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Avoiding Interference: Contrasting the Effects of Differentiation and Reminding

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AVOIDING INTERFERENCE: CONTRASTING THE EFFECTS OF DIFFERENTIATION AND REMINDING

By

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I dedicate this thesis to my Grandma, Claire

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Interference between similar events is known to be a major mechanism of forgetting. As such, it is important for us to understand how to reduce interference effects. While early research suggested that differentiation of the two sources of information was vital for preventing interference, more recent research has found that being reminded of similar material and making associations can be most beneficial. In the present thesis I put these two mechanisms in opposition, utilizing a two list A-B, A-D paradigm. Experiment 1 revealed little difference in memory for interfering word pairs between participants in a "reminding" condition asked to make associations vs. a "differentiation" condition asked to differentiate and forget old pairs while studying new pairs. Experiment 2a revealed an interaction, such that those told to make associations showed less interference than those told to forget the first list, while both conditions performed similarly on control pairs. However, Experiment 2b failed to replicate Experiment 2a. In Experiment 3 I sought to increase the degree of differentiation between lists by varying encoding. Using different encoding between lists resulted in equivalent interference in both the reminding and differentiation conditions. Experiment 4 varied encoding instructions to contrast the differentiation present in Experiment 3 against circumstances encouraging associations. One group used the same encoding method for both lists, while another was given different study methods between lists. Results reveal a unique discovery about the important interplay of encoding and study time in determining the likelihood of reminding.

Keywords: differentiation, reminding, interference, instructions

CHAPTER 1

INTRODUCTION

When people try to memorize something new, is it best to differentiate the present from the past, or would it be better to integrate the past and present and make associations with prior experiences? If I am trying to remember how well my team's quarterback is doing this season, I may think it best to try to forget how he did last year. However, if I am reminded of his performance last year during the new year, perhaps the memory for being reminded will preserve the knowledge of both years. Whether it is thinking about a football player and his performance across years, or learning a new lesson in a classroom, maintaining new information can be difficult when we already have memories for related material (Bower, 1974). A large body of work over the past half century or more has detailed the importance of interference among memory and how it may operate.

A typical method used to study interference is an A-B, A-D paradigm in which two lists of word pairs are presented to a participant to be studied. The first list may contain a pair such as "knee-bend" (A-B), while the second list may contain the pair "knee-bone" (A-D). After studying both lists participants may be tested on either the first (retroactive interference) or second (proactive interference) list, sometimes using cued recall. Because the two example pairs share the same cue word, but are paired with a different target word, they will often interfere with one another during the test. When a participant is presented with the cue "knee" and asked to recall the word it was paired with on the first list, say, they will be less likely to successfully report "bend" than if "knee-bone" had never appeared on the second list (for a review of interference effects see Anderson & Neely, 1996).

Underwood (1957) outlined how interference is an important factor in forgetting. When similar memories exist, they compete with one another during retrieval, and such response competition is thought to be the main mechanism behind interference (Banks, 1969). Competition operates between similar memories, not by causing unlearning of one memory when another is formed (Martin, 1971), but perhaps by creating a circumstance in which the target memory becomes inaccessible to retrieval attempts (Anderson & Neely, 1996).

How does an individual avoid response competition and interference? One early theory stated that differentiation is key for avoiding interference. Underwood and Ekstrand (1966, 1967) utilized distributed practice, which entails learning across multiple sessions at different times, for List 1, followed by a single session of List 2 learning to one perfect trial. Distributing practice for one list allowed participants to differentiate which word pair came from which list. Increased differentiation led to reduced interference. They also reduced differentiation by including repeated items between lists and found that the presence of repetitions increased the number of intrusion errors and the amount of proactive interference.

In a related study, Winograd (1968) presented participants with two lists of words. Each list contained 6 categories of 6 words each, with three of these categories repeated across lists. After studying, participants were asked to recall the list membership of each of the items they saw. Those items within the categories shared across lists were recalled significantly worse than those that were in a category that only appeared on one list. It is presumed that lack of differentiation was largely responsible for this decrease. Winograd and Smith (1966) varied the number of presentations between two lists of words, prior to asking for a judgement of list membership. When lists were presented the same number of times, list membership judgments were at their worst. However, when one list was presented more often than another, membership judgements were significantly better, due to the increased differentiation.

Kuhl, Bainbridge, and Chun (2012) told participants to forget a first list before studying a second list, and used fMRI to assess activation of competing A-B associations during recall of the second list. They found that the strength of neural reactivation of competing material at test is related to the level of interference observed behaviorally, that is, the stronger the activation of A-B when attempting to recall A-D, the less successful that retrieval attempt was. Greater differentiation in neural activation, it seems, is key to avoiding interference. However, they did not include a control condition where participants were told to remember the first list rather than forget it.

Research on source monitoring has also pinpointed differentiation as an important mechanism of avoiding interference. Source monitoring involves someone's ability to accurately recall the "source" of a memory. For example, a child may have difficulty remembering whether they personally experienced something, or whether they just saw it on television. Though they are not explicitly called source monitoring, the A-B A-D paradigm may require a large degree of source monitoring in order to allow recall of the target at test. Participants must be able to select from memory the target from the appropriate list. Johnson, Hashtroudi, and Lindsay (1993) examined the ability of participants to identify the list on which they studied a particular word after studying multiple lists. Participants were less likely to make an intrusion error when there was more temporal separation between lists, displaying the importance of differentiation.

Given that differentiation can have an impact on the degree of interference one may experience, it is important to understand a technique one might use to accomplish differentiation. To examine this we will look at an area of research where active differentiation is the goal;

directed forgetting. In list-method directed forgetting, some participants study a list of words and then are told to forget it and prepare for a new list. Typically, the instruction to forget will result in a detriment to memory for List 1, and a benefit to memory for List 2 (Bjork, 1970, Reitman et al., 1973). According to Sahakyan and Kelley (2002), the effects of directed forgetting are driven by differentiation of the contexts of the two lists. After studying List 1, some participants were asked to forget List 1, while others were told to remember List 1 but to imagine an alternative and distant context prior to studying List 2. Those who were directed to remember, but to change their mental context, had similar costs for List 1 memory and benefits for List 2 memory as those who were told to forget List 1. Furthermore, if the context of the first list is reinstated prior to the test for those who were told to forget, first list forgetting can be lessened.

Differentiation has some impact on the level of interference between related memories, and it also appears to be a major mechanism of directed forgetting. Returning to the classic A-B A-D interference paradigm, directed forgetting instructions may be an effective method for achieving differentiation between lists.

1.1 Being Reminded

Being reminded of a previous related memory can be helpful in memorizing the current stimulus (Wahlheim & Jacoby, 2013) and can produce facilitation rather than interference in an A-B, A-D paradigm. Wahlheim and Jacoby hypothesized that through the process of being reminded a recursive representation is formed. When people encounter an interfering word pair (A-D) while studying List 2, it is possible that they will be reminded of the corresponding pair from List 1 (A-B). If this reminding occurs, a memory of being reminded of the List 1 pair (A-B) is part of memory for the List 2 pair (A-D) (for more on recursive reminding see Hintzman, 2004). The critical measure of reminding takes two different forms for Wahlheim and Jacoby (2013): Change detection and change recollection. Change detection is an online measure during study of List 2 where participants report if they remember a related item from List 1 while studying an A-D pair. Change recollection is measured during test, where the participant is asked whether the pair changed from List 1 to 2, and if so, what both targets were. Change detection and change recollection are consistent with one another in measuring rates of reminding. In a series of experiments using these measures, being reminded created facilitation of memory for the information participants were reminded of (the A-B pair), as well as the information that triggered the reminding (the A-D pair), compared to control pairs that did not share a cue with a pair on another list (Jacoby, Wahlheim, & Kelley, 2015; Putnam, Wahlheim, & Jacoby 2014; Wahlheim, 2014; Wahlheim, 2015; Wahlheim & Jacoby, 2013; Wahlheim, Jacoby, & Yonelinas 2013).

Detecting and remembering change in our environment can greatly enhance the extent to which changed items are remembered. Wahlheim, Jacoby, and Kelley (2015) found that, in a two list A-B, A-D paradigm where some changes occurred across lists and some occurred within List 2, the likelihood of being reminded could be influenced by the instruction to either look back throughout both lists for changed pairs, or to maintain focus only on changes within List 2. When participants were asked whether the current pair had changed at all across both lists, they had facilitation in memory for between list changes, while those who were asked only if the current item had changed within List 2 did not have facilitation. The results of instructing participants to be aware of all prior items are consistent with results obtained by Asch (1969), who found that being aware that an item is repeating (i.e. being reminded of the first presentation) is essential for creating a memory benefit for a repetition. Wahlheim, Jacoby, and

Kelley’s findings indicate that the amount of reminding, and overall memory performance, can be brought under experimental control though a manipulation of instructions. Also, while differentiation should, at best, eliminate interference, it seems reminding should be able to turn it into facilitation.

