The Power of Optimal Encoding:
Distinctiveness and Differentiation Defeat Directed Forgetting

by

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A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Psychology

Waterloo, Ontario, Canada, 2008

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The goal of this dissertation is to examine circumstances that encourage optimal encoding in memory. To accomplish this, several encoding manipulations were examined in the context of intentional forgetting. The typically robust item method directed forgetting effect is attributed to selective rehearsal: Participants intentionally select the Remember items as having priority in memory and rehearse them, at the same time choosing not to rehearse Forget items. A series of new experiments demonstrate that when encoding is already optimal, intentional selection processes are ineffective at improving memory further, thus eliminating directed forgetting. These circumstances must serve to promote differentiation of items in a distinctive context. Distinctiveness is defined as a relatively well-remembered set of items standing out against a weaker background set of items. Differentiation refers to individual items being processed in a unique manner such that they stand out against all other items. Only when items are differentiated and in a distinctive context will optimal encoding occur and directed forgetting be eliminated.

Experiments 1-3 demonstrated that pictures, imagery, and production are all subject to intentional selection processes when studied alone (i.e., they produce directed forgetting). However, when these differentiated forms of encoding take place in the presence of weaker background items, encoding benefits from both differentiation and distinctiveness, and is optimal—resistant to intentional forgetting. Experiment 4 demonstrated that differentiation in a distinctive context is the key ingredient for eliminating directed forgetting: When encoding is improved with non-unique semantic processing, then item selection processes can still operate, and directed forgetting is produced.

Taken together, these experiments show that when differentiated items are studied in a distinctive context, the strong items are not subject to directed forgetting. Yet when these same differentiated items are studied in a non-distinctive context, directed forgetting does occur. Differentiation in the absence of distinctiveness is not sufficient to eliminate directed forgetting, nor is distinctiveness in the absence of differentiation sufficient to eliminate directed forgetting. Both encoding processes must be in place for directed forgetting to be abolished. This pattern provides evidence that optimal encoding can be achieved when differentiation occurs in a distinctive context.

Acknowledgments

I would like to thank my supervisor, Dr. Colin M. MacLeod, for guiding me throughout the extensive research process involved in producing this dissertation. I am grateful to Emily Bryntwick, Samatha Chaves, and Molly Pottruff for their assistance in programming and data collection. I would also like to thank Dr. Jonathan Fugelsang and Dr. Daniel Smilek for their insightful and constructive comments on this work.

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Human memory is ever-present, whether being used in a conscious, controlled manner, or operating without our awareness. Although our memories may ordinarily function without much effort, there also are many situations in which we intentionally focus our efforts on remembering certain things better than other things. Consider the simple task of planning an outing to a movie. As you peruse the list of movies that are playing, you read each movie title but choose to remember the show times for only a few movies. Even then, you decide to remember only the times that fit your schedule. When asked, you may be able to remember that there were other show times (and other movies) listed, but you will best remember the show times that are most relevant to your intentions. This is an example of where we can choose which items in a set are more important to us (the earlier show times for desired movies) than other items in the set (the movies we do not want to see and even the later show times for the desired movies). In everyday life, it is almost effortless to select important items out of a set as priority for our own memories, and to disregard and forget the irrelevant information. Our ability to use this memory selection process in various contexts is the focus of this dissertation.

Intentional forgetting

A necessary component of human memory is forgetting. Forgetting helps us to retain current information by replacing out-of-date information, such as when we forget a former phone number after learning a new one. Although it often feels like the ideal is to retain as much information as possible, it is in fact important to be able to forget or to edit information that is incorrect or no longer relevant. How do we accomplish this? How much forgetting is under our own control? Laboratory attempts to tackle these issues often use the directed forgetting paradigm (e.g., Golding & Long, 1998).

In the directed forgetting paradigm, participants are given a list of items to study for a memory test, but are told to forget some of the items (see MacLeod, 1998, for a review). When memory is later tested for all items, fewer of the to-be-forgotten items are reported: the directed forgetting effect. There are two different methods within the directed forgetting paradigm: the list method and the item method. In the list method, participants are told halfway through the list to forget the previous items (often with a cover story that the words were presented in error or were just for practice). The first half of the study list becomes the Forget list. Participants are told to remember the second half of the list for the memory test (the Remember list). When asked to recall the words from both list halves, participants recall fewer Forget list words than Remember list words. However, when tested with recognition memory, Forget list words are recognized as well as Remember list words, eliminating the directed forgetting effect.

The list method of directed forgetting is a useful tool for studying whether and how we can forget information that we have just learned (e.g., Bjork, 1989; Basden, Basden, & Gargano, 1993). However, the focus of this dissertation is how we can (and cannot) control the selection of information that we learn in the first place. Thus, the item method of directed forgetting is ideally suited for this pursuit. In the item method of directed forgetting, an instruction to Remember or Forget is paired with (usually following) each individual item on the study list. For each trial, participants know that they will be given a memory instruction, and that it may be to Forget the item just shown. When all studied items are tested with free recall, a directed forgetting effect is observed that is usually larger in magnitude than that produced by the list method (see MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). Unlike the list method, however, the item method produces directed forgetting effects on recognition tests as well. Even when re-presented with studied Forget items, participants cannot recognize them as well as the studied Remember items.

The robustness of the item method directed forgetting effect has generally been ascribed to a selective rehearsal mechanism (e.g., Basden et al., 1993; MacLeod, 1998). Again, participants know that each item they study will be followed by an instruction that may be to forget the item just presented. It is therefore efficient to delay any demanding rehearsal of the item until a Remember instruction is received, so as not to waste mental resources rehearsing items that (supposedly) will not be tested. Thus, Forget items are only maintained from the time of presentation to the time of instruction presentation; Remember items are more elaborated or simply rehearsed more when the instruction is presented. The item method directed forgetting effect therefore arises because the Forget items are not as well learned as the Remember items in the first place.

But is the process of selective rehearsal really as simple as it sounds? Are Forget items passively dropped from the rehearsal set while Remember items are not, or is the removal of Forget items from the rehearsal set a more demanding process? Taylor (2005) demonstrated that there are different spatial attention after-effects following Remember and Forget instructions. Attention seems to dwell on the location of a Remember item, while attention is withdrawn from the location of a Forget item (relative to a control condition without memory instructions). Functional magnetic resonance imaging (fMRI) indicates that a Forget instruction produces a different pattern of brain activity at the time of encoding than does a Remember instruction (Wylie, Foxe, & Taylor, 2008). Specifically, the right inferior frontal gyrus shows increased activation to a Forget instruction that is later successful (i.e., the item is a miss on a later recognition test), relative to a Remember instruction that is later unsuccessful (i.e., the item is also a miss on a later recognition test). Successful intentional forgetting produces different brain activity in areas involved in memory formation at the time of encoding than does unintentional forgetting (unsuccessful remembering).

The forgetting process appears to be one that is active, rather than passive (e.g., Fawcett & Taylor, 2008; Wylie et al., 2008). Certainly, item method directed forgetting effects demonstrate that we are capable of some form of memory selection. We can choose to select some items to learn better than other items presented in the same context. Yet there are many more circumstances wherein we learn some items better than other items simply due to the nature of the items themselves, the processing tasks that are completed on the items at the time of presentation, or the context in which the items are presented. Speaking to the role of presentation context, I will next examine the role of distinctiveness in memory.

Distinctiveness

Distinctiveness is a slippery concept. As Hunt (2006) is careful to point out, distinctiveness is not a property of a given item, but an abstract concept referring to mental processes that highlight the item(s) as standing out from a background context. That is, an item or set of items can only be distinctive *relative* to a weaker background context. Consider the isolation effect (e.g., Hunt & Lamb, 2001): An item that differs on some dimension from the majority of the background material will be remembered better. For example, the word “sheep” (the isolate) will be better remembered than other list items if all of the other items are vegetables. However, because distinctiveness is relative, and dependent on the background context, “sheep” will produce no memory benefit if presented in a list of farm animals. Thus the isolation effect is dependent on the processing of an item’s difference in the context of background similarity. In fact, the isolation effect can be eliminated by encouraging the processing of similarities among study items and the isolate (e.g., Smith & Hunt, 2000).

In the case of the isolation effect, it is clear that the isolate (sheep) is distinctive because it differs from the rest of the items on the list (vegetables). This exemplifies item-based distinctive processing (e.g., Hunt, 2003): A single item's difference from the rest of the list is processed, and processing this difference improves memory for that item. But what happens when participants are asked to study two lists: the original isolation effect list ("sheep" among vegetables) and a second list of unrelated items? When studying the original isolation list, "sheep" will be processed for its categorical difference from the background items, and is thus remembered better because of its item-based distinctiveness. However, when the second list of unrelated words is studied, the first list now stands out because of its internal similarities (all but one item from the same category), and thus items from the first list will be remembered better than items from the second list. Here, the entire event of the first list is distinctive, relative to the background context of the second list. This is event-based distinctiveness (e.g., Hunt, 2003). In this example, memory for the item "sheep" benefits from both item-based distinctiveness (because it was presented in the context of the vegetable list) and event-based distinctiveness (because the list it was presented in differs from the other list in the experimental context).

Clarification of terminology

Because these two forms of distinctiveness are central to this dissertation, I will further distinguish between item-based and event-based distinctiveness by reserving the term "distinctiveness" to refer to event-based distinctiveness. Item-based distinctiveness will be referred to as "differentiation" to highlight the fact that this process serves to differentiate a single item from others by focusing on a unique aspect of that item or by processing it in a unique manner. Thus, when describing an item as “distinctive,” I am referring to it being a member of a set of items that stands out against a background set of items. When describing an item as “differentiated,” I am referring to it being processed uniquely or having unique features that distinguish the item from all other items in the set (regardless of whether the set itself is distinctive).

