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Just Don't Do It!: A Comparison of Strategies for Reducing Commission Errors in Older and Younger Adults

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WASHINGTON UNIVERSITY IN ST. LOUIS

Psychological & Brain Sciences

Just Don't Do It!: A Comparison of Strategies for Reducing Commission Errors in Older and
Younger Adults

by

Emily Carole Streeper

A thesis presented to
The Graduate School
of Washington University in
partial fulfillment of the
requirements for the degree
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Table of Contents

List of Figures	iii
List of Tables	iv
Acknowledgments.....	v
Abstract.....	vii
Chapter 1: Introduction.....	1
1.1 The Finished Paradigm.....	1
1.2 Age Differences in the Finished Paradigm	14
1.3 Strategies for Reducing Commission Error Risk in Older Adults	15
1.4 The Current Study	14
Chapter 2: Method	14
2.1 Design and Participants.....	14
2.2 Procedure and Materials.....	14
Chapter 3: Results.....	15
3.1 PM Performance in the Active PM Phase.....	15
3.2 Commission Errors in the Finished PM Phase.....	14
3.2.1 Effect of Strategies for Older Adults	14
3.2.2 Effect of Strategies for Younger Adults.....	14
3.2.3 Age Differences	14
3.3 Ongoing Task Reaction Time	15
Chapter 4: Discussion	15
4.1 The Current Findings on Preparatory Strategies	15
4.2 Age Differences for the Repeated Instructions and Baseline Conditions	15
4.3 Potential Cognitive Mechanisms.....	15
4.4 Limitations of the Current Study.....	15
4.5 Applications of the Current Findings	15
References.....	15

List of Figures

Figure 2.1: The commission error paradigm	9
Figure 3.1: Percentage of participants who made a commission error	14

List of Tables

Table 2.1: Participant demographic information.....	8
Table 3.1: Average number of PM hits in active PM phase by age and condition	13
Table 3.2: Average number of commission errors by age and condition.....	15
Table 3.3: Average RTs on the ongoing lexical decision task	17

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August 2018

Dedicated to my parents and all my family for their unwavering support and love.

ABSTRACT OF THE THESIS

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by

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Master of Arts in Psychological & Brain Sciences

Washington University in St. Louis, 2018

Professor Julie Bugg

Prospective memory (PM) commission errors occur when an individual erroneously repeats an intention that is finished and therefore no longer relevant (e.g., accidentally taking a medication one no longer needs to take). Commission errors have been observed in younger and older adults with age exacerbating commission error risk in select conditions. Only one prior study has used the finished paradigm to investigate the use of explicit strategies to reduce commission error rates in older adults. Bugg, Scullin, and Rauvola (2016) found that forgetting practice, an experience-based strategy, minimized commission errors to floor levels but a preparation-based strategy was ineffective. The current study compared multiple strategies with a focus on a) examining whether a preparation-based strategy may be effective if additional guidance is provided regarding how to prepare, and b) identifying an effective strategy with translational value that could be used outside of the laboratory. Younger ($n = 96$) and older adults ($n = 96$) were instructed to perform a PM intention (e.g., press “Q” when they encountered the target words “corn” or “dancer” on a red or blue background) during an ongoing lexical decision task. After four target words were presented, participants were instructed that they either no longer needed to perform the intention (standard “baseline” condition) or they additionally engaged in

one of three randomly assigned strategies: imagined forgetting practice, implementation intentions, or repeated instructions. In the imagined forgetting practice condition, participants imagined seeing each target on the colored background and resisting the urge to respond. In the implementation intentions condition, participants wrote down their intention to no longer press “Q” when they saw the target words on the colored background. In the repeated instructions condition, participants simply received the standard instructions twice. Next, all participants performed the lexical decision task again. We examined whether they made a commission error (pressed Q) when target words reappeared. For older adults, imagined forgetting practice was the only strategy that significantly reduced the number of participants who made a commission error; however, for younger adults, all three strategies were effective in significantly reducing commission error rates compared to baseline. Contradicting previous findings, the number of participants who made a commission error did not significantly differ by age. Additional analyses are reported to evaluate the effects of age and strategy on the average number of commission errors. We found that a preparation-based strategy can effectively reduce commission errors in both younger and older adults when explicit guidance is provided. Critically, these novel findings have real-world translational value for younger and older adults.

Chapter 1: Introduction

It has been well established that prospective memory (PM), remembering to carry out a future action in a certain context, serves a crucial role in daily life. Habits like taking a daily medication require the retrieval of an intended action and the completion of that action in the appropriate context. Although remembering to carry out intentions is important, it is equally important to remember not to carry out intentions that are no-longer relevant. For instance, if a doctor instructs a patient to discontinue her course of medication, she must be able to stop herself from carrying out the habitual but now inappropriate response of taking the medication. Erroneously repeating a finished and therefore no-longer-relevant intention, referred to as a *commission error*, may create detrimental problems in daily life (cf. Kimmel et al., 2007; Gray, Mahoney, & Blough, 2001).

1.1 The Finished Paradigm

In recent years, a laboratory paradigm has been employed to examine PM commission errors (Scullin, Bugg, & McDaniel, 2012; cf. Walser, Fischer, & Goschke, 2012; see Einstein, McDaniel, Smith, & Shaw, 1998 and McDaniel, Bugg, Ramuschkat, Kliegel, & Einstein, 2008 for a related but distinct habitual PM paradigm in which commission errors reflect the performance of an already performed, and thus no longer relevant, intention). This “finished paradigm” involves two phases. In the first, “active PM” phase, participants perform an ongoing task (e.g., making word and nonword judgments about letter strings) and are tasked with remembering to perform a special action (e.g., press ‘Q’) when they see certain target words (e.g., *corn/dancer*). After participants complete this phase, they are instructed to no longer respond to the target words. Following these instructions, participants begin the “finished PM

phase” where they continue to perform the ongoing task and are presented again with the now irrelevant target words. If they press the ‘Q’ key, they have committed a commission error, representing a failure to deactivate the PM intention.

