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Control of Access to Memory: The use of Task Interference as a Behavioral Probe

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Abstract

Directed forgetting and prospective memory methods were combined to examine differences in the control of memory access. Between studying two lists of target words, participants were either instructed to forget the first list, or to continue remembering the first list. After study participants performed a lexical decision task with an additional requirement to respond with a designated key to targets from one or both of the lists. List discrimination performance supported the assumption that contextual representations associated with the two lists are more differentiated following forget instructions. Test instructions which directed participants towards both lists or to particular list(s) were more or less compatible with these contextual representations. Lexical decisions on non-target trials were slower when test instructions were compatible with study contexts compared to when incompatible, indicating that contexts reinstated by test instructions influenced the complexity of memory access. This finding is most compatible with theories of memory which locate an important component of control at the pre-decision stage.

Keywords; memory access, task interference, context reinstatement, recognition memory, prospective memory, directed forgetting

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A vast amount of information is stored in an adult human memory, including semantic information, information about one's life history, and specific episodic memories relating to recent and possibly not so recent events. If this information is to be useful there must be some control processes which determine which information is used. Jacoby, Shimizu, Daniels, and Rhodes (2005) have proposed that memory can be controlled in two ways. Memory output can be examined to determine if it is appropriate using post output decision processes, such as confidence judgments (Koriat & Goldsmith, 1996) and source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). Conversely, pre-access control processes can be allocated that place constraints on what information is likely to be retrieved from memory.

Recent work has started to establish the importance of pre-access control processes (e.g., Banks, 2000; Humphreys, et al., 2003; Marsh & Hicks, 1998; Jacoby, Shimizu, Daniels et al., 2005; Jacoby, Shimizu, Velanova, & Rhodes, 2005). Dennis and Humphreys (2001) proposed that memory decisions in a variety of memory tasks, including recognition, are based on a match between a reinstated context, and a context that is retrieved using the probe item as a cue. The reinstated context, at least in part, depends on the nature of the test instructions – what individuals are asked to do. Humphreys et al. tested this idea by asking participants to study a list containing visually and auditorally presented words. Participants then received a remember-know test (Test 1) followed by a source monitoring test (Test 2) presented in an exclusion format. If participants responded remember on Test 1 they were more likely to respond yes on Test 2 than if they had responded know on Test 1, regardless of whether instructions were congruent (e.g., a remember response was made to an auditorially presented word on Test 1 and the Test 2 question requested auditory information) or incongruent with test item study status.

According to a prominent post-access theory (the generic ideas about recollection embedded in the process dissociation procedure; Jacoby, 1991) a remember response on Test 1, as compared to a know response, should have been an indicator of those items for which recollection was more likely on Test 2. The result should then be a higher probability of a yes response to a congruent question and a lower probability to an incongruent question than the same probabilities following a know response. Instead, it appeared that participants were reinstating only the context specified in the test instructions, and based their decision on the degree to which the retrieved context matched the reinstated context (Dennis & Humphreys, 2001; Humphreys et al., 2003; Weeks, Humphreys, & Hockley, in press). Expectations at test regarding the kinds of information needed to be looked for in memory constrained the manner in which test items were processed.

In the current paper we provide evidence that converges with this view. In two experiments, we use methods from the directed forgetting (hereafter abbreviated as DF) and prospective memory (hereafter abbreviated as PM) literatures to measure the complexity of the preparations or processes required to access memory when contexts reinstated by test instructions varied in their congruency with contexts established at study. This paper depends on three assumptions: (a) That we can specify something about the contexts established during study; (b) That we can specify test trial instructions that are more or less compatible with these contexts, and (c) That we can measure any ensuing difficulty with memory access. We will first review the DF literature to demonstrate the plausibility of controlling the context associated with studied items. We then review the PM literature to show that we can plausibly measure the complexity of memory access. Finally we present an argument as to why the contexts reinstated by certain test instructions should be more or less compatible with different study contexts.

Establishing Study Context through DF Instructions

We use a version of the DF paradigm called the *list* method. A typical list method DF study presents participants with two lists of items to study. Between administrations of the two lists, participants are instructed to either forget the first list, or continue remembering the first list. After study, participants recall or recognize items from both lists. Participants given forget instructions typically recall fewer items from List 1 than those given remember instructions (the *costs* of DF). Conversely, participants given forget instructions typically recall more items from List 2 than those given remember instructions (the *benefits* of DF). However, list method DF effects are generally not found on recognition tests (e.g., Basden & Basden, 1996; Geiselman, Bjork, & Fishman, 1983). In contrast, the *item* method (when the instruction to remember or forget is given after each item presentation) typically yields DF effects on both recall and recognition tests (see MacLeod, 1998). Our concern was to use test instructions which were more or less compatible with the DF determined study contexts as a possible surrogate for contextual reinstatement effects in recognition. We chose the list method because it produces results more like contextual reinstatement effects found in recognition and recall than does the item method. That is, with a few exceptions such as incidental learning paradigms, very low levels of learning, and novel stimuli, contextual reinstatement effects are more likely to be observed in recall than in recognition (e.g., Godden & Baddeley, 1980; S. M. Smith, Glenberg, & Bjork, 1978; S. M. Smith & Vela, 2001).

Researchers have made a number of proposals regarding the representational changes that result from the processing of forget instructions using the list method. Bjork's (1970) original theory proposed that participants given a forget instruction segregate List 1 and List 1 items, and selectively rehearse List 2. Subsequently, Bjork (1989) proposed retrieval inhibition as an

alternative mechanism, claiming that the forget instruction initiates a process that inhibits access to List 1. Recently the retrieval inhibition account of list method DF has been challenged by a two-factor account which proposes different mechanisms for the costs and benefits of the forget instruction (Sahakyan & Delaney, 2003, 2005; Sahakyan & Kelley, 2002). Costs in recall are attributed to a mental context change. Upon processing the forget instruction, participants forget the preceding List 1 items by establishing a new mental context. The processing context at test mismatches the List 1 context and more closely matches the List 2 context, leading to costs to List 1. In addition, the processing of the forget instruction leads participants to adopting a deeper encoding strategy for List 2, leading to benefits to List 2.