1.2 Differentiation or Reminding: How to Escape Interference

One line of research suggests that differentiating material is the key to avoiding interference, while another shows that being reminded of similar material is best for memory. These opposing theories have also been the subject of experimentation in the past. Postman, Gray, and Thompkins (1982) presented interfering word pairs across two lists and between the two lists they instructed participants to either continue thinking about List 1 to avoid interference, or to suppress memory of List 1 to avoid interference. The authors reported the following instructions:

> The suppression groups were told that negative transfer may develop because people remember the first list while learning the second. They were urged to try not to think about the first list at all and were warned that this strategy would probably require some effort on their part. In contrast, the perseveration groups were told that negative transfer may develop because people try to forget the first list while learning the second. They were instructed to contrast and compare the first-list words with the new words attached to the same letters. Once they were sure that they knew the new pairs, they could discontinue this procedure. (p. 291-292)

Those who were told to suppress List 1 had better recall for List 2 than those that were told to “perseverate and create associations.” It would seem that differentiation results in better memory for new material in interference paradigms than an attempt to integrate with old material.

A similar study by Dallett and D'Andrea (1965) also instructed some participants to remember List 1 while instructing others to "unlearn" List 1 material. Participants studied stimulus-response pairings, where stimuli, CVC trigrams, were followed by a word response. The mediation, or remember, group was told the following:

> Now I would like you to learn a second list. The syllables will be the same but the words are different. Try to use the words you have already learned to help you in learning this new set of words. If you can, try to find some way in which you can relate them, or some way in which the word on the first list helps you remember the word on the second list. For instance, if the first-list word was speedy and the new word is lacy, you might want to think of a girl in a lacy dress driving a sports car—or you might just want to remember that lacy goes with the same syllable that speedy went with before. Some people claim that the more ridiculous the association you form between the words, the easier they are to learn and remember. Exactly what you do is, of course, up to you. Try to learn this second list as quickly as possible. But try to make what you have already learned on the first list help you as much as possible. (p. 461)

In contrast, the unlearning group was told this:

> Now I would like you to learn a second list. The syllables will be the same but the words are different. Try to forget the words you have already learned to these syllables: if you do not they will interfere with learning this second list. Most people who have trouble learning this second list say it is because words from the first list keep intruding; try to prevent this. Exactly what you do is, of course, up to you. Try to learn this second list as

quickly as possible. But be on the lookout for interference from the first list and try to suppress or forget the first-list words as soon as you can.

Immediately after study of List 2, participants were presented with each cue and were given the opportunity to recall the appropriate target from both lists in a modified modified free recall (MMFR) test. There was no overall difference in memory for List 2 items between the two conditions, however, there was a difference in the type of List 2 items that were remembered. Those who were asked to remember List 1, and allow List 1 associations to mediate the learning of List 2, did better learning List 2 items when they had a better memory for the List 1 associate. So if A-B was well learned, then learning the "D" item associated with the same cue was easier, possibly because reminding was more likely to occur. If participants in the remember condition were indeed following instructions and attempting to use "B" to mediate learning of "D," then a strong memory of "B" should be helpful. For those who had been told to unlearn List 1, memory for List 1 was not as important in determining memory for List 2, indicating that participants were responding to the instructions by varying strategy. In two experiments the correlation between memory of the List 1 pair and the corresponding List 2 pair was significantly higher in the remember condition. The importance of being reminded may in fact be dependent on the instructions given prior to List 2. To determine if this is true, we need to have an accurate measure of when reminding is actually occurring and its impact on memory.

In the current thesis I contrast differentiation and reminding as mechanisms for avoiding interference, in an A-B, A-D paradigm. Differentiation may be visualized as a continuum, where one end represents complete separation of context between two experiences and the opposite end represents complete similarity of context between experiences. The more similar context is, the more likely it is that the second experience will trigger a reminding of the first experience. As contexts between experiences have less overlap, and we move further along the continuum toward complete differentiation, reminding is less likely to occur. I sought to examine the optimal amount of differentiation, and reminding, along this continuum for maintaining memory of related experiences.

In Experiments 1-3, before participants viewed List 2 they were instructed to either remember List 1 and integrate memories, or to forget List 1 completely and update their memory. In Experiment 4, different encoding methods were used to differentiate lists. Critically, as in the experiments examining change recollection discussed earlier, I used a cued recall test with a measure of change recollection to quantify remindings.

In order to allow participants to actually forget List 1 when I instructed them to forget, I also took steps to enhance differentiation between lists. For all experiments Lists 1 and 2 were presented on differently themed background scenes for all participants. I included interference pairs where the cues repeated, so it is possible that those told to forget List 1 and differentiate would be unable to do so because they were naturally making associations between similar lists. Sahakyan and Goodmon (2007) highlight the rationale behind using enhanced differentiation. They used a standard list-method directed forgetting paradigm, but included material that was related across the two lists. If a participant was in the bidirectional condition, all items on List 1 had a corresponding associate on List 2 that would support association both backward and forward (e.g., chip & potato). They found that including items that were bidirectionally associated eliminated all directed forgetting effects. Bidirecitonal associations likely triggered a reminding of related List 1 material while studying List 2, preventing participants from being able to forget List 1. With additional contextual change I intended to avoid natural associations between A-B and A-D during List 2, eliminating unwanted reminding in the differentiation condition.

CHAPTER 2

EXPERIMENTS

2.1 Experiment 1

Here, I contrasted reminding and differentiation instructions in order to promote reminding and differentiation respectively. I predicted that those in the differentiation condition would be less likely to be reminded of List 1 pairs during List 2, causing worse performance on interference pairs than those in the reminding condition. While list separation may provide help in avoiding interference in the differentiation condition, I predicted the facilitation caused by associations made in the reminding condition would prove superior for memory.

2.1.1 Method

2.1.1.1 Participants. 80 undergraduate students at Florida State University participated in this experiment for credit in a psychology course.

2.1.1.2 Design. A 2 X 2 mixed design was used, where instructional condition (reminding vs. differentiation) was manipulated between subjects and item type (control vs. interference) was manipulated within subjects. Participants were tested on their memory for the second list presented, and asked if the target associated with that cue was different on List 1, whether they remember the first list response as well.

2.1.1.3 Materials. All words used were materials obtained from Jacoby (1996) and Nelson, McEvoy, and Schreiber (1998). These materials were also used in Wahlheim and Jacoby's work on recursive remindings (2013). Word pairs were drawn from three word sets, wherein one word served as a cue and two served as potential targets. Forward and backward associative strengths between items are low (Wahlheim & Jacoby, 2013). Each set of pairs was equally used for control and interference pairs across participants. Sets were also equally distributed across item types for both instructional conditions. Background images of two themes, forest and city, were presented behind each word pair for Lists 1 and 2. All background images were gathered through an online image search for “forest” and “city” scenes.

2.1.1.4. Procedure. Upon entering the experiment participants were told that they were going to study lists of words, with a memory test at the end. Prior to the first list, participants were asked to study the following word pairs for an upcoming test. List 1 consisted of 20 interference pairs of words, where the cue was repeated on List 2 with a different target. Each pair was presented for 8 seconds over a unique background image. List 1 backgrounds were either entirely forest scenes or entirely city scenes. Overlaying each background was a small black box approximately the size of the word pair, which was contained within, providing contrast between the words and images. Background type and item types were counterbalanced across participants.

After viewing all List 1 pairs, each condition received different instructions about what they had seen. Those in the reminding condition received the following instructions:

> In this part of the experiment, you will see a second list of individually presented word pairs. Your primary task will be to study the word pairs in this list for an upcoming memory test.
>
> Some of these pairs will have the same first word as in the previous list paired with a new second word (e.g., carry-hold & carry-load), and some will be completely new pairs. Noting that the second word has changed for a pair will greatly help you remember the new second word for a later test.
>
> So when you see a pair that looks like it has changed, and you are reminded of the original pair, thinking about how it was and how it has changed

will be really helpful later when you have the memory test. So take the time to notice which ones have changed and how.

Participants in the differentiation condition, on the other hand, were told that List 1 was merely a practice list and that it should be forgotten. Specifically they were instructed the following:

> The items on the list that you just saw were only practice to familiarize you with the structure of the experiment. We will not ask you to remember them. It is important to clear your head of that first practice list and get ready to learn the list that we will test you on.
>
> In this part of the experiment, you will see a second list of individually presented word pairs that you will be tested on. Some of these pairs will have the same first word as in the previous list paired with a new second word (e.g., carry-hold & carry-load), and some will be completely new pairs. Please focus your attention on the new word pairings and try not to even think of what the pair was on the first list, as that will hurt your ability to learn the new, updated pair.

As shown, both conditions were alerted to the presence of changed pairs and control pairs.

