to monitor for the target cue. The ability to fluently switch
between two tasks is an important part of executive functioning, particularly cognitive
flexibility (Diamond, 2006; see also Miyake et al. ’s (2000) shifting between tasks, for a
similar construct). In detail, cognitive flexibility refers to the ability to switch perspective,
focus of attention or response mappings. Research on the development of cognitive flexibility
has indicated age-related improvements in school age children (Crone, Ridderinkhof, Worm,
Somsen, & Van Der Molen, 2004; Meiran, 1996). Therefore, older children are thought to be
better at switching more easily between tasks and paying attention more effectively to the
ongoing task as well as to the prospective memory task. Thus, the demands of a nonfocal task
may exceed young children’s cognitive flexibility, leading to worse performance compared to
a focal cue presentation, while superior cognitive flexibility of older children allows them to perform on a rather stable level in both conditions.

In conclusion, general age effects were found for all three examined factors, but only task focality was revealed as a potential mechanism underlying prospective memory development. Conceptually, the multiprocess framework (McDaniel & Einstein, 2000) seems to be an appropriate theory to explore prospective memory development in school age children. Therefore, future studies should examine further factors of the multiprocess approach, to test possible processes that might contribute to the development of the ability to remember delayed intentions. Furthermore, the results of Study 2 require replication. In addition, potential underlying resources, as the development of cognitive flexibility, should be included in future studies.

5.1.3 Task setting and motivation in prospective memory in adulthood and old age

Can task setting and motivational effects dissolve the prospective memory age paradox? The best answer to this question might be “partly”. Previous research on prospective memory performance in younger adults and older adults revealed heterogeneous results (see Chapter 1.3.2), with the age prospective memory paradox as the most surprising. Therefore, Study 3 further explored the age prospective memory paradox by testing the effect of task setting and motivation on prospective memory performance in younger and older adults. The results of Study 3 clearly demonstrated that the two factors contributed to the pattern of different directions of age effects in laboratory and naturalistic prospective memory tasks. Yet, task setting and motivation did not exclusively account for the paradoxical findings (see Phillips et al., 2008, for further proposed factors). The age prospective memory paradox can be explored from two directions: (1) investigate possible mechanisms that affect age impairments in laboratory based tasks; (2) reveal possible factors that might underlie age
benefits in a naturalistic setting. The truth probably lies somewhere in between, as factors in laboratory tasks and mechanism in naturalistic tasks might contribute to the paradoxical findings. Therefore, the present study applied a laboratory based and a naturalistic prospective memory task.

