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INDIVIDUAL DIFFERENCES IN PROSPECTIVE MEMORY

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Prospective memory (PM) refers to the encoding, maintenance, retrieval, and execution of deferred actions in service of coordinating goal-directed behaviors. Over the past 40 years, a great deal of research has emerged that has focused on various aspects of PM. In our view, this increased interest in PM reflects the critical importance of goal-directed behavior in daily life. In a sense, PM is necessary for many different types of behaviors that individuals plan to complete on a day-to-day basis. Accordingly, PM deficits can have adverse effects on the enterprise of healthy living.

PM researchers straddle a fine line between theoretical and applied domains. Theoretically, conducting PM research requires some degree of immersion in *both* the literature on retrospective memory and the literature on attention and cognitive control. This point is important when considering why individuals differ in their PM abilities. Simply put, there are many different ways that a person can fail to complete their intentions. These failures can be broadly classified into memory-based failures and attention-based failures. The distinction between memory- and attention-based components of PM was made early on by Einstein & McDaniel (1990) when defining the retrospective and prospective components of PM.

Much of the research in PM has focused on the *prospective component* of PM, which involves noticing the target and becoming aware that an intended action should be initiated. Relatively less research has focused on the memory mechanisms underlying the *retrospective component*, which involves remembering the contents of the intention and retrieving the action from long-term memory. We believe that understanding the interaction of attention and memory processes in successful intention fulfillment is not only critical for theory development, but it is also exceedingly important for promoting healthy aging and mitigating PM deficits due to psychopathology as there are multiple ways in which PM can fail.

Based on this distinction between retrospective and prospective components of PM, research has investigated heterogeneity in the neurophysiological, or cognitive, processes that support intention fulfillment. In this chapter, our focus is on individual differences in long-term memory and attention, and how these differences result in PM success and failure. Our goal is to provide a framework for theorizing about individual differences in PM that will lead to new research and also motivate interventions that can help at-risk populations.

To motivate this distinction, individual differences in PM will be reviewed in two domains: healthy aging and psychopathology. In a third section, we will test this hypothesis in a healthy college-aged sample with existing data from our laboratory. In each section we will highlight evidence for the idea that individuals differ in their PM ability because of variability in *both* attention-based processes and long-term memory.

Healthy aging

Age is an important individual differences factor that influences PM (for meta-analyses see Henry et al., 2004; Kliegel, Jäger, & Phillips, 2008; Uttl, 2008, 2011). Age-related declines in PM are non-trivial, as every day PM tasks are critical for maintaining independence. Failures of PM are associated with a variety of health consequences and difficulties in instrumental activities of daily living (Woods et al., 2012). Consequently, understanding the mechanisms underlying prospective remembering is critical for healthy aging. Unfortunately, understanding these mechanisms becomes difficult when considering all the ways in which PM can fail. Moreover, there is a long-standing amount of literature demonstrating that a natural consequence of aging is declines in multiple cognitive abilities, including working memory (e.g., Braver & West, 2008), attention control (e.g., Hasher & Zacks, 1988), and episodic memory (e.g., Naveh-Benjamin, 2000), among others. This multifaceted nature of PM and age-related cognitive decline makes pinpointing specific PM-related deficits difficult. Thus, we believe that to fully characterize the trajectory of age-related PM declines researchers must consider the role of individual differences in both attention and memory in intention fulfilment.

As noted above, there are multiple ways in which PM can fail. For example, an individual (John) may have the intention to take heart medication once daily at noon. One way to forget is simply by failing to notice the PM target (i.e., medicine bottle) on the counter at the appropriate moment, or forget the contents of the intention (e.g., which medicine bottle; *standard* PM failures). Alternatively, John may later see the medicine bottle, but decide not to take the medication because he believes he took it earlier (*omission* error). Lastly, John may *successfully* remember to take the medication at noon. However, upon noticing the medication bottle later (e.g., 1 pm), he may accidentally readminister the medicine because he forgot he took it earlier (*repetition*, or *commission*, error). Of course, there are other types of errors that may occur as well (e.g., delay-execute PM failures, time- or activity-based PM failures, etc.). These different types of PM failures highlight the multifaceted nature of PM and the need to understand the interaction of attention and memory in intention fulfillment. In this section, we provide a brief overview of some of the relevant research on these different topics, but refer readers to other chapters in this volume that discuss these topics in more detail (Bugg & Hacker, this volume; Ballhausen et al., this volume).