Having clarified these terms, I must further clarify general terms that will be used throughout this dissertation. Because I will be discussing various encoding manipulations that improve memory relative to some control condition, I will generally refer to these encoding manipulations as “strong encoding” and to the control conditions as “weak encoding.” This is not meant to imply anything about the basis on which a “strong encoding” operates to improve memory (i.e., a form of “strong encoding” may be “differentiation”), only to generally refer to a manipulation that improves memory. Conversely, “weak encoding” is not meant to imply that memory is poor per se, or worse than some standard control condition, only to generally refer to the condition that produces poorer memory, relative to a “strong encoding.” For example, in considering the above example of the isolation effect list, the isolate itself is the strong encoding condition whereas the rest of the list items are the weak encoding condition.

Encoding manipulations

As mentioned earlier, although we are capable of selecting some items to learn better than other items (directed forgetting), there are many more circumstances wherein we learn some items better than other items for reasons other than our own selection strategies. This dissertation will consider four different sets of circumstances that affect how well we learn items, with the purpose of defining a particular set of circumstances that leads to optimal encoding. That is, certain circumstances at encoding allow items to be so well learned from the outset that they do not benefit further in memory from our intentional selection processes. In contrast, other circumstances improve memory but still allow for intentional selection processes to operate, further enhancing memory for the selected items. A summary of the encoding circumstances examined in this dissertation, along with the predicted patterns for directed forgetting, can be found in Table 1.

Generally speaking, some examples of circumstances that improve encoding without involving selection processes include the context in which the items are presented (distinctiveness), the nature of the items themselves, and the processing task that is completed on the item at the time of presentation. Focusing on the nature of the items themselves, this dissertation will consider the picture superiority effect: the robust finding that pictures are remembered substantially better than words (e.g., Shepard, 1967). In terms of processing tasks, this dissertation will consider imagery (e.g., Paivio, 1969), production (MacLeod, Gopie, Hourihan, & Neary, 2008), and level of processing (Craik & Lockhart, 1972). The purpose of examining these encoding manipulations is to demonstrate that differentiated encoding interacts with intentional selection processes differently than does undifferentiated encoding in a distinctive context. Specifically, the hypothesis is that differentiated items produce optimal encoding in distinctive contexts, whereas undifferentiated items do not. The result is that differentiated, distinctive encodings prevent selective rehearsal from having an influence.

Pictures

One of the best known findings in the memory literature is that pictures are remembered much better than words (e.g., Shepard, 1967). Our remarkable capacity to remember pictures is well demonstrated in Standing, Conezio, and Haber’s (1970) study that presented subjects with 1560 different pictures to study in two-hour sessions over a four-day period. When their memory was tested on a subset of the studied items using a two-alternative forced-choice recognition test, subjects were approximately 90% accurate in their recognition of the studied pictures, whether tested in their original orientation or in reverse orientation. Moreover, this “picture superiority effect” in memory holds not only for complex pictures like those of Standing et al. but also for simple object line drawings (e.g., Durso & O’Sullivan, 1983).

Aside from being highly memorable on their own, pictures are remembered better than words. Smith and Magee (1980) showed that pictures (line drawings of simple objects) tend to access different types of information than do the corresponding words. Their subjects completed either naming or categorizing tasks on stimuli where words were embedded in pictures. When asked to ignore the picture and attend to the word, subjects showed no interference from an incongruent picture on a naming (reading) task, but significant interference from an incongruent picture on a categorization task. The opposite was true for the same stimuli when subjects attended to the picture and ignored the word: Picture naming showed substantial interference from an embedded incongruent word, but picture categorizing was unaffected. Smith and Magee concluded that pictures tend to access semantic information more readily than name information. Processing items semantically has been shown to improve memory (e.g., Craik & Lockhart, 1972), so the picture superiority effect may be driven by the superior semantic processing afforded to pictures compared to words.

More recent research has also examined the role of both semantic and perceptual information in the picture superiority effect. Hamilton and Geraci (2006) proposed, contrary to other theories, that the picture superiority effect was not driven by perceptual distinctiveness of pictures per se. Instead, they claimed that the visual information provided by a picture draws attention to unique semantic features for that item. That is, the visual information is conceptually diagnostic, and thus the item is more memorable because it is highly differentiated on the basis of semantic information. They supported this theory by showing that the picture superiority effect is only observed on conceptual implicit tests when the test relies on semantically diagnostic features of the item rather than on general semantic information. Thus, converging with Smith and Magee's (1980) findings, pictures seem to access semantic information preferentially, relative to words. Pictures may be more memorable because they are highly differentiated, and thus seem a likely candidate for producing optimal encoding when studied in a distinctive context.

Imagery

Like pictures, mental imagery improves memory (Paivio, 1969), so dramatically that it is the basis of many mnemonic techniques. There are numerous studies examining imagery effects in memory (see Engelkamp, Zimmer, & de Vega, 2001, for a brief review), and many more studies examining imagery in diverse areas well beyond memory (e.g., spatial cognition and navigation; Denis, Daniel, Fontaine, & Pazzaglia, 2001). In memory, mental imagery produces robust memory benefits whether encoding is intentional or incidental (Paivio, 1969, 1971). Generally, imagery instructions are manipulated between subjects because carryover effects can be problematic (i.e., it is difficult to stop imaging some items once it has been used on other items in the same experiment; Paivio & Yuille, 1969). Even when imagery is manipulated between subjects, researchers must ensure that the control group participants are not spontaneously using imagery strategies (Engelkamp et al., 2001). For the most part, imagery effects tend to follow the same patterns as picture effects in memory. As with pictures, there is far too much research on imagery to thoroughly review it here. For this dissertation, it suffices to say that imagery very reliably improves memory (Paivio, 1969, 1971), and does so in part because each item is uniquely processed. Imagery, therefore, may also be capable of producing optimal encoding that does not benefit from further selection processes when studied in a distinctive context.

Production

The production effect is the simple observation that when some words are read aloud (produced) at study, and other words are read silently, the produced words are remembered better than the words read silently (MacLeod et al., 2008). This effect is robust, and is effective for pictures (pictures named aloud or silently at study), for non-words, for words generated from definitions, when produced words are only mouthed, and even when production is imagined. The production effect occurs in both free recall and recognition, and under both intentional (MacLeod et al., 2008) and incidental (MacDonald & MacLeod, 1998) encoding conditions.

The production effect relies on distinctiveness (MacLeod et al., 2008). The additional unique information of having read (or mouthed, or imagined reading) the word aloud at the time of study serves as a useful cue at the time of test for discriminating studied words from unstudied words. This is likely a conscious process, given that the production effect is only observed in recollection responses and not in familiarity responses when participants are asked to make Remember/Know judgments at recognition (Gopie & MacLeod, unpublished). Furthermore, the production effect is not observed in a between subjects design (MacLeod et al., 2008), indicating that the memory benefit for the produced words is only relative to a weaker background context: the words read silently. And the production effect is eliminated when the distinctiveness of production is undermined (Ozubko & MacLeod, unpublished).Although production may not improve memory with pictorial information (like studying pictures or imaging the referents of words), the fact that production relies on distinctiveness and differentiation also makes it a good candidate to produce optimal encoding.

Level of processing

Perhaps the best known encoding manipulation is Level of Processing (Craik & Lockhart, 1972; Lockhart & Craik, 1990). The idea behind the level of processing framework is that the more meaningfully (deeply) an item is processed, the more likely it is to be remembered. Experimentally, this is generally accomplished by requiring participants to complete an orienting task at the time of study, which usually takes the form of answering a question about each presented word. For example, deciding whether a word is printed in capitals requires only relatively shallow processing because the question can be answered by merely assessing a few of the word's letters, and consequently produces relatively poor memory. Deciding whether a word fits into the "animal" category requires deeper processing because the word must be read completely and analyzed semantically, and consequently produces relatively good memory. The earliest studies (e.g., Craik & Tulving, 1975) also examined the phonemic level of processing (deciding whether a word rhymes with "train", for example), but the majority of later studies generally consider only one Shallow condition (perceptual analysis) and one Deep condition (semantic analysis) (e.g., Gardiner, Java, & Richardson-Klavehn, 1996).

The level of processing manipulation produces very robust effects in explicit memory, with deeply processed words remembered better than shallowly processed words both in free recall (e.g., Moscovitch & Craik, 1976) and in recognition (e.g., Craik & Tulving, 1975). Deep processing leads to more recollective memory than does Shallow processing (e.g., Gardiner et al., 1996). Level of processing effects occur whether encoding is incidental or intentional (e.g., Craik & Tulving, 1975). Although level of processing effects are larger for Deep processing when unique processing questions are used for each item (Moscovitch & Craik, 1976), consistently answering the same Deep processing question still improves memory, relative to Shallow processing. In this manner, Deep processing does not serve to differentiate studied items from one another. While semantic analysis certainly improves memory, it does so by analyzing each item for the same semantic information (e.g., how pleasant is it? Is it an animal?), and thus unique aspects of studied items are not highlighted at encoding. Deciding whether “table” is a living thing cannot differentiate “table” from other studied items if all other items in the set were processed for the same information: “table” will not be differentiated from the other non-living items in the strong encoding condition. Thus, deeply processed items are distinctive when they are presented with shallowly processed background items, but are not well differentiated because they are not processed for unique information.

Level of processing effects do not rely solely on distinctiveness, however; semantic processing does improve memory even when depth of processing is manipulated between subjects (e.g., Hyde & Jenkins, 1969, 1973). In this dissertation, I will use the modern levels of processing manipulation (i.e., one Deep and one Shallow level, with consistent questions for each level) to demonstrate that optimal encoding is not achieved when memory is improved in a non-differentiated manner, regardless of whether the context is distinctive. That is, semantic processing will improve memory, but item selection processes will still be able to operate on this encoding to improve memory for the selected items, even when studied in a distinctive context.

