PROSPECTIVE MEMORY IS RESISTANT TO BUILD-UP OF PROACTIVE INTERFERENCE

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Submitted to the

Faculty of the College of Arts and Sciences

of American University

in Partial Fulfillment of

the Requirements for the Degree of

Master of Arts

In

Psychology

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Date April 25, 2012

2012

American University

Washington, D.C. 20016

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ABSTRACT

Proactive interference (PI), or memory impairment due to previously learned items, has been studied extensively in retrospective memory (RetroM). PI builds up rapidly when items learned recently are similar to those learned previously (e.g., all animal words). Release is observed if items learned subsequently are no longer similar (e.g., profession words), and memory improves. In six experiments, we examined whether a similar build-up and release would also be observed in prospective memory (ProM), which is memory for future intentions. In Experiments 1-5, although the usual findings were replicated in RetroM, there was no evidence of build-up of PI in ProM. Memory for the same words was unaffected when they served as ProM cues but impaired when they served as the to-be-recalled RetroM words. In Experiment 6, when the ProM and RetroM tasks were combined into a single task, a comparable build-up and release was observed in ProM, as well. Our findings suggest qualitative differences in ProM retrieval processes and we suggest that it is primarily the recursive remindings (Block & Zakay, 2006) that enable ProM to stay resistant to build-up.

ACKNOWLEDGMENTS

Many thanks to Daniel Dickison for his support and his programming help in data analysis.

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INTRODUCTION

Retrospective memory (RetroM) is memory for the past while prospective memory (ProM[1]) is memory for completing future intentions. ProM intentions can have indeterminate deadlines, can be formed for events months in advance or merely minutes into the future, as one can form an intention to think about entering the job market after graduation, attend a wedding 6 months from now, or retrieve keys from the kitchen before leaving the house. ProM helps us complete daily tasks such as remembering to buy bread or to relay a message to a colleague. ProM is defined by a delay between intention formation and intention completion, such that the person involved in completing the future intention relies on self-initiated resources for both the recognition of the ProM cue (the trigger) and completion of the intention (McDaniel & Einstein, 2007). Failure to recognize opportunities to complete intentions may have consequences. For example, if when you encounter your colleague you forget to relay that the time of a meeting has been changed, that colleague will most likely miss the meeting.

In comparison to recall and recognition processes common in RetroM tasks, memory processes in ProM tasks receive the least amount of environmental support in terms of the resources available to prompt the person into a retrieval mode (Craik, 1983). In recall tasks, the participant is prompted by the experimenter to recall the

[1] Although many researchers abbreviate prospective memory as PM, Roediger (1996) has issued a caveat for the reuse of abbreviations of previously established psychological concepts. Specifically, PM has been known in the literature (prior to prospective memory research) as the abbreviation for primary memory. Hence, we refer to prospective memory as ProM.

studied items. In recognition tasks, items are presented and the participant is specifically queried, “have you seen this item before?” In ProM tasks, there is no experimenter prompting the participant to identify any item as a cue to help the participant place himself or herself into a retrieval mode first, before proceeding with the recall itself.

ProM is a relatively new field of study in Psychology. Although there is a vast literature on RetroM spanning from the late 1800s to the present (Neath & Surprenant, 2003; Roediger, 2008) research on ProM did not emerge until the 1970s (McDaniel & Einstein, 2007). Since then, the popularity of ProM research has grown, with a pronounced increase in the 2000s (McDaniel & Einstein, 2007).

Like RetroM, ProM relies on cues, and requires successful encoding for successful retrieval. A principle of any type of memory is that it is cue-based (e.g., Surprenant & Neath, 2009). Since the majority of memories are not kept in the focus of attention, they must be actively retrieved and it is not possible to retrieve a memory if it has not been prompted. For instance, a person will not have in his/her focus of attention what s/he ate for dinner last night unless it has been prompted by a question, a person, a thought, *et cetera*. Similarly, remembering to carry out an intention cannot occur if there is no cue to trigger it. A person can form an intention to relay a message to a friend when that friend (cue) is encountered. To have successful retrieval, one needs to 1) notice the cue (e.g., see the friend), 2) identify the cue (e.g., realize that seeing the friend was supposed to be a cue for something), and 3) retrieve the associated intention (e.g., remember to relay the message as well as the content of the message; Graf, 2005). The *prospective* components of this memory are noticing and identifying the cue (Steps 1 and 2), whereas retrieving the intention is the *retrospective* component. Self-initiated ProM guides RetroM in remembering and carrying out the intention. Therefore, whereas cues in RetroM serve one purpose, to activate previously experienced information, cues in ProM must serve two purposes: to trigger the existence of an intention *and* to activate previously experienced information which comprises the contents of the intention.

In the literature, two distinct types of ProM have been proposed, differentiated by the types of cues that elicit the retrieval of the intended action: event-based and time-based ProM (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). In event-based ProM, a person, animal, place, thing, word, object, *et cetera*, acts as the cue for remembering. Time-based ProM, on the other hand, is cued by time itself. Time-based ProM is remembering to do something at a certain time, or before/after a certain amount of time has elapsed, (e.g. attend a meeting at 3pm, or check the cookies baking in the oven in 3 minutes).

Since everyday ProM intentions occur against the background of daily activities, experimental ProM tasks are often designed to occur against a background of activity as well. Thus, ProM tasks are typically embedded in an on-going task (Einstein & McDaniel, 1990; Harris & Wilkins, 1982). For example, a typical on-going task is lexical decision where a participant makes word or non-word judgments about strings of letters (Einstein et al., 2005; Marsh, Hicks, & Watson, 2002; McDaniel & Einstein, 2007). Prior to beginning that task, the participant is also instructed about the ProM task, which is typically to make a special button press when a special word or word from a category appears (e.g., press button if word is “zebra” or is from the category animals). When the participant thus encounters a ProM cue (e.g., “zebra”) while doing the primary task of lexical decision, s/he needs to notice the word and identify/recognize that it has been previously encountered as a cue, as well as retrieve the intention to make the button press, all without the aid of an external prompt to do so. Given the limited amount of environmental support for ProM, this distinction between retrieval modes in ProM and RetroM suggests that ProM performance should be at least as vulnerable to memory interference as RetroM, and indeed, may be *more* vulnerable. The participant might fail to notice the cue entirely (the aspect that is unique to ProM), let alone retrieve the associated intention to make a button press (retrieval from memory of past thoughts and events is the aspect common to both RetroM and ProM).

To further explicate Craik’s (1983) assertion that there are limited environmental resources available for ProM, consider this hypothetical experimental situation: 2 groups study a list of words, followed by an interpolated task and then a recall phase for the studied words. Group 2 is told that they will need to write down all the words they can remember from the studied list when “zebra” is encountered in the interpolated task. Group 1 is told that they will need to recall the list of words when prompted by the experimenter (the experimenter will prompt when “zebra” appears). The probability of Group 2 missing the opportunity to recall the list of words when “zebra” appears will always be greater than the probability for Group 1. Group 1 should *never* miss the opportunity to recall the words because the experimenter initiates the recall mode.

In order to explain the mechanism involved in such self-initiated retrieval, current theories of ProM divide on the processes involved in successful remembering and the effectiveness of the cues in triggering the existence of an intention (McDaniel & Einstein, 2000; Smith, 2003; Smith & Bayen, 2004). For ProM tasks, it is necessary to employ a way to check whether or not there is an opportunity for the task to be completed. It is relatively straightforward to determine if it is the appropriate moment to relay a message to someone. If the person is detected, the message can be relayed. However, the situation requires a different approach if the person is always around and the message needs to be relayed by a certain time deadline. Thus, in order to determine when it is appropriate to relay the message, the person must monitor the time.

Monitoring was the first process proposed early in the ProM literature and is a central component of all ProM models (Harris & Wilkins, 1982; McDaniel & Einstein, 2000; Smith, 2003). The first ProM model, Test-Wait-Test-Exit (based on the Test-Operate-Test-Exit model for problem solving; see Block & Zakay, 2006) explains time-based ProM, and the core assumption is that participants are actively engaged in monitoring in order to identify the appropriate time to carry out their task (Harris & Wilkins, 1982).

Harris & Wilkins (1982) applied Test-Wait-Test-Exit to a time-based ProM task requiring participants to hold up cards when set amounts of time had passed while concurrently watching a movie (on-going task) for a subsequent content test. Participants performed an initial check (test) to assess if the time was appropriate to carry out the task, followed by a waiting period. They reported that as time drew nearer to each card deadline (3 or 9 minute intervals), participants began checking the clock more frequently, and waiting periods in between became shorter and shorter, in order not to miss the time window (cue) for completion of the task. Participants would thus *test* and *wait*, *test* and *wait* until the arrival of the time cue when they could *exit* the *test-wait* cycle and complete the task. Harris & Wilkins reported that the cumulative record resembled the scalloping effect observed in fixed interval schedules of reinforcement.