All participants then studied List 2. List 2 consisted of 20 new control pairs and 20 A-D interference pairs. Background images were of a different theme than List 1 and consisted of either forest or city scenes accordingly. As in List 1, each pair was presented for 8 seconds.

Participants were then tested on targets presented on the second list they saw. The cue for each of the pairs presented on List 2 was shown over a black background and participants were asked to retrieve the target. After retrieving the target they were asked if any other word presented in the experiment came to mind prior to, or simultaneously with their answer. This was a measure of recollection of reminding, as Wahlheim and Jacoby (2013) found that the List

1 response would often come to mind first during attempts to recall List 2. I predicted that participants would detect and recollect change less often in the differentiation condition relative to participants in the reminding condition, eliminating facilitation due to reminding and so reducing performance on List 2 proactive interference items.

2.1.2. Results

A 2 X 2 repeated measures ANOVA was used to determine the difference in recall in control and interference items across the two conditions. There was no significant difference between performance on interference and control items, $F < 1$, consistent with previous findings that show mixed effects of facilitation due to reminding and interference when reminding did not occur, resulting in performance on interference pairs similar to that for control pairs (Wahlheim & Jacoby, 2013). There was also no significant effect for condition, and no significant interaction between the item type and condition, F's < 1. I had predicted that those in the reminding condition would experience more change recollection, and would therefore outperform those in the differentiation condition on interference items. Mean performance on interference pairs for both conditions was virtually identical (See **Table 1**). The rate of recollection of change, however, was significantly different between conditions, $F(1,78) = 11.8$, $p = .001$, $\eta_p^2 = .13$. As predicted, those who were told to remember List 1 while studying List 2 apparently were reminded of List 1 more often and were able to recollect that reminding during test (Reminding = .27, Differentiation = .14).

Table 1

Cued Recall Performance: Experiment 1

Condition	Control	Interference
Reminding	.37 (.03)	.40 (.03)
Differentiation	.39 (.03)	.39 (.03)

Notes. Mean cued recall performance by condition and item-type in Experiment 1 (SE)

A 2 X 2 repeated measures ANOVA was conducted to determine performance on interference items conditionalized on whether change was recollected or not for each condition. As predicted, and as found by Wahlheim and Jacoby (2013), performance was much better on items where change was successfully recollected compared to when change was not recollected, $F(1, 66) = 212.4$, $p < .001$, $\eta_p^2 = .76$. There was not a significant effect of condition, nor was there a significant interaction between condition and items conditionalized based on recollection of change, *F*'s < 1. However, mean performance indicates that those in the differentiation condition performed slightly better on interference items where change was not recollected compared to those in the differentiation condition, which accords with a benefit for differentiation in the reduction of interference, .32 vs. .27 ($F(1,66) = 2.3$, $p = .14$, $\eta_p^2 = .03$) (See **Figure 1**). Further analyses revealed that those pairs where change was recollected showed facilitation above control pairs, $t(67) = 12.8$, $p < .001$, while pairs where change was not recollected showed interference compared to controls, $t(67) = 4.84$, $p < .001$.

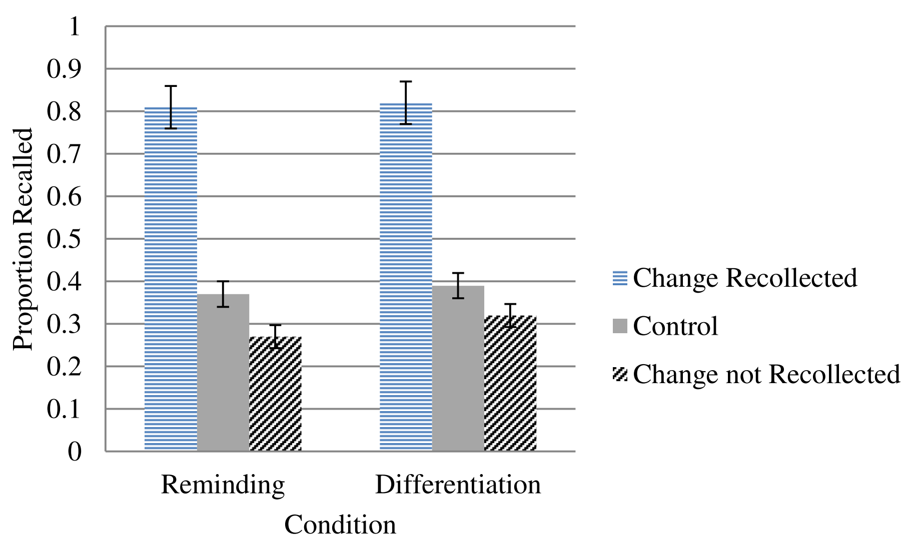

Figure 1. Recall Conditionalized on Recollection of Change: Experiment 1

2.1.3. Discussion

Instructions to forget or to attempt to be reminded did affect the likelihood of change recollection at test, which is an indirect measure of reminding during study of List 2, yet did not affect overall interference performance. There was no difference in memory for control items, indicating no difference in encoding strategy between conditions, as can often occur in a directed forgetting paradigm, where people told the first list was for practice often shift to a better encoding strategy for List 2 (Sahakyan & Delaney, 2003). The fact that the two lists had different background themes may have provided enough separation of context that the two lists did not interfere with one another as much for those participants in the differentiation condition, who were not asked to actively make associations between the two lists, in accord with reduction of interference due to list differentiation (Underwood & Ekstrand, 1967). As such, both the negative effects of interference and the tendency to be reminded between lists may have been reduced by the change in context and differentiation instructions working in conjunction. For those pairs where change was recollected despite the differentiation instructions, the reminding had great facilitative effects for memory of the List 2 target, as shown in the conditionalized analyses. However, as discussed earlier, those in the differentiation condition showed a slight trend toward better performance on interference items where change is not recollected. Enhanced memory without change recollection could reflect the reduced interference resulting from differentiation instructions and context change working in conjunction to differentiate the two lists.

2.2. Experiment 2a

In Experiment 2a I contrasted reminding and differentiation instructions in a retroactive interference paradigm. One concern using differentiation instructions is that being told to forget leads some participants to reflect on List 1, realize their memory is poor, and switch to a better encoding strategy for List 2 (Sahakyan & Delaney, 2003). Such a change of encoding due to the differentiation instructions could confound the interpretation of any differences in List 2 memory between the Differentiation and Reminding conditions. As such, I chose to use a retroactive interference paradigm. Reminding in a retroactive interference design can enhance List 1 memory because reminding entails retrieval of the List 1 target, just as memory is strengthened by retrieval in studies of the testing effect (Roediger & Karpicke 2006, Jacoby, Wahlheim, & Kelley, 2015, Negley & Kelley, in preparation). I used the same basic procedure as Experiment 1, with two changes made to the test procedure. The first change was that I tested on memory for List 1 instead of List 2 in the A-B, A-D paradigm, meaning that the additional measure of change recollection asked participants to recall target D if they could. My second change to the testing procedure was that I included the List 1 background at test to reduce the effects of my directed forgetting instructions (Sahakyan & Kelley, 2002), as I will discuss. If the effects of list differentiation follow from Experiment 1, we could expect that differentiation instructions would again produce fewer remindings, meaning a lower rate of recollection of change and worse performance on interference items compared to the reminding condition.

2.2.1. Method

2.2.1.1. Participants. 84 undergraduate students at Florida State University participated in this experiment for credit in a psychology course.

2.2.1.2. Design. A 2 X 2 mixed design was used, manipulating instruction condition (reminding vs. differentiation) and item type (control vs. interference). Instructional condition was manipulated between subjects and item type was manipulated within subjects. Participants were tested on their memory for the first list presented, and asked, if the target associated with that cue was different on List 2, whether they remember the second list response as well.

2.2.1.3. Materials. Identical materials to those in Experiment 1, including word pairs and background images, were used.

2.2.1.4. Procedure. The procedure was similar to Experiment 1 with the exception of List 1 composition and testing procedure. List 1 consisted of 20 control pairs, where the cue was not repeated across lists, and 20 interference pairs. At test, participants were prompted with a cue and told to recall the List 1 associate. After their response they were asked if another word came to mind prior to or simultaneously with their response, which was our measure of change recollection. The original background images were presented with the cue from the first list in order to aid recall and to minimize any potential impact of directed forgetting of List 1 in the differentiation condition. Sahakyan and Kelley (2002) have shown that, in a directed forgetting paradigm, reinstating context of List 1 during test reduces the effects of List 1 forgetting. If any effects of List 1 directed forgetting are still present, we would be able to see the difference in performance on control pairs between conditions. I predicted that more recollection of change would occur in the reminding condition, which would result in better performance on interference items compared to the differentiation condition while performance on control pairs should remain the same.