In the laboratory task of Study 3, moving the stop-clock into focal awareness eliminated age differences in the time-check task. This finding nicely dovetails with the multiprocess view (McDaniel & Einstein, 2000), proposing smaller age deficits in focal tasks. Similar results were obtained in school age children (see Study 2, Chapter 3.2), indicating that the effect of focal task presentation on prospective memory development is already evident in childhood. Furthermore, in line with previous studies conducted on adults (McDaniel et al., 2008), the results of Study 3 underline the importance of task focality contributing to age differences in realizing delayed intentions in adulthood (also for time-based prospective memory). Therefore, future studies need to take the focality of the prospective cue into account. In addition, so far only Rendell and Craik (2000) have examined the effect of task regularity on prospective memory performance. The present results support Rendell and Craik’s (2000) findings, as regular tasks attenuated age differences of prospective remembering in the laboratory, while age deficits became apparent only in irregular tasks. In previous studies, most laboratory paradigms have used irregular tasks, in which participants could not anticipate the prospective memory task (e.g. virtually every event-based laboratory study in the meta-analysis of Henry et al., 2004). Thus, prospective memory performance of older adults in the laboratory might be underestimated due to the irregular presentation of the prospective task. Following this rationale, the reported age deficits of the age prospective memory paradox in laboratory tasks might be primary to the low performance of older adults in irregular tasks. In contrast, if the elderly had a possibility to anticipate the prospective task, they remembered to perform delayed intentions as often as younger adults, and therefore the age deficits in the laboratory were attenuated. In consequence, if participants can anticipate
the prospective memory task, they may be able to link the necessary information to the ongoing task. Here, the information of the ongoing task may be used to support correct performance of the prospective memory task. In contrast, in an irregular prospective task, no linkage to ongoing activities is possible. Therefore, intrusion of prospective memory task irrelevant information of the ongoing task needs to be avoided. Executive functions are assumed to be the underlying mechanism of this ability, particularly inhibition and working memory. Hence, declining executive functions might be related to lower performance of older adults in irregular prospective memory tasks. *Inhibition* is the ability to ignore distractions and stay focused. An age-related decline of inhibitory control is found across adulthood (e.g. Hasher & Zacks, 1988; see Jurado & Rosselli, 2007, for an overview). As a result older adults are assumed to be preoccupied with task-irrelevant information. In addition, reduced *working memory* might be especially critical in irregular tasks, as information about the prospective task needs to be ready to retrieve during the entire time of performing the ongoing activity. In contrast, regular tasks enable participants to minimize working memory requirements by providing fixed periods to retrieve the delayed action. Studies on working memory development in early and later adulthood have indicated a climax in early adulthood and have shown a declining trajectory across the lifespan (see Park & Payer, 2006, for an overview). Thus, age differences in prospective memory performance might be affected by diminishing inhibitory control and working memory capacity.

The second aspect of the age paradox is the finding of age benefits in naturalistic tasks (see Henry et al., 2004, for an overview). Various factors are assumed to affect prospective memory performance of young and old adults in naturalistic tasks (see Phillips et al., 2008 for an overview). Amongst them, Maylor (1993a) proposed that differences in motivation may cause age benefits in prospective remembering. In detail, low motivation in younger adults might increase age differences. Therefore, in Study 3 motivation to perform the naturalistic prospective memory task was varied by applying monetary incentives. The results showed
that while performance of older adults did not increase in the incentive condition, younger adults performed significantly better if incentives were provided. This finding supports the assumption of motivation influencing prospective remembering. Hence, age benefits in naturalistic tasks might be, at least partly, due to the low motivation of young adults to perform the tasks. Thus, the view of age benefits in naturalistic prospective memory tasks might need to be reframed: the performance of older adults in a naturalistic environment is not necessarily enhanced, based on various mechanisms (e.g., use of reminder, Kvavilashvili & Ellis, 2004), instead young adults' performance may be reduced as they do not utilise their prospective memory abilities, due to low motivation to perform the tasks.

In sum, the results of Study 3 indicate that several factors underlie the paradoxical age-related findings of laboratory-based and naturalistic prospective memory tasks; two of these are task setting in the laboratory and motivation in naturalistic tasks.

Future studies should further explore the relation of task regularity and task focality on prospective memory performance in adulthood. Especially the effects of task motivation should be taken into account when further investigating the age prospective memory paradox. In addition, the role of possible cognitive resources underlying the age-related decline in prospective memory performance, like inhibitory control and working memory, should also be directly examined in future research.

5.2 Conceptual implications of the present findings: Prospective memory across the lifespan

The aim of the present thesis was to explore the development of prospective memory across the lifespan by applying the theoretical framework of the multiprocess view of McDaniel and Einstein (2000). After presenting the results of the present work, two key questions are emerging: (1) Does prospective memory develop across the lifespan; and (2) is
the multiprocess approach suitable to elucidate age-differences within prospective memory development? To give a short answer: yes and yes. In the following, the results from this work will be integrated in a larger, lifespan-oriented framework.