A common denominator in many of these accounts is that processing of a list method forget instruction leads to the separation of the two lists. For selective rehearsal to take place the lists need to be segregated. Under the two-factor account, sampling of new contextual cues or changes in encoding strategy serves to segregate lists. Thus, participants given the forget instruction segregate List 1 from List 2, and participants given the remember instruction are likely to view the two lists as part of the same event. On this basis, we assumed that list method instructions could be used to control the contexts established at study that were associated with list items. Furthermore, as argued below, the PM literature provided us with a useful technique for measuring the complexity of the preparations or processes required to access or maintain these contextual representations.

Task Interference in PM

In a typical laboratory *event-based* PM task, participants are required to perform a specific action (e.g., press the F1 Key) upon presentation of a specific target event (e.g., the word “dog”) whilst performing an ongoing task (e.g., rating words) (Einstein & McDaniel, 1990). The critical

question is whether attention to the target interrupts ongoing activity and the individual becomes aware of its relevance. The defining feature of PM tasks is that, unlike retrospective memory tasks there are no external requests from the experimenter directing participants to engage in a memory search. As a result, PM tasks have a greater emphasis on the maintenance of the intention to remember, or the ability of the target to initiate the intent to remember. However, this difference is likely to be a matter of degree. Instructions are usually only given at the start of retrospective memory tasks and thus must still be maintained by the participant.

There is evidence that attention to targets can lead to their spontaneous detection under certain conditions (see Einstein et al., 2005). However, under other conditions, there is evidence that target detection requires some form of resource-demanding control process. For example, PM task demands embedded in ongoing tasks have been shown to slow performance on ongoing tasks, even on *non-target* trials that are some distance from the presentation of targets (Loft & Yeo, in press; Marsh, Hicks, Cook, Hansen & Pallos, 2003; R. E. Smith, 2003; R. E. Smith & Bayen, 2004). For example, Loft and Yeo found that participants who held an intention to detect studied targets took 200-250ms longer to make lexical decisions on non-target trials compared to participants only performing lexical decisions, indicating that some form of control process was being engaged. This slowing on non-target ongoing task trials is commonly referred to as *task interference* (Hicks, Marsh, & Cook, 2005).

There are several theories regarding the cognitive mechanisms that give rise to task interference. According to the Preparatory Attentional and Memory Processes (PAM) theory (R. E. Smith & Bayen, 2004, 2006), task interference arises from the engagement of a preparatory attention process that serves to maintain the intention to detect targets while performing ongoing tasks. Other researchers have proposed similar processes that serve preparatory functions such as

maintaining the memory system in retrieval mode (Guynn, 2003). In addition, at least part of the task interference effect may be driven by the stimulus. For example, McDaniel, Guynn, Einstein, and Breneiser (2004) contend that attention to ongoing task items invokes processes similar to those involved in everyday experiences of familiarity, which may then stimulate the allocation of attention to determine what that familiarity signifies.

These accounts all hail from the basic idea that having an intention to detect targets within the context of performing an ongoing task involves the engagement of control processes that draw on a limited resource capacity. As a consequence, individuals have fewer resources available to perform ongoing tasks, and response costs to ongoing tasks are incurred. We argue that task interference can provide a behavioral probe into the complexity of memory access. Next, we present our task paradigm. In doing so, we present an argument as to why contexts reinstated by various test instructions will be more or less compatible with different study contexts. We also state our hypotheses regarding the preparations or processes that will be required to access memory (and the subsequent task interference) under these conditions.

The Present Paradigm and Hypotheses

We combined features of list method DF and PM into a single paradigm. The ongoing task was a lexical decision task, which is commonly used in PM research (e.g., Loft & Yeo, in press; Hicks et al., 2005). In this task, strings of letters were presented and participants determined whether they were words or non-words. When participants were given lexical decision instructions, they were also given an additional requirement to respond with a designated key to target words that they would study (target detection task). Thus, for the target detection task component, some of the words presented in lexical decision task were targets, and some were non-targets, but all non-words presented in the lexical decision task were non-targets.

Between studying two lists of 10 target words, participants were either instructed to forget the first list, or to continue remembering the first list (memory instruction). After studying the second list, participants completed an arithmetic task as a filler activity. Next, participants were given the test instruction. In Experiment 1, participants were told to respond to both lists (with the F1 key) during the lexical decision task (respond-all), or to selectively respond to List 2 (respond-list2). In Experiment 2, all participants were told to respond to both lists. However, half the participants were required to discriminate list membership (respond-all-discriminate), while the other half was not (respond-all). After completing a second arithmetic task, participants completed the lexical decision task in which targets from both lists were presented.

Figure 1 presents the primary and secondary contextual representations that we argue are likely to be established as a result of processing the memory instructions. According to DF theory (e.g., Bjork, 1970; Sahakyan & Kelley, 2002), participants given the remember instruction are likely to view the two lists as part of the same event and thus are unlikely to attempt to create different contexts for the two lists at study. In contrast, participants given the forget instruction are more likely to view the two lists as being definitely distinct and thus should be more likely to deliberately create different contexts for the two lists at study. Therefore, as illustrated in Figure 1, the primary contexts associated with the two lists are likely to be more distinct with forget than with remember instructions.

Participants given remember instructions and required to respond only to List 2 targets or to discriminate between List 1 and List 2 targets may reinstate separate contexts for the two lists by segregating their primary contextual representation of the experiment wide list. To do so may require them to think back to what they were doing or thinking that was different during study of List 1 as compared to List 2. In contrast, a test instruction that requires targets from both lists to

be recognized is more compatible with their primary contextual representation of the experiment wide list. It is possible that secondary representations may be more difficult to reinstate, or once reinstated more difficult to maintain, than primary representations. If so, then the effects of context compatibility should show up as task interference to non-target items on the lexical decision task. Therefore, task interference should be greater when the remember condition is required to respond selectively to List 2 (Experiment 1) or to discriminate list membership (Experiment 2), as compared to when required to respond to both lists (Experiments 1 & 2).