2.2.2. Results

Recall was analyzed using a 2 X 2 repeated measures ANOVA to determine the effects of item type (control, interference) and instruction condition (reminding, differentiation). No main effect of instruction condition or item-type was present ($F < 1$), however, as predicted, there was a significant interaction, $F(1, 82) = 8.01$, $p = .006$, $\eta_p^2 = .09$. The difference between control and interference items in the differentiation condition was significant, $t(41) = 2.32$, $p = .03$, showing interference as predicted. In contrast, there was not a significant difference between control and interference in the reminding condition, though it trended toward facilitation on interference pairs $t(41) = -1.66$, $p = .10$, as predicted if reminding actually occurred in the reminding condition.

Table 2

Cued Recall Performance: Experiment 2a

Condition	Control	Interference
Reminding	.40 (.03)	.44 (.03)
Differentiation	.45 (.03)	.39 (.03)

Notes. Mean cued recall performance Experiment 2a including all participants (SE)

While the interaction of instructions and item-type may indicate the predicted influence of our instructional manipulation causing greater recollection of change in the reminding condition, the difference in control performance indicates the potential for an unequal sample between conditions. As such, I examined the data excluding the highest performers in order to equate performance on control pairs. Five participants, four of them in the differentiation condition, exhibited recall of control items well above the mean (approximately two standard deviations). When these individuals were excluded control performance across conditions was more comparable (Reminding = .39 vs Differentiation = .41), while the difference in interference items remained substantial (Reminding = .43 vs Differentiation = .36), and the interaction remained significant $F(1, 77) = 7.33$, $p = .008$, $\eta_p^2 = .09$. The interference in the differentiation condition also remained significant, $t(37) = 2.09$, $p = .044$, and the difference between control and interference performance within the reminding condition remained nonsignificant, but trending toward facilitation, $t(40) = 1.72$, $p = .09$.

Next, I examined levels of change recollection. A one-way ANOVA revealed that change recollection was extremely low for both conditions (Reminding = .16 vs Differentiation = .13) and, contrary to predictions, did not significantly differ, $F(1, 83) = 1.09$, $p = .30$, $\eta_p^2 = .01$. Results excluding previously mentioned participants did not significantly impact the means (Reminding = .15 vs Differentiation = .11) nor the significance of recollection of change differences, $F(1, 77) = 1.92$, $p = .17$, $\eta_p^2 = .02$. The low rate of change recollection may be a result of the way it was measured, as I will discuss later.

A 2 X 2 repeated measures ANOVA was used to analyze recall conditionalized on correct change recollection (See **Figure 2**). As in Experiment 1, and as found by Wahlheim and Jacoby (2013), those items where change was successfully recollected were recalled better than items where change was not recollected, $F(1, 51) = 106.5$, $p < .001$, $\eta_p^2 = .68$. No significant interaction between condition and item type existed, $F(1, 51) = 2.70$, $p = .11$, $\eta_p^2 = .05$. Further analyses revealed that recollection of change created facilitation compared to control performance $t(51) = 9.14$, $p < .001$, and recollection was more helpful for memory for those in the reminding condition, $t(32.4) = 2.08$, $p = .046$. There was no significant difference in performance on interference pairs when change was not recollected compared to control pairs, $t(51) = 1.06$, $p = .30$. However, as reviewed earlier, change recollection does not seem necessary to create facilitation of memory as long as reminding occurred and the List 1 target was retrieved during List 2 (Wahlheim, Jacoby, and Kelley, 2015). One potential explanation for a lack of interference when change is not recollected may have to do with the wording of the change recollection measure, as discussed later.

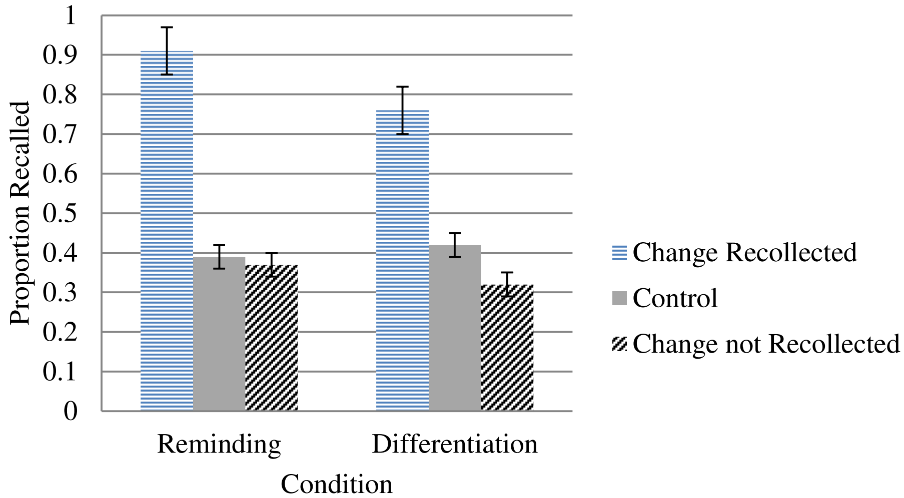

Figure 2. Recall Conditionalized on Recollection of Change: Experiment 2a

2.2.3. Discussion

Significant interference was found in the differentiation condition. I predicted that a reduction in interference in the reminding condition would be due to an increased likelihood of reminding, as indexed by recollection of change at test. However, recollection of change rates were very low, and no difference between conditions was detected. There are many potential factors that may have influenced the low change recollection rates. First, my manipulation of background context may have caused memory for the second item, as well as memory for the experience of reminding to be tied to the second list context. Because I reinstate first list context at test to overcome directed forgetting effects, it may be much more difficult to remember being reminded, an experience that occurred during List 2. Perhaps, though, the most notable explanation for low rates of change recollection is my wording when asking for the other list target. I used the same measure of change recollection from Wahlheim and Jacoby (2013) and Experiment 1, even though I changed the testing procedure to assess memory for List 1 rather than List 2. I asked participants whether another word presented in the experiment came to mind "prior to, or simultaneously with," their response, but because I am testing on List 1 any recollection of a changed item from List 2 would likely come to mind *after* their response. The confusing instruction may have prevented some from reporting change, even if they did recollect it, which is a problem that I will rectify in Experiment 2b.

Conditionalized data trend toward better all-around performance in the reminding condition. One reason that lack of recollection of change was not as influential over memory for List 1 as it was in Experiment 1 may have to do with the fact that I reinstated List 1 context at test. In a retroactive interference paradigm, where the participant is being tested on List 1, it is only significantly beneficial that change detection occurs while encoding List 2 (Jacoby, Wahlheim, & Kelley, 2015). It is not necessary for the change to be recollected at the time of test. Once the memory for the List 1 pair is retrieved during a reminding, the boost for that List 1 pair has already occurred. Even if the corresponding List 2 pair is not recalled, the participant will still show better memory for the List 1 pair due to its retrieval during List 2. While change recollection indicates that change detection during List 2 occurred, a lack of change recollection does not necessarily mean that an item did not get a memory boost from change detection.

2.3 Experiment 2b

In Experiment 2b I sought to use a more appropriately worded measure of change recollection during test in a retroactive interference paradigm. The experiment is identical to Experiment 2a, with the sole exception that participants are simply asked if "the word pair changed from List 1 to List 2" and if so, what was the List 2 associate? As such, I predicted that recollection of change would be higher for those in the reminding condition, while the overall interaction of instruction condition and item-type found in Experiment 2a should also occur, such that interference is seen in the differentiation condition while facilitation is seen in the reminding condition.

2.3.1. Method

2.3.1.1. Participants. 60 undergraduate students at Florida State University participated in this experiment for credit in a psychology course. One participant was excluded due to their familiarity with the materials from another experiment.

2.3.1.2. Design. Identical to Experiment 2a, a 2 X 2 mixed design was used, manipulating instruction condition and item type. Instructional condition (reminding vs. differentiation) was manipulated between subjects and item type (control vs. interference) was manipulated within subjects. Participants were tested on their memory for the first list presented, and asked, if the target associated with that cue was different on List 2, whether they remember the second list response.

2.3.1.3. Materials. Identical materials to those in Experiments 1 and 2a, including word pairs and background images, were used.

2.3.1.4. Procedure. Experiment 2b was the same as Experiment 2a in procedure, with the exception of the recollection of change measure. During the cued recall test, after reporting the List 1 target, participants were asked whether the word pair changed from List 1 to List 2.

2.3.2. Results

List 1 Recall was assessed using a 2 X 2 repeated measures ANOVA in order to determine the effects of item type (control, interference) and instruction condition (reminding, differentiation). As in Experiment 2a, no main effect of instruction condition or item-type was present, $F < 1$. Contrary to Experiment 2a, there was no interaction, $F < 1$. Mean recall rates show little variance (**Table 3**).