Test-Wait-Test-Exit offered an explanation for the steps involved in ProM retrieval for time-based tasks, but it was not until almost two decades later that a more comprehensive model of ProM emerged (McDaniel & Einstein, 2000), which could account for both time- and event- based tasks. The Multiprocess Model of Prospective Memory is based on three main components: 1. Successful ProM retrieval is not just based on monitoring processes, but reflexive retrieval processes as well. A reflexive retrieval process is one where identification of the cue and retrieval of the associated intention requires minimal effort. 2. The process that is chosen for a situation and the success of the process is dependent on the individual's capacity, the nature of the ProM task, and the relationship with the on-going task. 3. There is a bias to use the least effortful process: reflexive retrieval (McDaniel & Einstein, 2007). The major difference between Test-Wait-Test-Exit and the multiprocess model is that in the multiprocess model, participants can use nearly automatic processes to retrieve intentions. Use of reflexive retrieval occurs when the cue to intention association is very strong, when the ProM cue is highly familiar, and when the cue differs from the other items in the on-going task (the discrepancy between the cue and the other items leads to a search for the intention). Although not necessarily automatic, reflexive retrieval processes require only minimal effort. When encountered the cue is noticed immediately and the intention ‘pops into mind’, with little if any decrement to the performance on the on-going task (McDaniel & Einstein, 2000; Scullin, McDaniel, & Einstein, 2010). According to the multiprocess model, the way to examine which processes participants are engaging in for a ProM task is to measure the effect on the on-going task (McDaniel & Einstein, 2007). This is accomplished by comparing the on-going task performance with the embedded ProM task to the performance in the on-going task alone (no embedded ProM task, known as the control condition). If there is no change in performance, participants are assumed to be using reflexive retrieval processes to carry out their ProM intentions. If there is a cost to the on-going task (e.g. longer reaction times, decrements in accuracy) then participants are assumed to be engaging in effortful monitoring processes that usurp cognitive resources allotted to the ongoing task. As a caveat, reflexive retrieval processes are not always cost free, however, and ProM performance can diminish if the on-going task demands are high (McDaniel & Scullin, 2010).

Typically participants monitor when the ProM task is more difficult or more important (McDaniel & Einstein, 2007). ProM tasks that are more difficult include time-based tasks (as in the Test-Wait-Test-Exit model and monitoring for time) and non-focal tasks (McDaniel & Einstein, 2007). Focal ProM tasks are defined as such because they use the same type of processing (e.g. semantic) as the on-going task, whereas non-focal tasks use different processing, thereby making them more effortful (McDaniel &

Einstein, 2000). For example, if a person is engaged in editing a paper for grammatical errors (on-going task), a focal task would be to correct any incomplete citations that are encountered. The person is assumed to be using the same semantic processing to edit the paper as to detect incomplete citations. On the other hand, if the person was editing the paper and also needed to relay a message when a specific colleague appeared, that would be considered a non-focal task. Presumably, one would identify the colleague by using either voice or face recognition, neither of which is congruent with the type of processing employed in editing a paper. In a non-focal task, attention needs to be diverted from the on-going task in order to notice the cue (colleague) and retrieve the associated intention (relay message).

Einstein and colleagues explored the monitoring involved in ProM by manipulating the focality and importance of the ProM task (Einstein, et al., 2005). All participants performed word categorization (“is this word a member of this category?”) as the on-going task. They were told to make a special button press when either a word (e.g., “dormitory”; focal group) or a syllable (e.g. “tor”; non-focal group) appeared. Thus, for the focal group, processing in both the on-going task and ProM task required semantic processing and was congruent[2]. For the non-focal group, however, searching for syllables, which required non-semantic processing, was not congruent with the on-going task. In addition, the importance of the ProM task was also varied (moderate vs. high) through instructions, since importance of the ProM task engages monitoring which

[2] One could presumably think of a focal task as involving less processing than a non-focal task because the cue(s) are processed in the on-going task in a manner that readily enables identification. So when “dormitory” is processed as a word in the on-going task, it can then be identified as a cue. On the other hand, in the non-focal task, one identifies “dormitory” as a word in the on-going task and then must search the letters for “tor”, which is the ProM cue. The processing in the non-focal task is not afforded an advantage from the processing in the on-going task.

is measured by cost (increased reaction times or decreased accuracy) to the on-going task. Einstein et al. found increased reaction times in the on-going task and concluded that the non-focal and the high importance ProM conditions required monitoring whereas the focal and low importance conditions did not.

Shortly after the inception of the multiprocess model, the Preparatory Attentional and Memory processes (PAM) model was proposed (Smith, 2003; Smith & Bayen, 2004). In PAM, as in Test-Wait-Test-Exit, successful ProM cannot occur unless participants engage in monitoring processes. Unlike Test-Wait-Test-Exit that accounts only for time-based tasks, PAM predicts both time- and event-based ProM performance. As a multinomial model, PAM demonstrates that the probability of retrieving a ProM intention if monitoring is not engaged is zero. In PAM, participants must discriminate cues from non-cues while remaining alert for the time window to carry out their intentions. The constant vigilance that PAM requires for successful ProM retrieval is unlike the multiprocess model that allows for low-cost reflexive processing. For a ProM retrieval attempt, PAM assumes that there must always be a cost to the on-going task, even if that cost is small. Indeed, it may be the case that with some ProM tasks, the cost to the on-going task is too small to be easily measured.

Focal ProM tasks and tasks with low-load (e.g., only one cue) pose a problem for the PAM model that assumes there is always monitoring, because there is typically no cost to the on-going task, implying participants are not engaged in monitoring for the ProM cue(s). Thus, PAM can account for data only if the process involves monitoring (if there is a cost to the on-going task), which occurs in time-based tasks and event-based tasks that are either non-focal or high-load.

Often, ProM intentions can be prompted by several cues. For instance, noticing the grocery store might be an initial cue that triggers your intention to buy bread, but inside the store, seeing butter or jam can also act as reminders and re-trigger your intention to buy bread. If a cue is associated with several intentions, however, it is more difficult to retrieve a specific intention (Cook, Marsh, Hicks, & Martin, 2006). Grocery store is often associated with multiple intentions: buy bread, buy paper towels, buy juice, *et cetera*. As the number of intentions subsumed under the cue of grocery store increases, the more interference is encountered in the retrieval of a single intention, a finding that can be explained in RetroM by the cue overload principle (Watkins & Watkins, 1975). According to cue overload, as the number of items that a category (e.g. animal words) subsumes increases, the more difficult it is to retrieve any single item from that category.

Any memory interference can be said to occur either retroactively or proactively. In retroactive interference (RI), newer memories interfere with the retrieval of older memories. For example, new email passwords can interfere with the ability to remember an older password. Conversely, proactive interference (PI) occurs when older memories make it more difficult to remember newer memories. Older passwords can interfere with remembering a newer password. Further, interference effects are most acute when information is similar, or is of the same type, or from the same category (MacLeod, 1975; McGeoch, 1932; Wickens, 1973). Retrieving an email password will be hurt by memories of other email passwords, but should not make it harder to retrieve memories for faces, or *vice versa*, since the two types of information are dissimilar.

The increase, or build-up in PI has been studied extensively in RetroM (Underwood, 1957; Wickens, 1970). Although most studies have involved free recall, PI build-up has been reported in recognition memory, as well (Petrusic & Dillon, 1972). In general, in PI build-up, performance decreases as the number of successive lists of similar to-be-remembered items increases (Wickens, 1970). The build-up in performance decrement can be relieved if the category of the items on the last list is changed, which leads to an improvement in performance on that list compared to the previous lists (Craik & Birtwhistle, 1971; MacLeod, 1975; Petrusic & Dillon, 1972; Wickens, 1970; Wickens, 1973). For example, if the build-up lists all contain words from the category "animals", there will be a release from PI if the last list changes to a different category such as "professions".

The first study on memory for everyday intentions (Loftus, 1971) was aimed at demonstrating that ProM did not differ from RetroM in regards to the effects of RI. Prior to completing a survey, (on-going task), participants were instructed to tell the experimenter their states of birth when the survey was completed (ProM task). The variables manipulated were length of survey (5 or 15 questions) and presence of a retrieval cue[3] (no-cue condition—just the initial instructions, or cue condition—give state of birth after the last question which will be about the Black Panther Party). Loftus

[3] The cue vs. no-cue condition was not an entirely accurate depiction of the experiment. Participants in the "no-cue" condition were told to indicate the state that they were born in at the end of the survey, so the "end of the survey" was really an event-based cue. The "cue" condition, was to give the birth state response after the last question, which would be about the Black Panther Party. What Loftus was really testing was presence of a general cue, vs. a more appropriate cue.

predicted that a retrieval cue and shorter retention duration (fewer intervening questions, less RI) would aid memory, and indeed found that memory was better when there were fewer intervening questions and also when a cue was available.