1.2 Age Differences in the Finished Paradigm

This paradigm has been useful for examining the relationship between aging and commission errors. Scullin et al. (2012) found that older adults and younger adults successfully remembered to perform the PM intention in the active PM phase. However, in the finished PM phase, older adults struggled to inhibit the prepotent response to the no-longer-relevant target words with a significantly higher number of older adults committing commission errors (see also Bugg, Scullin, & Rauvola, 2016). The age-related increase in commission errors can be interpreted through the lens of the dual-mechanism account of commission errors (Scullin & Bugg, 2013). This account attributes commission errors to the interplay of two processes: spontaneous retrieval and cognitive control. The idea is that presentation of the target in the finished PM phase brings the relevant action to mind even though participants are no longer monitoring for the PM targets (Scullin & Bugg, 2013). This is referred to as spontaneous retrieval, and there is evidence it may be spared by the aging process (Henry, MacLeod, Phillips, & Crawford, 2004; Mullet et al., 2013; Scullin, Bugg, McDaniel, & Einstein, 2011). Having spontaneously retrieved the intention, participants must then control the urge to emit the prepotent, but no-longer-relevant response associated with the intention. Because cognitive control is diminished with age (Braver, Satpute, Rush, Racine, & Barch, 2005; Braver & West, 2008; but see Bugg, 2014b; Verhaeghen, 2011 for contradicting findings), including response inhibition (Lustig, Hasher, & Zacks, 2007; Zacks & Hasher, 1994), older adults may be at an increased risk of making commission errors (but see Bugg, Scullin, & McDaniel, 2013).

1.3 Strategies for Reducing Commission Error Risk in Older Adults

A critical question that emerges from these findings concerns potential strategies that older adults can employ to minimize commission error risk. To date, only one study has attempted to empirically validate cognitive strategies for older adults in the context of PM commission errors in the finished paradigm. Bugg et al. (2016) examined the effectiveness of two different strategies for reducing commission errors in both older adults and younger adults. A preparatory instructional strategy informed participants that they would see the no-longer-relevant targets in the finished PM phase, and encouraged them to prepare to counter the urge to inappropriately respond to the targets. This strategy did not reduce commission error rates. The authors posited that the self-initiation required to generate and engage an effective approach to counteracting the urge to respond may have limited the effectiveness of this preparation-based strategy for older adults. Thus, they tested an alternative, experience-based strategy that did not require participants to self-initiate an effective approach. Coined by the authors as “forgetting practice,” participants encountered and practiced withholding the response to the no-longer relevant targets before beginning the finished PM phase. Forgetting practice successfully brought commission error rates to floor in older adults. Collectively, the findings suggested that strengthening the stimulus-response (S-R) link (i.e., associating the target word with the response of stopping) through actual practice enabled older adults to more easily inhibit their responses to targets in the finished PM phase but simply instructing them to self-initiate a strategy did not.

Despite the success in identifying an effective strategy for minimizing commission error risk, there were two major limitations of the Bugg et al. (2016) study. First, the strategy that was successful lacks translational utility. Relating back to the example of no longer taking an

unnecessary medication, it is difficult to envision someone engaging in forgetting practice at home. In order to do so, they would have to make sure they were in the correct context, look at the PM target (e.g., medication bottle), practice not responding (i.e., taking the medication), and then repeat this process several times. Not only does this seem implausible but it may risk the occurrence of commission errors. Second, the study examined only one preparation-based strategy and it proved to be ineffective, but this does not mean that such strategies should be wholly abandoned. In fact, a preparation-based strategy could have broader translational utility because it can be practiced anytime and anywhere and involves only mental “exposure” to the stimuli that could trigger intention retrieval and commission errors.

1.4 The Current Study

The goal of the current study was to determine whether a preparation-based strategy may be effective if additional guidance is provided to participants thereby reducing demands on self-initiation. Our primary interest was examining strategies that might reduce commission error risk in older adults, but we additionally tested younger adults. The study employed a modified version of the commission error paradigm used in Bugg et al. (2016) that was intended to increase commission error risk (see Method for details). This served two purposes. The first purpose was to increase commission error rates (baseline rates were 0% and 24% for younger and older adults, respectively, in Bugg et al., 2016) so that there was room to observe potentially large strategy-driven reductions. The second purpose was to enable us to evaluate strategy effectiveness in circumstances where risk of making a commission error is relatively high. Most importantly, three strategies were tested and compared to a baseline condition that received the standard instructions: imagined forgetting practice, implementation intentions, and repeated instructions. The imagined forgetting practice condition served as one preparation-based

strategy. Participants were guided step-by-step to imagine seeing the previously relevant targets, feeling the urge to respond to them, and practicing withholding that response. The implementation intentions condition served as a second preparation-based strategy. Participants wrote down their intention to no longer respond to the targets before continuing to the finished PM phase. In the repeated instructions condition, participants simply received the standard instructions twice.