Attention and aging

Standard PM errors

Most theories of PM (e.g., Multiprocess Framework, Preparatory Attentional and Memory Theory) share the assertion that engagement of attentionally demanding monitoring processes are needed during nonfocal processing conditions in which the ongoing task processing (e.g., making lexical decisions) does not orient attention to the relevant features of the PM target (e.g., the syllable TOR). Monitoring is inferred by showing that ongoing task responding is slowed when possessing a nonfocal intention compared to when the same task is performed without an intention. This slowing, or cost, to ongoing task performance is thought to occur because the PM task reduces processing resources necessary for ongoing task responding. It is generally assumed that age-related differences in PM performance (Kliegel et al., 2008) occur due to general declines in attentional capacity (e.g., Hasher & Zacks, 1988), whereby older adults are less able to monitor the environment for PM targets while also performing a demanding ongoing task (Rendell et al., 2007). Interestingly, however, certain task or instructional manipulations can improve performance for older adults. For example, Rendell et al. (2007) demonstrated that reducing the ongoing task demands eliminated age differences in PM, presumably by allowing older adults to devote more attention to the PM task (see also Ball & Bugg, 2018). Conversely, Ball and Aschenbrenner (2017) found that the typical age differences in PM performance were eliminated when the importance of the PM task was emphasized (see also Hering et al., 2013). This benefit to performance occurred due to increased allocation of attention to the PM task as evidenced by changes in ongoing task responding. These findings suggest that older adults' attentional deficits may not preclude them from effectively monitoring, per se, but rather that they may not necessarily self-initiate these monitoring processes if not deemed important.

Commission errors

Age-related declines in attentional abilities may put older adults at risk for other types of PM failures. For example, in the commission error paradigm (see Bugg & Streeper, this volume) participants respond to PM targets in the "active phase" as usual. Importantly, this is followed by a "finished phase" in which the PM intention is cancelled, and participants are told they should no longer respond to targets. Despite the cancelled instructions, participants often accidentally respond (i.e., commit a commission error) when targets are presented in the finished phase (Bugg, Scullin, & Rauvola, 2016; Schaper & Grundgeiger, 2017; Scullin & Bugg 2013). These errors are thought to occur due to failures of inhibiting execution of a prepotent response following retrieval of the PM intention (Scullin & Bugg, 2013). Importantly, research has indicated that older adults often show higher rates of commission errors than younger adults (Boywitt, Rummel, & Meiser, 2015; Bugg, Scullin, & Rauvola, 2016; Scullin, Bugg, & McDaniel, 2012; but see Bugg, Scullin, & McDaniel, 2013). These findings suggest that age-related declines in attention control (Hasher & Zacks, 1988) result in greater difficulty in inhibiting the prepotent PM response following retrieval of the intention. Consistent with this idea, Scullin and Bugg found a positive correlation between inhibitory control and error rates for older adults. These findings highlight the need to account for individual differences in attention control ability, as sometimes controlled attention processes are needed to reduce PM failures (e.g., commission errors). This may be particularly important in everyday scenarios in which strong retrieval cues (e.g., medicine bottles) may stimulate prepotent response tendencies that can result in over-medication if one is not careful.

Episodic memory and aging

Standard PM errors

The previous section highlights the role of accounting for attention abilities in PM. However, memory ability is also of critical importance in prospective remembering. For example, when going to the grocery store one often intends to pick up multiple items (e.g., for cooking dinner that night), or one may plan to make multiple stops while running errands (e.g., grocery story, bank, gas, etc.). In such scenarios, episodic memory is critical for being able to remember all the contents of the PM intention and binding the PM target (e.g., grocery store) to the intended action (e.g., pick up medication at the pharmacy). Importantly, considerable research has demonstrated that aging is associated with declines in episodic memory, which occurs in part due to difficulty in binding and retrieving multiple pieces of information in memory (Naveh-Benjamin, 2000). Consistent with this idea, research has shown that the age difference in PM is reduced when the association between PM target (e.g., post office) and intended action (e.g., buy stamps) is high (i.e., low demands on binding) compared to when the target (e.g., school) and action (e.g., buy glasses) is low (i.e., high demands on binding; Lecouvey et al., 2017). Notably, in unpublished work we have shown that strengthening the association between multiple targets and the intended action via generative encoding can eliminate age differences in