Since then, there has been minimal research on interference effects in ProM. In addition to the tapering off of the interest in classical interference theory after the 1970s (Anderson & Neely, 1996), some memory researchers[4] assume there is no reason to believe there would be a difference in interference effects between ProM and RetroM. Indeed Loftus (1971) had predicted that ProM would not be affected any differently by RI than RetroM, since there was no reason to assume that intentions are special types of stimuli. Yet, it is not the intention that is special or different in ProM *per se*, but rather the processing differs from that in RetroM. Unlike RetroM, ProM requires self-initiation. In addition, whereas ProM cues do not have special mnemonic properties when compared to cues in RetroM, they do require an additional processing step. That is, RetroM cues prompt retrieval directly (in one step) but ProM cues must first prompt the existence of an intention before that intention can be retrieved. The multiprocess model proposes that under conditions where reflexive retrieval can be employed (low-load focal and event-based ProM), the cue and the associated intention spontaneously appear in mind or, at worst, require minimal effort (McDaniel & Einstein, 2007). This suggests that low-load focal and/or event-based ProM are/is less effortful than free recall in RetroM, especially when one or more of the following is true: the ProM cue to

[4] In their book Principles of Memory, Surprenant and Neath (2010) outline corollaries of their Encoding-Retrieval Principle one of which is that items, processes, and cues cannot have inherent mnemonic properties and that any forgetting is due to interference (versus decay). Given that, the function and memorability of items, cues, and processes should not differ between ProM and RetroM, or any other type of memory, for that matter.

intention association is strong, the cue is highly familiar, the ProM cue is distinctive from the other items in the ongoing task. Further, the multiprocess model posits that the ProM steps that are unique to ProM, cue noticing and identifying, are automatic processes akin to what McDaniel and colleagues call recognition without an episodic component or familiarity-based recognition (McDaniel, Guynn, Einstein, & Breneiser, 2004). To the extent that participants can utilize automatic processing, multiprocess predicts no PI build-up in ProM. This is in contrast to PAM that always requires monitoring for ProM cue identification and intention retrieval attempt, and therefore, would predict a PI build-up.

To date, only two studies have reported RI in event-based ProM (Loftus, 1971; Scullin & McDaniel, 2010) and two studies have reported PI in time-based ProM (Cicogna, Nigro, Occhionero, & Esposito, 2005; Occhionero, Esposito, Cicogna, & Nigro, 2010). Further, there was no evidence of PI in event-based ProM (Cicogna et al. 2005). In the Cicogna et al. study, the on-going task required participants to complete general knowledge multiple-choice questions ("the French Revolution began in: a) 1769, b) 1779, c) 1789, or d) 1799"). Participants were allowed to check the time by pressing the F1 key. The primary time-based ProM task (press "A" key) could be completed anytime after 20 minutes of the on-going task, while the interpolated tasks (press "B" key) had to be completed either when 4 minutes had passed or when a question on a yellow background appeared[5]. Cicogna et al. found that performance on the interpolated

[5] Instruction for the interpolated ProM task was given at either 12 or 15 minutes into the on-going task, regardless of type of interpolated task (event- or time-based). Cicogna et al. reported that while the performance in the event-based task was unaffected by the primary task compared to the control group,

event-based task was unaffected while performance on the interpolated time-based task was hurt. They concluded that the PI effects in the interpolated time-based task were due to the similarity and difficulty of the two ProM tasks: both were time-based, and time-based tasks have been reported to be more difficult than event-based tasks (e.g., McDaniel & Einstein, 2007). When the primary ProM task was time-based and the interpolated task was event-based, no effects of PI were found and Cicogna et al. proposed that the lack of PI was due to lack of difficulty of the event-based task and the dissimilarity of the two tasks. That is, the types of ProM cues were not similar, and therefore the cue in the primary task did not interfere with the cue in the interpolated task.

If processing in ProM is not different from that in RetroM (e.g., Loftus, 1971), then ProM should also be vulnerable to the build-up of PI. Over the course of successive lists of stimuli, (e.g. words, trigrams), to the extent that the lists are similar in composition, PI should attenuate ProM performance in terms of accuracy or reaction times. Given that cues in ProM operate in two steps, triggering the existence of an intention *and* evoking the retrospective component of remembering (contents of the intention), there are two ways in which ProM can fail. Thus, one could even speculate that due to the extra step where things can go wrong, ProM should be even more vulnerable than RetroM to the effects of PI build-up.

The multiprocess model posits that participants can use either nearly effortless processing or monitoring to retrieve ProM intentions, while PAM posits that monitoring is

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when instruction for the interpolated task was time-based and administered at 15 minutes (closer to deadline for primary task), performance was the worst.

the only process available for successful ProM intention retrieval. Since PAM predicts that both ProM identification and retrieval require monitoring, it suggests that attentional resources would not be resistant to an accumulation of PI. According to PAM, the effects of ProM monitoring, at the very least, should be observed in reaction time data; the more cues that need to be monitored, the slower the reaction times across lists. On the contrary, the multiprocess model would predict that to the extent that ProM retrieval can rely on automatic cue identification and subsequent intention retrieval, there should be no build-up of PI in ProM.

In this study, we examined the effects of PI on both event-based ProM as well as RetroM, using a build-up and release-from proactive interference paradigm (Wickens, 1970). Both ProM and RetroM tasks were embedded within a lexical decision task in all but one experiment where a consonant-vowel decision was the on-going task. Build-up lists comprised words from the same category (e.g., "animals"). To allow for release from PI, the last list comprised words from a different category, (e.g., "professions"). In Experiment 1, we tested ProM and RetroM separately, and in Experiments 2, 3, 4, and 5 we tested only ProM. In all experiments, the purpose was to determine if ProM performance would follow the typical build-up and release from proactive interference pattern found in RetroM where performance decreases across successive lists of stimuli and improves on the last list (release). Failing to find any PI in ProM, in Experiment 6, we combined the ProM and RetroM tasks in the same procedure to determine if PI build-up could be induced when resources and items are shared.

CHAPTER 2

EXPERIMENTS 1A & 1B

Participants

Twenty American University students participated to fulfill a research requirement or for extra credit in their psychology courses.

Materials, Design & Procedure

The stimuli lists were generated from Battig & Montague's category norms (Battig & Montague, 1969) for words and the ARC Nonword Database (Rastle, Harrington, & Coltheart, 2002) for non-words. There were 3 category pools of word stimuli: animals, household items, and professions. Each pool contained 120 words, 3-10 letters in length. The professions pool was taken directly from Battig & Montague's Profession category. The animals pool was created by combining items from the "Four-Footed Animals", "Birds", and "Insects" categories. The household items pool was created by combining items from the "Kitchen Utensils" and "Furniture" categories. The 120 non-words were collected from the ARC Database using the parameters "pseudohomophones", "only orthographically existing onsets", "only orthographically existing bodies", "only legal bigrams", with lengths 3-10 letters. In order to keep level of ProM cue difficulty equal across categories, only words of 5-6 letters in length were used.

Stimuli lists for Experiments 1a & 1b were created from the animals and the household items pools. There were 4 lists with 120 items per list. Each list comprised 3 ProM cues (PI build-up in RetroM occurs with as few as even 3 items in each to-be-recalled list; Wickens, 1970; Wickens, 1972), 27 words, and 30 non-words, with all items presented twice. Words were novel for each list and randomly repeated within list with the constraint that a cue would never appear twice in a row. Cue repetition forced participants to be responsible for more than one presentation of each cue; they could not just forget about the word after its first presentation. The positions of cues on each list differed, (e.g. the first cue might appear on position 16 in list 1, but on position 23 on list 2 *et cetera*), but were the same positions by list regardless of stimulus category, that is the first cue for list 2 would always appear on position 23, regardless of category type—animals or household items. Cues were spaced apart by at least 15 trials. Each cue was assigned to 1 of 3 colored (red, green, or yellow) button responses at the beginning of each list. For half of the participants, the first 3 lists comprised all animals and the last list all household items, and for the other half of the participants household items comprised the build-up lists with the release list consisting of animals.

Participants were tested individually on a Dell computer with a Pentium 4 processor. The experiment script was coded in SuperLab 4.0 using a Cedrus RB-830 button-box to collect all button presses and the reaction times associated with those button presses.

The on-going task was self-paced lexical decision; a string of letters appeared in the middle of the computer screen and remained until the word or non-word judgment was made as quickly and accurately as possible. Participants were told at the beginning of the experiment that the primary task was making word judgments. In addition to that task, they would need to keep a few words in mind (ProM cues). If one of the ProM cues happened to appear, participants would indicate the appearance by making a special button press (e.g., press the red button if “zebra” appears). They were instructed to always make the lexical decision response first, followed by the colored button press if the word happened to be one of the words to keep in mind. ProM cues were always from the same category used in the lexical decision task. Three new ProM cues were assigned at the beginning of each list. To clarify the instructions, participants first completed a short practice list comprised of items from categories that were not used during the experiment.

In each trial, a fixation cross “+” appeared in the middle of the computer screen for 250 ms signaling for the participant to prepare for the item. Immediately after, a string of letters in Tahoma font size 48 appeared in the center of the screen and participants were required to make a lexical decision response using the “W” button (right hand) for word or the “N” button (left hand) for non-word. Since the lexical decision task was only meant to be the background for our experimental tasks and not a question of interest, we did not counterbalance the buttons for handedness. Immediately after the lexical decision was made, a screen appeared with the italicized word *Waiting* in the center. The reaction times of interest were those associated with the ProM response: the amount of time that elapsed between the appearance of the *Waiting* screen and the colored button press.