One hypothesis was that imagined forgetting practice would successfully reduce commission error rates in older adults compared to the baseline condition. The imagined forgetting practice strategy comprised all elements of the previously successful, forgetting practice condition (Bugg et al., 2016) except that it was preparation-based instead of experience-based. Critically, unlike the previously unsuccessful preparatory instructional strategy (Bugg et al., 2016), participants did not have to self-initiate a strategy. If demands on self-initiation prevent older adults from effectively using strategies to reduce commission error rates, imagined forgetting practice should be more effective than standard instructions. A second hypothesis was that implementation intentions also would reduce the commission error rates of older adults compared to the baseline condition because implementation intentions strengthen the encoding of intentions (e.g., help individuals remember to perform an intention when it is relevant; e.g., (Brom & Kliegel, 2014; Burkard et al., 2014; A. L. Chasteen, Park, & Schwarz, 2001), and there is preliminary evidence that they may reduce commission errors at least for younger adults (Brewer & Pitães, 2014). Implementation intentions are believed to be effective because once the stimulus-response link has been established through this method, the participant can rely on the environment to automatically bring the necessary response to mind instead of using effortful control of their behavior (Gollwitzer, 1997; 1999). In the present paradigm, the intention being

encoded is to *not* press the ‘Q’ key when presented with the target words—stronger encoding of this intention via implementation intentions should make it easier to withhold the response relative to the baseline condition. We were additionally interested in determining whether one of these two, preparation-based strategies was more effective than the other for reducing commission error rates. Our final hypothesis was that commission error rates would be comparable for older adults in the repeated instructions and baseline conditions. The repeated instructions condition provided no more environmental support or guidance for the participants than the baseline condition as it simply showed the standard instructions a second time. The utility of each strategy relative to the standard instructions was also examined for younger adults. Although the primary interest of this study was finding strategies that reduced commission error rates for older adults, we also tested these strategies on younger adults after finding that their commission error risk in the baseline condition, which was run prior to the strategy conditions, was off floor and much higher than previous studies.¹ A strategic reduction in commission errors was therefore possible.

¹ As will be discussed later, this is likely due to use of a modified finished paradigm (see Procedure and Materials section below for details on the modifications).

Chapter 2: Method

2.1 Design and Participants

The current experiment was a 2 (age: younger, older) \times 4 (condition: baseline, imagined forgetting practice, implementation intentions, repeated instructions) between-subjects design. We aimed to collect data from 96 participants in each age group (i.e., stopping rule was 24 per each of four conditions). *A priori*, we specified that only participants that responded to two or more targets in the active PM phase would be included given prior evidence that the degree to which an intention is fulfilled in the active PM phase has a profound effect on commission errors (Bugg & Scullin, 2013). Five older adult participants and one younger adult participant were excluded for failure to respond to two or more targets in the active PM phase. In addition, eight older adult participants were excluded due to confusion in the finished phase (i.e., at the end of the task, they volunteered to the experimenter that they pressed the ‘Q’ key in the finished phase because they did not know how to advance to the next trial when a target appeared). We did not anticipate this *a priori*; however, after it occurred the first time, it was decided that all participants who reported this issue to the experimenter would be excluded so as to minimize any effects of confusion.

Participant demographic information is presented in Table 2.1.

Table 2.1 Participant demographic information.

	Older adults	Younger adults
<i>N</i>	96	96
% female	61.5	75.0
Mean age (<i>SD</i>)	73.29 (6.25)	19.70 (1.22)
Age range	64-92	18-23
Shipley vocabulary (<i>SD</i>)	29.68 (4.52)	27.73 (3.39)
Health ratings (<i>SD</i>) 1 [<i>poor</i>] to 5 [<i>excellent</i>]	3.98 (.70)	3.96 (.66)

Ninety-six older adults aged 64 to 92 ($M = 73.29$, $SD = 6.25$; 61.5% female) were recruited from the local community through Washington University’s Older Adult Subject Pool and Washington University’s Volunteers for Health Subject Pool and participated for monetary compensation. Ninety-six younger adults aged 18 to 23 ($M = 19.70$, $SD = 1.22$) and 75% female from the Washington University undergraduate community participated for course credit or monetary compensation. The older adults ($M = 29.68$, $SD = 4.52$) displayed higher average Shipley vocabulary scores than the younger adults ($M = 27.73$, $SD = 3.39$), $t(190) = 3.38$, $p < .001$. Health ratings on a 5-point scale ranging from 1 [*poor*] to 5 [*excellent*]) were comparable for older adults ($M = 3.98$, $SD = .70$) and younger adults ($M = 3.96$, $SD = .66$), $t < 1$. Older adult participants were randomly assigned to baseline ($n = 24$), imagined forgetting practice ($n = 24$), implementation intentions ($n = 24$) or repeated instructions ($n = 24$). Participants in these conditions did not differ significantly in vocabulary scores or self-reported health; however, participants in the imagined forgetting practice condition ($M = 76.25$, $SD = 5.55$) differed marginally in age from participants in the baseline ($M = 71.92$, $SD = 6.24$) and repeated

instructions conditions ($M = 72.08$, $SD = 6.45$), $ps > .07$. Within the younger adult sample, the baseline condition ($n = 24$) was collected independently of the imagined forgetting practice ($n = 24$)², implementation intentions ($n = 24$), and repeated instructions ($n = 24$) conditions, to which participants were randomly assigned. These conditions were statistically similar in age, vocabulary scores, and self-reported health.

2.2 Procedure and Materials

The procedure, adapted from Bugg et al. (2016), is displayed in Figure 2.1.