Table 3

Cued Recall Performance: Experiment 2b

Condition	Control	Interference
Reminding	.47 (.04)	.48 (.04)
Differentiation	.49 (.04)	.47 (.04)

Notes. Mean cued recall performance Experiment 2b (SE)

Next, I examined levels of change recollection. A one-way ANOVA revealed that change recollection (Reminding = .33 vs Differentiation = .33) did not significantly differ between conditions, $F < 1$, which implies equal amounts of reminding between conditions. A 2 X 2 repeated measures ANOVA was used to analyze recall conditionalized on correct change recollection (See **Figure 3**). Those items where change was successfully recollected were recalled better than items where change was not recollected, $F(1,50) = 139.8$, $p < .001$, $\eta_p^2 = .74$. No significant main effect of condition or interaction was found, F's < 1. Further analyses revealed that those pairs where change was recollected showed facilitation above control pairs, $t(51) = 8.50$, $p < .001$, while pairs where change was not recollected showed interference compared to controls, $t(51) = 5.20$, $p < .001$.

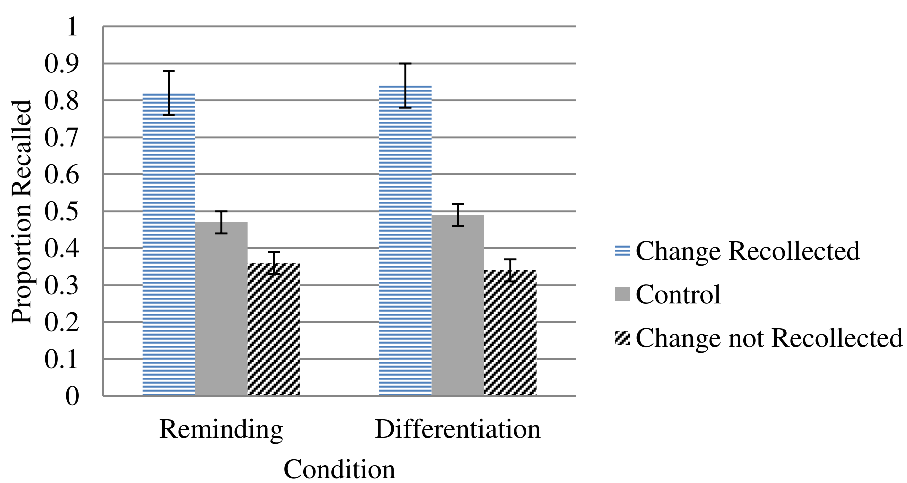

Figure 3. Recall Conditionalized on Recollection of Change: Experiment 2b

2.3.3. Discussion

Contrary to predictions, the interaction of instruction condition and item-type appearing in Experiment 2a was not replicated. While change recollection rates were higher than those in the previous experiment, there was no difference between conditions. The difference in mean performance seen in Experiment 2a, however, would suggest that some difference should have appeared.

If differentiation had occurred, and those in the differentiation condition were attempting to forget List 1 and not make associations, then I would not expect recollection of change rates to be as high as .33. An inability to differentiate would mean that participants in both conditions were naturally reminded of List 1 while viewing List 2, resulting in equal performance between conditions across the board. In order to examine this possibility, I enhanced differentiation between Lists 1 and 2 in Experiment 3 by using different encoding instructions between lists.

2.4 Experiment 3

To increase differentiation between lists I manipulated encoding strategies used between lists. I instructed participants to create a mental image of the word pairs on List 1, and to create a sentence using the word pairs during List 2. I also recorded participants during List 2 to ensure that participants were complying with instructions, and to potentially garner some reports of being reminded. With increased differentiation due to different encoding strategies across lists, I predict that those in the differentiation condition will be able to forget List 1 while encoding List 2, resulting in less reminding and less recollection of change during test. Those in the reminding condition, however, should be able to actively make associations between the lists and recollect change more often, overcoming the differentiation, when directed to do so. The differences in recollection of change between conditions should cause memory for interfering items to be better in the reminding condition than the differentiation condition.

2.4.1. Method

2.4.1.1. Participants. 84 undergraduate students at Florida State University participated in this experiment for credit in a psychology course.

2.4.1.2. Design. As in experiments 1, 2a, and 2b, a 2 X 2 mixed design was used: Instructional condition (reminding vs. differentiation) was manipulated between subjects and item type (control vs. interference) was manipulated within subjects. Participants were tested on their memory for the first list presented, and asked, if the target associated with that cue was different on List 2, whether they remember the second list response as well.

2.4.1.3. Materials. Materials were the same as those used in Experiments 1, 2a, and 2b, including word pairs and background images.

2.4.1.4. Procedure. Experiment 3 was similar to Experiment 2b in procedure, except that encoding strategy was also manipulated. Prior to viewing List 1 participants were told to say each of the word pairs out loud and to form a mental image of the two words interacting in some way. All word pairs on List 1 and 2 were shown for 12 seconds each. After encoding List 1, participants were given a new encoding strategy for List 2. They were asked to talk aloud, and to create a sentence using the two words. For example, if a participant were to see the pair "carry-load" they may say, "My friend asked me to carry a heavy load of books to class." Participants were recorded during List 2 to ensure that they were complying with instructions, and also to see if they reported being reminded of an interfering List 1 pair. I predicted that those in the differentiation condition would be able to successfully differentiate lists, resulting in less reminding and therefore less recollection of change, while those in the reminding condition would be able to actively overcome differentiation and remember changes, creating improved performance on interference pairs for those in the reminding condition.

2.4.2. Results

A 2 X 2 repeated measures ANOVA was used in order to determine the effects of item type (control, interference) and instruction condition (reminding, differentiation) on recall of List 1. No main effect of instruction condition, $F(1,82) = 2.16$, $p = .15$, $\eta_p^2 = .03$, was present. There was a significant effect of item type, $F(1,82) = 100.1$, $p < .001$, $\eta_p^2 = .55$, showing worse performance on interference pairs compared to control pairs. However, contrary to prediction, the interaction between instruction condition and item-type was not significant, $F(1,82) = 2.18$, $p = .14$, $\eta_p^2 = .03$ (**Table 4**). Further analyses reveal the difference in control performance failed to reach significance, $F(1,83) = 3.58$, $p = .06$, $\eta_p^2 = .04$, but was lower in the differentiation condition, which may indicate a directed forgetting effect that made retrieval difficult. No significant difference in performance on interference pairs was present, $F < 1$.

Table 4

Cued Recall Performance: Experiment 3

Condition	Control	Interference
Reminding	.57 (.03)	.36 (.03)
Differentiation	.49 (.02)	.33 (.03)

Notes. Mean cued recall performance Experiment 3 (SE)

A one-way ANOVA revealed that change recollection rates were quite high (Reminding = .42 vs Differentiation = .45), however, contrary to prediction, they did not significantly differ between conditions, F < 1. A 2 X 2 repeated measures ANOVA was used to analyze recall conditionalized on correct change recollection (See **Figure 4**). Those items where change was not recollected were recalled worse than items where change was recollected, $F(1,50) = 84.9$, $p <$

.001, $\eta_p^2 = .51$, and no significant interaction existed, $F < 1$. However, recall rates when change was recollected were much lower than in prior experiments (Reminding = .58 vs Differentiation = .55) and did not show facilitation relative to control performance in either the reminding condition, $t(41) = 0.3$, $p = .77$, or the differentiation condition, $t(41) = 1.5$, $p = .15$. A lack of facilitation when change was recollected is contrary to all prior work done in our lab, including when a retroactive interference paradigm has been used, the implications of which will be addressed in the discussion.

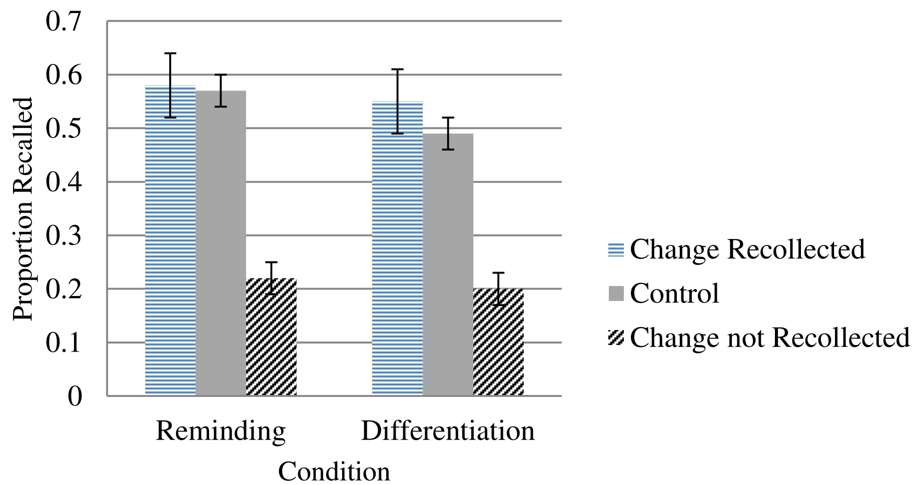

Figure 4. Recall Conditionalized on Recollection of Change: Experiment 3

2.4.3. Discussion

While no interaction between condition and item-type was found, and no difference in change recollection was observed, evidence suggests that my attempt to have participants differentiate lists was perhaps too successful. The absence of facilitation may mean that change was not, in fact, detected during study of List 2, but was inferred at the time of test. Participants may have formed a strong memory for a cue and target being presented on List 2 without ever being reminded of the interfering List 1 pair, due to increased differentiation. The reason that reminding during List 2 causes facilitation of the List 1 pair in a retroactive interference paradigm is because the List 1 pair is retrieved (Jacoby, Wahlheim, Kelley, 2015). If the List 1 pair is not retrieved when viewing the changed pair on List 2, then no facilitation should be seen if change is noticed for the first time at test. With extreme differentiation we see overall interference among A-B, A-D pairs, without any benefit for reminding, perhaps because reminding rarely actually occurred during List 2.