PM (Ball & Brewer, 2018). Likewise, encoding strategies such as implementation intentions that are thought to increase the target-action associations are beneficial for older adults (e.g., Chasteen, Park, & Schwarz, 2001; McFarland & Glisky, 2011). These findings highlight the importance of accounting for episodic memory when considering how to improve prospective remembering across the lifespan. Notably, a common practice is to exclude participants that forgot the contents of the PM intention (e.g., Ball & Aschenbrenner, 2017; Zimmerman & Meier, 2006), as this is thought to reflect a retrospective memory failure rather than a PM failure. While this seems reasonable when investigating the influence of a manipulation on PM ability, it may ultimately underestimate actual declines in PM due to episodic memory failures.

Output monitoring errors

Age-related declines in episodic memory may also increase other types of PM errors. For example, when PM targets (e.g., a medicine bottle) are encountered multiple times throughout the day, the selection of the appropriate action (e.g., do or do not take medication) is dependent one's memory for the past (i.e., "did I already take this?"). In PM output monitoring tasks, PM targets (e.g., animal words) are repeated throughout the ongoing task (Ball et al., 2018; Marsh et al., 2002; Marsh, Cook, & Mayhorn, 2007). On the first presentation of the cue, participants are instructed to make a "first" response upon noticing it (similar to standard PM tasks). On the second presentation of a cue, participants are instructed make a "first" response if they *do not* remember having previously responded to it, or a "repeat" response if they *do* remember having previously responded to it. There are therefore two different types of output monitoring failures that can occur: a *repetition error* (e.g., over-medication) occurs when a "first" response is made on both the first and second presentations, or an *omission error* (e.g., under medication) occurs when no response is made on the first presentation and a "repeat" response is made on the second presentation. Research suggests that younger adults are more likely to erroneously believe that they successfully responded on the first presentation, resulting in greater omission errors for younger than older adults. In contrast, older adults are more likely to forget that they previously responded on the first presentation, leading to greater repetition errors for older than younger adults (Marsh et al., 2007; Sklazdien, 2010). It is suggested that both types of PM memory failures occur due to failures of source monitoring, which involves remembering the origin of a memory. Notably, younger adults may be better able to correct output monitoring errors than older adults. For example, when memory traces for the original encoding are made more distinctive, younger, but not older, adults show reduced repetition errors on the second presentation (Marsh et al., 2007; Skladzien, 2010). Thus, older adults may have greater difficulty in binding the action to a PM target on the original presentation that, in turn, results in increased output

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monitoring errors. Alternatively, older adults may have a general disposition to be more cautious in their responding, such that underconfidence in their own memory ability (e.g., Touron & Hertzog, 2004) leads to greater repetition errors. Regardless, these findings highlight the importance of understanding the memory processes underlying PM errors with increased age.

Psychopathology

PM is critical for a variety of clinical populations because failures could be detrimental to one's health, like forgetting to take one's seizure medication, or taking too much medication by accident. Unfortunately, many clinically impaired groups of individuals are known to have moderate to severe PM deficits, which certainly depend on the individual's cognitive dysfunction. Some people may have impaired executive functioning, like those with obsessive-compulsive disorder (OCD; Olley, Malhi, & Sachdev, 2007) and others have particular memory deficits, such as those with Alzheimer's dementia (Grober, & Buschke, 1987). Heterogeneity in memory and attention processes differentially impaired in these clinical populations likely lead to similar profiles of PM deficits. Thus, research with these clinical populations can help researchers investigate the mechanisms behind PM, which can in turn aid development of PM compensation strategies.

Attention failures in a population with obsessive tendencies

When individuals complete an event-based PM task, there are attentional abilities that could influence performance (Brewer, Knight, Unsworth, & Marsh, 2010; Unsworth, Brewer, & Spillers, 2012; Smith & Bayen, 2005). The ongoing task has the opportunity to draw attentional focus toward or away from PM targets (Marsh et al., 2009; Einstein & McDaniel, 2005). When the ongoing task draws attention away from the features of the targets, PM performance may be dependent on central executive functioning (Marsh & Hicks, 1998; Kliegel et al., 2002), which is shown to be easier for individuals with more available working memory resources (Marsh et al., 2009; Cherry & LeCompte, 1999; Smith & Bayen, 2005). It has since been concluded that people that are placed under divided attention conditions, and/or those with lower working memory capacity, perform poorer on these event-based tasks. One group affected by this are those with obsessive checking tendencies. It has been shown that when individuals have checking obsessions, in comparison to a control group, they have a lower working memory capacity (Sher, Frost, Fushner, Crews, & Alexander, 1989; Purcell, Maruff, Kyrios, & Pantelis, 1998). In addition, there have been weaker correlations with PM performance and working memory capacity in subclinical populations (Cuttler & Graf, 2007, 2008; Marsh et al., 2009). Therefore, subclinical checking obsession individuals tend to have characteristics that would suggest poor PM performance.