Participants given forget instructions and required to recognize targets from both lists may reinstate an experiment wide list context by combining their separate primary representations of List 1 and List 2. In contrast, a test instruction that requires these participants to selectively respond to List 2 targets, or to discriminate between List 1 and List 2 targets, is more compatible with their relatively distinct primary contexts of the two lists. Therefore, task interference should be greater when the forget condition is required to respond to both lists (Experiments 1 & 2), as compared to when required to respond selectively to List 2 (Experiment 1) or to discriminate list membership (Experiment 2). This is opposite to what we predicted for participants given the remember instruction. Thus, we predicted an interaction between memory instruction and test instruction in Experiments 1 and 2, in that task interference to non-target items should be greater when test instructions are incongruent with the contextual representations established at study and associated with targets, compared to when congruent.

We have argued that participants may have more difficulty reinstating and/or maintaining the requisite context(s) when a secondary contextual representation has to be used as compared to a primary contextual representation. However, it does not follow that recognition accuracy will necessarily be lower when secondary as compared to primary contextual representations are

used. Although secondary representations may be less complete or noisier than primary presentations, the general failure to find list based DF costs in recognition (e.g., Geiselman et al., 1983) and the almost universal failure to find contextual reinstatement effects in recognition (e.g., S. M. Smith & Vela, 2001) indicates that recognition may be insensitive to the amount of degradation that occurs. For example, combining two contextual representations together to form a single experiment wide contextual representation may be more complex but it might lead to the same level of accuracy in deciding about whether or not a word occurred in either list.

Experiment 1

In designing Experiment 1 we used some procedures which were standard in the PM literature, and other procedures which were standard in the DF literature, and others which were a compromise between procedures in the two literatures. For example, we use five study trials which is standard for the PM literature but not for the DF literature. Here our intuition was that weaker items may not show effects against the background of the ongoing task. In addition, the list length is short for the DF literature but quite long for the PM literature. Here our intention was to stay fairly close to the PM literature while getting enough observations to test some of the issues which have been addressed in the DF literature. The overall intention was to create a workable paradigm which could address memory access issues, with the ability to address issues traditionally examined in either the PM or the DF literatures being a secondary consideration.

Method

Participants. A total of 112 students enrolled in undergraduate psychology classes at the University of Queensland volunteered to participate in return for course credit. Two participants were excluded from the forget conditions because they did not make a single F1 key response.

Design. The design was a 2 (memory instruction: remember vs. forget) X 2 (test instruction: respond–all vs. respond-list2) between-subjects design. There were 28 participants in each of the remember conditions, and 27 in each of the forget conditions.

Materials. The presentation of stimuli and the collection of responses were accomplished through a program written with E-Prime (Schneider, Eschman, & Zuccolotto, 2002). Two hundred medium frequency words (4-6 letter length) were randomly chosen from the 1994 issues of the Sydney Morning Herald (Dennis, 1995). For each participant, 10 words were randomly chosen to serve as List 1 targets, and 10 words randomly chosen to serve as List 2 targets. Two hundred non-words (4-6 letter length) were randomly chosen from English Lexicon Project Database (Balota et al., 2002). Four hundred letter strings (200 words, 200 non words) were presented on the lexical decision task. The order of presentation was random except for the presentation of targets. There were 10 blocks of 40 trials. Two targets were randomly chosen from List 1 or List 2 to be presented in each block. The 10 targets from List 1 and the 10 targets from List 2 were presented once each over the course of the lexical decision task.

Procedure. Table 1 outlines the procedure that was followed by participants in Experiments 1 and 2. Participants were informed that letter strings would be displayed on a computer screen and they were required to decide as quickly and as accurately as possible whether or not each string was a word. Responses were made by pressing one of the two home keys (D = word, K = non-word). Each trial contained three displays. The first display instructed participants to press the space bar to initiate the next trial. The next display was a focus point, “+”, displayed in black on the centre of the screen on a white background. The duration of each focus point was randomly selected from a set of possible display times (437, 500, 562, 625, 687, 750, 822, or 886 ms) to ensure participants could not anticipate the appearance of strings. The focus point was

replaced by a string which remained on the screen until the participant made an appropriate response.

Next, participants were given the target detection instructions. These instructions were identical to those used previously in the PM literature to study task interference (e.g., Loft & Yeo, in press; Marsh et al., 2003). The experimenter told participants that she was interested in their ability to remember to perform actions in the future, and that they would soon study target words. The instructions specified that when a target word was detected in the lexical decision task, the word response to the lexical decision task should be made first, *and that the 'F1' key should be pressed during the subsequent waiting message between trials*. Participants were instructed that if they mistakenly pressed the space bar instead of the F1 key after detecting a target, they could press the F1 key on the next trial (instead of making a lexical decision).

Participants then studied List 1. Each of the 10 targets from List 1 were presented a total of five times, for 2-sec each presentation. Specifically, targets were randomly selected for presentation once each in five blocks of back to back study trials. After presentation of these five blocks, participants were verbally presented the memory instructions. The forget instruction specified that List 1 was “only for practice” to familiarize participants with the task and that there was no need to remember those words for the target detection task component. The remember instruction specified that List 1 included only the first half of the words from the study list and that those words needed to be remembered for the target detection task component. Next, all participants studied List 2, which were presented in the exact same manner as List 1.

Following the presentation of List 2, participants completed a two-minute arithmetic task. Next, participants were verbally presented with the test instructions. The respond-all test instruction specified that the F1 key was required to be pressed in response to both List 1 and

List 2 targets. The respond-list2 test instruction specified that the F1 key was required to be pressed only in response to List 2 targets, but not in response to List 1 targets. Participants were instructed to follow this test instruction, regardless of whether it was congruent or incongruent with the memory instruction they were previously administered. Participants then completed a second two-minute arithmetic task. The experimenter then initiated the lexical decision task, without reference to the target detection task component.