Participants were instructed to press either “W” or “N” again to advance to the next trial. If the item that they had just made a word decision response to also happened to be a ProM cue, participants were told to make the colored button press associated with that cue during the *Waiting* screen, before pressing W or N again to advance to the next trial (cf. Marsh et al., 2002).

On the fourth and last list, the category of the words, including the ProM cues, changed as did the type of response buttons for the ProM decisions. Instead of a color, a shape was assigned as the response to each ProM cue, and stickers with drawings of shapes (circle, square, triangle) were placed over the color buttons.

Experiment 1b

The purpose of this experiment was to ensure that the standard build-up and release from proactive interference results would be obtained in a RetroM task with the same materials and methodology used in Experiment 1a.

Participants

Twenty American University students participated to fulfill a research requirement or for extra credit in their psychology courses. None had participated in the previous experiment.

Materials, Design & Procedure

The design and materials were exactly the same as Experiment 1a, however a RetroM task instead of a ProM task was embedded in the on-going lexical decision task. That is, in addition to the lexical decision task, participants were instructed to memorize all the words on each list. A recall test ensued immediately after the end of each list. Participants were given a pen and a blank half-sheet of paper (5.5 x 8.5 inches) and told to write down as many of the words that they could remember from the previous list.

They were given 2 minutes and timed with a stop-watch. The experimenter collected each recall sheet before moving onto the presentation of the next list.

Results and Conclusions

As expected, a PI build-up and release was observed in the RetroM task of Experiment 1b, (Figure 1, top panel)[6]. A repeated measures ANOVA of proportion correct on the first three lists revealed an effect of build-up, $F(2, 38)=3.6$, $p<.05$, $MSE=.008$), as well as a significant release from PI from the third to last list, $t(19)=7.8$, $p<.001$. For the ProM task in Experiment 1a, however, there was no evidence of PI build-up (Figure 1, bottom panel), and performance was equivalent across all lists, $F(2, 38)=1.3$, $p>.25$, $MSE=.019$. Further, reaction times for correct ProM responses did not increase across lists, (means of 1913 ms, 1601 ms, and 1328 ms, respectively), indicating that the lack of a PI build-up for the ProM cues was not simply an artifact of a speed-accuracy tradeoff. However, one problem was that in Experiment 1a, the ProM performance was near the ceiling, and this overall high performance could have masked the effect of any build-up. Thus, the purpose of the next experiment was to see if the lack of a PI build-up would be replicated even when we doubled the amount of ProM cues per list and performance was no longer at ceiling.

[6] To our knowledge, Craik and Birtwhistle (1971) were the only researchers to test/demonstrate build-up and release from proactive interference in long-term memory (LTM). Regardless, there was no reason for us to believe our LTM RetroM task would not show the typical build-up and release from PI.

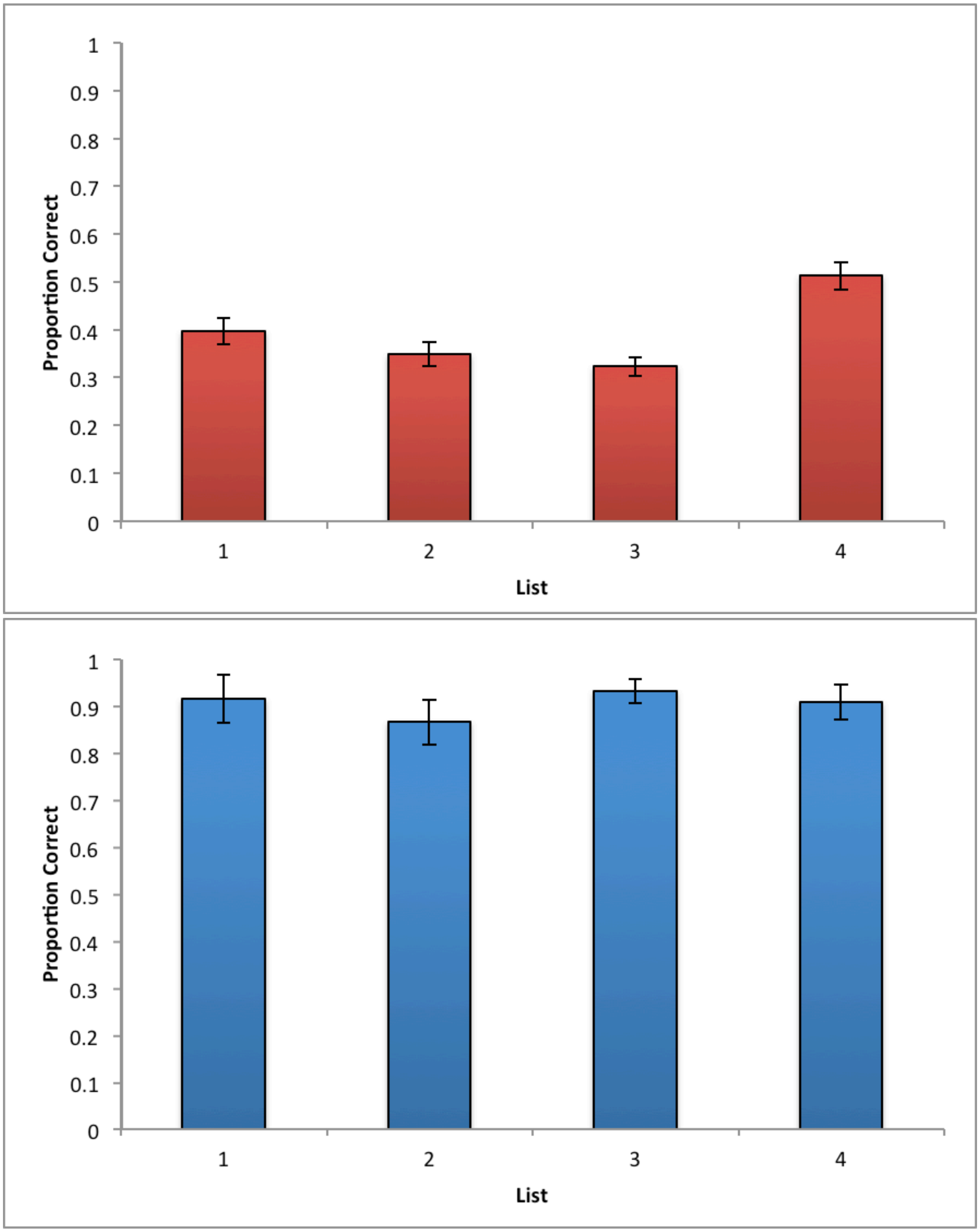

Figure 1. Proportion correct as a function of list for Experiment 1. The top panel is Experiment 1B, RetroM only task, while the bottom panel is Experiment 1A, ProM only task. Error bars represent the standard error of the mean.

CHAPTER 3

EXPERIMENT 2

Participants

Eighteen American University students participated to fulfill a research requirement or for extra credit in their psychology courses. None had participated in the previous experiments.

Materials, Design, and Procedure

The materials were the same as in the previous experiments. This time, however, in each list, there were 6 ProM cues, 24 words, and 30 non-words, with each item repeating once within list; thus, participants made decisions on 120 items, comprising 12 ProM cues, 48 words, and 60 non-words. The design and procedure were the same as in Experiment 1a except that two cues were assigned to each color button (or shape button in the release condition) in any given list. For example, both “monkey” and “pigeon” were assigned to the red button, “horse” and “eagle” to the green button and “jaguar” and “whale” to the yellow button within the same list.

Results and Conclusions

As can be seen in Figure 2, the ceiling effect observed in Experiment 1a was eliminated in this experiment (Figure 2). Yet there still was no effect of PI build-up; performance across the lists was equivalent (F<1). Once again, reaction times did not increase across lists (means of 835 ms, 580 ms, and 544 ms respectively), making a speed-accuracy trade-off explanation unlikely.