Rationale

The goal of this dissertation is to demonstrate that our ability to select which information is important to remember is dependent on the context in which the information is presented. Certain encoding circumstances exist that produce optimal encoding, such that our ability to select items is overridden. Specifically, I will examine how memory under the different encoding manipulations just described is affected by item method directed forgetting instructions. Further, I will demonstrate that directed forgetting effects are dependent on the context in which items are presented, and not solely on the items or encoding manipulations in and of themselves.

The core idea is that, for the most part, we are able to select some information to learn better than other information when we wish to do so. This is why item method directed forgetting effects are so robust (MacLeod, 1998). However, there are conditions under which information is so well learned at first exposure that our efforts to further select among these learned items are not useful. That is, there are conditions under which directed forgetting effects are not observed. For example, when a Forget instruction is not expected and words are rehearsed for several second as if they were to-be-remembered, then item method directed forgetting is eliminated (Hourihan & Taylor, 2006). When we have selected an item for memory, we can change our minds about it, so long as we have not rehearsed it too much.

This dissertation will focus on the interaction between item differentiation and a distinctive study context and how these study list properties ultimately influence our ability to select. Both differentiation and distinctiveness improve memory, as does our intentional selection of an item as to-be-remembered. However, I propose that when items that are both differentiated and distinctive are presented for study, they will be so readily learned that selecting some of these items as preferential to be learned will not work. That is, items that are both differentiated and distinctive are encoded optimally, and should not be subject to directed forgetting effects. This is one of the central facts to be demonstrated by the experiments in this dissertation.

Although differentiation on its own will certainly improve memory, differentiated items can still be selected for further priority in memory. When a set of items is differentiated in the distinctive context of having a more weakly encoded background against which to stand out, they are already so well learned at the time of encoding (i.e., the differentiation process) that further selection among them will not succeed in differentially influencing memory. Any further rehearsal of these highly memorable items either does not take place or is ineffective at improving memory for these items beyond their initially encoded state.

Empirically, this argument would be expressed as an interaction between memory instruction and encoding condition, such that the weak encoding condition produces directed forgetting effects but the strong encoding condition does not. This is another of the central facts to be demonstrated by the experiments in this dissertation. Note that it is essential that items are both distinctive and differentiated to eliminate the directed forgetting effect. An encoding manipulation that improves memory via differentiation would still be subject to directed forgetting effects in a non-distinctive context. That is, if there were no weak encoding condition to constitute a background against which the strong encoding condition could be distinctive, differentiation alone would not be sufficient to eliminate directed forgetting. When items are sufficiently encoded, there is no need to further rehearse them to ensure their memorability. Items that are differentiated in a distinctive context meet the conditions of optimal encoding and are not easily forgotten.

This dissertation presents four pairs of experiments examining how the encoding manipulations described above are affected by directed forgetting. For each manipulation, strong and weak encoding conditions are studied together in a randomized trial procedure, with half of the items in each encoding condition followed by a Remember instruction and the other half followed by a Forget instruction. I predict that strong encoding conditions that improve memory via differentiation will not produce directed forgetting when studied in a distinctive context. That is, when studied in a mixed list presentation, strong items will not be subject to directed forgetting whereas the weak items that accompany them will produce directed forgetting. Further, I will show that it is not simply that strong encoding always eliminates directed forgetting, by showing that the same strong encoding produces directed forgetting when studied in a pure list context (i.e., without a weak background against which the items can be distinctive).

In the first experiment, I compare pictures (strong encoding) to words (weak encoding). Because pictures are highly differentiated both perceptually and conceptually, picture stimuli seem like the best candidate for obtaining optimal encoding. I will show that, when studied with a weak background context of words, pictures are not subject to directed forgetting. However, when pictures are studied alone in a pure list context, they are subject to directed forgetting. In the second experiment, I compare pictorial imagery to word imagery. Imagery improves memory via differentiation in a similar manner to actual pictures. Because of the strong similarities between perceived pictures and imagined pictures, imagery will produce the same pattern as picture stimuli.

In the third experiment, I will show that memory does not have to be improved with pictorial information to be differentiated. Using the production effect, I will show that produced words (strong encoding) are not subject to directed forgetting when studied in the context of read words (weak encoding). However, when all words are produced, they are subject to directed forgetting. Finally, in the fourth experiment, I will examine levels of processing to demonstrate that when memory is improved in a non-differentiated manner, then both strong encoding (Deep) and weak encoding (Shallow) are subject to directed forgetting. That is, when items are distinctive but not differentiated, then optimal encoding is not produced, and items can still be further selected for enhancement in memory.

Experiment 1: Pictures

Pictures are memorable, at least in part, because they are highly differentiated. The rich perceptual details of a picture (even of a simple line drawing) highlight the unique semantic information associated with the picture's referent (Hamilton & Geraci, 2006). Considering the vast amount of research that has examined memory for pictures, it is surprising that there are only two studies that have applied directed forgetting instructions to picture materials (Lehman, McKinley-Pace, Leonard, Thompson, & Johns, 2001; Basden & Basden, 1996). Basden and Basden (1996) compared the list and item methods using words, words with imagery instructions, and pictures. However, they used only a very small number of items (24 total), all from the same taxonomic category (animals). Although they did observe an item method directed forgetting effect in free recall of pictures, it is difficult to tell whether their results would generalize to pictures that were not members of the same category. Given the now quite extensive research on retrieval-induced forgetting (see, e.g., Anderson, 2003) showing that selectively strengthening some members of a category is detrimental to the recall of other studied members of that category, it is not clear that Basden and Basden's results would replicate with unrelated pictures, nor indeed that they are not evidence of retrieval induced forgetting rather than directed forgetting.

Furthermore, this dissertation emphasizes how the interaction between differentiation and distinctiveness affects our ability to select items for memory enhancement. Therefore, directed forgetting effects for pictures will be examined in both a pure list context (cf. Basden & Basden, 1996), and a mixed list context. The prediction is that, as the strong encoding material, pictures will show directed forgetting only when studied in the pure list context. In the mixed list context, where words will serve as the weak encoding context, pictures will become distinctive, and hence the prediction is that pictures now will not show directed forgetting. This will be the case despite the weak encoding material—the words—showing reliable directed forgetting.

Experiment 1A

In this experiment, participants studied a list of pictures and words, presented in random order. Half of each type of study material was followed by a Remember instruction and the other half was followed by a Forget instruction. Immediately following study, memory was tested with a recognition test. The prediction is that, in this distinctive context, pictures should not produce directed forgetting whereas words should. Pictures will fail to show directed forgetting because they are made distinctive in the presence of the words.

Method

Participants

Twenty-one individuals from the University of Waterloo participated in Experiment 1A in exchange for course credit or pay. All participants reported normal or corrected-to-normal vision. None of the participants in this experiment had participated in any of the other experiments in this dissertation.

Materials and apparatus

The pictures used in this experiment were selected from the pool of 244 object pictures available online as freeware from the set used by Székely et al. (2003). These pictures are line drawings of common objects in black on a white background. From the 244 pictures, 100 were selected for their visual clarity and naming consistency to compose the stimulus pool for this experiment. The words were selected from a pool of 100 words (see Appendix A), and were presented in 18-pt black Courier font. Study lists were created individually for each participant from a random selection of 120 items (60 words and 60 pictures) from the two pools.

An IBM-compatible microcomputer with a 15-inch colour monitor was used for testing. The controlling program was written in E-Prime (version 1.1.4.1, Schneider, Eschman, & Zuccolotto, 2002). The same apparatus and computer programming software were used for all of the experiments reported in this dissertation.

Procedure

Participants were informed that they would be shown a list of items to learn for a memory test, but were not told the exact nature of the test. The study phase consisted of 120 trials. Half of the trials presented words and the other half presented pictures; half of each of these types of materials was followed by a Remember instruction and the other half was followed by a Forget instruction. Participants were told that they should try to remember items followed by a Remember instruction, but that items followed by a Forget instruction did not need to be remembered because they would not be tested. Item order and memory instruction were randomly determined for each subject. Each trial began with a fixation cross (“+”) presented at the centre of the screen for 500 ms. After a 500 ms blank screen, the picture or word was presented at the centre of the screen for 2000 ms. Following a 500 ms blank screen, the memory instruction was presented at the centre of the screen for 2000 ms. A 1000 ms blank screen preceded the next trial.

Following completion of the study phase, participants were given instructions for the recognition test. They were asked to respond “yes” to every picture or word that they had previously seen, regardless of the memory instruction that had followed the item during study. The studied pictures (30 Remember and 30 Forget) and words (30 Remember and 30 Forget) were all presented on the recognition test, along with 30 new pictures and 30 new words from the pools. Presentation order was randomly determined for each subject. On each trial, the picture or word was presented at the centre of the screen and remained visible until the subject responded "Yes" by pressing the "m" key or "No" by pressing the "z" key. A 500 ms blank preceded the next trial.

Results

The mean proportions of "Yes" responses on the recognition test are shown in the first row of Table 2. A 2 (memory instruction; Remember vs Forget) x 2 (materials; pictures vs words) repeated-measures ANOVA was conducted on the proportions of "Yes" responses to studied materials. The main effect of memory instruction was significant ($F(1, 20) = 8.03$, $MSe = .009$, $p = .01$, $\eta^2_p = .287$), with Remember items (.81) recognized better than Forget items (.75) overall. The main effect of materials was also significant ($F(1,20) = 54.97$, $MSe = .013$, $p < .001$, $\eta^2_p = .733$), with pictures (.87) recognized considerably better than words (.68) overall. Importantly, the main effects were qualified by a significant memory instruction x materials interaction, $F(1,20) = 15.48$, $MSe = .005$, $p < .01$, $\eta^2_p = .736$. Planned comparisons revealed that whereas words produced the typical directed forgetting effect, with Remember items recognized better than Forget items ($t(20) = 3.77$, $p < .01$), there was no directed forgetting effect for pictures ($t(20) = 0.00$, $p = 1.0$). Note that a power analysis cannot be computed on this null effect because the means are identical (i.e., an infinite number of participants would be required for the observed "difference" to be significant). Finally, a one-sample t-test showed that recognition of pictures was significantly less than 1.0, indicating that performance was not at ceiling ($t(20) = 3.55$, $p < .01$, for Remember and $t(20) = 5.65$, $p < .001$, for Forget).