5.2.1 Does prospective memory develop across the lifespan?

Already pre-school age children were able to remember to perform intended actions (see Study 1, Chapter 3.1). Children at the age of three could remember to ask the experimenter to write down their names or to give them a present. Yet, the ability to (more or less) constantly remember to initiate intended actions is still developing in pre-school age children (performance of younger children was affected by task importance, while older children could sustain their performance level; see Chapter 3.1.3). It should be noted, that Study 1 used an age-equated ongoing task, thus developmental effects were not masked by higher cognitive load in young children because of a more challenging ongoing task (see Kvavilashvili et al., 2008). In addition, development of prospective memory abilities continued across school age, as shown by results of Study 2. Children at the age of 9 to 10 years outperformed children that had just entered school (6 to 7 years) in prospective remembering. This finding is in line with previous reported results (see Chapter 1.3.1.5). Again, even when statistically controlling for ongoing task performance, older children showed better prospective memory performance compared to younger school children. Therefore, increases in prospective remembering across school age can not be attributed solely to higher cognitive demands in young children due to the more challenging ongoing task. Instead, some developmental mechanisms (e.g. cue focality, and therefore the involvement of working memory and inhibition) in prospective memory became apparent. Taken together, the present results indicate that the ability to remember intended actions develops in the early years and continues to develop across childhood.
Concerning prospective memory in adulthood, the present findings are less clear. There seems to be a critical distinction between tasks that produce different age effects: laboratory based vs. naturalistic (see Henry et al., 2004). In the laboratory, most studies show that older adults are outperformed by younger adults. Yet, to propose a general decline in prospective memory performance in old age would be too simplistic. The results of Study 3 indicated that the occurrence of age impairments in prospective remembering in the laboratory seemed to depend on task characteristics (see Chapter 3.3.2). Hence, older adults may be able to perform equal to younger adults in the laboratory, if they are cognitively prepared to perform the task (regular occurrence of the task) or if focal processing is required. In contrast, older adults may be able to perform at a rather high level outside the lab, but it may be the low motivation of younger participants that seems to facilitate their benefits (see Chapter 3.3.3). Therefore, the present results indicated a decline with age on a pure performance level (maybe due to neurodegenerative processes or limited cognitive resources, see e.g. Salthouse, 1991; Wilson, 2008). Yet, possibly because of life experience and the knowledge about their own memory abilities (see Eakin & Hertzog, 2006, for results on metamemory in older adults), older adults may be able to compensate for prospective memory impairments if basic conditions facilitate (e.g. predictable tasks, focal presentation, familiar surroundings).

In summary, a developmental trend of prospective memory abilities becomes apparent that begins in early childhood with age-related improvements across pre-school- and school age. In later life, the ability to remember intended actions depends on specific factors, therefore compensation-strategies and selection of appropriate tasks might be necessary and helpful to maintain prospective memory abilities in later life (for a similar approach on aging-strategies, see Baltes & Baltes, 1990).
5.2.2 Is the multiprocess approach suitable to elucidate age-differences within prospective memory development?

The multiprocess framework by McDaniel and Einstein (2000) proposes several factors that determine if event-based prospective remembering depends on automatic or strategic processes. While automatic retrieval of an intended action does not require cognitive processing, cognitive resources are needed in strategic retrieval of a prospective task.

Moreover, cognitive resources and cognitive capacity develop in childhood and across adulthood (Craik & Bialystok, 2006). Thus, the multiprocess approach can provide a subsidiary framework to integrate possible underlying mechanisms of event-based prospective memory development. The present results support this notion, as factors of the multiprocess framework were found to affect the development of prospective remembering across the lifespan (see Figure 12).