Results and Discussion

Task Interference

There was no evidence of task interference when the accuracy of lexical decisions was examined, and accuracy was at ceiling (95%). Therefore, consistent with previous PM research (e.g., Loft & Yeo, in press; Marsh et al., 2003, R. E. Smith, 2003) the average response time to the lexical decision task (non-target trials) was the dependent measure. Also consistent with previous PM research, several trials were excluded. First, we excluded trials that contained List 1 or List 2 targets, and non-target trials where the F1 key was pressed (6.75% excluded). These trials were excluded in order to avoid response costs associated with target recognition - verification processes that are evoked on target trials, retrieval of responses (i.e., press F1), and co-ordination of target detection responses with ongoing task responses (see Einstein et al., 2005; Loft & Yeo, in press; Marsh et al., 2003). Second, we excluded the two trials that followed these aforementioned trials (13.5%). These trials were excluded in order to avoid response costs associated with post-output target detection monitoring processes (see Einstein et al., 2005). Third, we excluded responses greater than 3SD from a participant's grand mean, and trials that contained a lexical decision error (6.5%). On the basis of effect sizes in the PM literature, power calculations were based on the detection of medium size effects (Cohen, 1988).

Figure 2 presents the task interference data. We proposed that contexts reinstated by test instructions would vary in their compatibility with the contexts established at study, and that task interference would provide a behavioral probe into the complexity of accessing the targets associated with these study contexts. The task interference data supported this proposal. A 2 (memory instruction) X 2 (test instruction) ANOVA revealed a significant interaction between memory instruction and test instruction, $F(1,106) = 4.32$, $MSE = 64500.32$, $p < .05$. Neither main effect were significant, $F_s < 1$. As predicted, task interference was greater when test instructions were incongruent with study contexts, compared to when congruent. This interaction remained significant when yes responses to words were analyzed separately, $F(1,106) = 4.1$, $MSE = 101338.62$, $p < .05$. The interaction effect for no responses to non-words approached significance, $F(1,106) = 3.02$, $MSE = 34077.95$, $p = .08$ (power = .45)

Follow up simple effect tests (words/non-words combined) for the forget condition indicated that task interference was significantly greater when responding to both lists ($M = 767.38$, $SD = 137.73$), compared to when responding selectively to List 2 ($M = 701.87$, $SD = 122.78$), $t(52) = 1.85$, $p < .05$. However, for the remember condition, the predicted increase in task interference when responding selectively to List 2 ($M = 745.89$, $SD = 128.77$), compared to when responding to both lists ($M = 714.51$, $SD = 96.45$), did not reach significance, $t(54) = 1.03$, $p = .15$ (power = .58). While the manipulation of test context does not appear to be as sensitive for tapping into the memory structures established by the remember instruction as it was for tapping into the memory structures established by the forget instruction, this may alternatively be due to a lack of power.

Target Detection

Targets were scored as correctly detected if participants remembered to press the F1 key on the target trial (92.1% of correct responses), or for late responses where the F1 key was pressed on the trial that followed (7.9% of correct responses). Exclusion of late responses did not significantly influence the results reported, so we scored them as correct. In this and the subsequent experiment the parameter d' was used as the measure of sensitivity (Green & Swets, 1966). In cases where d' was calculated we used the loglinear method to adjust for extreme Hit (=1) and FA (=0) values (Stanislaw & Todorov, 1999). The loglinear method involves adding 0.5 to the number of hits and false alarms, and adding 1 to the number of signal (target) and noise trials (non-target). Uncorrected Hits and false alarms, as a function of memory and test instructions, are presented in Table 2.

Benefits of DF (List 2). A 2 (memory instruction) X 2 (test instruction) ANOVA on hits for List 2 revealed a main effect of memory instruction, $F(1,106) = 5.51$, $MSE = .276$, $p < .05$, and test instruction, $F(1,106) = 4.84$, $MSE = .242$, $p < .05$. The interaction was not significant, $F(1,106) = 2.34$, $MSE = .117$, $p = .13$. Analysis of false alarms revealed a main effect of memory instruction, $F(1,106) = 15.68$, $MSE = .035$, $p < .01$. Participants in the forget condition recognized more List 2 targets and made fewer false alarms than those in the remember condition (mirror effect). Greater learning of List 2 by participants in the forget condition was confirmed by a main effect of memory instruction on d' , $F(1,106) = 23.67$, $MSE = 13.99$, $p < .01$, indicating that participants in the forget condition ($M = 2.65$, $SD = .86$) discriminated List 2 targets from non-targets better than those in the remember condition ($M = 1.94$, $SD = .65$). This finding converges with recent studies that have found benefits of the forget instruction on recognition performance with longer lists (Benjamin, 2006; Sahakyan & Delaney, 2005).

Inspection of hit rates in Table 2 indicates that List 2 targets were not detected as often as List 1 targets by participants in the remember condition when responding to both lists. In contrast, detection of List 2 and List 1 targets were almost identical for those in the forget condition when responding to both lists. This pattern of data suggest that, in addition to the possible use of more elaborate encoding strategies following forget instructions (Sahakyan & Delaney, 2003), participants in the remember condition may have been rehearsing List 1 targets while List 2 was being presented (Benjamin, 2006; Bjork, 1970), or were not paying as much attention to List 2 as they had to List 1 (Underwood, 1978). Regardless of the explanation it is apparent that participants in the remember condition did not learn List 2 targets as well as List 1 targets, whereas List 1 and List 2 targets were equally learned by those in the forget condition.

Costs of DF (List 1). In order to facilitate the interpretation of the List 1 data separate analyses were conducted for the two test conditions. It is clear from Table 2 that participants in the forget condition made fewer false alarms than those in the remember condition, under both respond-all, $F(1, 53) = 4.66$, $MSE = .002$, $p < .05$, and respond-list 2 test conditions, $F(1, 53) = 12.31$, $MSE = .002$, $p < .01$. However, when participants were responding to both lists at test, there was no difference in hits to List 1 or d' ($F_s < 1$) between forget and remember conditions. This is consistent with DF research (e.g., Sahakyan & Delaney, 2005), and the common failure to find contextual reinstatement effects in recognition (e.g., S. M. Smith & Vela, 2001).

When participants were instructed to only respond to List 2, although there was no significant difference in hits, $F(1, 53) = 1.21$, $MSE = .04$, $p > .05$, analysis of d' indicated that participants in the forget condition ($M = 1.97$, $SD = .60$) discriminated List 1 targets from non-targets better than those in the remember condition ($M = 1.17$, $SD = .68$), $F(1, 53) = 21.45$, $MSE = .41$, $p < .01$. However, participants following the test instructions should have been saying no to

List 1 targets so this represents poorer performance. Further, the difference between the means for the List 2 and List 1 distributions (measured in d' units) for the forget condition ($M = .66$, $SD = .92$) was not significantly different from that of the remember condition ($M = .75$, $SD = .64$), $F < 1$. This trend is actually suggestive of slightly poorer list discrimination performance following forget instructions not the better performance that an enhanced contextual discriminability of List 1 from List 2 targets would seem to predict.