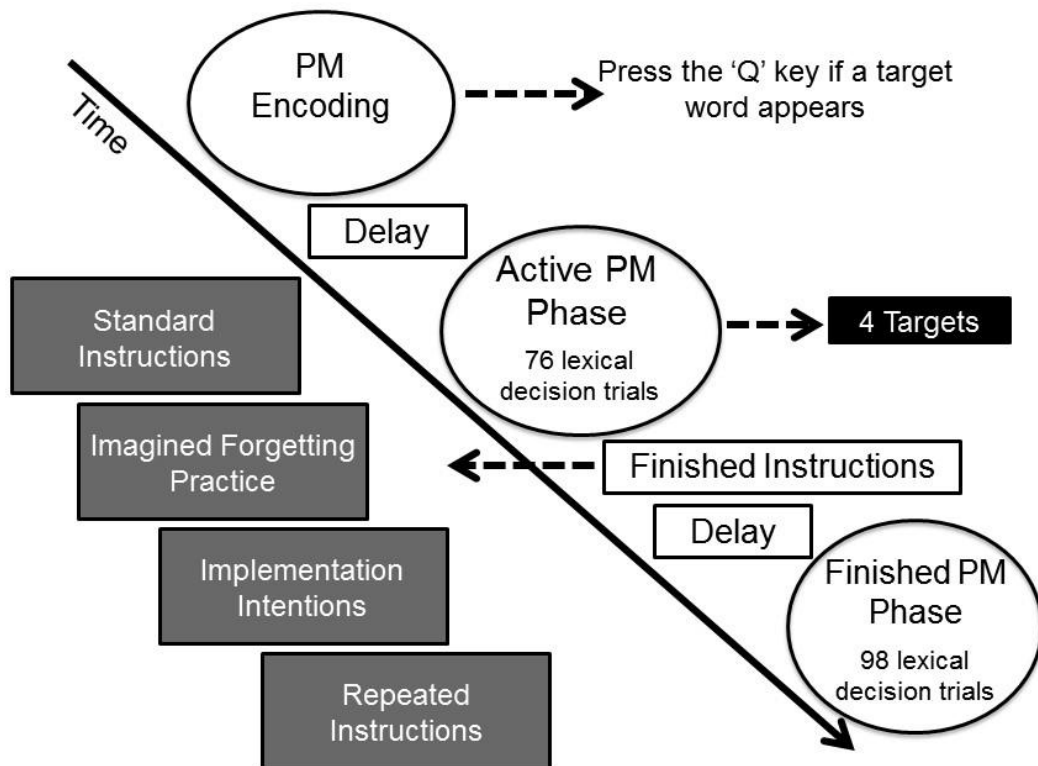


Figure 2.1 The commission error paradigm procedures used. PM = prospective memory.

² We initially ran the baseline condition to confirm that commission error risk was indeed higher in this modified paradigm relative to the paradigm used previously (Bugg & Scullin, 2013; Bugg et al., 2016).

All participants (regardless of condition) first practiced a lexical decision task in which they were asked to make word/nonword judgments as quickly and as accurately as possible. They indicated their choice for each letter string by pressing keys labeled with a “Y” sticker and an “N” sticker (5 and 6 on the number pad, respectively). Following the practice block, participants received PM instructions to press the “Q” key if they encountered a target word during the lexical decision task. Participants were informed they could press the “Q” key before or after making their word/nonword judgment. The two sets of target words (*corn/dancer* or *fish/writer*) were counterbalanced across participants. The target words were presented on a colored background (red or blue) that was counterbalanced across participants (Scullin et al., 2012, for evidence that commission errors are heightened in the presence of a salient background). Participants were told which target words and what color background to expect.

After receiving the PM instructions, participants were asked to write down their target words on a form. To create a delay between encoding and testing (Einstein & McDaniel, 1990), participants then completed a demographics form and a vocabulary test. Following this delay, the active PM phase began. There were 76 lexical decision trials and the target words appeared four times with each word in the assigned set appearing twice. On each trial, a fixation cross appeared for 500 ms which was followed by the stimulus. The stimulus was presented in white on a black screen until a response was made and was followed by a blank screen which was shown for 500 ms. Unlike in Bugg et al. (2016), there were no control trials (e.g., seeing *fish/writer* on a blue background when the targets were *corn/dancer* on a red background) and, if participants pressed ‘Q’ in response to a target word, the program advanced immediately to the next (non-target) lexical decision trial.³ Previously the target would remain on screen if ‘Q’ was pressed before the

³ We thank Michael Scullin for sharing preliminary findings from his lab indicating that changing these features of the paradigm may increase commission error risk.

participant made the lexical decision, such that the participant would have to additionally press the Y or N key.

After completing the active PM phase, all participants (regardless of condition) were initially given the standard instructions: *“PLEASE NOTE THAT YOU NO LONGER NEED TO PRESS ‘Q’ IN THE PRESENCE OF TARGET WORDS. THAT TASK IS FINISHED AND SHOULD NOT BE PERFORMED AGAIN. Just as before, you will determine whether a string of letters forms a word or a nonword by pressing the keys marked Y and N on the number pad. YOUR ONLY GOAL is to make word/nonword judgments.”* In the baseline condition, participants simply received these instructions.

In the imagined forgetting practice condition, participants were subsequently told to slow down and read the following instructions: *“Before you begin the second SPEED task, you are going to imagine NOT PRESSING THE ‘Q’ KEY when you see the target word on the colored background screen. The purpose is to help you achieve the goal of only performing the speed task and not pressing ‘Q’ when you see the target words later on in the experiment.”* They were then guided through the following instructions: *“Imagine nonwords and words appearing on the screen and pressing the Y and N key for each. Suddenly, you see the word [target word] on the [color] background screen. You may feel the urge to reach over and press the ‘Q’ key, but resist this urge. Instead of pressing the ‘Q’ key, imagine keeping your hands in your lap. Imagine looking down at your lap and seeing your hands there.”* The target words and color background matched the target words and color background they received for their PM intention in the active PM phase. Participants practiced these instructions one time for each specific target word

In the implementation intentions condition, following receipt of the standard instructions, participants were asked to write down the exact following intention three times: “When I see [target word 1] or [target word 2] on a [color] background I will NOT press the 'Q' key.” The target words and color background matched the target words and color background they received for their PM intention in the active PM phase.