![Figure 12. The multiprocess framework (McDaniel & Einstein, 2000). Lined areas indicate factors of the framework that were examined in the present thesis. Plain lines indicate a significant relation between the factor and prospective memory development, dashed lines indicate that no age-specific relations were found. PM = Prospective memory](image-url)
Already in early childhood, the importance of the prospective memory task seems to be a relevant factor for prospective remembering. While younger pre-schoolers were outperformed by older children in a task without direct benefit for themselves, performance of younger and older pre-school age children was almost equal in a task that was perceived as important due to a direct reward. The results are partly in line with previous findings (see Somerville et al., 1984, but also Guajardo & Best, 2000). Thus, performance may be enhanced in young children by applying a task that induces a high self-perceived importance. In contrast, performance in a task that was not perceived as important was rather low. In conclusion, older children seem to be more effective in tasks that demand strategic processing because of superior cognitive resources. Yet, younger children were able to allocate resources in order to apply strategic retrieval processes if the prospective memory task was perceived as important and desirable. Therefore, older pre-school age children appear to be already capable to permanently remember intended actions, even when being only “normal” motivated. Thus, the present results revealed that task importance, a factor proposed by the multiprocess approach (McDaniel and Einstein, 2000), indeed seems to be related to age-differences of prospective remembering in pre-school age.

In later childhood, i.e. school age, prospective memory development appears to continue (see Chapter 4.2.1). Results of the Study 2 indicated that characteristics of the task can lead to the differences in performance of younger and older school children. Here, the focality of the prospective cue affected performance of children in this age-range. Thus, the multiprocess approach can contribute to exploration of prospective memory development. A focal presentation of the external cue increased prospective memory performance in school age children in contrast to applying a prospective cue outside of the actual processing. Yet, the benefit of a focal cue was higher for young school children compared to older children. Thus, automatic retrieval as facilitated by focal presentation appears to attenuate age differences due to low cognitive demands. In contrast, the distinctiveness of the target cue and
the ongoing task absorption did not affect younger and older children differentially. Therefore, varying prospective memory performance in school age children seems to be partly dependent on the ability to deal with the (non-)focality of the target cue, as younger children are assumed to have less cognitive resources (e.g. Gathercole, 1998), and thus are more affected by nonfocal cue presentation than older children.

In adulthood, the present results indicated that factors of the multiprocess framework can account for the paradoxical pattern of previous studies (Henry et al., 2004). First, in the laboratory task setting (i.e. task regularity and task focality) affected prospective memory performance, especially in older adults. If a task was within focal processing or had to be performed regularly older adults could achieve an equal performance level as younger adults, presumably due to automatic retrieval processes. Second, perceived importance of the task seems to contribute to age-differences in a naturalistic setting. Superior prospective memory performance of older adults in tasks that have to be performed outside of the lab seems to (at least partly) arise from low motivation of younger participants. If younger adults did not perceive the task as important, they remembered to perform the task less often than older adults, possibly due to allocation of cognitive resources. Yet, performance of younger adults significantly increased in a rewarded task, which might arise from focussing cognitive resources on the prospective memory task and therefore enabling strategic retrieval processing. In contrast, older adults’ performance remained stable. Thus, age differences outside of the laboratory might be due to motivational differences of the age groups.

Taken together, these present results indicate that factors of the multiprocess framework by McDaniel and Einstein (2000) may indeed affect age-differences in prospective memory performance throughout the lifespan, as cue focality and task importance were related to prospective memory development in children and adults. These findings have implications for the multiprocess view and developmental prospective memory research. Originally, the multiprocess frameworks aimed at delineating general principles in
prospective memory. The development of prospective remembering was not the focus of the authors. However, the present thesis indicates that the multiprocess approach is not only suitable to explain age-differences in adulthood but also in childhood. Factors of the multiprocess framework seem to affect prospective memory performance across the lifespan and therefore, this approach might serve as foundation for a lifespan theory of the development of prospective memory. To date research on the development of prospective remembering is only marginally or domain-specific theory driven because a comprehensive theoretical concept is not available. Thus, the results of the present thesis suggest the multiprocess framework as a starting point for proceeding steps towards a capable developmental theory of event-based prospective memory across the lifespan.