Marsh et al. (2009) investigated event-based PM performance in a group of individuals with subclinical obsessive-compulsive symptoms. The individuals' obsessive-compulsive symptoms were discovered by the obsessive-compulsive inventory (OCI; Foa, Kozak, Salkovskis, Coles, & Amir, 1998) and their washing obsessions served as an index of obsessive behaviors. The washing obsessions subscale was chosen because both neutral and threat-related event-based PM targets could be found for each participant, which were specific to their obsessions. In one condition of the experiment, participants were asked to count the amount of syllables in a word and make a special key press when they encountered a neutral (furniture or animal) item prior to making their syllable rating. In another condition, the instructions were the same, except for the special key press being made whenever they encountered a bodily fluid. The obsessive subclinical checking group displayed lower detection of targets, which is thought to be due to difficulties related to attention bias toward obsessive information. As predicted, this experiment showed that targets that were emotionally disturbing to these individuals heightened their attention and resulted in better target detection than neutral targets. A similar study by Cuttler and Graf (2008) including participants with compulsive checking behaviors showed that intrusive thoughts associated with obsessive-compulsive disorder have negative influences on PM processes. Together, these findings suggest that those with obsessive-compulsive tendencies tend to have worse PM performance due to attentional difficulties.

episodic Memory in a population with mild Alzheimer's

Episodic memory ability is another critical mechanism for successful PM. Many clinical populations display episodic memory impairment, but perhaps the population with the most notable deficits are those suffering from Alzheimer's dementia (AD). As noted by several researchers (e.g, Buckner, 2004; Head, Snyder, Girton, Morris, & Buckner, 2005; Jack et al., 2008; see also McDaniel et al., 2011), the signature of AD is the degradation of the medial temporal lobe, more specifically, the hippocampal structure. As proposed by Moscovitch (1994), this degradation is related to impaired reflexive retrieval of associative information. Prior AD research shows that PM performance declines significantly, likely due to degradation or impairment of the medial temporal lobe. This effect has also been shown in patients with preclinical AD and early stage dementia (Jones, Livner, & Backman, 2006; Shelton et al., 2016; Troyer & Murphy, 2007; Thompson, Henry, & Rendell, 2010; Spíndola & Brucki, 2011; Tam & Schmitter-Edgecombe, 2013; Pereira et al., 2015). The overarching finding in these studies is that PM performance is significantly worse in these individuals due to their episodic memory dysfunction.

One study that evaluates the relation between preclinical AD and episodic memory functioning is Jones, Livner, & Backman (2006). This study evaluated prospective and retrospective memory performance in healthy older adults (n = 188) and those with preclinical AD (n = 46). These groups were matched for age and education (*M age = 84.04, M years of education = 8*). The PM task had participants remind the researcher to make an important phone call when the experiment was over. These researchers evaluated performance through free recall (no reminder of intention) or cued recall ("What was I supposed to do when we were finished with the study?"). Total recall was defined as a correct recall in either condition. Results from this study found a marked difference in recall between groups, which suggests impaired ability in keeping the intention, detecting the cue, or both in the preclinical AD group. Additionally, a higher proportion of preclinical AD participants failed to successfully complete the task with or without provision of a cue as compared to control participants. Results from this task further suggest that episodic memory impairments determine PM ability (Jones, et al., 2006; Goschke & Kuhl, 1993; McDaniel & Einstein, 1992; Mäntylä & Sgaramella, 1997).