However, according to the reasoning behind the process dissociation procedure, neither of these measures is a pure measure of list discrimination (Humphreys, Dennis, Chalmers, & Finnigan, 2000, Jacoby, 1991). We required one group of participants to say yes to List 2 targets (exclusion condition) and a second group to say yes to both List 1 and List 2 targets (inclusion condition). When we subtract the exclusion probability from the inclusion probability the result is .16 for the forget condition and .03 for the remember condition. According to Jacoby (1991) this is an estimate of recollection which is the memory component which produces list discrimination. More generally, as Humphreys et al. showed, it is the probability of successful list discrimination conditional on successful recognition. Thus it does look like list discrimination performance is better following forget than remember instructions. This finding is consistent with our assumption that participants create more highly differentiated List 1 and List 2 contexts following forget instructions. However, because participants in the forget condition better learnt List 2 targets, we cannot rule out the possibility that this better list discrimination performance is due to the superior learning, and not to a more discriminating List 2 context.

Experiment 2

A second experiment was conducted to replicate the task interference effects found in Experiment 1 using an alternative manipulation of test context. In Experiment 2, the test

instructions informed all participants to respond to both lists during the lexical decision task. Half of the participants were also told that they would be required to discriminate list membership (respond-all-discriminate; Whetstone, Cross, & Whetstone, 1996), while the other half were not given this additional requirement (respond-all). The reason for choosing this specific manipulation is that the respond-all-discriminate condition gives us a direct measure of list discrimination. That is, it measures the probability of successful list discrimination conditional on successful recognition. Note that the use of a condition where participants responded to only List 1 targets was not used as it may be more complex to do this than responding to only List 2 targets (see Dennis and Humphreys, 2001) and because neither of the exclusion tasks provides a direct measure of list discrimination.

Participants given remember instructions and required to discriminate between List 1 and List 2 targets may be required to reinstate separate contexts for the two lists by segregating their primary contextual representation of the entire experimental list. In contrast, participants given the forget instruction will already have two relatively distinct contexts associated with the two lists. Identical to Experiment 1, we predicted an interaction between memory instruction and test instruction, in that task interference should be greater when test instructions are incongruent with the contextual representations established at study and associated with targets, compared to when they are congruent. We also hoped to get converging evidence on the process dissociation analysis in Experiment 1 by showing that list discrimination accuracy was greater following forget than following remember instructions.

Method

Participants. A total of 116 students from the same population as Experiment 1 participated in return for course credit. No participants in Experiment 2 had previously participated in

Experiment 1. Two participants were excluded (forget/respond-all, & remember/respond-all-discriminate) because they did not make a single F1 key response.

Design. The design was a 2 (memory: remember vs. forget) X 2 (test: respond-all vs. respond-all-discriminate) between-subjects design. For participants given respond-all test instructions, there were 29 participants in the remember condition and 28 participants in the forget condition. For participants given respond-all-discriminate test instructions, there were 28 participants in the remember condition and 29 participants in the forget condition.

Materials and Procedure. The materials and procedure were identical to Experiment 1, with two exceptions. There were a relatively large number of late responses in Experiment 1. In order to improve both the reliability of our recognition accuracy data and the generality of our findings, instructions in Experiment 2 did not specify that if participants mistakenly pressed the space bar instead of the F1 key after detecting a target, then they could press the F1 key on the next trial. Instead, they were told to press F1 on actual target trials in order to be scored correct. Second, test instructions were modified. Identical to Experiment 1, the respond-all test instruction specified that the F1 key was to be pressed in response to both List 1 and List 2. The respond-all-discriminate test instruction also specified that the F1 key was required to be pressed in response to both List 1 and List 2. However, the respond-all-discriminate test instruction also stated that if the F1 key was pressed, a response box would be presented asking from which study list the target originated.

Results and Discussion

Task Interference

Consistent with Experiment 1, there was no evidence of task interference when the accuracy of lexical decisions was examined and accuracy was at ceiling (95%). Using the same criteria as

Experiment 1, we excluded trials that contained List 1 or List 2 targets, and non-target trials where the F1 key was pressed (6.32% excluded). Second, we excluded the two trials that followed these aforementioned trials (12.64%). Third, we excluded responses greater than 3SD from a participant's grand mean, and trials that contained a lexical decision error (6.4%).

Figure 3 presents the task interference data. A 2 (memory instruction) X 2 (test instruction) ANOVA revealed a significant interaction between memory instruction and test instruction, $F(1,110) = 4.1$, $MSE = 61691.89$, $p < .05$. Neither main effect was significant, $F_s < 1$. Replicating Experiment 1, task interference was greater when test instructions were incongruent with study contexts, compared to when congruent. This interaction remained significant when yes responses to words were analyzed separately, $F(1,110) = 4.1$, $MSE = 77520.98$, $p < .05$. Although the trends in means were in a consistent direction, the interaction for no responses to non-words did not reach significance, $F(1,110) = 2.51$, $MSE = 39035.56$, $p = .12$ (power = .46).

Follow up simple effect tests (words/non-words combined) for the remember condition indicated that task interference was significantly greater when required to respond to both lists and discriminate list membership ($M = 756.84$, $SD = 172.86$), compared to when only responding to both lists ($M = 688.77$, $SD = 73.13$), $t(55) = 1.95$, $p < .05$. However, for the forget condition, the predicted increase in task interference when responding to both lists ($M = 735.28$, $SD = 127.67$), compared to when responding to both lists and discriminating list membership ($M = 710.27$, $SD = 96.07$), did not reach significance, $t(55) = .84$, $p = .20$ (power = .59). Thus the manipulation of test context in Experiment 2 does not appear to be as sensitive for tapping into the memory structures established by the forget instruction as it was for tapping into the memory structures established by the remember instruction. This is the opposite pattern to that obtained in Experiment 1. However, at this stage we cannot tell whether this is a real difference produced by

the ways we manipulated test context or simply represents a lack of power in the individual experiments.