Discussion

As predicted, pictures did not produce directed forgetting effects when studied in the context of a weaker background (words). The picture superiority effect was observed, showing the usual benefit of memory for pictures over words; this was true for both Remember and Forget items. Differentiated items studied in a distinctive context are sufficiently encoded that they are not subject to any further memory selection processes.

Experiment 1B

In Experiment 1A, pictures did not produce directed forgetting effects when studied with words. However, it is possible that pictures are simply so well differentiated that they will never produce directed forgetting effects, regardless of whether they are studied in a distinctive context. The goal of Experiment 1B was to determine whether pictures, which are highly differentiated, are subject to directed forgetting when they are not distinctive—when there are no weakly encoded items with which to contrast the pictures. The hypothesis is that, when pictures are studied in a pure list condition, they should be subject to memory selection processes and therefore should display directed forgetting.

Method

Participants

Twenty undergraduates from the same pool as Experiment 1A participated in the experiment. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The pictures used in this experiment consisted of the 100 pictures used in Experiment 1A as well as an additional 20 pictures selected from the same original source. Study lists were created individually for each participant from a random selection of 80 items from the pool. Memory instructions consisted of a row of capital letters (“RRRRR” for Remember or “FFFFF” for Forget), and were presented in 18-pt black Courier font. The apparatus and software were identical to those used in the previous experiment.

Procedure

The study phase was nearly identical to that of Experiment 1A, except that there were 80 trials and only pictures were presented (40 Remember and 40 Forget). Between the study phase and the recognition test, participants completed an implicit picture naming task on half of the studied items; the remaining half of the studied items were presented on the recognition test. The picture naming task presented a random half of the studied pictures (20 Remember and 20 Forget) along with 20 of the new pictures not previously shown from the pool of 120 pictures. The results of the implicit test are not relevant to this dissertation, and therefore will not be discussed.

Participants then were given instructions for the recognition test. They were asked to respond “yes” to every picture that they had previously seen, regardless of memory instruction during study. The remaining half of the studied pictures (20 Remember and 20 Forget) that had not been shown on the picture naming task were presented on the recognition test, along with 20 new pictures from the pool. Presentation order was randomly determined for each subject. On each trial, the picture was presented at the centre of the screen and remained visible until the participant responded “Yes” by pressing the “m” key or “No” by pressing the “z” key. A 500 ms blank preceded the next trial.

Results

Recognition performance

The mean proportions of “Yes” responses on the recognition test are shown in the third row of Table 2. A paired-samples t-test revealed a reliable directed forgetting effect—a greater proportion of Remember pictures was recognized than of Forget pictures, $t(19) = 5.86$, $p < .001$. A one-sample t-test showed that recognition of pictures was significantly less than 1.0, indicating that performance was not at ceiling ($t(19) = 6.29$, $p < .001$, for Remember and $t(19) = 9.19$, $p < .001$, for Forget).

Comparison with Experiment 1A

The directed forgetting effect for pictures was computed for both experiments by subtracting the proportion of Forget pictures recognized from the proportion of Remember pictures recognized. A t-test showed that the size of the directed forgetting effect was significantly larger in the pure list context than in the mixed list context ($t(39) = 4.88$, $p < .001$). Separate one-sample t-tests showed that the directed forgetting effect was significantly larger than zero in the pure list context ($t\ (19) = 5.86$, $p < .001$) but did not differ from zero in the mixed list context ($t(20) = 0.00$, $p = 1.0$).

Discussion

As predicted, this experiment demonstrated that when pictures are studied alone (i.e., without a distinctive context), they are subject to directed forgetting. This fits well with the sparse literature examining directed forgetting of pictures, extending Basden and Basden’s (1996) findings obtained using categorically related pictures. Even very highly memorable stimuli, like pictures, are subject to intentional item selection processes. However, when studied in the presence of a weaker background context, as in Experiment 1A, pictures are not subject to intentional item selection processes and do not produce directed forgetting.

Taken together, the results of Experiments 1A and 1B demonstrate that when study materials are highly differentiated by nature, they are still subject to directed forgetting effects when studied on their own. However, these same highly differentiated items are not subject to directed forgetting effects when placed in a distinctive context by being studied with weaker background items.

Experiment 2: Imagery

I have shown that when the information we study is in a pictorial format, items are differentiated from one another, but that when studied in a distinctive context, these same pictures do not produce directed forgetting. With pictures, items are differentiated because the rich perceptual features serve to highlight an item's unique semantic features (cf. Geraci & Hamilton, 2006). Empirically, instructions to form a pictorial mental image produce memory effects very similar to those produced by pictures themselves (e.g., Basden & Basden, 1996). The key difference is that mental imagery requires participants to create the picture image themselves, and thus it is the process enacted on the item (based on the experimenter's instruction) rather than the item itself that drives differentiation. Therefore, the participant adds the unique information that differentiates items, rather than the unique information being present in the item itself (or accessed relatively automatically, as with pictures; cf. Smith & Magee, 1980). Thus, although pictures are highly differentiated materials, imagery is a highly differentiating process which should still produce optimal encoding when items are studied in a distinctive context.

In the context of directed forgetting, there is only one study that has examined how directed forgetting instructions affect imaged words. In the same experiment that examined pictures, Basden and Basden (1996) examined both list and item method directed forgetting effects for words studied with instructions to form a mental image of each word as it was presented. As with pictures, they found directed forgetting for imaged words under both variants of directed forgetting. However, the words used in this experiment were the names of the pictures used, and therefore all items came from the same single taxonomic category, so it is difficult to determine whether Basden and Basden's results would replicate with a list of unrelated items.

Although it may be true that imaged words are subject to directed forgetting in a pure list context, there are no data examining a mixed list context. Yet one of the practical difficulties in using imagery instructions experimentally is that it is difficult to manipulate imagery successfully within subjects (Paivio & Yuille, 1969). Once a participant has begun to image words, they are aware of how effective it is, and may then image all presented words (whether intentionally or unintentionally), even those for which they were not instructed to do so. Blocked instructions have some success, but there are carryover effects if imagery instructions are given in block one that could contaminate block two results. Thus, this powerful encoding strategy is difficult to stop on a trial-by-trial basis, at least in the absence of an alternate task to perform.

For the critical theoretical framing in this dissertation, imagery must be examined not only by itself in a pure list design but also in the distinctive context of a mixed list design, intermingled with more weakly encoded background items. The typical control condition (again, generally manipulated between subjects) used in imagery experiments features standard learning instructions—simply to study the words for a later memory test. As stated above, it is not practical to require participants to carry out imagery on some trials and simply learn the word on other trials in the same study phase. Thus, participants must be given an alternate task to perform on non-imagery trials to prevent imagery from occurring.

To address the practical difficulty of requiring participants to use imagery on some trials and not on others, a new "shallow imagery" task was devised for use in the present experiment. In this shallow imagery condition, participants are presented with a word in lower case letters and are asked to imagine the word instead printed in upper case letters (cf. Roediger & Blaxton, 1987). This instruction was designed to occupy processes similar to those involved in typical pictorial imagery to prevent those processes from occurring, but to do so without actually improving memory substantially on a later memory test. Pilot testing of this new shallow imagery task required participants to perform either the usual pictorial imagery task (hereafter referred to as "Deep imagery" for simplicity) or the new Shallow imagery task at study, in a mixed list, randomized trials study phase. Results indicated that the manipulation functioned as intended: Words studied under Deep imagery instructions were recognized at least 30% better than words studied under Shallow imagery instructions. Participants reported little difficulty in performing the two different imagery tasks in the randomized trial procedure used.

Experiment 2A

Thus armed with an appropriate weak encoding condition to serve as the background context against which imaged words could be distinctive, Experiment 2A examined how, when they occur together in a mixed list design, Deep and Shallow imagery are affected by directed forgetting instructions. Participants were presented with a list of words to study, half of the list under instructions to form a pictorial mental image and the other half under instructions to form a mental image of the word in capitals. Half of the items in each of the two imagery conditions were followed by a Remember instruction and the other half were followed by a Forget instruction. The prediction was that, in the distinctive context of the background of Shallow imaged items, the highly differentiated Deep imaged items would not display directed forgetting whereas the Shallow imaged items would.

Method

Participants

Twenty-eight individuals from the same pool participated in Experiment 2A. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The item pool consisted of 160 words ranging from 4 – 7 letters in length obtained from the MRC online database (2008). The items were relatively high in imageability, ranging from 506-667, with a mean of 602 (compared to the mean rating of 480 for the entire database, which ranges from 100-700) (see Appendix B).

From the 180 words, a random 120 were selected for study for each participant, with 60 items assigned to the Deep imagery condition and 60 items assigned to the Shallow imagery condition. Half of the items in each imagery condition were followed by a Remember instruction ("RRRRR") and the other half were followed by a Forget instruction ("FFFFF"). Memory instructions and imagery condition were randomly determined for each participant. The remaining 60 items from the pool not selected for study were presented as foils on the recognition test. All study words and memory instructions were presented in 18-pt black Courier font on a white background. The apparatus and software were identical to those used in the previous experiments.