Healthy college-aged samples

Many individual differences studies in college-aged samples have examined correlations between PM target detection and various cognitive ability measures (Kliegel et al., 2002; Martin, Kliegel, & McDaniel, 2003; Rose et al., 2010). One important finding in this field is that individuals with higher working memory capacity (WMC) tend to detect more PM targets than those with lower WMC. WMC refers to people's ability to maintain task-relevant representations while simultaneously processing task-irrelevant information (Baddeley, 2007). WMC has traditionally been measured with complex-span tasks that make demands on both maintenance and processing (e.g., operation span; Turner & Engle, 1989). There have been many demonstrations of WMC differences underlying errors in a variety of cognitive tasks which require some degree of attentional control (Engle & Kane, 2004). For example, individual differences in WMC predict various patterns of performance in the Stroop task when conditions encourage goal neglect. Specifically, high WMC participants made fewer errors than low WMC participants when there was a large proportion (75%) of congruent trials in the Stroop task. Based on these results, Kane and Engle (2003) argued that performance in the Stroop task is jointly determined by attentional functions such as goal maintenance and competition resolution, and that both of these functions are related to WMC.

More recent work has suggested that controlled attention is not the sole contributor to individual differences in WMC (Unsworth & Engle, 2007; Unsworth, 2016). The multi-facets model of WMC proposes that active maintenance in primary memory, primary memory capacity, and controlled retrieval from secondary memory jointly contribute to individual differences in WMC. According to the multi-component model, individual differences in working memory can be decomposed into multiple factors including attention control and controlled retrieval. Evidence for individual differences in controlled retrieval has been documented in multiple episodic memory tasks including free recall, source memory, and even nonfocal event-based PM (Unsworth, Brewer, & Spillers 2012).

Several studies have been published that have examined the relation between WMC assessed with complex-span tasks and performance in event-based PM tasks (Arnold, Bayen, & Smith, 2015; Ball & Brewer, 2018; Ball, Knight, Dewitt, & Brewer, 2013; Brewer et al., 2010; Meeks, Pitães, & Brewer, 2015; Smith & Bayen, 2005). These studies have reliably demonstrated that individuals differ in their ability to detect event-based PM targets and retrieve intended actions. Smith and Bayen (2005) found that when executive control was necessary for successful target detection, high WMC participants outperformed low WMC participants. Based on fMRI contrasts, Reynolds et al. (2009) suggested that PM and working memory are functionally dissociable, but that they also rely on similar neural mechanisms. Specifically, they reported that the anterior prefrontal cortex and right temporal lobe supported monitoring for PM targets and realizing delayed intentions. Again, this result dovetails with the assertion regarding attention-based and memory-based contributions to PM.

We have suggested that individual differences in both attention and episodic memory abilities underlie the relation between WMC and event-based PM and that both components may be necessary for fully accounting for the relation (Brewer, Knight, Unsworth, & Marsh, 2010). To address this hypothesis, we report a reanalysis of unpublished data here that sought to explore the relation between WMC and event-based PM by using the multi-facets model of WMC as a vehicle for accounting for individual differences in PM.

In the present study, a total of 170 undergraduates were recruited from the University of Georgia. Participants were between the ages of 18 and 35 and received course credit for their participation. Each participant was tested individually in two laboratory sessions lasting approximately two hours each. All participants completed the following tasks in order: operation span, symmetry span, reading span (WMC), delayed free recall with unrelated words, picture-source recognition, delayed free recall with related words (episodic memory), antisaccade, arrow flankers, Stroop (attention control), and six-cues, low cue-target, and syllable detection (PM) tasks. Full task details for the cognitive ability measures can be found in our prior work (Brewer & Unsworth, 2012; Unsworth et al., 2012). Here we will describe only the PM tasks which were selected to represent a broad prospective memory ability factor.

Six-cues prospective memory

Participants decided whether strings of letters were valid English words or not (i.e., lexical decision task, LDT) and made their response by pressing one of two keys on the keyboard (F and J). After making each response, participants were presented with a "waiting" message, at which point they pressed the space bar to initiate the next trial. In addition to completing the LDT, they were instructed to press the slash key during the "waiting" message anytime that they saw the words JUNK, RISE, THIN, BUTTER, TREATY, and DECADE. Only four of these cues were selected and they occurred on the 25th, 50th, 75th, and 100th trials of the LDT. The dependent measure for all PM tasks was the proportion of cues detected.