In the repeated instructions condition, participants were instructed to slow down and thoroughly read the instructions before reading through the standard instructions twice. Each sentence of the instructions was shown on a separate slide and required an alternating keypress to continue (e.g., a sentence requiring the participant to press the ‘Enter’ key to continue would be followed by a sentence that required the ‘spacebar’ to proceed) to ensure participants read through the instructions step-by-step, thereby matching the way the imagined forgetting practice instructions were displayed.

Once they received these instructions, participants completed a second vocabulary test and a block of 20 lexical decision trials before beginning the finished PM phase. The no-longer relevant target words with their corresponding colored background appeared on 4 out of 98 lexical decision trials. There were two presentations of each of the target words. A ‘Q’ press during the finished PM phase was indicative of a commission error.

Chapter 3: Results

3.1 PM Performance in the Active PM Phase

PM hits were defined as a ‘Q’ press within two trials after the target was presented in the active PM phase.⁴ Maximally, participants could have four hits. A 2 (age group: younger, older × 4 (condition: baseline, imagined forgetting practice, implementation intentions, repeated instructions) between-subjects Analysis of Variance (ANOVA) showed no significant effects for PM hits, largest $F(3, 192) = 1.61, p = .19$. These patterns indicate equivalent initial PM performance for older adults ($M = 3.95, SE = .03$) and younger adults ($M = 3.91, SE = .03$) in all conditions (see Table 3.1).

Table 3.1 Average number of PM hits in active PM phase by age group and condition. IFP = imagined forgetting practice. ImIn = implementation intentions. Repeated = repeated instructions.

Condition	Older adults	Younger adults
	Average (<i>SD</i>) number of PM hits	Average (<i>SD</i>) number of PM hits
Baseline	3.92 (.28)	3.96 (.20)
IFP	3.96 (.20)	4.00 (.00)
ImIn	3.96 (.20)	3.88 (.34)
Repeated	3.96 (.20)	3.79 (.51)
Total	3.95 (.22)	3.91 (.33)

⁴ Following past research by Bugg et al. (2016) and Scullin et al. (2012), we examined when PM hits occurred. In this sample, 71.09% of PM hits occurred on the presentation of the target word, and 28.91% occurred the trial after the target word. No PM hits occurred two trials after the presentation of the target.

3.2 Commission Errors in the Finished PM Phase

A commission error was defined as a Q press during the finished PM phase.⁵

3.2.1 Effect of Strategies for Older Adults

First, we examined the effectiveness of each strategy by comparing the number of older adults who made a commission error in each strategy condition to the baseline condition (see Figure 3.1 for both younger and older adult commission error rates).

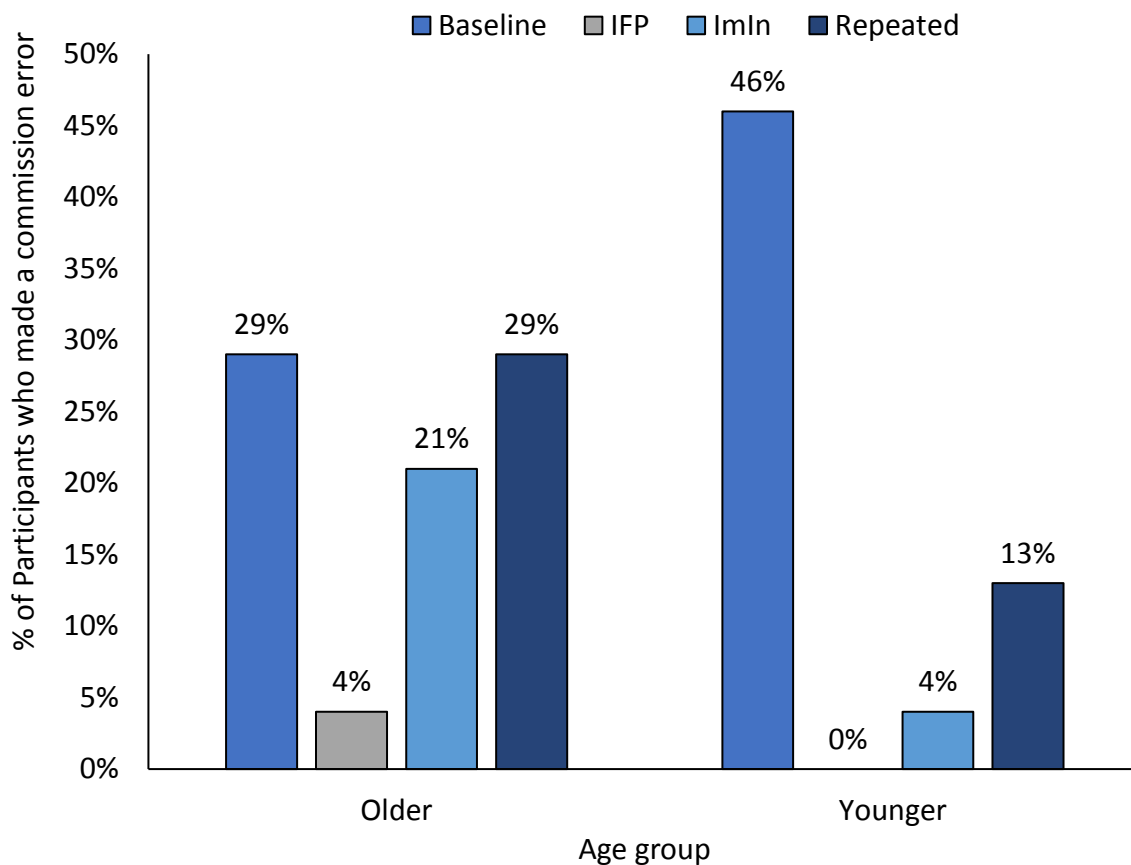


Figure 3.1 Percentage of younger and older participants who made a commission error by condition. IFP = imagined forgetting practice. ImIn = implementation intentions. Repeated = repeated instructions.