Procedure

Participants were informed that they would be shown a list of items to learn for a memory test, but were not told the exact nature of the test. They were told that they would be asked to perform one of two types of imagery for each word. When a word followed the "IMAGE" instruction, they were to imagine a picture of the word's referent, and to press the spacebar when they had formed the image. If a word followed the “CAPS” instruction, they were to imagine the word printed in capital letters, and to press the spacebar when they had formed the image.

The study phase presented 120 words, 60 preceded by the “IMAGE” instruction and 60 preceded by the “CAPS” instruction. Half of each of these words were followed by a Remember instruction and half were followed by a Forget instruction. Participants were told that they should try to remember items followed by a Remember instruction, but that items followed by a Forget instruction did not need to be remembered because they would not be tested. Item order, imagery condition, and memory instruction were randomly determined for each subject. Each trial began with a fixation cross (“+”) presented at the centre of the screen for 500 ms. Following a 500 ms blank, the imagery task instruction (either “CAPS” or “IMAGE”) was presented at the centre of the screen for 1000 ms. The word was then presented at the centre of the screen for 3000 ms. Following a 500 ms blank screen, the memory instruction was presented at the centre of the screen for 2000 ms. A 500 ms blank screen preceded the next trial.

Following completion of the study phase, participants were given instructions for the recognition test. They were asked to respond “yes” to every word that they had previously seen, regardless of memory instruction during study. The studied words (30 Deep Remember, 30 Deep Forget, 30 Shallow Remember, and 30 Shallow Forget) were intermingled with the remaining 60 new words from the pool that had not been. Presentation order was randomly determined for each participant. On each test trial, the word was presented at the centre of the screen and remained visible until the participant responded “Yes” by pressing the “m” key or “No” by pressing the “z” key. A 500 ms blank preceded the next trial.

Following completion of the test phase, participants were asked the following questions: (1) On the trials where you were asked to imagine the word in capitals, were you able to successfully do so? If not, how often were you unsuccessful? (2) Did imagining the word in capitals prevent a picture image from also forming, or did you find that pictures sometimes spontaneously came to mind? If so, how often did this happen? These questions were included to ascertain the success of the Shallow imagery condition.

Results

Study phase latencies

Image formation times at study were provided by 23 participants (the remaining four participants either did not press the spacebar at all or did not press it during the 3000 ms of word presentation). On average, participants took 1311 ms (*SE* = 76.92) to form an image in the Deep condition and 1319 ms (SE = 75.99) to form an image in the Shallow condition; these latencies did not differ from one another, $t(22) = .187$, $p = .853$. Note that image formation times were collapsed across memory instruction because the instruction occurred after the response latency was collected. Nevertheless, a repeated measures ANOVA was conducted on the response latencies for the four study conditions (Remember Deep, Remember Shallow, Forget Deep, and Forget Shallow) and showed no differences among the conditions ($F(3, 66) = 1.08$, $MSe = 25431.73$, $p = .36$, $\eta_p^2 = .047$).

Recognition performance

Initially, the data were analyzed removing any participants who reported that they always or nearly always experienced pictorial images while performing the CAPS imagery task, on the grounds that these participants were not actually performing two different imagery tasks. This removed eight participants from the analysis. The data were also analyzed retaining these participants. Although some effects were slightly larger with these eight participants removed, the pattern of results was identical. Therefore, the reported analysis includes all 28 participants.

The mean proportions of "yes" responses on the recognition test are shown in the first row of Table 3; the third row displays the means excluding the 8 participants mentioned above. A 2 (memory instruction: Remember vs Forget) x 2 (imagery task: Deep vs Shallow) repeated-measures ANOVA was conducted on the recognition responses to studied items. The main effect of memory instruction was significant ($F(1,27) = 11.33$, $MSe = .008$, $p < .01$, $\eta_p^2 = .296$), with Remember words (.79) better recognized than Forget words (.73). The main effect of imagery task was also significant ($F(1,27) = 48.70$, $MSe = .018$, $p < .001$, $\eta_p^2 = .643$), with words in the Deep imagery condition (.85) considerably better recognized than words in the Shallow imagery condition (.67). Finally, the memory instruction x imagery task interaction was also significant ($F(1,27) = 13.24$, $MSe = .002$, $p < .01$, $\eta_p^2 = .330$). Planned comparisons revealed that whereas Shallow images produced the typical directed forgetting effect ($t(27) = 4.02$, $p < .001$), there was no directed forgetting effect for Deep imaged words ($t(27) = 1.42$, $p = .17$).

Given the theoretical interest in the observed null difference, a power analysis of the comparison between Remember Deep and Forget Deep was conducted. The observed difference of 0.02 produced a δ value of 0.987. To obtain a power of 0.80, this small effect would require approximately 217 participants to reach statistical significance (at $p = .05$). Note that observed power for the 0.089 difference between Remember Shallow and Forget Shallow was already 0.80 ($\delta = 2.79$). The power analyses were re-calculated on the dataset excluding the eight participants who were unable to prevent pictorial images from forming at study. This smaller data set produced an observed difference of .0065 between Remember Deep and Remember Shallow, resulting in a δ value of 0.246. To obtain a power of 0.80, this even smaller effect would require approximately 923 participants to reach statistical significance (at $p = .05$). Again, the observed power for the 0.082 difference between Remember Shallow and Forget Shallow was approximately 0.56 ($\delta = 2.12$). Finally, a one-sample t-test showed that recognition of Deep imaged words was significantly less than 1.0, indicating that performance was not at ceiling ($t(27) = 4.80$, $p < .001$, for Remember and $t(27) = 6.26$, $p < .001$, for Forget).

Discussion

Paralleling the pattern of results observed in Experiment 1A, where pictures and words were studied together, the present experiment found that imaged words did not display directed forgetting when studied in the context of more weakly encoded words. First, it is important to point out that the new Shallow imagery task served its function: Most participants reported that they did not form a pictorial mental image on these trials, and memory for Shallow imaged words was markedly worse than memory for Deep imaged words. Yet this relatively weak encoding condition did display directed forgetting. It is worth noting that this non-pictorial imaging task may prove to be quite useful as a control task for those who wish to examine imagery effects in a within subjects context.

Although the Shallow imaged words did display directed forgetting, the more differentiated, Deep imaged words did not in the context of the weaker background. Again, this parallels the results of Experiment 1A quite nicely; in fact, examination of Tables 2 and 3 shows that the cell means for each memory instruction and encoding condition are nearly identical across the two experiments. As is usual in most memory experiments examining the effects of mental imagery, imagining the referents of concrete nouns functioned almost identically to actually seeing pictures during study.

Experiment 2B

As was the case when pictures were studied in the context of words in Experiment 1A, Deep imaged words in Experiment 2A did not display directed forgetting when studied in the context of Shallow imaged words. The account put forth here is that Deep imaged words became distinctive and differentiated when studied in the context of weaker Shallow imaged words, and hence were no longer subject to selective rehearsal. What should we expect to happen when Deep imaged words are studied alone, without the weaker encoding context of the Shallow imaged words? Imaged words generally function like pictures, except that the picture that arises during imagery is self-generated rather than physically present. That is, imagery requires the participant to process the item to arrive at a picture image, rather than viewing an actual picture. However, because this differentiating process does not occur in a distinctive context words encoded via imagery should still be subject to further item selection when studied in a pure list design.

The goal of Experiment 2B was therefore to demonstrate that whereas imagery serves to differentiate studied items, those items will still be subject to directed forgetting when presented in a non-distinctive context: a pure list study condition. In this experiment, participants were given a list of highly imageable words to study, and were instructed to form a mental image of each word as they read it. Half of the words were followed by a Remember instruction and the other half were followed by a Forget instruction. All items were tested on a recognition test immediately following study. As seen with pictures in Experiment 1A, it was predicted that imaged words would display a directed forgetting on the recognition test.

Method

Participants

Twenty-six individuals from the same pool participated in Experiment 2B. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The item pool consisted of 120 of the 160 words used in Experiment 2A. The mean imageability rating for this pool was 579 (see Appendix B). From the 120 words, a random 80 were selected for study, with half followed by a Remember instruction (“RRRRR”) and the other half followed by a Forget instruction (“FFFFF”). Memory instructions and item order were randomly determined for each participant. The remaining 40 items from the pool not selected for study were presented as foils on the recognition test. All study words and memory instructions were presented in 18-pt black Courier font on a white background. The apparatus and software were identical to those used in the previous experiments.

Procedure

Participants were informed that they would be shown a list of words to learn for a memory test, but were not told the exact nature of the test. They were instructed to form a mental image of each word as they read it, and to press the spacebar when they had formed the image (although no response latency was collected in this experiment; the instruction here served to encourage participants to form an image on every trial). The study phase presented 80 words, 40 followed by a Remember instruction and 40 followed by a Forget instruction. Participants were told that they should try to remember items followed by a Remember instruction, but that items followed by a Forget instruction did not need to be remembered because they would not be tested. Each trial began with the word presented at the centre of the screen for 3000 ms. Following a 500 ms blank screen, the memory instruction was presented at the centre of the screen for 1000 ms. A 500 ms blank screen preceded the next trial.

Following completion of the study phase, participants were given instructions for the recognition test. They were asked to respond “yes” to every word that they had previously seen, regardless of memory instruction during study. The studied words (40 Remember and 40 Forget) were presented along with the remaining 40 new words from the pool that had not been seen at study. Presentation order was randomly determined for each participant. On each trial, the word was presented at the centre of the screen and remained visible until the participant responded “Yes” by pressing the “m” key or “No” by pressing the “z” key. A 500 ms blank preceded the next trial.