Combined Experiment Analysis. To increase power, analyses were conducted on the combined data for Experiments 1 and 2, with a total of 224 subjects. An ANOVA for non-word trials revealed a significant interaction between memory instruction and test instruction, $F(1,220) = 5.51$, $MSE = 72967.01$, $p < .05$. Thus, even on non-word trials, task interference was greater when test instructions were incongruent with study contexts, compared to when congruent. Simple effects tests were also conducted (words/non-words). For the remember condition, the test instruction to respond to both lists (Experiments 1 & 2) was congruent with study context, whereas the test instruction to respond selectively to List 2 (Experiment 1) or to discriminate list membership (Experiment 2) was incongruent. For the forget condition the reverse was true. Simple effect tests confirmed that task interference was significantly greater for the remember condition when test instructions were incongruent with study ($M = 751.36$, $SD = 151.13$), compared to when congruent ($M = 701.42$, $SD = 85.60$), $t(111) = 2.17$, $p < .05$. The same simple effect test for the forget condition reached significance (incongruent, $M = 751.04$, $SD = 132.46$; congruent, $M = 706.22$, $SD = 108.83$), $t(109) = 1.95$, $p < .05$.

Target Detection

Targets were scored as correctly detected if participants remembered to press the F1 key on the target trial (99.3%), or on the trial that immediately followed (0.7%). It is clear that the change in instruction was effective in decreasing late responding (in Experiment 1 7.9% of correct responses were made late). Uncorrected Hits and false alarms, as a function of memory and test instructions, are presented in Table 3.

Benefits of DF (List 2). A 2 (memory instruction) X 2 (test instruction) ANOVA conducted on hits for List 2 revealed no main effect for memory instruction, $F(1,110) = 1.68$, $MSE = .11$, $p > .05$. However, inspection of hit rates in Table 3 indicates that, consistent with Experiment 1, List 2 targets were not detected as often as List 1 targets by participants in the remember condition under either test condition. In contrast, detection of List 2 and List 1 targets were almost identical for participants in the forget condition under both test conditions. Consistent with Experiment 1, analysis of false alarms revealed a main effect for memory instruction, $F(1,110) = 6.62$, $MSE = .01$, $p < .05$, with participants in the forget condition making fewer false alarms than those in the remember condition. A main effect was also found for test instruction, $F(1,110) = 5.87$, $MSE = .007$, $p < .05$, indicating that participants required to discriminate list membership made fewer false alarms than those not required to discriminate list membership. Although the mirror effect found in Experiment 1 was not as strong in Experiment 2, greater learning of List 2 by participants in the forget condition was confirmed by a main effect of memory instruction on d' , $F(1,110) = 4.28$, $MSE = 3.28$, $p < .05$, with participants in the forget condition ($M = 2.67$, $SD = .74$) discriminating List 2 targets from non-targets better than those in the remember condition ($M = 2.32$, $SD = 1$).

Costs of DF (List 1). Analysis of hits revealed no effects, $F_s < 1$. Analysis of d' for List 1 revealed that there was no main effect for memory instruction, $F < 1$, no main effect for test instruction, $F(1,110) = 3.3$, $MSE = 2.4$, $p = .07$, and no interaction, $F < 1$. This is consistent with the respond-all test condition in Experiment 1, DF research (e.g., Sahakyan & Delaney, 2005), and the lack of context reinstatement effects in recognition (e.g., S. M. Smith & Vela, 2001)

List Discrimination. List discrimination was scored as correct if participants correctly identified the source (List 1, List 2) of a detected target. Participants in the forget condition ($M =$

.79, $SD = .23$) discriminated list membership more accurately than those in the remember condition ($M = .60$, $SD = .23$), $t(55) = 3.12$, $p < .01$, conditional on successful recognition.

Experiment 2 provides converging evidence on the process dissociation analysis in Experiment 1 by showing that list discrimination accuracy was greater following forget than remember instructions. However, this finding is still complicated by the superior learning of List 2 following the instruction to forget, which makes it difficult to determine whether the enhanced ability to discriminate between lists is due to the creation of more highly distinct contexts or the greater learning of List 2.

General Discussion

We have used the Dennis and Humphreys (2001) theory to motivate the experiments in this paper. This was done because the Dennis and Humphreys theory along with other writings by Humphreys and colleagues (Bain & Humphreys, 1988; Humphreys, Bain, & Pike, 1989; Humphreys, Tehan, O'Shea, & Boland, 2000; Humphreys et al., 2003; Tehan, Humphreys, Nolan, & Pitcher, 2004; Weeks et al., in press) directly addresses the role of context in human memory, including the role played by instructions in reinstating experimental context. This body of work has produced specific support for the assumption that the use of context with explicit but not implicit retrieval instructions is a major factor in the processes differentiating the effects of these instructions (Humphreys et al., 2000; Tehan et al.). It has also supported the idea of pre-access control processes (Humphreys et al., 2003; Weeks et al.). Most importantly it has provided guidance in the design of the current set of experiments. However, there is no contention that the results uniquely support the Dennis and Humphreys theory. In addition there is no contention that a specific role for instructions cannot be identified in other theoretical approaches such as source monitoring (Johnson et al., 1993), dual processing theory (Jacoby, 1991), and transfer

appropriate processing (Roediger, Weldon, & Challis, 1989). Nevertheless the role of instructions has been better developed in the work of Humphreys and his colleagues than it has in these other approaches, and thus provided more guidance to the design of experiments.

Although most if not all memory researchers would support a role for context and for the test instructions in reinstating the experimental context, quality demonstrations of this have been lacking. The problem is due to the insensitivity of the recognition paradigms to contextual reinstatement effects (e.g., Godden & Baddeley, 1980; S. M. Smith et al., 1978; S. M. Smith & Vela, 2001). That is, it has not been possible to consistently demonstrate that recognition accuracy is higher when the recognition context matches the study context than when it mismatches, other than in incidental learning conditions, when initial learning of stimuli are poor, or when novel stimuli are used (see S. M. Smith & Vela, 2001). These equivocal effects of context change on recognition accuracy are potentially problematic for theories of memory where context plays a critical role (e.g., Dennis & Humphreys, 2001; Hintzman, 1988; Humphreys et al., 1989; Gillund & Shiffrin, 1984; Raaijmakers & Shiffrin, 1981).