⁵ Following past research by Bugg et al. (2016) and Scullin et al. (2012), we examined when commission errors were made. Less than 2% of commission errors occurred two trials or more after the presentation of the target word, while 87.72% of commission errors occurred on the presentation of the target, and 10.53% occurred the trial after the target word.

Significantly fewer older adults made a commission error in the imagined forgetting practice condition compared to baseline, $\chi^2(1) = 5.40, p = .02$. In contrast, neither implementation intentions nor repeated instructions effectively reduced the number of older adults who made a commission error, compared to baseline, $\chi^2s(1) < 1$.

Next, we examined the average number of commission errors made in each condition. This measure was created by counting how many times participants responded to the target words (via a Q press) in the finished PM phase with a maximum of four possible commission errors and deriving the average number made in each condition (see Table 3.2 for average commission error rates).

Table 3.2 Average number commission errors made by age group and condition. IFP = imagined forgetting practice. ImIn = implementation intentions. Repeated = repeated instructions.

Condition	<u>Older adults</u>	<u>Younger adults</u>
	Average (<i>SE</i>) number of CEs	Average (<i>SE</i>) number of CEs
Baseline	1.08 (.36)	1.29 (.35)
IFP	.17 (.17)	0 (0)
ImIn	.79 (.32)	.13 (.13)
Repeated	.92 (.34)	.38 (.23)

A one-way between-subjects ANOVA showed no significant difference in the average number of commission errors between the four conditions, $F(3, 95) = 1.73, p = .17$. However, the mean number of commission errors was highest for the baseline condition ($M = 1.08, SE = .36$), then the repeated instructions condition ($M = .92, SE = .34$), followed by the implementation intentions condition ($M = .79, SE = .32$), and finally, the imagined forgetting practice condition ($M = .17, SE = .17$), which had the lowest average number of commission errors.

3.2.2 Effect of Strategies for Younger Adults

Adopting the same statistical approach used for the data collected from older adult participants, the number of younger adult participants who made a commission error and the average number of commission errors made by younger adult participants was examined. Compared to baseline, significantly fewer younger adults made a commission error in the imagined forgetting practice, $\chi^2(1) = 14.27, p < .001$, implementation intentions, $\chi^2(1) = 11.11, p = .001$, and repeated instructions, $\chi^2(1) = 6.45, p = .01$, conditions (see Figure 2).

The one-way between-subjects ANOVA showed significant differences in the average number of commission errors between conditions for younger adults, $F(3, 95) = 7.15, p < .001$ (see Table 3 for average commission error rates). Compared to baseline ($M = 1.29, SE = .35$), younger adult participants had a lower average number of commission errors in the imagined forgetting practice, $M = 0, SE = 0, t(23) = 3.71, p = .001$, implementation intentions, $M = .13, SE = .13, t(28.83) = 3.15, p < .01$, and repeated instructions, $M = .38, SE = .23, t(40.02) = 2.19, p = .03$, conditions.⁶

3.2.3 Age Differences

The number of younger and older adults who made a commission error did not significantly differ in the baseline, $\chi^2(1) = 1.42, p > .10$, imagined forgetting practice, $\chi^2(1) = 1.02, p > .10$, or repeated instructions conditions, $\chi^2(1) = 2.02, p > .10$. However, in the implementation intentions condition, marginally more older adults made a commission error than younger adults, $\chi^2(1) = 3.05, p = .08$. A 2 (age group: younger, older) \times 4 (condition: baseline, imagined forgetting practice, implementation intentions, repeated instructions) between-subjects ANOVA only showed significant differences in the average number of commission errors made between

⁶ Levene's Test for Equality of Variances found significant differences in the variances for implementation intentions and repeated instructions. These degrees of freedom have been corrected accordingly.

conditions, $F(3, 192) = 8.11, p < .01$. The main effect of age was nonsignificant, $F(1, 192) = .98, p > .32$, while the age by condition interaction was marginally significant, $F(3, 192) = 2.24, p = .09$.

3.3 Ongoing Task Reaction Time

We examined RTs on nontarget trials in the active PM phase and finished PM phase (see Table 3.3).

Table 3.3 Average RTs in milliseconds on the ongoing lexical decision task in the active PM and finished PM phases by age group and condition. IFP = imagined forgetting practice. ImIn = implementation intentions. Repeated = repeated instructions.

Condition	<u>Older adults</u>		<u>Younger adults</u>	
	Active PM phase $M (SD)$	Finished PM phase $M (SD)$	Active PM phase $M (SD)$	Finished PM phase $M (SD)$
Baseline	1344 (412)	913 (177)	758 (152)	579 (106)
IFP	1233 (387)	892 (355)	742 (143)	566 (70)
ImIn	1106 (238)	843 (181)	724 (143)	555 (80)
Repeated	1226 (357)	873 (165)	718 (88)	562 (74)

A 2 (phase: active, finished) \times 2 (age group: younger, older) \times 4 (condition: baseline, imagined forgetting practice, implementation intentions, repeated instructions) ANOVA showed a significant main effect of phase, $F(1, 184) = 439.92, p < .01$, main effect of age, $F(1, 184) = 181.92, p < .01$, and interaction effect of phase and age group, $F(1, 184) = 51.50, p < .01$. The effect of condition, age group by condition interaction, phase by condition interaction and 3-way interaction were not significant, $ps > .09$. Participants were significantly faster in the finished PM phase ($M = 723, SE = 17$) than the active PM phase ($M = 981, SE = 26$), $t(191) = 18.43, p < .01$.