Following completion of the test phase, participants were asked the following questions: (1) Did you feel like you had enough time to form an image of each word?; (2) Were there any words that you could not image in time? If so, about how many?; (3) Did you form an image of all the words as you read them, or did you wait for the “R” instruction before trying to form an image?; and (4) Did you find the memory test easy?

Results

Recognition performance

The mean proportions of “yes” responses on the recognition test are shown in the fifth row of Table 3. A paired-samples t-test revealed a significant directed forgetting effect: Remember words were recognized better than Forget words, $t(26) = 3.99$, $p < .01$. Based on their responses to the debriefing questions, participants were grouped according to their reported imagery strategy. Of the 26 participants in the experiment, 15 reported forming a mental image of each word as they read it; the remaining 11 participants reported that they waited for the memory instruction and only imaged Remember words. The mean proportions of “yes” responses on the recognition test for each of these two subgroups are shown in the seventh and ninth rows of Table 3.

A 2 (memory instruction: Remember vs Forget) x 2 (imagery strategy: as read vs waited for instruction) mixed ANVOA was conducted on the hits to studied items on the recognition test. A main effect of memory instruction was present ($F(1,24) = 23.96$, $MSe = .008$, $p < .001$, $\eta_p^2 = .500$), but the main effect of imagery strategy was not significant ($F(1,24) = 2.09$, $MSe = .032$, $p = .16$, $\eta_p^2 = .080$). However, the memory instruction x imagery strategy interaction was significant ($F(1,24) = 7.95$, $MSe = .008$, $p < .01$, $\eta_p^2 = .249$). Planned comparisons revealed a significant directed forgetting effect both for the participants who imaged as they read ($t(15) = 2.22$, $p < .05$), and for those who waited for the memory instruction and only imaged Remember words ($t(11) = 3.92$, $p < .01$), although the effect was significantly smaller for those who imaged each word as they read it ($t(24) = 2.82$, $p < .01$. Finally, a one-sample t-test showed that recognition of imaged words was significantly less than 1.0, indicating that performance was not at ceiling ($t(25) = 6.56$, $p < .001$, for Remember and $t(25) = 7.54$, $p < .001$, for Forget).

Comparison with Experiment 2A

The directed forgetting effect for Deep imaged words was computed for both experiments by subtracting the proportion of Forget words recognized from the proportion of Remember words recognized. A t-test showed that the size of the directed forgetting effect was significantly larger in the pure list context than in the mixed list context ($t(52) = 8.52$, $p < .001$). Separate one-sample t-tests showed that the directed forgetting effect was significantly larger than zero in the pure list context ($t\,(25) = 3.99$, $p < .001$) but did not differ from zero in the mixed list context ($t(27) = 1.42$, $p > .10$).

Discussion

As predicted, when presented in a non-distinctive, pure list context, imaged words are subject to directed forgetting. These results extend Basden and Basden’s (1996) findings in free recall, obtained using a categorically related study list. Highly differentiated items, like those which have been imaged, are still subject to intentional item selection processes. In this pure list condition, the difference in participant imagery strategies is particularly interesting.

Typically, imagery is difficult to manipulate within subjects because it is such a powerful encoding mechanism. Participants may (intentionally or unintentionally) use imagery even for the items that they are instructed to learn under standard (i.e., non-imagery) conditions (Paivio & Yuille, 1969. In the present experiment, some participants employed the opposite strategy to facilitate not learning Forget items: They waited for the memory instruction before beginning the imagery process to prevent this strong encoding from happening on a Forget trial. Here, rather than using selection strategies to improve the encoding of Remember items, selections strategies were used to prevent the application of a good encoding operation to Forget items. This exemplifies an active (rather than passive) selective rehearsal account of item method directed forgetting. The effect of this intentional strategy is clear in the data: Participants who waited to image recognized substantially fewer Forget words (.66) than did participants who imaged each word—whether ultimately Remember or Forget—as it was presented (.80), rather than waiting for the instruction.

Taken together, the results of Experiments 2A and 2B demonstrate that when study items are highly differentiated by an elaborate, pictorial imagery process, they are still subject to directed forgetting when studied in a pure list context. Yet, when these differentiated items are studied in the context of weaker background items that make up a distinctive context, they do not produce directed forgetting. This pattern coincides completely with that observed for actual pictures in Experiment 1.

Experiment 3: Production

Thus far, I have demonstrated that two different strong encoding manipulations produce directed forgetting when there is also a weaker encoding condition present at the time of study (mixed list) but not when encoded alone (pure list). I have argued that this is because the manipulations on their own—whether of items (pictures) or processing mode (imagery)—serve to highly differentiate the studied items from one another. In such a distinctive context, the strong encoding condition is so well learned that further intentional selection processes either are not used or do not improve memory further.

Differentiation has been defined as an item either being processed uniquely or possessing unique features that make that item distinguishable from the other items in the study list. First, I showed that pictures, which have unique features, produce the predicted memory pattern based on differentiation in a distinctive context (no directed forgetting) and non-distinctive context (directed forgetting). Second, I showed that mental imagery, which requires a process that creates a unique representation for each item, produces this same memory pattern. In both cases, the unique information involved in differentiating studied items from one another is pictorial, whether physically present in perceiving the item (pictures) or created at the time of encoding (imagery). As discussed, pictorial information is both visually and conceptually rich, and provides relatively elaborate information at encoding beyond the distal stimulus. What if items were to be differentiated in a less elaborate manner than is the case with pictures and mental images? Are items that are differentiated in a non-pictorial manner also subject to the same dependence on the distinctiveness of the study context to produce optimal encoding?

To demonstrate that it is differentiation of items per se, and not their representation as pictures, that drives the dependence on context to produce directed forgetting, the third experiment uses another encoding task: production. As discussed previously, the production effect is the observation that when some items are read aloud and other items are read silently, Aloud items are later remembered better than Silent items. The production effect relies on the additional unique information of having read the word aloud serving to differentiate the Aloud items from the Silent items; production does not improve memory unless the weaker Silent encoding condition is present at the time of encoding (MacLeod et al., 2008). Thus, the production effect itself is entirely dependent on distinctiveness, whereas both picture superiority effects and imagery effects improve memory even without a distinctive context. That is, they still produce effects in a between subjects design, whereas production does not. Reading aloud does not seem to provide sufficiently differentiating information to improve memory unless those items read aloud are in the context of more weakly encoded items—those read silently.

Thus the production effect is ideal for testing the present hypothesis: that any encoding manipulation that differentiates items at study will not be subject to directed forgetting if studied in a distinctive context. Given that the differentiation provided by production is relatively weak, showing that production results in the same memory pattern as pictures and imagery would support the theory that it is differentiation itself, and not pictorial information specifically, that determines the pattern of directed forgetting in a distinctive (mixed list) and non-distinctive (pure list) context.

Experiment 3A

In this experiment, participants studied a list of words by reading half of them aloud and half of them silently. Half of each of the Aloud and Silent words were followed by a Remember instruction and the other half were followed by a Forget instruction. The prediction is that, in this distinctive context, words in the Aloud condition should not produce directed forgetting on a standard explicit recognition test whereas words in the Silent condition should.

Method

Participants

Fifty-five individuals from the same pool participated in Experiment 3A. None had participated in any of the other experiments in this dissertation. Two participants were removed from the study because their false alarm rates were greater than 70%, resulting in 53 participants contributing to the final analyses.

Materials and apparatus

The item pool consisted of the same 120 words that appeared in MacLeod et al. (2008; see Appendix C). All stimuli were presented in 16-point lower case font against a black background. From the 120 words, a random 80 were selected for study, with 40 presented in blue and 40 in white, in random order. Half of the items presented in each colour were followed by a Remember instruction (“RRRRR”), and the other half were followed by a Forget instruction (“FFFFF”). Memory instructions were randomly determined and were always presented in yellow.

For the recognition test, 20 words studied in each colour (10 Remember and 10 Forget), plus the remaining 20 unused words from the pool, were presented in a new random order.[1] The apparatus and software were identical to those used in the previous experiments.

Procedure

In the study phase, participants were instructed to read the words presented in blue aloud and the words presented in white silently. They were informed that each word would be followed by an instruction indicating whether the word just shown would be tested; words followed by "RRRRR" were to be remembered for the memory test and words followed by "FFFFF" did not need to be remembered because they would not be tested.

Study trials began with a 250-ms blank preceding each word's appearance at the centre of the screen. Blue words were read aloud into a microphone, which caused the word to disappear; white words stayed on the screen for 2000 ms. Following a 250-ms blank, the memory instruction was presented for 3000 ms, followed by a final 2000 ms blank.

On the explicit recognition test, half of the blue words (10 Remember and 10 Forget), half of the white words (10 Remember and 10 Forget), and 20 unstudied new words were shown one at a time in random order, and the subject responded Yes (the "c" key) or No (the "m" key). Participants were told to disregard the initial memory instructions, and to respond "yes" to any item they had seen before, even if it had been followed by "FFFFF." All test items were presented in yellow font. There was a 500-ms blank before each word, and the word disappeared with the participant's key response. The next trial began immediately.

Results

The first row of Table 4 presents the recognition data expressed as proportions of "yes" responses. A 2 (memory instruction: Remember, Forget) x 2 (production: Aloud, Silent) repeated measures ANOVA was conducted. This revealed a main effect of memory instruction ($F(1,52) = 11.81$, $MSe = .017$, $p < .001$, $\eta_p^2 = .185$), with Remember words (.75) better recognized than Forget words (.69) overall. There was also a main effect of production ($F(1,52) = 38.86$, $MSe = .022$, $p < .001$, $\eta_p^2 = .428$), with Aloud words (.79) better recognized than Silent words (.66) overall. The memory instruction x production interaction was marginally significant ($F(1,52) = 3.32$, $MSe = .016$, $p = .07$, $\eta_p^2 = .060$). Because of the marginal interaction, and consistent with the a priori hypothesis, theoretically motivated planned comparisons were conducted. These comparisons revealed that there was no directed forgetting for words studied Aloud, $F(1,52) = 1.42$, $p = .24$, but that words studied in the Silent condition did show reliable directed forgetting, $F(1,52) = 13.89$, $p < .001$.