5.3 Outlook

The results of the present thesis delineate the development of prospective memory from early childhood to older age and reveal possible contributing factors. Thus, the methods developed for the present thesis have been shown to be successful for examining the development of delayed intentions and might be applied in future studies. As outlined earlier, more research is needed to further explore the development of prospective memory across the lifespan and the relation to possible underlying mechanisms (see Chapter 4.1). One critical aspect of lifespan research of prospective memory should be pointed out: the review of previous results on prospective memory development in childhood revealed a lack of studies in this area (see Chapter 1.3.1; see also Kvavilashvili et al., 2008). Moreover, by applying the taxonomy of Einstein and McDaniel (1990), an unequal distribution on event-based and time-based prospective memory becomes apparent. Most of research (also this thesis) has focused on event-based prospective memory, while only five studies have investigated time-based prospective memory development (Aberle & Kliegel, in press; Ceci & Bronfenbrenner, 1985;
Kerns, 2000; Mackinlay et al., in press; Mäntylä et al., 2007). Furthermore, out of these five studies, only one explored time-based remembering abilities in young children (Aberle & Kliegel, in press). Thus, a major direction for future studies should be the investigation of emerging time-based prospective memory abilities in young children and its progression across childhood. Furthermore, the impact of variables that possibly contribute to prospective memory development is still not clear. So far, only few factors that are assumed to affect time-based prospective memory have been studied (see Chapter 1.3.1); and we do not fully understand the way these factors are related with the developing ability of realizing delayed intentions. Therefore, revealing what drives prospective memory development in childhood is an important topic for future research. In the following, a possible design to test these issues will be outlined.

Kvavilashvili et al. (2008) proposed essential criteria that an appropriate measure should meet to test prospective memory performance in children (see Chapter 1.3.1). Furthermore, they suggested video games as an ongoing task with an embedded prospective memory task as a “simple and elegant method” (p. 122) to test prospective remembering in children. As previously described in this thesis, the Dresden Cruiser (see Chapter 3.2) is a videogame, in which a car has to be driven down the road without hitting other cars on the track and is therefore capable of meeting the above-mentioned criteria. By applying the prospective memory task embedded in a video game, the measure is interesting and motivating for younger and older children. Moreover, the prospective task to refill the car is not too prominent to cause ceiling effects. The difficulty of the ongoing task can be modulated by varying the number of other cars on the road and by modifying the speed of occurring vehicles. Thus, the Dresden Cruiser is a versatile measure of prospective memory performance across childhood. The version described in Chapter 3.2 assessed event-based prospective memory performance. Though, the Dresden Cruiser is also capable to test time-based prospective memory performance. Here, the gas level is displayed by a fuel gauge in
the left lower corner. The fuel gauge can be viewed by hitting a button. Yet, the car can be refueled only when the gauge shows that the tank is less than a quarter full, as indicated by a red area on the gas display. The rest of the game is identical with the previous version.

Importantly, the variability of the Dresden Cruiser allows testing the same participant’s event-based and time-based prospective memory performance within the same session with the same measure. Thus, for the first time, a direct comparison of event-based and time-based prospective memory development in young children is possible to explore if developmental trajectories of these two domains differ.

To reveal underlying mechanisms, in a first step, potential variables should be assessed by validated measures. The present research suggests the development of executive functions as a possible affecting mechanism. Following Miyake and colleagues’ (2000) approach executive functions are categorized into three dimensions: updating and monitoring working memory representations, inhibition of dominant responses and shifting between tasks or mental sets. Thus, a line for further research could be to apply children-appropriate measures to systematically explore the effect of those three executive functions for prospective memory development in children. Importantly, for all those constructs appropriate measures are available in the literature. Working memory abilities in children, for example, can be assessed non-verbally by the self-ordered pointing-task (Archibald & Kerns, 1999; Kerns, 2000). Here, children are shown two pictures on a sheet and asked to select one. Then another sheet with the same two pictures in a different order is shown and they are asked to select one they did not already choose. The number of pictures increases until children make two consecutive errors. Another measure of non-verbal working memory is the children’s size ordering task (CSOT; McInerney, Hramok, & Kerns, 2005). Children are read aloud progressively longer lists of common objects and asked to repeat them back to the experimenter ordered by size from smallest to largest. Thus, it does not require numerical or alphabetical knowledge. Inhibition measures for children are the Day-Night-task and Simon
5. General Discussion