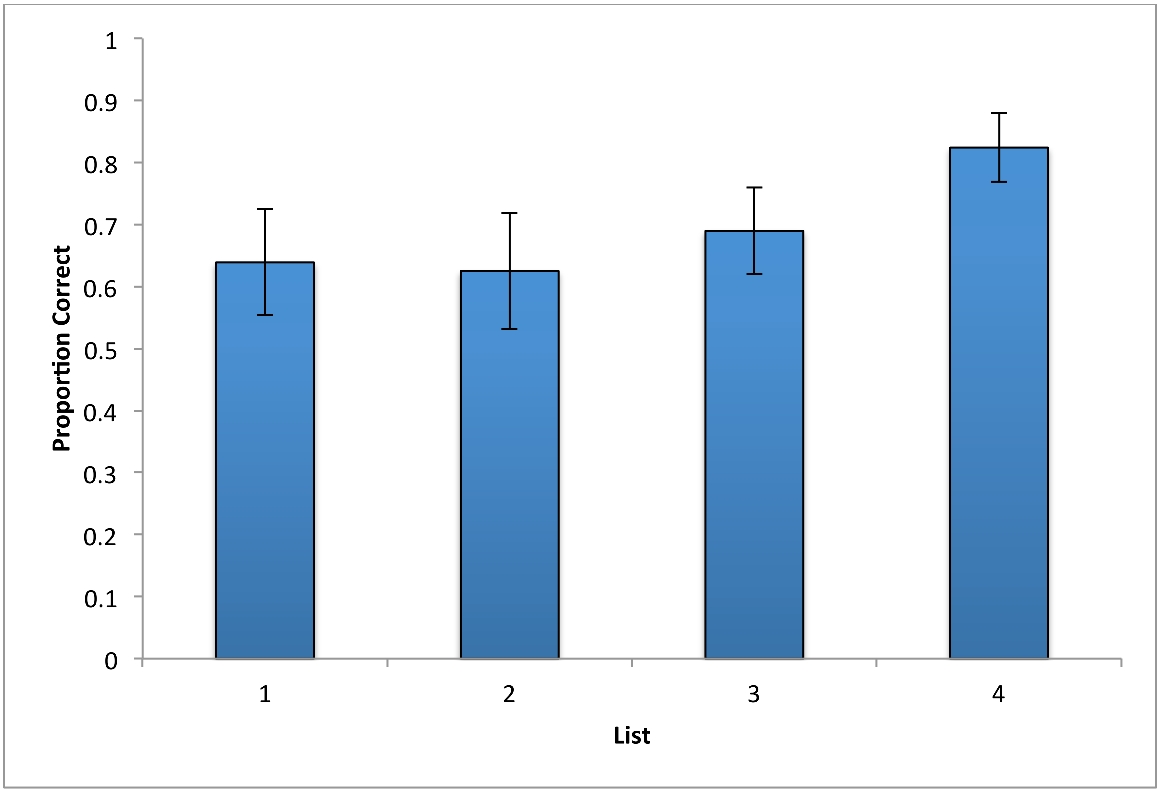

Figure 2. Proportion correct as a function of list for Experiment 2, the high-load ProM task. Error bars represent the standard error of the mean.

CHAPTER 4

EXPERIMENT 3

Another possible concern in Experiments 1a and 2 was about the type of ProM we were actually measuring (Uttl, 2008). Uttl theorizes that there are 3 subtypes of ProM: vigilance/monitoring, ProM Proper, and habitual ProM, which map respectively to STM/working memory, long-term memory (LTM), and semantic memory in RetroM. According to Uttl's definition, vigilance/monitoring ProM occurs when there is no delay or distractor task between ProM instruction and commencement of the experiment. Our ProM task fell into that category since each list began immediately following the presentation of the ProM cues for that list. Therefore, in Experiment 3 we included a delay between the ProM cue instruction and list commencement to see if the lack of PI build-up was indeed because of the specific nature of our task.

Participants

Twenty American University students participated to fulfill a research requirement or for extra credit in their psychology courses. None had participated in any previous experiments.

Materials, Design & Procedure

The materials and design were exactly the same as in Experiment 1a, except that after the presentation of each ProM cue instruction page, the computer screen was cleared and instructions for a multiplication distractor task were presented. Participants were then given two minutes (timed with a stop-watch) to solve two digit multiplication problems on paper. After the multiplication task was completed, the participants were instructed to prepare for the “word decision task” and the experiment list began with no further mention of the ProM cues.

Results and Conclusions

Despite the delay between ProM cue instruction and list commencement, there was still no PI build-up (Figure 3). As before, performance was equivalent across all lists (F<1) while reaction times did not increase (1655 ms, 1266 ms, and 1396 ms, respectively. Thus, there was no evidence that the lack of a PI build-up in the previous two experiments was due to the lack of a delay between the presentation of the ProM cues and the memory task.

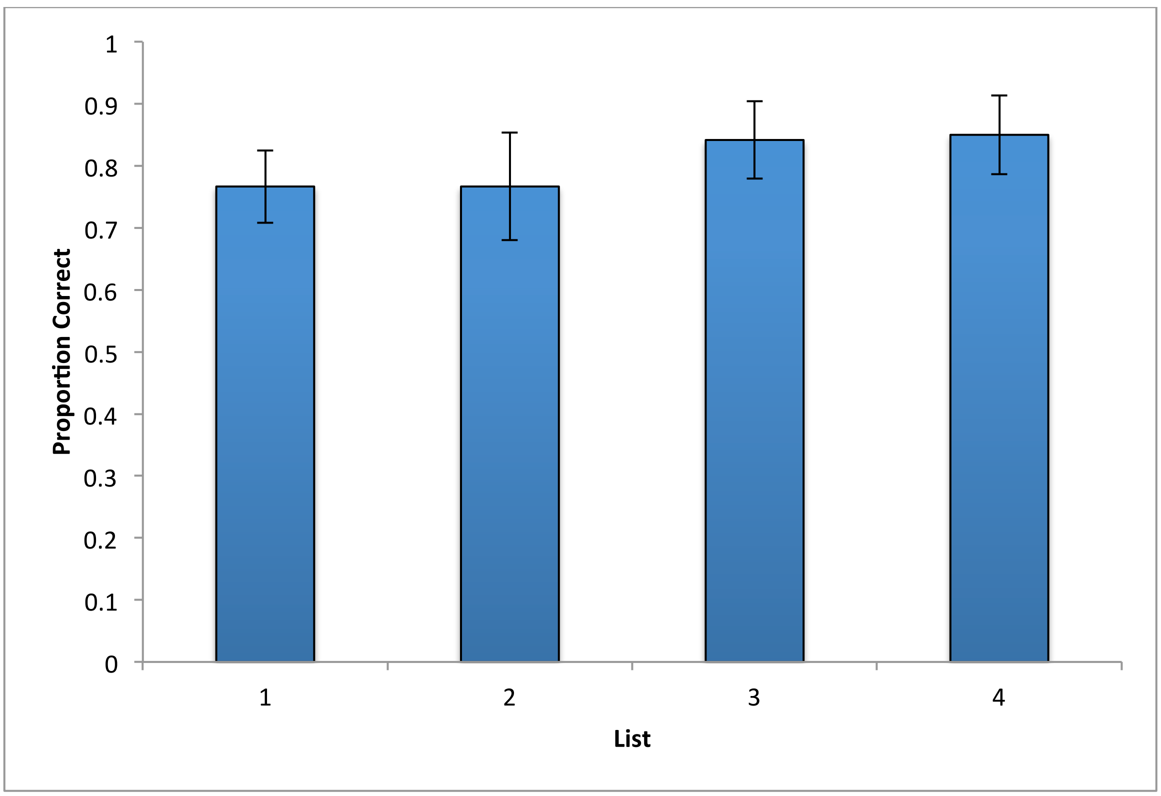

Figure 3. Proportion correct as a function of list for Experiment 3, the ProM task with delay. Error bars represent the standard error of the mean.

CHAPTER 5

EXPERIMENT 4

In this experiment we investigated another possibility for why we did not observe any PI build-up in ProM while observing it in RetroM. Perhaps the build-up in ProM was slower than that in RetroM and there were not enough lists in Experiments 1a, 2, and 3 to observe this effect. Therefore, we tripled the number of lists. Thus, to the extent that PI build-up is a function of cue overload (Watkins & Watkins, 1975) in that as the number of items a category cue subsumes increases, so does the interference observed, tripling the number of lists subsumed by our single category cue provided an increased chance of observing any PI build-up with the ProM items.

Participants

Eighteen American University students participated to fulfill a research requirement or for extra credit in their psychology courses. None had participated in any previous experiments.

Materials, Design, and Procedure

There were nine PI build-up lists, with the tenth list serving as the release list. In this experiment, we added a third category (professions) to ensure that the previous results were not due to the particular categories we had used. Thus, we had three combinations of build-up and release lists. Across three groups of participants and two subgroups within each of those groups, each category was used in the build-up and release lists equally often. Each list comprised 105 items: 33 words (six of which were also ProM cues) and 72 non-words. Since the pool of category words was finite, there were more non-words than words in order to space out the appearance of the ProM cues. The words assigned as the ProM cues (3 words) were repeated once in each list and were unique in that they did not appear in any other list. In order to space out the ProM cues by at least 15 items, 9 words repeated once on each list while 9 repeated once across lists such that each non-cue word was seen 3 times across the entire experiment. Similarly, 24 non-words were also repeated once in each list while 24 were repeated once across lists. The basic procedure was the same as those in the previous experiments.

Results & Conclusions

To make comparisons to the previous experiments easier we combined Lists 1 - 3 Lists 4 - 6 Lists 7 - 9 to comprise the three build-up blocks. List 10 comprised the release list. Results are presented in Figure 4.

There was again no evidence of build-up of PI; indeed performance *improved* over the first three blocks, $F(2, 34)=2.0$, $p>.1$, $MSE=.009$, along with the typical lack of increase of reaction times (means of 2023 ms, 1846 ms, and 1663 ms respectively). In fact, performance in ProM across all successive blocks (including the release list) was monotonically increasing, $F(1, 17)=8.4$, $p<.05$, $MSE=.011$, perhaps indicating a learning to learn effect instead, which will be discussed later in the General Discussion. For the present purposes, the finding of interest was that there was no PI build-up, and the surprising improvement in performance across all lists had the unintended consequence of further ruling out a ceiling effect explanation of the observance of no PI.