Given the theoretical interest in the observed null effect of memory instruction in the Aloud condition, a power analysis of the comparison between Remember Aloud and Forget Aloud was conducted. The observed difference of 0.03 produced a δ value of 0.848. To obtain a power of 0.80, this small effect would require approximately 578 participants to reach statistical significance (at $p = .05$). Note that observed power for the 0.094 difference between Remember Silent and Forget Silent was 0.71. Finally, a one-sample t-test showed that recognition of produced words was significantly less than 1.0, indicating that performance was not at ceiling ($t(52) = 9.28$, $p < .001$, for Remember and $t(52) = 10.39$, $p < .001$, for Forget).

Discussion

As predicted, there was no directed forgetting effect for the Aloud words when studied in the context of a weaker background encoding: the Silent words. A production effect was observed for both the Remember and Forget items, but a directed forgetting effect was observed only in the weak encoding condition. These results are particularly informative because the differentiation involved in production is different from that involved with picture stimuli or imagery instructions. That is, produced words are differentiated from one another on the basis of the unique experience of saying that word aloud, and not on the basis of unique conceptual, pictorial information (whether perceived or imagined). The form of differentiation that occurs with production seems to be weaker than that involved with pictures or imagery, given that (1) production does not improve memory between subjects whereas pictures and imagery do, and (2) the benefit of production is considerably smaller than the benefit of either pictures or imagery.

Even when differentiation is not sufficient to produce between subjects effects, if studied in a distinctive context, strong items are not subject to further item selection processes. This indicates that any form of differentiation (i.e., unique processing) studied in a distinctive context can produce optimal encoding, not just pictorial processing in particular.

Experiment 3B

Given that the production effect itself is reliant on a distinctive encoding context, the weak differentiation provided by reading all studied words aloud will not be sufficient to eliminate directed forgetting in a pure list context. Particularly because the highly differentiated picture stimuli used in Experiment 1B and the imaged words used in Experiment 2B both still produced directed forgetting in a pure list context, produced words should also display directed forgetting in a pure list context. Thus, the present experiment was conducted to test this empirically: Participants studied a list of words by reading them all aloud. Half of the words were followed by a Remember instruction and half were followed by a Forget instruction. A recognition test was administered immediately following study, and a directed forgetting effect was predicted.

Method

Participants

Sixteen individuals from the same pool participated in Experiment 3B. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The item pool was the same as in Experiment 3A. All stimuli were presented in 16-point lower case font against a black background.

From the 120 words, a random 80 were selected for study, with 40 presented in blue and

40 in white, in random order. In fact, colour was not salient in this experiment, and was only retained for consistency, given that all items were to be read aloud. Half of the items presented in each colour were followed by a Remember instruction ("RRRRR"), and the other half were followed by a Forget instruction ("FFFFF"). Memory instructions were randomly determined and were always presented in yellow. All of the studied words, along with the remaining 40 items from the pool that had not been presented for study, were presented on the recognition test, in random order. The apparatus and software were identical to those used in the previous experiments.

Procedure

In the study phase, participants were instructed to read all presented words aloud and to ignore the colour of the words. They were informed that each word would be followed by an instruction indicating whether the word just shown would be tested; words followed by "RRRRR" were to be remembered for the memory test and words followed by "FFFFF" did not need to be remembered because they would not be tested.

Study trials began with a 250-ms blank preceding each word's appearance at the centre of the screen. Participants were asked to read each word aloud into a microphone when it appeared. Words stayed on the screen for 2000 ms. Following a 250-ms blank, the memory instruction was presented for 3000 ms, followed by a final 2000 ms blank.

Immediately following the study phase, participants were given instructions for the recognition test. Here, the 80 studied words (40 Remember and 40 Forget) and 40 unstudied new words were shown one at a time, and the participant responded Yes (the "c" key) or No (the "m" key). Participants were told to disregard the initial memory instructions, and to respond "yes" to any item that they had seen before, even if it had been followed by "FFFFF." Again, all test items were presented in yellow font. There was a 500-ms blank before each word, and the word disappeared with the participant's key response. The next trial began immediately.

Results

Recognition performance

The mean proportion of "Yes" responses on the recognition test are shown in the third row of Table 4. A paired-samples t-test revealed a directed forgetting effect—participants recognized a greater proportion of Remember words than of Forget words, $t(15) = 4.05$, $p < .01$. A one-sample t-test showed that recognition of words was significantly less than 1.0, indicating that performance was not at ceiling ($t(15) = 5.86$, $p < .001$, for Remember and $t(15) = 8.26$, $p < .001$, for Forget).

Comparison with Experiment 3A

The directed forgetting effect for produced words was computed for both experiments by subtracting the proportion of Forget words recognized from the proportion of Remember words recognized. A t-test showed that the size of the directed forgetting effect was significantly larger in the pure list context than in the mixed list context ($t(67) = 2.20$, $p < .05$). Separate one-sample t-tests showed that the directed forgetting effect was significantly larger than zero in the pure list context ($t\ (15) = 4.05$, $p < .01$) but did not differ from zero in the mixed list context ($t(52) = 1.21$, $p > .20$).

Discussion

The directed forgetting observed in this experiment indicates that reading words aloud does not prevent directed forgetting from occurring. This is unsurprising, given that directed forgetting was observed for the more highly differentiated pictures and imaged words in Experiments 1B and 2B when presented in a pure list context. Thus, although reading words aloud provides unique, differentiating item information, unless the study context is also distinctive, intentional memory processes can still select some items (Remember) as preferred for memory over others (Forget).

The results of Experiments 3A and 3B provide a third confirmation of an encoding manipulation that improves memory via differentiation, but only eliminates directed forgetting when that encoding occurs in a distinctive context (i.e., in the presence of a weaker encoding condition to serve as background items). Perhaps, though, these results are even more persuasive than those of Experiments 1 and 2, in which items were differentiated on an elaborate, pictorial basis. Recall that imagery and pictures produce memory benefits, relative to standard learning of words, in both within subject and between subject manipulations. That is, the differentiation that occurs with these manipulations is powerful enough to improve memory in general, not just to improve memory in one condition in the presence of another condition. Production, on the other hand, relies on distinctiveness to benefit memory. The unique differentiating information associated with reading words aloud is beneficial to later memory only when this information is associated with a portion of the studied words—when there is a weaker, background context of words read silently at study.

Discussion of Experiments 1-3

Experiments 1-3 demonstrate three different ways that encoding can be improved by differentiating items from one another via the encoding of unique item information. These experiments have shown that, in pure list conditions, these encoding manipulations are all subject to intentional item selection processes. Pictures, imaged words, and produced words all displayed directed forgetting when studied in a pure list condition. However, when a weaker encoding condition was added at study, these strong encoding manipulations became distinctive, relative to the weaker background, and no longer were subject to directed forgetting. I have argued that this is because the items are so well learned when they are made distinctive that any further selection processes either are not employed or are ineffective when differentiated items are studied in a distinctive context.

The obvious question is: Will every combination of strong and weak encoding manipulations result in the same data pattern? That is, could you ever observe directed forgetting for strong encoded items when studied in the context of weak encoded items? The answer, under the present account, is yes: When the strong encoding manipulation improves memory without differentiating studied items from one another, directed forgetting should still be observed even when the material is studied in a distinctive setting. For example, presenting an item multiple times improves memory relative to a single presentation (e.g., Hintzman, 1970; Nelson, 1977), but this clearly does not improve memory via differentiation. Although a participant might well remember that an item was presented several times, there is typically a set of items that was presented multiple times, and thus knowing this does not differentiate any of these items from one another. The items presented multiple times are therefore distinctive, but not differentiated. I have already shown that differentiation on its own is not sufficient to overcome directed forgetting (Experiments 1B, 2B, and 3B), and I will now show that distinctiveness on its own is not sufficient to overcome directed forgetting either. Only when differentiation occurs in a distinctive context is directed forgetting eliminated from the strong encoding condition.

Experiment 4: Level of Processing

The level of processing framework was originally devised as an alternate to the short-term store/ long-term store distinction in memory. Craik and Lockhart (1972) proposed that the way in which we initially process items determines how well they are remembered—the deeper the level of processing, the more memorable the item. Although early studies examining level of processing considered multiple levels of processing (e.g., Craik & Tulving, 1975; Moscovitch & Craik, 1976), discriminating multiple levels proved to be difficult (Baddeley, 1978; Nelson, 1977), so most studies now only consider one Deep and one Shallow condition (e.g., Gardiner et al., 1996). It is a robust finding that Deep processing (generally involving processing semantic properties of the item) results in better memory than Shallow processing (generally involving processing perceptual properties of the item), whether encoding is intentional or incidental (Craik & Tulving, 1975), and whether level of processing is manipulated between subjects or within subjects (e.g., Hyde & Jenkins, 1969, 1973).

It had not escaped researchers' attention that improving encoding in a directed forgetting paradigm might eliminate the usual directed forgetting effect. Wetzel (1975) conducted the first study examining how level of processing and directed forgetting interact, and found that orienting task only affected memory for Remember words and not Forget words (although orienting task was manipulated between subjects, and it is important to note that the group given standard learning instructions outperformed the Deep processing group). Horton and Petruk (1980) examined how depth of processing interacted with directed forgetting instructions depending on the inter-item relations in a given study list, and the relative timing of the memory instruction. Their basic results were that level of processing influenced both Remember and Forget items, though effects were often larger for Remember items, and the effects on Forget items depended on whether their semantic orienting task was compared to their phonemic or to their structure orienting task. Overall, Remember items were recalled and recognized better than Forget items, regardless of orienting task. Thus, early research did not indicate that improving encoding via semantic processing could eliminate directed forgetting.