Older adults ($M = 880$, $SE = 24$) were significantly slower on nontarget trials than younger adults ($M = 565$, $SE = 8$), $t(199.04) = 12.59$, $p < .01$.⁷ After performing a within-subject Z -score transformation on the RTs of the active PM phase and the finished PM phase to account for general slowing in older adults, a 2 (phase: active, finished) \times 2 (age group: younger, older) analysis showed the phase by age group interaction was no longer significant, $F(1, 190) = .45$, $p = .51$. This indicates older and younger adults sped up from the active phase to the finished phase at similar rates.

⁷ Levene's Test for Equality of Variances found significant differences in the variances. These degrees of freedom have been corrected accordingly.

Chapter 4: Discussion

This study yielded novel and theoretically interesting findings. Consistent with our first hypothesis, imagined forgetting practice effectively reduced commission error rates in older adults compared to the baseline condition. Contrary to our second hypothesis, however, implementation intentions did not reduce the commission error rates of older adults compared to the baseline condition. The results also confirmed our final hypothesis, finding commission error rates to be comparable for older adults in the repeated instructions and baseline conditions.

4.1 The Current Findings on Preparatory Strategies

As discussed in Bugg et al. (2016), the preparatory instructional strategy (which informed participants they would be seeing the previously relevant target words in the finished block and reminded them to suppress the urge to respond to targets) appeared to rely on a self-initiated process that is impaired in older adults (e.g., Craik, 1986; Craik & Bialystok, 2006; see also Bugg, 2014a, for evidence that older adults are less effective at sustaining an attentional bias). The purpose of using the imagined forgetting practice and implementation intentions strategies in the current study was to see if preparatory strategies with little to no demands on self-initiation could create a new stimulus-no response association that would be strong enough to “win” against the old stimulus-response association and effectively reduce commission error rates in older adults. Imagined forgetting practice and implementation intentions were both preparatory as they were given to participants prior to the finished PM phase. However, only the imagined forgetting practice guided participants through the preparatory part while implementation intentions simply had participants commit to the idea of not responding to the cue without telling

them how to do so. For older adults, the additional guidance may be needed for a preparatory strategy to be successful.

The finding that imagined forgetting practice effectively reduced commission errors in older adults but implementation intentions did not was surprising in light of previous literature showing implementation intentions to be a highly effective strategy for strengthening the relationship between a cue and an intention when used by younger or older adults (Chasteen, Park, & Schwarz, 2001; Mcfarland & Glisky, 2011; Zimmermann & Meier, 2009; but see Schnitzspahn & Kliegel, 2009 for evidence that implementation intentions may be effective for young-old adults but not old-old adults). One possible explanation for the null benefit of implementation intentions for older adults in the current study is the nature of the intention being strengthened by implementation intentions. Typical intentions consist of a “go” action instead of a “stop” action like the intention in this study. For example, when implementation intentions are used to guide health behavior either by resisting a “negative” health behavior (e.g., smoking) or engaging in a “positive” health behavior (e.g., eating enough vegetables), an effective implementation intentions sentence structure is, “if situation Y occurs, then I will initiate goal-directed behavior Z” even if they are inhibiting an action (Sheeran, Milne, Webb, & Gollwitzer, 2005). More specifically, a person might create the implementation intention sentence, “if a work colleague offers me a cigarette, then I will tell them I no longer smoke” (Armitage, 2007). However, previous research has shown that associations between a stop response and a stimulus are functionally equivalent to the associations between a go response and a stimulus and both types of associations can be learned through instructions and without overt practice (Liefoghe, Degryse, & Theeuwes, 2016), but this work only examined younger adults which makes it difficult to extend these results to older adults.

4.2 Age Differences for the Repeated Instructions and Baseline Conditions

As predicted, repeating the standard instructions again did not significantly reduce commission error rates in older adults. The repeated instructions condition did not provide any more environmental support than the baseline condition and did not provide a preparatory strategy for participants to engage. However, repeating the instructions effectively reduced commission error rates in younger adults. It is unlikely that the repeated instructions condition simply resolved confusion about the task given prior findings in a related paradigm. Anderson and Einstein (2017) included a “clarity” condition which had participants repeat out-loud and write down the finished PM instructions to make it clear the PM task was complete and should not be performed again. They found no difference in the amount of persisting activation for the original intention between the “clarity” condition and the baseline condition, indicating that participants were not confused when given the baseline finished instructions. Additionally, the data from the post-experimental questionnaire in the current study showed only five participants in the baseline condition (two older adults and three younger adults) indicated they did not believe the finished instructions while 43 participants (22 older adults and 21 younger adults) reported believing the finished instructions. This pattern supports the idea that participants were not confused about the finished instructions and most believed these instructions. However, as has been noted elsewhere (Scullin et al. 2012), these self-reported data are not without limitations.

As an alternative explanation, it is possible that younger adult participants in the baseline condition were inattentive during the finished instructions. In the baseline condition, participants were not told to slow down and thoroughly read the instructions, and they were not required to press different keys on each instruction slide to move on to the next slide. Both features occurred

in the repeated instructions condition, on the other hand, and commission error rates fell nearly in half compared to the baseline condition. The repeated instructions condition may have forced participants to slow down and properly encode the instructions, while the baseline condition did not. This inattentiveness-based explanation receives support from the finding that younger adults actually made nominally more commission errors in the baseline condition than older adults, which is contrary to prior results (Bugg et al., 2016; Scullin et al., 2012).