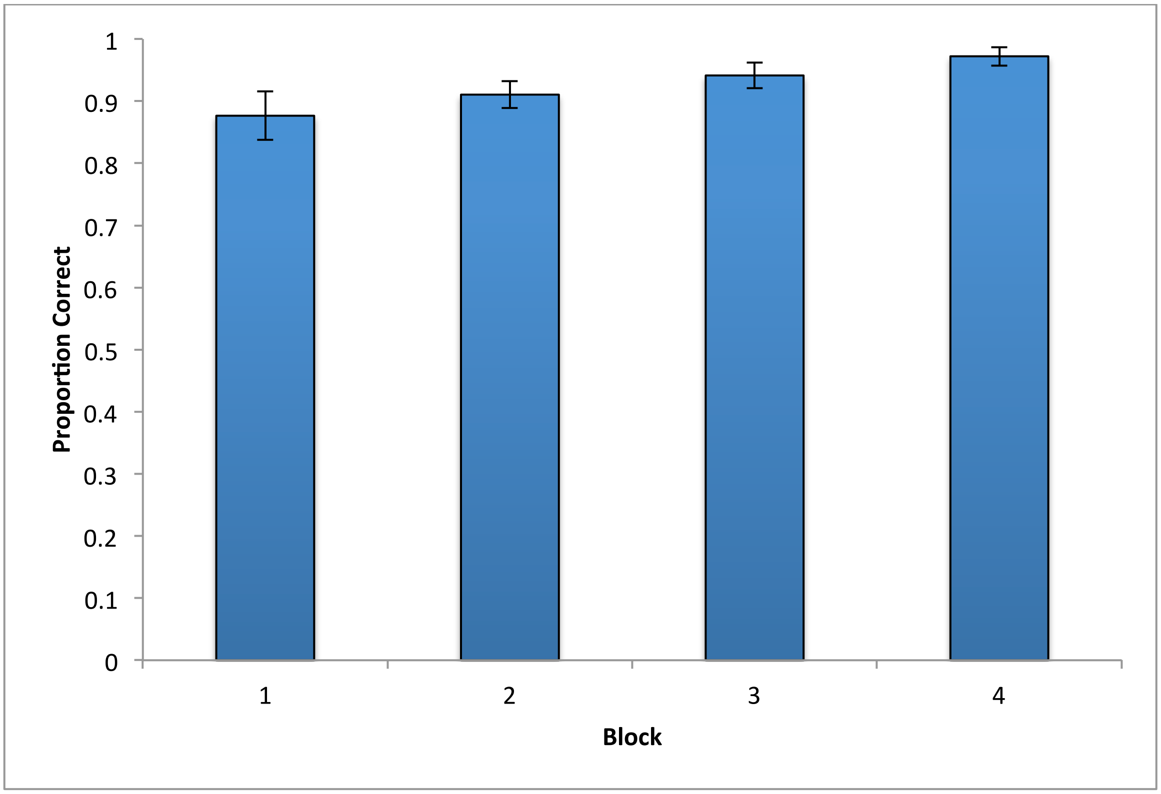

Figure 4. Proportion correct as a function of block for Experiment 4, the 10 list ProM task. Error bars represent the standard error of the mean.

CHAPTER 6

EXPERIMENT 5

Thus far, all our ProM tasks were focal tasks; semantic processing was used in both the on-going task and the ProM task. One possibility was that the lack of a PI build-up reflected the processing advantage the ProM cues received during the on-going task, due to the lack of conflict in task processing. Thus, in this experiment, we used a non-focal on-going task to remove this extra advantage. A ProM task embedded in an on-going task that does not use the same processing as the ProM task should decrease ProM performance. The question of interest was whether or not ProM would still be resilient to PI build-up under an incongruent processing condition. Thus in Experiment 5, participants encoded ProM cues using semantic processing but performed the on-going task using letter processing. Since they would be paying attention to individual letters to be able to perform the on-going task, noticing the ProM cues and identifying that they have associated intentions should not benefit from performance of that task.

Participants

Eighteen American University students participated to fulfill a research requirement or for extra credit in their psychology courses. None had participated in any previous experiments.

Materials, Design, and Procedure

The method was identical to that of Experiment 4, with 9 build-up lists, followed by a release list, except that instead of an on-going lexical decision task, participants performed an on-going letter decision task. They made a decision on the third letter of each string of letters that appeared. If the letter was a vowel, they were to press the “V” button (right hand), if it was a consonant, they were to press the “C” button (left hand).

Results & Conclusions

As can be seen in Figure 5, there was again no build-up of PI. Performance across all blocks (each block consisted of 3 lists) was equivalent (F<1) while reaction times did not increase, (means of 2945 ms, 2480 ms, and 2379 ms, respectively). It appears that even when processing in the ProM task is separate from the processing required in the on-going task, there is still no build-up in PI.

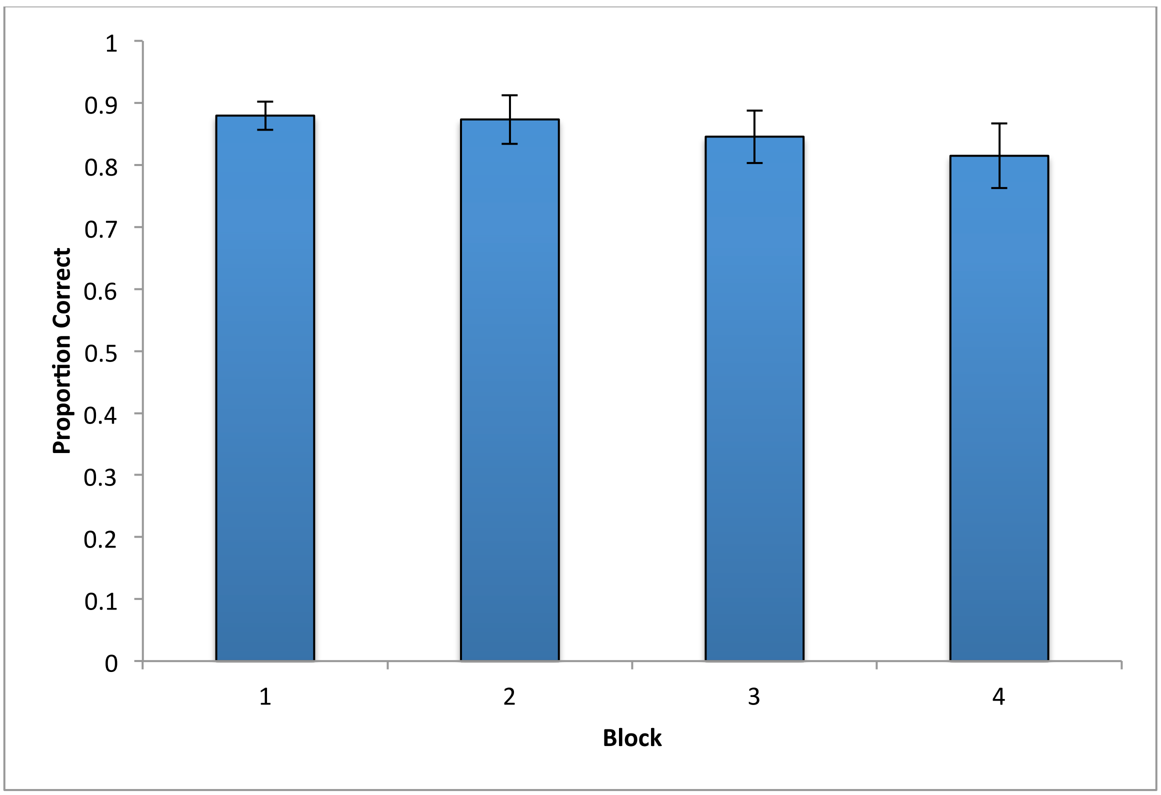

Figure 5. Proportion correct as a function of block for Experiment 5, the 10 list non-focal ProM task. Error bars represent the standard error of the mean.

CHAPTER 7

EXPERIMENT 6

In none of the previous experiments, did we find evidence of PI in ProM, although the typical build-up and release from proactive interference pattern was observed in RetroM in Experiment 1b. In Experiment 6, participants were asked to do both a ProM and a RetroM task at the same time and using the same lists. The purpose was to see if, when cognitive resources as well as the actual stimuli were shared in the two tasks, the PI build-up in RetroM would drive a PI build-up in ProM because participants would be responsible for remembering *all* the words on each list, not just the cue words. An additional purpose was to see whether the occurrence of ProM cues also as non-cue words in other lists would cause greater errors in cue discrimination and help PI build-up.

Participants

A total of 102 American University students participated to fulfill a research requirement, for extra credit in their psychology courses, or for $10. None had participated in any previous experiments.

Materials, Design, and Procedure

The materials were the same as in Experiment 4. The procedure and design, however, were changed such that in addition to the ProM task in Experiment 4, participants were also asked to recall all the words at the end of each list. Further, for one group of participants, each ProM cue repeated once on a different list as a non-cue word (a word to be recalled only in the RetroM task). To explicate, a ProM cue was presented twice in a list, but also appeared one more time in a different list as a regular word not associated with a special button press. More specifically, 10 of the critical words appeared once before being assigned as a cue in a future list, and the rest appeared after having already been assigned as a cue in a previous list. All critical words appeared as ProM cues only in a single list in the experiment. During the learning phase, participants pressed the assigned button when a designated ProM cue appeared, and at the end of the learning phase of each list they were asked to recall all the words, including the ProM cues.