Low cue-target association prospective memory

Participants completed a similar LDT to that used in the six cue prospective memory task. In this LDT, participants were instructed to type a target word during the "waiting" message after classifying the cue as a word. The four cue-target pairs were SPAGHETTI-STEEPLE, THREAD-SAUCE, CHURCH-PENCIL, and ERASER-NEEDLE. For example, when participants encountered the word SPAGHETTI in the LDT, they made a word response and then typed STEEPLE during the waiting message before initiating the next LDT trial. Cue trials always occurred on the 25th, 50th, 75th, and 100th trials of the LDT.

Syllable detection prospective memory

Participants made judgments on words as quickly and accurately as they could. Specifically, if the word only had one syllable, participants pressed the 1 key, and if the word had two syllables, participants pressed the 2 key. All one and two syllable words were presented in lower case in the center of the screen. After making each response, participants were presented with a "waiting" message, at which point they pressed the space bar to initiate the next trial. Participants were told that we were also interested in their ability to remember to press the slash key whenever they detected a word with the syllable TOR in it. Each participant judged 105 words in this task and TOR cues always occurred on the 25th, 50th, 75th, and 100th trials.

Covariance modeling was used to clarify which component processes contribute to the working memory and event-based PM relation. Our thinking about heterogeneity of cognitive processes (attention and memory abilities) that are required for PM developed from exploring the relation between WMC and PM. Critically, the multi-facets model of individual differences in working memory suggests that working memory capacity reflects differences in attention control, secondary memory, and primary memory capacity (Unsworth, 2016).

Four hypothesized structural equation models representing the theoretical relation between WMC and PM can be considered. We have hypothesized that individual differences in *both* attention control and episodic retrieval abilities should mediate the relation between WMC and PM. However, it is possible that only attention control or episodic retrieval may be necessary for understanding the relation between WMC and PM. Finally, the relation between WMC and PM can be measured after accounting for additional factors (i.e., attention control and episodic memory abilities only partially mediate the relation between WMC and PM). These competing hypotheses are tested via structural equation modeling in the current study.

Descriptive statistics and correlations for the WMC, episodic memory, attention control, and PM measures are shown in Tables 8.1 and 8.2 respectively. As can be seen in Table 8.1, most measures had generally acceptable values of internal consistency and were approximately normally distributed with values of skewness and kurtosis under the generally accepted values. Additionally, inspection of Table 8.2 reveals moderate correlations among the dependent measures collected from the tasks.

Confirmatory factor analysis was used to examine the interrelations among the PM tasks and their association with other cognitive ability measures. In this approach, a theoretically derived model is specified and the corresponding hypothetical variance-covariance matrix is compared to the true variance-covariance matrix that was collected in the study of interest. The relative fit of the hypothetical and true variance-covariance matrices is assessed with a chi-square statistic for which non-significant results are desired. A non-significant chi-square value indicates that the hypothetical variance-covariance matrix resembled the true variance-covariance matrix. If so, the theoretical model could be considered a reasonable account of the data. Because sample size is an important determinant of rejecting the null hypothesis for the chi-square statistic, other statistics have been proposed that assess the overall model's fit which are not biased by large sample sizes.

TABLE 8.1 Descriptive statistics and reliability estimates for all the measures.

Measure	*M*	*SD*	*Skew*	*Kurtosis*	α
Ospan	60.57	11.46	-1.69	4.68	.79
Symspan	30.37	7.30	-1.04	1.18	.89
Rspan	59.04	11.40	-0.90	0.76	.81
DFRU	32.18	8.42	0.44	0.52	.82
DFRR	37.08	5.71	-0.18	0.09	.74
Source	0.78	0.14	-1.38	2.87	.79
Anti	0.54	0.13	0.24	-0.39	.67
Flanker	125.65	65.83	1.09	1.81	n/a
Stroop	159.91	99.34	1.49	5.53	n/a
Six	0.49	0.32	0.01	-0.95	.63
LCT	0.47	0.36	0.04	-1.30	.72
Syllable	0.51	0.39	-0.16	-1.48	.81

Note: Ospan = operation span; Symspan = symmetry span; Rspan = reading span; DFRU = delayed free recall unrelated words; DFRR = delayed free recall related words; PicSour = picture source recognition; Anti = antisaccade; Flanker = Arrow Flankers; Stroop = stroop; Six = six cues prospective memory; LCT = low cue-target prospective memory; Syllable = Syllable detection prospective memory.