Across two experiments we have been able to demonstrate this long sought after interaction between study and test contexts. However, the interaction was not in recognition accuracy but in the interference with a concurrent ongoing task. As argued earlier, it is probable that primary representations were easier to reinstate or maintain in an active format than secondary representations, leading to differences in task interference. However, it is also probable that secondary representations could be reinstated or maintained, and sufficiently accessed, given the allocation of a certain amount of resources, thus producing no decrement in recognition accuracy. For example, while the secondary representation of the combined lists may have been slightly degraded following forget instructions, the lack of costs of DF indicate that recognition

memory was not sensitive to this level of degradation. Task interference could be used in future research to investigate the kinds of contextual reinstatement effects (e.g., physical environment, background context, state dependence) on recognition performance which have long eluded memory researchers. This alternative approach to examining context reinstatement in recognition may prove more sensitive than traditional measures of recognition accuracy.

This notwithstanding, the concept of ‘context’ is often imprecise and difficult to define, and has been used to refer to varying phenomena across different research settings. Thus, it is important to be clear regarding what context might represent in the current study. Dual-processing approaches emphasize the way in which a participant has been instructed to process words within a list as a source of context and list discriminating information (Johnson et al., 1993). In this manner, context may be linked to participants’ representation of the task that they perform, possibly represented as a cue or tag attached to a word or word lists in memory (Anderson & Bower, 1973). In the current study, contexts may include any or all of the following: a) summaries of memory and test instructions, b) task descriptions established by participants in response to these instructions, c) temporal codes, or d) explicit symbolic tags (Bain & Humphreys, 1988; Dennis & Humphreys, 2001).

List discrimination following forget instructions, compared to following remember instructions, was better in Experiment 2 which used a direct measure and in Experiment 1 which used an indirect measure. This finding supports our assumption that contextual representations were more sharply differentiated following forget instructions than following remember instructions. Unfortunately it may also result from the superior learning of List 2 targets following forget instructions, though this is less likely in Experiment 2 where there was less of a List 2 learning difference than in Experiment 1. Note that in some models such as REM (Shiffrin

& Steyvers, 1997) features are learned probabilistically. As more features are learned there is an increase in discriminability. This is the reason we are hesitant to claim that we have evidence that the contexts established by the forget instructions are more discriminable as long as there is evidence for greater List 2 learning following these instructions. The benefits of DF (greater List 2 learning following forget instructions) for recognition that we demonstrated here have generally not been found in the DF literature, although some research has found that benefits emerge with longer study lists (30+) (Benjamin, 2006; Sahakyan & Delaney, 2005). We used comparatively short lists of 10 words per list, but this was coupled with multiple (five) study trials. Thus, our study duration, and subsequent opportunity for the effects of encoding strategy (Sahakyan & Delaney, 2003), selective rehearsal (Benjamin, 2006; Bjork, 1970) or task fatigue/boredom (Underwood, 1978) to occur, was comparable to those studies that used longer lists. Most importantly, the benefits of DF clearly do not represent context reinstatement effects as they were found irrespective of test condition.

Our results also allow us to reject an extreme form of post-access decision making which would be compatible with at least some ideas about source monitoring (Johnson et al., 1993) or dual process theory (e.g., Jacoby, 1991; Mandler, 1980). Suppose that the decision about whether or not a test stimulus is a target only takes place after the memory access process is complete. That is, after recollection has occurred and after the familiarity of the test stimulus is known. The match or mismatch of the test instructions (press the F1 key for both List 1 and List 2 targets, or press the F1 key for List 2 targets only) may influence the speed of the decision if it is based on recollection. That is, if asked to say yes to List 2 targets only, the participant must decide what kind of thoughts or reactions constitute evidence for List 2. This decision may be easier after forget instructions than after remember instructions. For example, if a participants thoughts or

reactions change more after a forget instruction than after a remember instruction, the decision about whether to accept or reject a List 1 and List 2 target might be easier and faster after forget than after remember instructions.

However, a critical point and innovation of the current paper is that it made testable predictions regarding response times to *non-target* trials. That is, the task interference was not measured on List 1 and List 2 targets (for demonstrations of this in the DF literature see Cruse & Jones, 1976; Howard, 1976), but rather on non-targets, items which had not been previously presented. These items might vary in familiarity but they should support little or no recollective experience. A decision based on familiarity (is the observed familiarity greater than or less than the criterion) should not vary as a function of the match between study and test conditions. In the current study this would be especially true for non-targets that were non-words. These non-words can be readily distinguished from the targets and it is unlikely that participants would ever make a decision about which list they came from. While the interaction between study and test condition for the task interference non-words did not reach significance in either experiment, in the combined analysis this interaction was significant. Thus, the task interference is not compatible with theories of memory where context (source) is assumed to be recollected only at the late decision stage. We are not disputing the fact that post-access decision processes play a clear and large role in controlling memory output. However, the problem is that these post-access decision theories are silent to the operation of pre-access processes, and in our view, over-emphasize the importance of post-access processes.

Thus, we contend that task interference to non-targets is better explained by a theory that locates an important component of control at the pre-decision stage. According to Dennis and Humphreys (2001), the contexts reinstated by test instructions would have influenced

individual's expectations about what kinds of information they were looking for in memory (e.g., all words, List 2 only), thus changing how memory was inspected. This interpretation converges with Humphreys et al. (2003), who argued that individuals in their study accessed modality-specific information at test in accordance with the context reinstated by test instructions. Similarly, Jacoby, Shimizu, Daniels, et al., (2005) argue that specification to individuals regarding how information is previously encoded (e.g., meaning-based versus semantic-based) influences the manner in which items are processed on memory tests, constraining what information comes to mind during retrieval (source-constrained retrieval).

Although we can reject an extreme form of a late selection theory in favor of some form of early selection, it is difficult at this stage to pinpoint the precise nature of the cognitive mechanisms that operate on non-target trials to give rise to task interference. PM theories differ considerably in their proposals, and none of these accounts have been well detailed. PAM theory claims that task interference arises from the engagement of preparatory attention process that serves to maintain the intention to detect targets (S. M. Smith & Bayen, 2006). In line with this, Guynn (2003) proposed that a prerequisite for the successful detection of targets is that individuals maintain their memory system in a retrieval mode (cf. Tulving, 1983), described as a general preparedness or a readiness to treat ongoing task items as retrieval cues.