Differences in encoding strategy were the primary addition to Experiment 3, which resulted in overall interference and a lack of facilitation for items where change was recollected at test. If interference effects were driven by the differentiation caused by different encoding methods that reduced reminding, then similar encoding between lists should result in more detection of change during List 2, more facilitation when change is recollected, and less overall interference. I predicted that manipulating encoding strategies across lists would give further insight into whether being reminded or differentiating memories is most beneficial for avoiding interference.

2.5. Experiment 4

Experiments 1, 2a, and 2b did not reveal interference in cued recall, but Experiment 3, using different encoding strategies on each list, did reveal interference. The main difference in design between these experiments was the use of different encoding strategies between lists. One possibility is that differentiation of encoding strategy reduced reminding which caused greater interference. While previous research would suggest that greater differentiation should reduce interference, perhaps the reduction of reminding was the most notable impact of different encoding strategies between lists, which led to overall interference. Experiment 4 explored whether differences in encoding strategy are more harmful to memory of related material than maintaining the same study strategy across lists. I predicted that the use of different encoding strategies would effectively create a circumstance of differentiation, while maintaining the same encoding strategy between lists would still allow reminding to occur. I also predicted that those with different encoding strategies between lists would be less likely to be reminded, due to increased differentiation, compared to those who use the same encoding method. Decreased likelihood of reminding would mean that those with different encoding strategies would recall fewer interference items.

2.5.1. Method

2.5.1.1. Participants. 96 undergraduate students at Florida State University participated in this experiment for credit in a psychology course.

2.5.1.2. Design. A 2 X 2 X 2 mixed design was used, manipulating encoding method on List 1, encoding method on List 2, and item type. List 1 encoding (using imagery for List 1 vs. making a sentence for List 1) and List 2 encoding (using imagery for List 2 vs. making a sentence for List 2) were manipulated between subjects, and item type (control vs. interference) was manipulated within subjects. Participants were tested on their memory for the first list presented, and asked if the target associated with that cue was different on List 2 and whether they remember the second list response as a measure of recollection of change.

2.5.1.3. Materials. The same materials as those in Experiments 1, 2a, 2b, and 3, including word pairs and background images, were used.

2.5.1.4. Procedure. Half of the participants encoded List 1 by creating interactive images, while the other half created sentences using List 1 word pairs. List 1 encoding was crossed with same vs. different encoding strategy on List 2 (See **Table 5**). Those who received imagery instructions saw an additional screen that asked them to rate how vivid their mental image was from 1 to 6 (1 = Not vivid at all, 6 = Extremely vivid). All participants were given 8 seconds for each word pair to do their respective encoding task.

Table 5

Experiment 4 Encoding Conditions

Encoding Strategy	
List 1	List 2
Image	Sentence
Image	Image
Sentence	Sentence
Sentence	Image

Notes. Four pairings of encoding strategy in Experiment 4

Additionally, the testing procedure included a question about whether reminding occurred during List 2. After the participant had an opportunity to recall the List 1 target, and any corresponding target from List 2, they were asked whether they were reminded of the List 1 response while viewing the corresponding target from List 2.[1]

2.5.2. Results and Discussion

2.5.2.1. Recollection of Change. The rates of recollection of change were analyzed across all pairings of encoding method using univariate ANOVA.[2] List 1 encoding did not have a significant effect on change recollection, $F < 1$. However, there was a significant main effect of List 2 encoding, $F(1,92) = 26.2$, $p < .001$, $\eta_p^2 = .22$, and a significant interaction, $F(1,92) = 7.71$, $p = .007$, $\eta_p^2 = .08$.

An unexpected main effect of List 2 encoding revealed that differential effects were present as a result of whether sentence creation or imagery was used on List 2. When participants made sentences of the word pairs on List 2, recollection of change was lower (Mean = .31, SE =

.04) than when they created mental images during List 2 (Mean = .54, SE = .03). The demands of sentence creation during List 2 may be responsible for reduced reminding.

An interaction of List 1 and List 2 encoding method was present, supporting the prediction that when encoding method matched between lists reminding occurred more often. Given the large main effect of List 2, I explored the results with comparisons holding List 2 encoding constant. When participants used mental imagery on List 2, more recollection of change occurred when mental images had also been used on List 1 (Mean = .60) than when sentences had been created on List 1 (Mean = .48), $t(46) = 2.17$, $p = .04$. When participants created sentences on List 2, they trended toward reporting recollection of change more often when sentences were created on List 1 (Mean = .37) than when images were created on List 1 (Mean = .25), however this difference did not reach significance, $t(40.5) = 1.80$, $p = .08$.

Table 6

Recollection of Change: Experiment 4

		List 2	
		Image	Sentence
	Image	0.60 (.05)	0.25 (.05)
List1	Sentence	0.48 (.05)	0.37 (.05)

Notes. Rates of recollection of change for all four encoding conditions (SE)

2.5.2.2. Cued Recall. A 2x2x2 repeated measures ANOVA was used to examine the influence of List 1 encoding, List 2 encoding, and control vs. interference item type on proportion recalled (See **Table 7**). There were significant main effects for item type, $F(1,92) = 74$, $p < .001$, $\eta_p^2 = .45$, List 1 encoding, $F(1,92) = 9.24$, $p = .003$, $\eta_p^2 = .09$, and List 2 encoding, $F(1,92) = 26.5$, $p < .001$, $\eta_p^2 = .224$. The main effect of item type reflects that there was significant interference overall when performance on interference pairs (Mean = .58, SE = .02) was compared to control pairs (Mean = .73, SE = .02). All encoding conditions revealed interference except when imagery encoding occurred on both lists (Control = .70 [SE = .03], Interference = .70 [SE = .04]). The effect of List 1 indicates that those who used sentence encoding (Marginal Mean = .70, SE = .03) on List 1 had better recall overall than those who used image encoding (Marginal Mean = .61, SE= .03). However, those who created sentences on List 2 trended toward worse performance on control pairs (Marginal Mean = .70), $F(1,94) = 3.85$, $p = .05$, $\eta_p^2 = .04$, and showed much worse performance on interference pairs (Marginal Mean = .45), $F(1,94) = 39.7$, $p < .001$, $\eta_p^2 = .30$, relative to those who created mental images on List 2 (Control = .77, Interference = .70). Increased interference when sentences are created on List 2 is consistent with the idea that as the stronger encoding method, as evidenced by control performance, sentences create more interference with List 1 memory. List 2 sentences were also shown to reduce probability of reminding, which may also increase interference. The detriment to control performance for those who created sentences during List 2 is consistent with findings of the list strength effect in a cued recall paradigm (Ratcliff, Clark, & Shiffrin, 1990). The list strength effect occurs when strongly encoded material reduces recall of more weakly encoded material. In this case, the more recent sentence encoding on List 2 may have reduced recall of List 1 overall.

There was a significant interaction of item type (control vs. interference) with List 1 encoding, $F(1,92) = 5.72$, $p = .02$, $\eta_p^2 = .06$. As stated earlier, those who used sentence encoding on List 1 had better recall overall than those who used imagery. Further analyses reveal that this was mainly driven by improved performance on control pairs for those who used sentences (Mean = .80, SE = .02), compared to those who used imagery (Mean = .66, SE =.03), $F(1,94) = 16.9$, $p < .001$, $\eta_p^2 = .15$. Performance on interference pairs did not differ for sentence encoding on List 1 (Mean = .60, SE = .03), relative to imagery encoding on List 1 (Mean = .55, SE = .03),

$F(1,94) = 1.11$, $p = .30$, $\eta_p^2 = .01$. Item type also significantly interacted with List 2 encoding, $F(1,92) = 22.3$, $p < .001$, $\eta_p^2 = .20$. Again, those who used sentence encoding on List 2 performed worse on interference pairs than those who used imagery. While control performance was also affected by List 2 encoding, it was not influenced nearly as much as performance on interference pairs. Sentences on List 2 create stronger interfering memories, but also reduce reminding as noted in the section on recollection of change.