If younger adults were indeed inattentive during the baseline condition, it may be more appropriate to consider the repeated instructions as their true “baseline.” Treating the repeated instructions condition as the baseline in the analyses, there was a marginally significant reduction in the number of younger adults who made a commission error in the imagined forgetting practice condition relative to baseline, $\chi^2(1) = 3.20, p = .07$, whereas implementation intentions did not differ significantly reduce commission error risk, $\chi^2(1) = 1.09, p = .30$. Additionally, a one-way ANOVA showed there was no significant difference in the average number of commission errors across imagined forgetting practice, implementation intentions, and baseline conditions for younger adults, $p = .214$. Moreover, the pattern of age differences in baseline commission error rates more closely mirrored the previous literature (Bugg et al., 2013, 2016; Scullin et al., 2012). Overall these patterns suggest that younger adults can devise their own strategies and successfully apply them but only if they have properly encoded the instructions. For older adults, however, this is not enough. Combined with Bugg et al.'s (2016) finding that older adults rated “doing absolutely nothing but reading the instructions” significantly higher than younger adults when asked about what approaches they employed after reading the preparatory instructions, it is likely that providing the same instructions over again in a slowed

down and step-by-step form did not assist them with thinking of or engaging with useful strategies on their own.

4.3 Potential Cognitive Mechanisms

Although this study found a beneficial strategy (imagined forgetting practice) that successfully reduced commission error risk, seemingly allowing older adults to retrieve the new intention instead of the old one, the study design makes it difficult to conclude this is the mechanism behind the benefit. One possible explanation for why the strategy reduced commission error rates is because it successfully overwrote the previous intention. However, it is difficult to dissociate between the two mechanisms that are at play when a commission error occurs. The first possibility is the strategy helps stop the spontaneous retrieval of the previous intention, because the participant is retrieving the new intention instead, for example. This would mean when the participant sees the cue, only the new intention is retrieved while the old intention is not. The alternative explanation is that the strategy enables participants to inhibit the old response despite spontaneous retrieval of the old intention. In this case, participants do spontaneously retrieve the original intention when they see the cue, but they are now able to inhibit their urge to respond which ultimately fulfills the new intention. Because spontaneous retrieval seems to be spared in older adults when many other cognitive functions are impaired, it seems unlikely that older adults would be able to stop retrieval of the previous intention completely (Scullin et al., 2012). Future work should investigate this mechanistic difference and explore strategies that could approach the problem from both sides: spontaneous retrieval and inhibitory control.

4.4 Limitations of the Current Study

A limitation of this study is that the paradigm used in the current experiment was modified to remove control trials and not require participants to respond to the target words with both a

lexical decision response and a PM response. Because our version differs from the design used by Bugg et al. (2016), comparisons between effects of our strategies and their strategies are more difficult to interpret. However, it seems unlikely that these minor changes would impact how well participants would be able to engage with the strategies provided by Bugg et al. (2016) as the changes did not change the nature of the strategy. For example, the preparatory instructional strategy was believed to be ineffective for older adults because of its preparatory nature. Slightly modifying the paradigm in which it is used would not change this fact.

An additional limitation of this study was not collecting cognitive functioning measures such as inhibitory control, working memory, perseveration, etc. or confidence in cognitive ability measures as it is likely these cognitive abilities played a role in how well participants were able to engage with each strategy. Some research suggests that older adults are less likely to engage with strategies they view as cognitively taxing because they believe engaging in these strategies will not benefit them, but despite these low metacognitive ratings, when older adults are forced to apply these strategies, their performance benefits (Touron, 2015; Touron & Hertzog, 2004b, 2004a). More research should be conducted to examine the relationship between cognitive functioning and metacognitive ratings in older adults and ability to effectively engage with these strategies. Another limitation of this study was the lack of a measure examining engagement with the strategies. Though the strategies were provided openly to the participants, and participants were instructed to use the strategies, there was no clear measure to gauge if participants used the specific strategy they were told to use. Although future studies should investigate this measure, both the lower commission error rates in the imagined forgetting practice condition and previous work showing older adults can adopt beneficial strategies when

environmental support is provided (Naveh-Benjamin, Craik, & Ben-Shaul, 2002) may indicate that participants were able to successfully engage in the strategies provided.

4.5 Applications of the Current Findings

The current findings are particularly exciting because of the seemingly high translational value of the imagined forgetting practice strategy. Imagined forgetting practice shows the same beneficial effect for reducing commission error rates as Bugg et al. (2016)'s forgetting practice but does not have the same limitations. One advantage of imagined forgetting practice is that it is unlikely to unintentionally cause older adults to commit a commission error because unlike the forgetting practice, older adults do not need to physically be in the context tied to the intention and see the cue associated with the intention. For example, if an older adult were to use forgetting practice to remember to stop taking a medication, she would have to go to where the medicine is kept (e.g., a bathroom), look at the medication bottle, and not take the medication. This practice carries the danger of the original intention that is tied to that context and cue (i.e., taking the medication) being spontaneously retrieved and the older adult accidentally taking the medication.

Another positive quality of the imagined forgetting practice that increases its translational value is its accessibility. It provides a step-by-step strategy that older adults would simply need to read and apply which could be either memorized and used in a variety of situations or provided through a website or a cell phone. It is easy to imagine mobile smartphone applications that could guide older adults through the guided imagination steps to help them from committing commission errors in real life situations. Although more research should be conducted to examine the contexts in which these strategies may be useful, this study is a useful first step

towards empirically validating effective strategies that can potentially be used by older adults in everyday life to minimize commission error risk.

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