What it actually entails to 'maintain an intention', or to 'maintain a retrieval mode', is difficult to specify. One possibility is that these preparatory functions require that representations of targets are maintained at an increased level of activation, which persists until the stored target is detected in the ongoing task. In line with this view, Goschke and Kuhl (1993) proposed that targets (intentions) are maintained in memory at a higher level of sub threshold activation than other information. In the current study participants were presented with a higher number of

targets (20 targets) than in traditional PM tasks (typically one to four targets are presented). It is unlikely that participants maintained such a high number of targets at an increased level of activation. Instead, participants may have maintained a contextual cue or pointer (tag) to the information that needed to be retrieved as well as maintaining intent to use this pointer (tag). In this theory the contextual cue is maintained at a higher level of activation but the targets subsumed by the contextual cue are not. Successful target detection would occur because a memory retrieval process using the contextual cue and maintained context would be initiated whenever an ongoing task item is presented, regardless of whether the item is a target or non-target. The initiation of this retrieval process would thus slow ongoing task performance on both target and non-target trials. The greater slowing on non-target trials in the incongruent conditions as compared to the congruent conditions would occur due to the greater complexity involved in maintaining or using a secondary representation of context, as opposed to maintaining or using a base level representation of context.

Other researchers would contend that the memory access processes involved in identifying a presented ongoing task item as a target would only occur for a minority of the ongoing task items. The idea here is that targets and some non-targets would elicit a sense of familiarity (McDaniel et al., 2004). This sense of familiarity would initiate the memory retrieval process required to identify a target. The greater interference in the incongruent conditions as compared to the congruent conditions would occur because the memory retrieval process is more difficult when a secondary contextual representation has to be reinstated or used than when a base-level representation has to be reinstated or used. In this version the greater amount of task interference which commonly occurs with an increased emphasis on the importance of detecting targets in ongoing tasks (Loft & Yeo, in press; S. M. Smith & Bayen, 2004) would occur because

participants set a lower threshold for the initiation of a retrieval attempt. That is, participants require less familiarity before attempting to retrieve the information that is needed in order to identify an ongoing task item as being a target.

Of course, it is equally plausible that a portion of the task interference effect arose from preparatory processes, and a portion created anew by familiarity with attended items. One potentially diagnostic test would be to present consonant strings as non-words, making discrimination between words and non-words easier. We demonstrated intermediate task interference effects (trend in consistent direction) for pronounceable non-words. If task interference reflects general preparations made for memory access (perhaps via an attention allocation policy set at encoding; Marsh, Cook, & Hicks, 2007), then we should find similar task interference for non pronounceable non-words as for pronounceable non-words. In contrast, if task interference is created anew by a sense of significance or familiarity with attended items, we would not expect to find task interference with non pronounceable non-words. An alternative could be to have participants link their intention to detect targets to a particular stimulus class (e.g., pictures, words), or a pre-specified block of trials. It has been demonstrated that task interference can be reduced by warning participants on a trial by trial basis of the relevance of ongoing task items to target detection (Marsh et al., 2007), and even eliminated by informing participants that targets will not be presented in an upcoming block of trials (Marsh, Hicks, & Cook, 2006). Thus, preparatory attention can be adjusted when participants can predict the relevance of upcoming trials to target detection. An interesting twist would be to present stimuli relevant to target detection (but not actual targets) on blocks of trials where targets are not expected. If task interference effects are demonstrated on such trials it would suggest that at least

part of the task interference effect is created by a sense of significance or familiarity with attended stimuli, in addition to any control processes prepared in advance.

In conclusion, there has been more emphasis in the memory literature on post-output decision processes than on pre-access control processes. The current study has contributed to addressing this imbalance. We successfully merged methods from the DF and PM literatures to create a task paradigm that could be used to examine the processes involved in the control of memory access. Contexts reinstated by test instructions influenced the complexity of the preparations or processes required to access memory, and we measured the emergence of this complexity through task interference. Several avenues were raised for further enquiry. Continued systematic investigation using the experimental task paradigm introduced here has potential for continuing to delineate how individuals constrain and select information that is stored in memory, and how context reinstatement affects recognition memory.

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Table 1

Procedure for Experiments 1 and 2

Step	Procedure
1	Lexical decision task instructions
2	Target detection task instructions
3	Study List 1
4	Memory instructions
5	Study List 2
6	2-min arithmetic task
7	Test Instructions
8	2-min arithmetic task
9	Lexical decision task/Target detection task

Table 2

Uncorrected Hits on List 1 and List 2, and Uncorrected False alarms, as a Function of Memory and Test Instruction in Experiment 1

	<u>Test Instructions</u>		
	Respond-All		
<u>Study Instructions</u>	Hits: List 1	Hits: List 2	False Alarms
Remember	.73	.57	.06
Forget	.72	.74	.03
	Respond-List 2		
	Hits: List 1	Hits: List 2	False Alarms
Remember	.28	.54	.05
Forget	.33	.58	.01

Table 3

Uncorrected Hits on List 1 and List 2, and Uncorrected False alarms, as a Function of Memory and Test Instruction in Experiment 2

	<u>Test Instructions</u>		
	Respond-All		
<u>Study Instructions</u>	Hits: List 1	Hits: List 2	False Alarms
Remember	.67	.59	.04
Forget	.66	.66	.03
	Respond-All-Discriminate		
	Hits: List 1	Hits: List 2	False Alarms
Remember	.70	.63	.03
Forget	.69	.68	.01

Figure Captions

Figure 1. Primary contextual representations and secondary contextual representations assumed to be established a result of processing remember and forget memory instructions.

Figure 2. Response times to non-target trials (task interference) as a function of memory instructions and test instructions in Experiment 1. Error bars represent standard errors.

Figure 3. Response times to non-target trials (task interference) as a function of memory instructions and test instructions in Experiment 2. Error bars represent standard errors.

Figure 1

Figure 2

Figure 3