Results and Conclusions

In this experiment, we had two groups of participants. The only difference between the two groups was that for one group (n=42), ProM cues repeated once on a different list as a non-cue word, whereas for the other group (n=60), no ProM cues ever appeared as a non-cue word. The purpose was to see if participants were more likely to misattribute the source (list) of the ProM cues when ProM cues appeared as non-cue words, which might have an additional contribution to any observed PI. There was, however, no difference in the percentage of non-cue words identified as cue words between the two groups (F<1) indicating that source misattribution did not contribute to memory failure[7]. Thus, because the groups were identical in all other respects, we collapsed the two groups into one for all of the other analyses.

Unlike in previous experiments, PI build-up was observed not only in the RetroM task but also in the ProM task, as well. Figure 6 shows the decline in performance across lists in both cases.

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[7] In fact, the number of spurious ProM responses to non-cue words was extremely low in both groups. Across all 102 participants, for all 10 lists, the total number of ProM button presses to non-cue words was only 32.

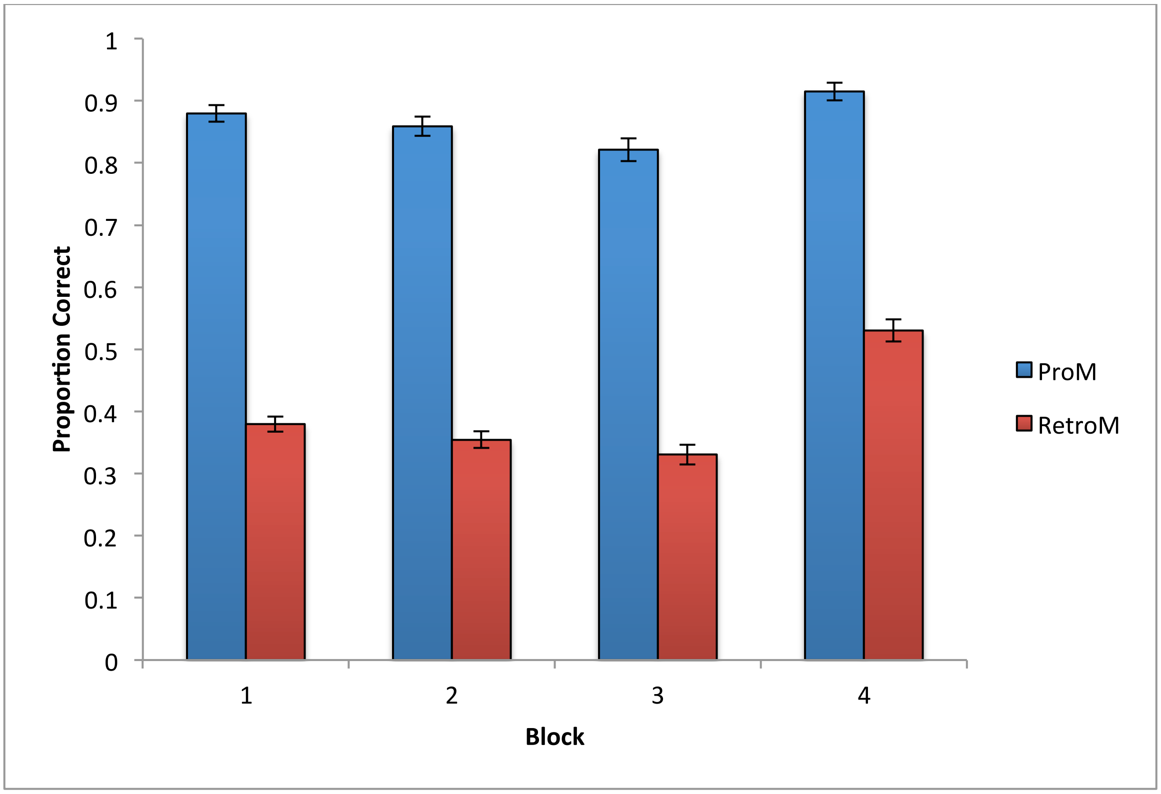

Figure 6. Proportion correct as a function of block for Experiment 6, the 10 list ProM and RetroM tasks combined. Error bars represent the standard error of the mean.

Two repeated measures ANOVAs revealed a main effect of build-up in RetroM ($F(2, 202)=12.1$, $p<.001$, $MSE=.005$; means of respective accuracy 38.0%, 35.4%, and 33.1%) and ProM ($F(2, 202)=6.0$, $p<.01$, $MSE=.015$; means of respective accuracy 88.0%, 85.9%, and 82.1%). In addition, the expected release from PI on the last list compared to the third block was also significant in both tasks, $t(101)=5.5$, $p<.001$ in ProM and $t(101)=12.1$, $p<.001$ in RetroM, indicating that the observed performance decrements were indeed due to a build-up of PI. The ProM reaction times were 1395 ms, 1169 ms, and 1086 ms across the three blocks.

We also conducted a separate analysis for when the ProM task failed but the RetroM task was successful for any given word. That is, we looked at the words that were missed entirely (no attempt was made to make a special button press) as ProM cues despite being nevertheless recalled during the RetroM task. These percentages across the three blocks were 2.9%, 2.3%, and 5.7% respectively, $F(2, 202)=7.0$, $p<.01$, $MSE=.005$, followed by a release list of 1.3%, $t(101)=4.5$, $p<.001$. To explicate, while performance on blocks 1 & 2 did not differ ($t<1$), performance on block 3 (last block of build-up), was worse than both block 1($t(101)=2.5$, $p<.02$) and block 2 ($t(101)=3.5$, $p<.001$), indicating that, by the last block of build-up, participants were less likely to remember the ProM cues while retaining ability to recall those words on the RetroM task.

CHAPTER 8

GENERAL DISCUSSION

Loftus (1971) had made the prediction that because ProM involved similar processes as RetroM, traditional interference effects should be observed in ProM tasks, as well. Indeed, she found comparable effects of RI on ProM in that performance for the ProM trial was hurt when the number of interpolated items on the on-going task increased. Further, Cicogna et al. (2005) found PI in time-based ProM. However, they did not find it in event-based ProM, and attributed this to lack of similarity and lack of difficulty of the interpolated task (event-based) compared to the primary task (time-based). The assumption was that if the primary and interpolated tasks were similar (both time-based or both event-based) and the interpolated task was difficult enough, PI should arise in all ProM tasks, as well, just like in RetroM tasks.

We tested this prediction directly by exploring whether the lack of PI in event-based ProM was indeed due to the lack of similarity and lack of difficulty of the interpolated task. In our experiments, both our primary and interpolated tasks were event-based and relied on items from the same category. In addition, difficulty was manipulated by doubling the number of cues per list (Experiment 2) or tripling the number of lists (Experiment 4), introducing a delay between instruction and list commencement (Experiment 3), and testing non-focal cues (Experiment 5). Our results demonstrated no build-up of PI in any of these ProM tasks. Thus, lack of similarity or lack of difficulty was unlikely to have been an explanation for the lack of PI in the event-based ProM task of Cicogna et al. (2005).

There are several possible explanations for not observing a PI build-up. One explanation could be the "learning to learn" effect (Keppel & Underwood, 1962; Nowaczyk, Shaughnessy, & Zimmerman, 1974; Wickens, Born, & Allen, 1963) where across lists of similar to-be-remembered items, participants develop better strategies to perform the task, which in turn can mask the building up of PI. In fact, the finding of the significant monotonic increase in performance in Experiment 4 as well as the relatively unusual finding of release list performance consistently exceeding first list performance (ps<.05) when there was PI build-up in ProM (Experiment 6) or RetroM (Experiments 1 & 6) suggest the presence of a learning to learn effect. However, that does not necessarily mean that there was also PI build-up that was being masked by this effect. If there was indeed a PI build-up that was not detectable because of being counteracted by the learning to learn effect, we should have still observed a release on the last list when the category changed. That is, an improvement in performance above and beyond what would be predicted by more "learning" alone should have occurred. Thus, we examined whether there was such an improvement on the last list by comparing the difference in performance between successive lists. There was no evidence in any of the 5 experiments that a learning to learn effect was masking PI build-up (p>.10 for all Friedman tests).

We speculate that ProM was afforded resistance to PI because the present task was essentially one of paired-associate learning (cf. Murdock, 1964; Poppei, Finlay, & Tedford, 1970), where the identification of the cue was just as important as the response, which may not be the case in some ProM situations in everyday life. In classical interference terms, the pairs were of the A-B, C-D type on each list (except in Experiment 2 where we also had A-B, C-B pairings where two different cues were associated with the same response). In neither case does one expect much interference when the cue terms are presented to the participants (e.g., Osgood, 1949). Although the theory is primarily for explaining RI rather than PI, to the extent that the underlying mechanism of interference is similar, these predictions should also hold for PI build-up (cf. Dallett, 1962). Thus, in everyday life, we would not expect much of an interference effect in such a paradigm. When one needs to relay a message to a specific colleague, (or press a button for “zebra”), one should not confuse the colleague to relay the message to, despite the fact that many people encountered during the day will all be from the category “colleague”. An interference would likely have emerged had we used A-B, A-D pairs (where a single cue would be associated with different intentions or button presses in different lists). However, even this would apply only to the RetroM part of the ProM task—remembering the intentions associated with the cues—and not be surprising. The fan effect of the cues (e.g. one cue associated with several different intentions) on retrieval of a specific intention is indeed a RetroM component which has been well documented in the literature (e.g., Anderson, 1974). This would be akin to intending to relay several messages to a single colleague at different times. The cue (colleague) can be easily identified (ProM), but the difficulty arises in trying to retrieve the specific message (RetroM).