I predicted that performance on interference pairs relative to control pairs would have varied dependent on whether List 1 and List 2 encoding methods were the same or different; however this triple interaction did not reach significance, $F(1,92) = 2.92$, $p = .09$, $\eta_p^2 = .03$. The effects of same vs. different encoding were not apparent in overall interference performance; however, it may have merely been overshadowed by effects of encoding strategy. Sentence encoding on List 1 provided significantly better control performance, and on List 2 sentence encoding provided greater interference and less reminding. Given the effect of different encoding, participants who use sentence encoding on both lists perform much differently on control vs. interference than participants who use imagery on both lists, even though both conditions used the same encoding between lists. The large amount of variance means that it would take a large number of participants to show a significant effect, suggesting that we may be underpowered to detect a significant triple interaction.

Some facet of sentence encoding in the present experiment seems to prevent reminding during List 2. Along with the greater potential for interference offered by a stronger method of encoding, less reminding translates into more interference. Sentence creation may in fact be so demanding on attention that participants were exclusively focused on the task at hand, without sufficient time to think of other things, including pairs from List 1. Berntsen (1998) found in a diary study that involuntary autobiographical memories, which are very similar to a reminding of a prior related experience, rarely happen when a participant is heavily engaged in an attention demanding task. In fact remindings happen much more often when attention is diffuse and the participant is not otherwise occupied. In Experiment 4 the timing of 8 seconds of study for each word pair was specifically chosen because participant recordings from Experiment 3 indicated that this was the upper range of time taken to make a sentence. Unknowingly, this manipulation may have driven down reminding rates by creating time pressure, particularly for the more complex task of making a sentence.

One possibility is that the rate of reminding is dependent on available time for the second encoding task (Negley & Kelley, In preparation), encoding strategy, and the relationship between the two. A more demanding encoding task may not result in the same probability of reminding as a less demanding task if the same amount of time is given. It may seem counterintuitive that better encoding by making sentences rather than mental images would be less likely to trigger a reminding. If a word pair is encoded better, one may be inclined to believe that it would activate more related concepts and experiences than a less effective encoding. However, being reminded may not occur during encoding itself, but rather during some extra time that is not being filled by a demanding task. Additional time may allow people to look back to other relevant experiences, such as prior list pairs.

Table 7

Cued Recall Performance: Experiment 4

List 2 Encoding	List 1 Encoding	Control	Interference	Difference
Image	Image	0.70 (.03)	0.70 (.04)	0.00
	Sentence	0.83 (.03)	0.69 (.04)	0.14
Sentence	Image	0.63 (.03)	0.40 (.04)	0.23
	Sentence	0.77 (.03)	0.51 (.04)	0.26

Notes. Mean cued recall for all encoding conditions (SE).

2.5.2.3. Recall of Interference Pairs Conditionalized on Recollection of Change. A 2 X 2 X 2 repeated measures ANOVA was used to examine the rate of recall of interference pairs conditionalized on whether change was recollected or not at test across List 1 and List 2 encoding methods. There was a main effect of recollection such that when change was recollected recall was higher than when change was not recollected, $F(1,86) = 214.7$, $p < .001$, $\eta_p^2 = .71$. A main effect of List 2 encoding was also present, $F(1,86) = 18.2$, $p < .001$, $\eta_p^2 = .18$. Further analyses reveal that when participants who used sentence encoding on List 2 did not recollect change, they exhibited greater interference than those who created mental images on List2, $F(1,89) = 13.2$, $p < .001$. Lack of recollection of change does seem to be more detrimental when sentences are made during List 2, consistent with the notion that sentences produce strong encoding and have more potential to interfere with previously learned material. Combined with the decreased probability of reminding due to the demands of sentence creation during List 2, the negative impact of lack of recollection of change explains the large degree of interference observed when sentence creation is used on List 2. Returning to the classical conception of interference as response competition (Banks, 1969), when a competing response becomes strengthened by better encoding, retrieval of the target becomes more difficult. No effect of List 1 encoding on conditionalized recall was evident, $F(1,86) = 1.80$, $p = .18$, $\eta_p^2 = .02$, nor was there an interaction between item type and List 1 encoding, $F(1,86) = 1.10$, $p = .30$, $\eta_p^2 = .01$, an interaction between item type and List 2 encoding, $F(1,86) = 2.23$, $p = .14$, $\eta_p^2 = .03$, or a triple interaction, $F(1,86) = 0.47$, $p = .49$, $\eta_p^2 = .01$.

When recall of interference pairs conditionalized on recollection of change is compared to control performance, there is facilitation relative to recall of control pairs when reminding occurs, $t(89) = 4.34$, $p < .001$, and interference relative to control when there is a lack of reminding, $t(89) = 13.7$, $p < .001$, as in Wahlheim and Jacoby (2013) (See **Figure 5**). Further analyses revealed that encoding method seemed to moderate the effect of recollection of change. When sentences were created on List 1, no significant facilitation compared to control performance resulted from recollecting change, $t(44) = 1.29$, $p = .21$. However, those who created mental images on List 1 did have significant facilitation when change was recollected, $t(44) = 5.06$, $p < .001$. While lack of facilitation when List 1 was encoded via sentences may seem odd given the previous experiments and prior research (Wahlheim & Jacoby, 2013), the level of control performance due to sentence encoding in the current experiment was also exceptional. Levels of recall on control pairs were higher than ever previously shown in this series of experiments, allowing little room for facilitation for interference pairs when change is recollected.

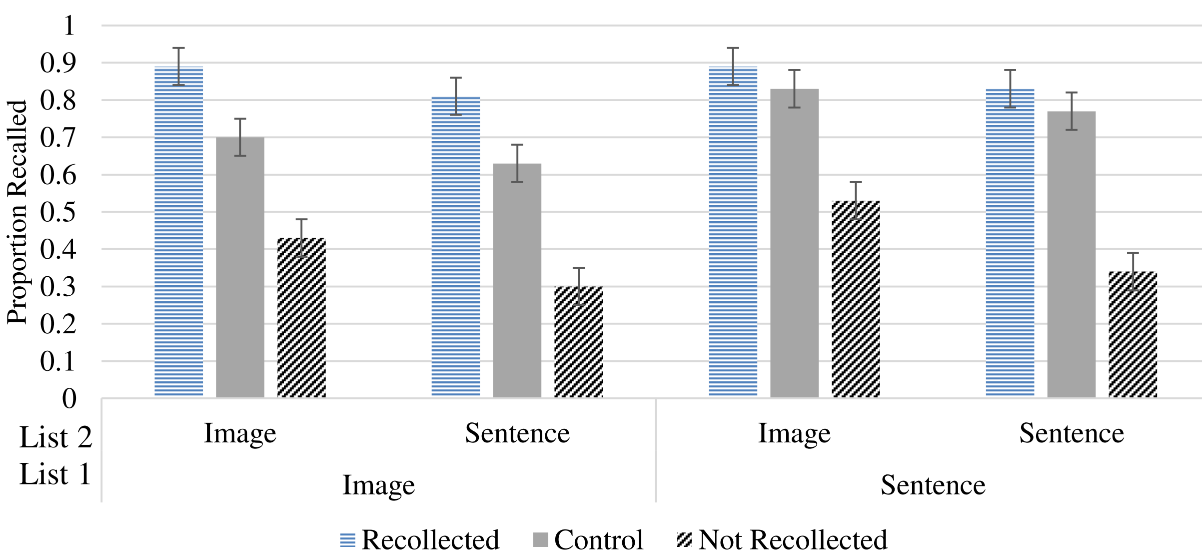

Figure 5. Recall Conditionalized on Recollection of Change: Experiment 4

Varying encoding similarity had some impact on rate of reminding, such that those who used the same encoding method between lists were reminded more often, as predicted. However, the differences between mental imagery and sentence creation also affected recall. Sentence creation was a demanding task that enhanced control memory on List 1, but offered greater potential for interference when used during List 2, and may have prevented reminding from occurring during List 2.

CHAPTER 3

GENERAL DISCUSSION

This series of five experiments sought to explore the differences between differentiation and reminding in avoiding interference. The classic interference literature, as well as source monitoring literature, favors differentiation as a way to reduce interference. However, while differentiation may be useful in these tasks, it may not truly be the truly most effective way to aid recall. Activating previously learned material during the learning of new, related material is also beneficial in escaping interference. Reminding can, in fact, create facilitation compared to control performance, while differentiation would at best eliminate interference resulting in performance equal to control (See Jacoby, Wahlheim, & Kelley 2015). Jacoby, Wahlheim, and Kelley (2015) find that when a reminding occurs in an A-B, A-D paradigm there is retrieval of the A-B pair. In a retroactive interference experiment, where participants are tested on List 1, retrieval strengthens memory for A-B, much like the effects of retrieval in the testing effect. In a proactive interference experiment, where participants are tested on List 2, memory for the A-B pair and a memory for the fact that a change occurred provide additional cues to retrieve the A-D pair at test.