says. To perform the Day–Night-task (Gerstadt, Hong, & Diamond, 1994), children must respond “night” to a picture of the sun and “day” to a picture of the moon. At the Simon says-task (Murray & Kochanska, 2002), the child is only allowed to reproduce a shown action when the action is preceded by “Simon says”. Finally, task shifting abilities can be measured by a digital categorizing task of Karbach and Kray (2007) or the dimension change card sort (DCCS; Frye, Zelazo, & Palfai, 1995). Karbach and Kray (2007) asked children to categorize pictures on a computer screen either as fruit (e.g., strawberry) or animals (e.g., horse) or to categorize the pictures as grey or coloured. Responses were given by pressing buttons. Whether the picture or the colour task had to be performed was indicated by symbolic cues. The DCCS asks children to sort test cards that vary on two dimensions (e.g., shape and color) into two trays. Applying the presented (or similar) tasks, a reliable measure of the status of executive functions in children can be assessed.

In addition, further suggested underlying factors that contribute to prospective memory development are retrospective memory (e.g. Zöllig et al., 2007), time-monitoring (e.g. Kerns, 2000; Mackinlay et al., 2009) and time-estimation (e.g. Carelli, Forman, & Mäntylä, in press). First, as Einstein and McDaniel (1990) proposed, prospective remembering can be subdivided in prospective and retrospective components. Thus, retrospective memory abilities are needed to remember what has to be done at the appropriate point of time. Retrospective memory in children can be tested by subscales from the children's memory scale (CMS, Cohen, 1997). Second, for time-monitoring behaviour Ceci and Bronfenbrenner (1985) found two different strategies which affect time-based prospective memory performance. Time-monitoring can be assessed by the Dresden Cruiser, since every gas check is recorded in the database and therefore different time-monitoring strategies can be determined. Third, although the Dresden Cruiser does not require children to have any clock-reading skills, time-based prospective memory performance is suggested to partly rely on time-estimation abilities (Mäntylä & Carelli, 2005). Mackinlay et al. (2009) used a battery of
5. General Discussion

four tasks to investigate time estimation skills (e.g., child was asked to produce a time duration of two minutes). Finally, the relation of prospective memory performance and meta-cognition is an emerging issue that is under discussion (Kvavilashvili et al., 2008; Meeks, Hicks, & Marsh, 2007). One possible factor of superior prospective memory performance in older children contrasted to younger children might be the better knowledge about their own prospective memory performance, resulting in a more appropriate and strategic behaviour. Thus, children should be asked to predict their performance in the upcoming prospective-memory task, extended with an estimation of performance after the task.

As an initial study, a cross-sectional design could give first insights of prospective memory development and underlying mechanisms by using a comprehensive battery of tests to measures the above mentioned possible factors. Thus, applying a correlative approach could reveal relations between prospective memory task performance and suggested variables. The outlined tasks will be feasible for children from the age of four, therefore the onset of time-based prospective memory could be explored more precisely. So far, the onset of time-based prospective memory in childhood has only been examined in our own study (Aberle & Kliegel, in press; data not included in this thesis), indicating that already children at the age of five are able to successfully perform time-based prospective memory tasks successfully. The proposed design would enable to further explore the earliest age of time-based prospective memory abilities.