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TABLE 8.2 Correlations for all the measures

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Ospan	1.00											
2. Symspan	0.42	1.00										
3. Rspan	0.60	0.37	1.00									
4. DFRU	0.06	0.18	0.11	1.00								
5. DFRR	0.06	0.16	0.12	0.30	1.00							
6. Source	0.13	0.16	0.20	0.26	0.18	1.00						
7. Anti	0.15	0.18	0.28	0.13	0.22	0.21	1.00					
8. Flanker	−0.13	−0.15	−0.21	−0.11	−0.16	−0.21	−0.35	1.00				
9. Stroop	−0.22	−0.19	−0.14	−0.20	−0.06	−0.21	−0.16	0.22	1.00			
10. Six	0.07	0.09	0.13	0.16	0.18	0.10	0.21	0.05	−0.17	1.00		
11. LCT	0.13	0.08	0.23	0.24	0.25	0.36	0.31	−0.25	−0.18	0.36	1.00	
12. Syllable	−0.11	0.08	0.01	0.05	0.15	0.07	0.10	0.02	−0.12	0.25	0.30	1.00

Note: Ospan = operation span; Symspan = symmetry span; Rspan = reading span; DFRU = delayed free recall unrelated words; DFRR = delayed free recall related words; PicSour = picture source recognition; Anti = antisaccade; Flanker = Arrow Flankers; Stroop = stroop; Six = six cues prospective memory; LCT = low cue-target prospective memory; Syllable = Syllable detection prospective memory. Correlations greater than $r = .15$ are significant at $p < .05$.

All three PM tasks loaded onto a unitary PM construct, which was then specified in a model with the other constructs. The PM construct represented the variance which was common across all three PM tasks. The WMC (operation span, reading span, and symmetry span), episodic retrieval (delayed free recall and the picture-source recognition tasks), and attention control (antisaccade, arrow flanker, and Stroop tasks) constructs were left free to correlate with the PM construct and with each other. All of the task measures loaded significantly onto their respective constructs and this model fit the data very well, χ^2 (48) = 58.68, p =.14, RMSEA = .04, SRMR = .06, NNFI = .96, CFI = .97. As shown in Figure 8.1, the WMC, attention control, and episodic memory factors correlated with the PM factor.

The measurement model from the previous analysis demonstrated significant relations among all constructs, but shared covariance can cause two constructs to show a relation which may be due to a third, mutually related construct. Critically, the relations between the WMC, attention control, and episodic retrieval constructs with the PM construct may be due to either shared or unique variance. Consequently, structural equation modeling is a useful technique for examining the specific effects one construct has on another construct when their shared relations with other constructs have been taken into account. The four hypothetical models discussed earlier were tested and compared. Models 1 (Attention only; $\chi^2(51) = 84.68$, $p < .05$) and 2 (Episodic only; $\chi^2(51) = 78.41$, $p < .05$) were statistically equivalent, but fit worse than Model 3 (Full mediation; $\chi^2(50) = 71.96$, $p < .05$), smallest $\Delta\ \chi^2(1) = 6.45$, $p < .05$. Model 4 (Partial Mediation; $\chi^2(49) = 70.98$, $p < .05$) fit the data well, but failed to provide a better fit than Model 3 (full mediation), $\Delta\ \chi^2(1) = .98$, n.s. Also, Model 4