One caveat is that in classical interference, the cues are provided and the task is to remember the responses that go with them. This modifies the PI build-up observed in

RetroM. Both Murdock (1964) and Poppei et al. (1970) have demonstrated that when the stimuli are paired associates and the response is paired with an explicit cue, there is no evidence for PI build-up. However, in the present case, participants were not told when a cue word appeared, and, further, not prompted to recall the response term for that cue word. They were expected to "recognize" the cues on their own. Even then, one should still expect a build-up of PI given that it has been demonstrated extensively when using recognition tests, as well (e.g., Bowles & Glanzer, 1983; Brown & Gorfein, 2004; Carey, 1973; Gardiner & Klee, 1978; Gorfein, 1974; Gorfein & Jacobson, 1972, 1973; Öztekin & McElree, 2007; Petrusic & Dillon, 1972; Schulman, 1974; Yarmey, 1974). Thus, the question remains about what makes the recognition of the cues as to-be-identified items resistant to PI.

We suggest that these ProM cues have a privileged status and receive additional processing that makes them more strongly organized, which may make them more resistant to interference. For chess players, chess positions are resistant to PI build-up when compared to trigrams (Charness, 1976). Charness explains this resistance as resulting from the strong organization of chess positions in LTM versus the relatively impoverished organization of less meaningful verbal information (trigrams). Charness posits that less meaningful information is more vulnerable to the effects of interference. Further, by virtue of being associated with a response term, these items are also relatively more distinctive compared to other items of the same category, and thus less easily interfered with (cf. Wickens et al., 1963).

Another factor aiding in the resistance of cue-recognition to PI might be that ProM performance benefits from “recursive remindings” (Block & Zakay, 2006). According to Block & Zakay, in circumstances where event-based cue to intention associations are similar, when encountering a cue, participants not only can automatically recall the intention (similar to the reflexive retrieval proposed in McDaniel et al.’s multiprocess model, McDaniel & Einstein, 2007), but this recall also serves to remind them of other similar cue to intention associations, essentially acting as rehearsal opportunities (similar to those provided by “monitoring” but without the need to use attentional resources).

Thus, from the outset, the idea of recursive remindings as a possible mechanism of providing resistance to PI build-up is consistent with the predictions of the multiprocess model. The PAM or Test-Wait-Test-Exit models require active monitoring at all times in order to detect a ProM cue. In the multiprocess model, participants sometimes use active monitoring (when the task is more important or more difficult) but reflexive retrieval is the preferred or default process (McDaniel & Einstein, 2007). Reflexive retrieval processes require minimal effort, the intention ‘pops into mind’ when the cue is encountered. Further, cue noticing and identifying is also an automatic process and is akin to familiarity-based recognition. Therefore, we suggest that recursive remindings not only allow automatic identification of cues and retrieval of intentions, especially when they are so closely knit as in a paired-associate paradigm, but also automatically initiate a reminding process that allows participants to rehearse all other cues when *any* cue is encountered. We emphasize that while recursive reminding is initiated automatically, it does not preclude active rehearsal of cue to intention associations and thus can even benefit active monitoring through these rehearsals. In a sense, then, to explain the resistance of event-based ProM to PI we suggest a hybrid of both reflexive retrieval and monitoring processes, something that might be useful to both the multiprocess and the PAM, or Test-Wait-Test-Exit models.

In testing the limits of the resistance of ProM to PI, we combined the ProM and RetroM tasks in the same procedure in Experiment 6, and observed a PI build-up and release in ProM comparable to that observed in RetroM. Given that the method was identical to that in Experiment 4, except for the inclusion of the RetroM component, it appears that the build-up of PI in RetroM somehow induced the PI build-up in ProM. As a requirement of the RetroM task, participants were responsible for all the words on each list, and as the number of lists increased, so did the memory load for that category of items (e.g., animals). Since the tasks were combined and participants needed to remember all the words in addition to the ProM cues, the load on the ProM cues was also increased.

Thus, the recognition of ProM cues could have been compromised by these shared stimuli along with cumulative decrements in attentional and working memory resources. Given that even reflexive retrieval in ProM is not entirely cost free (McDaniel & Scullin, 2010), being responsible for all words for the RetroM task could have reduced the ability to identify the ProM cues. In addition, recursive remindings might have been dampened because there were simply too few resources left to effectively engage in the remindings.

As support for how “shared” stimuli could influence the PI build-up, one can also examine the effects of cue overload in ProM demonstrated by Cook, Marsh, Hicks, and Martin (2006). In their study, Cook et al. had participants study a list of paired associates for a subsequent recall test. Unbeknownst to the participants, what would later become ProM cues appeared with associates in the study phase. Cook et al. manipulated the number of words paired with each ProM cue (they did not manipulate the number of intentions associated with each cue), such that ProM cues were either paired with no word, (did not appear in the study phase), one word, or four different words. After the paired- associate study phase, ProM instructions, and then and a distractor task, participants performed a lexical decision task where the ProM task was to press a special button when an animal word appeared. Cook et al. found that cues with greater fan (e.g. appeared with 4 different words) were more likely to be missed than words that were only presented with one word or no word. They concluded that when cues are associated with more items, a cue overload effect can occur which makes the cue less effective in triggering an intention.

Likewise, in Experiment 6, as the cue overload builds-up across lists in RetroM, the discriminability of ProM cues also becomes increasingly difficult. Participants need to constantly monitor for new words to learn for recall and meanwhile, the sheer number of category membership increases. Across lists, then, each cue becomes less and less memorable in the ProM task (evidenced in the increasing percentage of missed cues) as the number of words subsumed by the category increases.

As cue overload builds in RetroM, more and more attentional and working memory resources need to be recruited in order to remember each new list of words. Even if noticing cues and retrieving ProM intentions are reflexive, they are not free from the costs due to concurrent task load (McDaniel & Scullin, 2010). Therefore, as more attention and working memory are increasingly allotted to committing more and more word lists to memory, (RetroM task), less resources are available to perform the ProM task. Compared to performance on the first few lists, later lists show that cues are missed entirely as a result of increased attentional load, and, if noticed, are more vulnerable to retrieval of incorrect intentions, as a result of increased working memory load, in the form of incorrect button presses.

In conclusion, we found no evidence of build-up of PI when an event-based ProM task was the only activity embedded in the on-going task. In the absence of other concurrent attentional and memory loads, ProM was resistant to PI build-up regardless of the similarity to the on-going task and cue competition. We suggest that it is primarily the recursive remindings that enable ProM to stay resistant to build-up. PI in ProM was observed only when the ProM task and RetroM task were combined, thereby sharing both stimuli and attentional and working memory resources. We suggest that the cue overload in RetroM drove the PI build-up in ProM by the cumulative usurping of attention and working memory.

APPENDIX A

CUE WORDS FROM EXPERIMENTS 1A, 1B, AND 3

Animal Cues	Household Item Cues
badger	chair
camel	clock
cougar	funnel
coyote	grater
horse	grill
jaguar	kettle
lizard	knife
monkey	mixer
otter	saucer
rabbit	sponge
skunk	spoon
zebra	towel

APPENDIX B

CUE WORDS FROM EXPERIMENT 2

Animal Cues	Profession Cues
badger	carpet
camel	clock
cougar	cradle
donkey	grater
eagle	grill
gopher	hutch
hamster	kettle
horse	lounge
jaguar	mixer
kitten	pillow
monkey	plate
otter	saucer
parrot	sponge
pigeon	spoon
rabbit	stereo
skunk	table
weasel	towel
whale	vanity

APPENDIX C

CUE WORDS FROM EXPERIMENTS 4, 5, AND 6

Animal Cues	Profession Cues	Household Item Cues
badger	actor	beater
beaver	agent	bench
beetle	artist	buffet
camel	baker	carpet
cougar	banker	chair
coyote	barber	clock
donkey	boxer	cradle
eagle	buyer	funnel
horse	cadet	glass
iguana	chief	grater
jaguar	clerk	grill
kitten	doctor	kettle
lizard	driver	knife
monkey	editor	ladle
mouse	farmer	mixer
otter	grocer	opener
parrot	jockey	pillow
pigeon	lawyer	radio
rabbit	mayor	range
raven	medic	saucer
shark	miner	sheet
skunk	nurse	shelf
tiger	priest	sifter
trout	queen	slicer
turkey	rabbi	spoon
turtle	sailor	stereo
walrus	tailor	stool
weasel	teller	stove
whale	tutor	towel
zebra	writer	trunk

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