In a next study, correlative results from the initial study could be verified with an experimental manipulation. Bull, Phillips, and Conway (2008) applied a sophisticated dual task paradigm to explore the role of executive functions in Theory of Mind. While participants were engaged in Theory of Mind-tasks (i.e., "Reading the Mind in the Eyes" test, Baron-Cohen, Wheelright, Hill, Raste, & Plumb, 2001; Stories tests, Channon & Crawford, 2000) additional verbal executive function tasks had to be performed. In all executive function tasks a string of numbers was presented verbally. The inhibition task involved
participants adding three to each number, but withholding their answer until it totaled eight or
15. At the switching task, participants were asked adding two to each number, until they were
auditory cued to switch to subtracting one from each number. As an updating-task, a variant
on a 1-back working memory task was applied. Following this approach, the effect of
previously revealed factors could be tested directly. Thus, executive functions could be
experimentally stressed one by one by concurrent performance and the effect on prospective
remembering would become apparent. As an ongoing and prospective memory task, the
Dresden cruiser could be applied once more. In contrast to Bull et al. (2007), executive
function tasks should not consist of arithmetic content due to the age of the participants.
Instead, age-appropriate executive function tasks should be applied (e.g. McInerney et al.,
2005). Thus for the first time, the effect of executive functions as underlying factors of time-
based prospective memory performance in children could be directly tested. In addition,
possible different effects of underlying factors on time-based and event-based prospective
memory could be explored.

5.4 Summary

To summarise the present thesis, to remember future intentions is an essential ability
in everyday life. Young children were shown to already be able to carry out event-based
prospective memory tasks at least as early as three years old, yet this ability continued to
develop throughout childhood. In later life, while many cognitive abilities decrease it was
revealed that prospective memory performance can be sustained to a certain degree by
compensative mechanisms (e.g. good performance in regular tasks). Possible factors that are
related to the development of prospective remembering across the lifespan are still being
discussed, with virtually no theoretical framework of prospective memory development. The
present thesis took a first step on the way to theory-based research on prospective memory
development by examining the ability to perform event-based delayed intentions in four different age groups, guided by the multiprocess framework of McDaniel and Einstein (2000). Motivation and task focality were related to prospective memory performance in children and in adulthood. In addition, task regularity did affect performing intended actions in older adults. Further research has been suggested to explore the neglected area of the development of time-based prospective memory in childhood.

To come full circle, a quote of Friedrich Nietzsche will be presented as closing word, revealing the improvements in our knowledge about prospective memory. Although still a long way lies ahead, the picture of processes of prospective memory and prospective memory development become clearer, as shown in this thesis, and we can therefore disagree with Nietzsche as he said:

“The existence of forgetting has never been proved: We only know that some things don't come to mind [...].”

_Friedrich Nietzsche_
6. References


6. References


(Eds.), *Handbook of the psychology of aging*. New York: Van Nostrand Reinhold.

Hagendorf (Eds.), *Human memory and cognitive capabilities* (pp. 409-422).
Amsterdam, North-Holland: Elsevier Science.

development. In E. Bialystok, & F. I. M. Craik (Eds.), *Lifespan cognition:*
*Mechanisms of change* (pp. 3-14). New York: Oxford University Press.

resources. In F. I. M. Craik, & S. E. Trehub (Eds.), *Aging and cognitive processes* (pp.

Prospective and Retrospective Memory Questionnaire (PRMQ): Normative data and

Crone, E. A., Ridderinkhof, K. R., Worm, M., Somsen, R. J. M., & Van Der Molen, M. W.


Delbecq-Derouesné, J., & Beauvois, M. (1989) Memory processes and aging: A defect of
automatic rather than controlled processes? *Archives of Gerontology and Geriatrics,
Suppl., I*, 121-150.

6. References


6. References


6. References


6. References


Hiermit versichere ich, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Die Arbeit wurde bisher weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde vorgelegt.

Die Arbeit wurde am Institut für Pädagogische Psychologie und Entwicklungspsychologie der Technischen Universität Dresden unter wissenschaftlicher Betreuung von Prof. Dr. phil. Matthias Kliegel angefertigt.

Es haben keine früheren erfolglosen Promotionsverfahren stattgefunden.


Dresden, Mai 2009

Ingo Aberle