The results of Experiments 1-3 showed some partial, but scattered, support for the idea that reminding is more beneficial for memory than differentiation in typical interference situations. Experiment 1 showed that in a proactive interference paradigm, a manipulation of instructions could successfully influence the rate of recollection of change, which is an indirect measure of reminding taken at the time of test. Next, Experiment 2a revealed a reduction in retroactive interference for those in the reminding condition compared to those in the differentiation condition. These results were not, however, replicated in Experiment 2b.

Experiment 3 adopted a strong paradigm for differentiation, using different encoding methods between lists in both instruction conditions. While my intention was that differing encoding would allow those in the differentiation condition to truly differentiate the two lists, it may have caused both conditions, even those told to be reminded, to differentiate lists so much that reminding seldom occurs. The most compelling evidence for the importance of being reminded among the first 4 experiments was that Experiment 3 seemed to create a circumstance of extreme differentiation, yet overall interference was nonetheless observed. If differentiation were truly the best way to avoid interference, then one might expect Experiment 3 to show performance on interference pairs equal to that of control pairs; however, this was not the case.

The strong effects of encoding manipulation pointed me toward a powerful means of contrasting the effects of reminding and differentiation in Experiment 4. Differing encoding in order to create differentiation, while keeping encoding consistent to promote reminding, proved to be an influential manipulation. It was predicted that different task contexts between lists would create a reduction in recollection of change, and this prediction was confirmed. While reminding was influenced as intended between same and different encoding groups, differing effects emerged dependent on the specific encoding strategy used. Demanding sentence encoding during List 2 decreased rates of reminding. One may have assumed that the very process of deep encoding would trigger high rates of reminding of similar material that was encoded with the same method; however, this does not appear to be the case.

Other research done in the Kelley lab has used the sentence encoding task, but with longer encoding time. All participants were given sentence encoding on both lists in a proactive interference paradigm, and encoding time was 12 seconds rather than the 8 seconds used here. Results revealed that 12 seconds of study time for each word pair during List 2 resulted in more reminding and better performance on interference pairs than the 8 seconds of study time used in Experiment 4. Control performance was high at .85, but there was little interference (.80), compared to the .77 and .51 in Experiment 4. Recollection of change was much higher at .70, compared to the .37 in Experiment 4. A number of differences existed between the designs of these experiments apart from the timing, notably that participants were tested on List 2 and no background images were used in this related experiment. The most obvious difference across experiments that would explain such a large difference in reminding is that in my Experiment 4, participants may have been more pressured by the 8 seconds given to make a sentence, while those in the prior experiment in the lab were given 12 seconds.

The idea that reminding happens when people are not otherwise occupied is consistent with research in autobiographical memory. The majority of involuntary autobiographical memories seem to occur when attention is “diffuse,” or the individual is not highly engaged in the task at hand (Berntsen, 1998, Berntsen, Staugaard, & Sørensen, 2013). In order to further examine the importance of time pressure, another study is currently being run in the Kelley lab in which 8 seconds of sentence encoding is given for each word pair on List 1, while half of the participants receive 8 seconds to make sentences on List 2, and the other half receive 12 seconds on List 2. The hypothesis is that those with longer time to encode on List 2 will be reminded more often and exhibit less interference.

The complexity of separating out the effects due to encoding strength from those due to differentiation vs. reminding highlights a major difficulty in this series of experiments. The difficulty was in creating an appropriate way to contrast differentiation and reminding in an experimental setting. Each experiment in this line has informed the technique for creating this contrast. Experiment 4 provided unique insight into the process of being reminded. Particularly, the idea that reminding, and the memory benefits associated with it, occurs when someone is unoccupied by encoding is a novel result worth further research.

The ability to understand the process of being reminded, and strategically employ this process where possible could be profoundly useful in both academic settings and everyday life. This line of experiments continues to peel back the curtain on the ubiquitous phenomenon of reminding by revealing that the time needed to allow reminding to occur may be dependent on the demands of the task at hand. Further research manipulating timing in different encoding circumstances (currently being carried out by the Kelley lab) can reveal optimal timing to allow deep encoding and extra time for prior memories to be retrieved.

Memory often suffers when attention is divided during retrieval (Wammes & Fernandes, 2016). Wammes and Fernandes (2016) found that, after studying a group of faces, when participants were required to complete a secondary task that requires the same type of processing as the memory task, during a recognition test, recognition suffers. As such, another potential avenue for future research could examine the effects of divided attention on memory and being reminded. It appears through Experiment 4 that engaging in a demanding encoding task can prevent a reminding of similar material, but will a secondary task prevent the memory benefit for a reminding? It has yet to be determined whether the benefits of reminding in an A-B, A-D paradigm are susceptible to the presence of a secondary task during retrieval. Under divided attention during retrieval, participants would need to allocate resources between tasks, which should influence how much is retrieved, and may prevent the retrieval of a reminding.

Is it more beneficial to differentiate or be reminded when we experience new things that are related to prior memories? Here I offer partial support for the benefit and facilitation of being reminded over the removal from interference typically observed with differentiation.

While instructional manipulation had inconsistent effects, control of encoding method proved to be influential in creating circumstances of differentiation and reminding. The amount of interference when the same encoding was used between lists was not significantly better, but was trending toward being better than when different encoding was used between lists. Given the variance caused by unforeseen differences in effects of encoding strategy and timing pressure, this may merely indicate a lack of sufficient power.

APPENDIX A

IRB APPROVAL

The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 2/16/2016

To: Nicholas Gray

Address: 4301
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Context and Cued Recall

The application that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and one member of the Human Subjects Committee. Your project is determined to be Expedited per per 45 CFR § 46.110(7) and has been approved by an expedited review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to thisapproval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 2/14/2017 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted forapproval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is FWA00000168/IRB number IRB00000446.

Cc: Colleen Kelley, Advisor
HSC No. 2016.17041

APPENDIX B

INFORMED CONSENT FORM

FSU Human Subjects Committee approved on 2/16/2016. Void after 2/14/2017.
HSC # 2016.17041

INFORMED CONSENT FORM: CONTEXT AND CUED RECALL

I freely and voluntarily consent to be a participant in the research project entitled "Context and Cued Recall." I have been informed that Nicholas Gray, a graduate student in the Department of Psychology, and Dr. Colleen Kelley, an Associate Professor in the Department of Psychology at Florida State University, have requested my participation in a research study at Florida State University.

The purpose of this research is to better understand the processes of memory. My participation will involve studying lists of words, taking a memory test for the material I have studied. The experiment will last between 30 minutes and 1 hour.

Compensation. I will receive research credit for General Psychology or extra-credit for any upper level psychology course I might be taking that offers extra credit for research. The rate at which I will receive ½ credit for any time up to 35 minutes, and an additional ½ credit if the experiment lasts between 35 minutes and an hour. If I chose to end the experiment early for any reason, credit will be pro-rated. This credit is the only direct benefit that I will receive for my participation; however, I may also benefit from learning about memory. Depending on the method of recruitment, I may instead be offered monetary payment, $5 dollars per half hour, rather than class credit for my participation.

Confidentiality. My performance on the memory test will be confidential to the extent allowed by law. No individual results of the experiments will ever be reported. My responses in the experiment will be associated with a unique number code, and there will be no link between that number and my identity.

Risk. There is a possibility that I may experience some mild frustration if I am unable to perform the task as well as I want. I am only to complete the task as best as I can. I understand that I am free to end my participation at any time without prejudice, penalty, or loss of benefits to which I am otherwise entitled. That is, I will still receive credit if I choose to withdraw from the experiment. I will receive a ½ credit for every 35 minutes that I participate.

I may contact Nicholas Gray (***************) or Dr. Kelley (***************** or ********) if I have questions about this project. If I have any questions about my rights as a participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at 644-8633.

I have read and understand this consent form.

____ __________________

(Participant) (Date)

ENDNOTES

[1] Special thanks goes to Chris Wahlheim for creating this measure

[2] My newly employed measure of reminding (i.e. asking if participants were reminded during List 2) did not differ significantly from “Yes/No” responses to the question of whether the pair changed from List 1 to List 2. For this reason, and the fact that these analyses necessitate examination of false alarms, those data are not reported here. The results of said analyses did not differ from those presented here.

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BIOGRAPHICAL SKETCH

Nicholas Gray was born and raised in Cincinnati, Ohio. He graduated with a Bachelor's degree in Psychology from Ohio State in 2012. As a graduate student he works under the guidance of Dr. Colleen Kelley. In the summer of 2016 Nicholas defended his Master's thesis in the field of cognitive psychology. Nicholas' research interests center around human memory, including the functionality and neuroanatomy of processes involved in memory. Nicholas enjoys spending his time outside of work in the outdoors, playing games, or exercising.