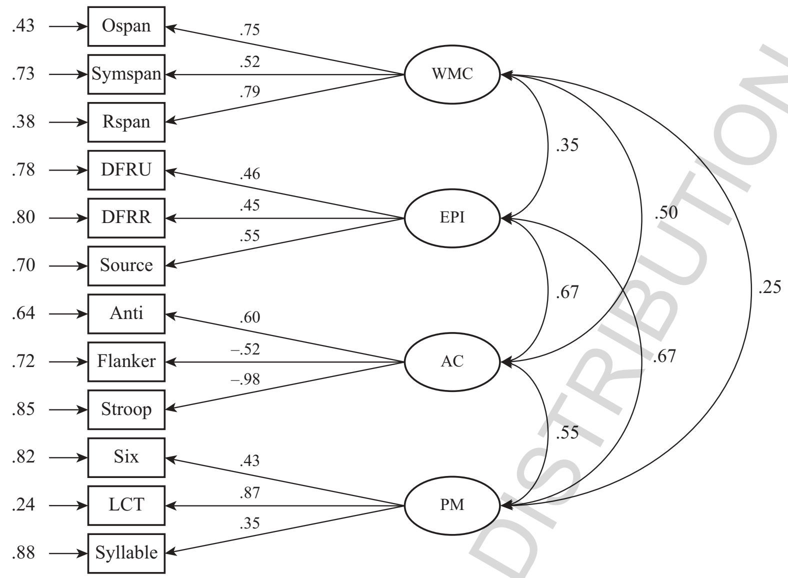

FIGURE 8.1 Confirmatory factor analysis for the measurement model. Paths connecting latent variables (circles) to each other represent the correlations between the constructs, the numbers from the latent variables to the manifest variables (squares) represent the loadings of each task onto the latent variable, and numbers appearing next to each manifest variable represent error variance associated with each task. Working memory capacity (WMC), episodic memory (EPI), attention control (AC), and PM (PM) were left free to correlate. All loadings and paths are significant at the $p < .05$ level.

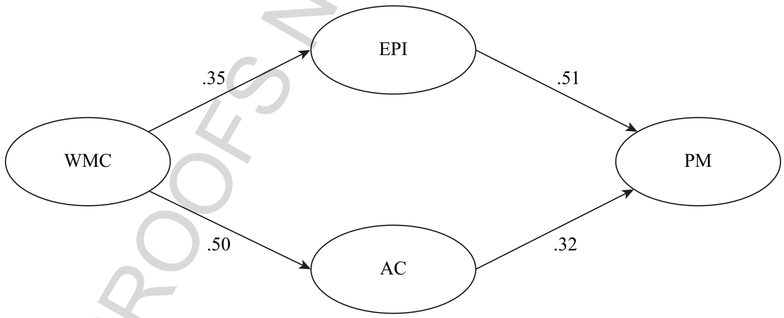

FIGURE 8.2 Structural equation model showing that episodic memory (EPI) and attention control (AC) fully mediate the working memory capacity (WMC) and PM (PM) relation (dashed lines represent nonsignificant relations). Single-headed arrows connecting latent variables (circles) with each other represent standardized path coefficients, indicating the unique contribution of the latent variable. Solid paths are significant at the $p < .05$ level, whereas dashed paths are not significant.

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indicated no statistically significant relation between WMC and PM after accounting for attention control and episodic memory abilities. This result supports the hypothesis that both forms of cognitive control differentially and fully mediated the WMC and PM relation in Model 3 (full mediation), which is shown in Figure 8.2.

Across the full range of participants, the three PM tasks formed a distinct construct which was correlated with WMC, episodic retrieval, and attention control constructs (see also Salthouse, Berish, & Siedlecki, 2004). In addition, structural equation modeling was used to uncover more nuanced relations between the component processes which underlie WMC and relate to PM. In the current study, both attention control and episodic memory abilities uniquely predicted event-based PM performance. This is a key finding for researchers exploring individual differences in event-based PM, as it demonstrates that multiple ability factors are needed to account for the relation between WMC and PM.

Conclusions and future directions

All in all, this review has highlighted research examining individual differences in attention, long-term memory, and working memory, and how these differences are related to PM. Basic research investigating individual differences in healthy college aged samples can be translated to improve PM in populations that tend to exhibit PM deficits. Importantly, this translational research must focus on the core reasons for why PM deficits occur. Future interventions that attempt to mitigate PM failures associated with healthy aging and psychopathology should target specific cognitive ability deficits to help improve PM.

Working memory is an important predictor of individual differences in event-based PM across many domains (e.g., Marsh & Hicks, 1998). When people are forced to use strategic processes, which require some degree of attention control, they detect fewer targets. In addition to these attention processes, people will often have to rely on their episodic retrieval abilities to revise contextual associations formed at encoding. In both of these situations where PM demands cognitive control, individual differences in WMC should be a predictor of the ultimate likelihood that intentions will be fulfilled. Critically, the relation between WMC and PM is due to people's strategic regulation of *both* their attention and memory abilities.

Finally, this chapter also highlights an important distinction between multiple components of prospective remembering (e.g., the prospective versus retrospective components). While this distinction is logical and clear, the current review provides important empirical evidence for the distinction across three different individual differences research areas. Moving forward, more research is warranted that aims to develop a better understanding of the interaction between memory and attention in PM. We expect that this research will use multiple methodological tools including individual differences designs. However, this research need not depend solely on differential methodology and should also adopt tools from basic experimental design and neuroimaging. Moreover, clever combinations of these methods can be useful for this goal.

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