More recently, Marks, Dulaney, and Link (2004) examined how level of processing and directed forgetting interact for both younger and older adults. Older adults tend to show smaller directed forgetting effects than younger adults (Zacks, Radvansky, & Hasher, 1996), indicative of a decline in the ability to selectively learn some items preferentially over other items presented in the same context. As did Zacks et al. (1996), Marks et al. (2004) found that, relative to their older adults, their younger adults produced larger magnitude directed forgetting. More relevant to this dissertation, they found that level of processing did not directly influence directed forgetting—even items that were processed semantically were forgotten.

In relation to this dissertation, Deep processing does not seem to influence directed forgetting, or at least not very consistently. I argue that this is because level of processing experiments typically require the same orienting task to be completed over and over again for every item in a given condition. That is, although it does require semantic analysis to judge how pleasant an item is (a typical Deep processing task), the same judgment is made for all Deep items, and therefore does little to differentiate the items from one another. No unique item information is encoded at the time of study, and thus items in each encoding condition (both strong and weak) are not differentiated from one another. Thus, although memory is improved by Deep processing, this is not accomplished via differentiation, yet it is the combination of differentiation and distinctiveness that eliminates directed forgetting in the strong encoding condition.

Experiment 4A

Despite several studies having examined how level of processing affects directed forgetting, most other studies have been interested in other research questions besides level of processing itself (e.g., how selective rehearsal can deal with related items: Horton & Petruk, 1980; how post-cue rehearsal time and aging affect directed forgetting: Marks et al., 2004), and therefore have included other experimental factors besides level of processing and directed forgetting. The present study will therefore examine only level of processing and directed forgetting to determine how the two factors operate in an otherwise uncluttered experiment. The goal is to demonstrate that, as found by past researchers, deeply processed words still produce directed forgetting. This is because Deep processing does not encourage differentiation of items from one another—it only promotes semantic processing. Therefore, Deep items will still be distinctive when studied in a mixed list (i.e., in the presence of Shallow items), but because they are not differentiated, they should still be subject to directed forgetting.

In this experiment, participants studied a list of words for each of which they answered a processing question. Half of the words were paired with a Deep processing question (“Is it living?”) that required analysis of the semantic properties of the word, and the other half of the words were paired with a Shallow processing question (“Is there an ‘e’?”) that only required analysis of the surface properties of the word. Half of the words in each of the Deep and Shallow conditions were followed by a Remember instruction, and the other half were followed by a Forget instruction. A recognition test for all studied words was administered immediately following study. It was predicted that both Deep and Shallow items would produce directed forgetting. Because the Deep condition requires the same semantic judgment to be made on all words, there is no unique information encoded with each item, and therefore Deep processing does not encourage differentiation. Although Deep items are distinctive in the context of Shallow items, they are not differentiated, and intentional item selection processes can still operate to produce directed forgetting.

Method

Participants

Twenty-seven individuals from the same pool participated in Experiment 4A. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The items pool consisted of 160 concrete nouns selected from the Battig and Montague category norms (1969). The items were selected so that half were living things (selected from the categories of birds, four-legged animals, fish, trees, flowers, insects, occupations, and relatives) and half were non-living things (selected from the categories of tools, metals, clothing, human dwellings, kitchen utensils, furniture, jewels, and musical instruments. Half of the items in each of these subsets contained at least one letter “e” and the other half did not contain the letter “e”. All words were presented in 18-pt black Courier font on a white background.

From the 160 words, a random 80 were selected for study, with 40 paired with the Deep processing question and 40 paired with the Shallow processing question, in random order. The Deep processing question was “Is it living?” and the Shallow processing question was “Is there an “e”?”. Half of the items presented in each condition were followed by a Remember instruction (“RRRRR”); the other half were followed by a Forget instruction (“FFFFF”). Order of memory instructions was randomly determined. The remaining 80 words from the pool were used as foils for the recognition test. The apparatus and software were identical to those used in the previous experiments.

Procedure

Before beginning the study phase, participants completed four practice trials (one trial in each condition). They were informed that they would have to answer a question about each word they studied. They were further informed that each word would be followed by an instruction indicating whether the word just shown would be tested; words followed by “RRRRR” were to be remembered for the memory test and words followed by “FFFFF” did not need to be remembered because they would not be tested.

Each study trial began with a fixation cross (“+”) presented at the centre of the screen for 1500 ms. The processing question then appeared centred at the top of the screen. After 1000 ms, the study word was then presented in a box at the centre of the screen for 3000 ms (the question remained visible at the top of the screen). Participants were instructed to answer the processing question about the word by pressing the “m” key to respond “yes” and the “z” key to respond “no.” The box surrounding the word disappeared when a keypress response was detected, but the word itself remained visible for 3000 ms. The word was then replaced by the memory instruction (either “RRRRR” or “FFFFF”) for 2000 ms. The memory instruction and processing question were then removed from the screen, and a blank screen was presented for 1000 ms prior to the next trial.

Immediately following the study phase, participants were given instructions for the recognition test. They were asked to respond “yes” to all words that they had previously seen and answered questions about, regardless of memory instruction at study. The studied words (20 Remember Deep, 20 Remember Shallow, 20 Forget Deep, and 20 Forget Shallow) were presented on the recognition test along with the remaining 80 words from the pool that had not been presented. Presentation order was randomly determined for each participant. On each trial, a fixation cross ("+") was presented at the centre of the screen for 500 ms. Following a 500 ms blank screen, the word was presented at the centre of the screen and remained visible until the participant responded "Yes" by pressing the "m" key or "No" by pressing the "z" key. A 1000 ms blank preceded the next trial.

Results

The mean proportions of "Yes" responses in each condition are shown in the first row of Table 5. A 2 (memory instruction; Remember vs Forget) x 2 (depth of processing; Deep vs Shallow) repeated-measures ANOVA was conducted on the proportions of "Yes" responses to studied materials. The main effect of memory instruction was significant ($F(1, 26) = 27.98$, $MSe = .043$, $p < .001$, $\eta_p^2 = .518$), with Remember items (.76) recognized better than Forget items (.55) overall. The main effect of depth of processing was also significant ($F(1,26) = 27.63$, $MSe = .009$, $p < .001$, $\eta_p^2 = .515$), with Deep processing (.70) resulting in better recognition than Shallow processing (.60) overall. The memory instruction x depth of processing interaction was not significant ($F(1,26) = 2.18$, $p > .10$, $\eta_p^2 = .077$). Planned comparisons revealed a directed forgetting effect (better recognition of Remember than Forget words) for both Deep ($t(26) = 4.48$, $p < .01$) and Shallow ($t(26) = 4.72$, $p < .01$) processing. Finally, a one-sample t-test showed that recognition of Deep words was significantly less than 1.0, indicating that performance was not at ceiling ($t(26) = 6.69$, $p < .001$, for Remember and $t(26) = 10.16$, $p < .001$, for Forget).

Discussion

As predicted, directed forgetting and level of processing did not interact—a directed forgetting effect was found for both Deep and Shallow items. Again, this coincides with the general finding in the literature that directed forgetting still operates on deeply processed items. This pattern of data is also distinctly unlike the pattern of data observed in the previous three experiments, in which the strong encoding condition did not produce directed forgetting when studied in a distinctive context. Here, the Deep items benefited from being studied in a distinctive context (i.e., against the background of the more weakly encoded Shallow items), but the orienting task did not serve to differentiate items from one another. Hence, they were not encoded well enough to countermand any intentional item selection processes, and directed forgetting was produced.

When differentiated items (e.g., pictures, mental images, produced words) are studied in a distinctive context, they will not be subject to directed forgetting, but when studied in a non-distinctive context, they will be. Conversely, when non-differentiated items are studied in a distinctive context, they will be subject to directed forgetting. The results of the present experiment provide converging evidence that both differentiation and distinctiveness are required to eliminate directed forgetting in the strong encoding condition: Neither differentiation nor distinctiveness alone are sufficient.

Experiment 4B

As with production, it seems highly unlikely that Deep processing in a pure list context would eliminate directed forgetting. This is especially unlikely, given that when Deep items are studied in the context of Shallow items, they are subject to directed forgetting because the items are not sufficiently differentiated. However, for completeness, this experiment examined how Deep processing in a non-distinctive context affects directed forgetting. Participants studied a list of words by answering a semantic orienting question (“Is it living?”) for each word that they studied; half of the words were followed by a Remember instruction and the other half were followed by a Forget instruction. A recognition test immediately followed study and, because semantic processing does not serve to differentiate items, nor is there a distinctive context present at encoding, a directed forgetting effect was predicted on this test.

Method

Participants

Sixteen individuals from the same pool participated in Experiment 4B. None had participated in any of the other experiments in this dissertation.

Materials and apparatus

The item pool consisted of 120 of the 160 words used in Experiment 4A (selected so that half of the items were living and half were non-living). From the 120 words, a random 80 were selected for study. Half of the items presented in each condition were followed by a Remember instruction (“RRRRR”), and the other half were followed by a Forget instruction (“FFFFF”). Order of memory instructions was randomly determined. The remaining 40 words from the pool were used as foils for the recognition test. All words were presented in 18-pt black Courier font on a white background. The apparatus and software were identical to those used in the previous experiments.

Procedure

Participants were informed that they would be given a list of words to study for a memory test, and that they would have to decide whether each word they studied was a living thing. They were further informed that each word would be followed by an instruction indicating whether the word just shown would be tested; words followed by “RRRRR” were to be remembered for the memory test and words followed by “FFFFF” did not need to be remembered because they would not be tested.

Each study trial began with a fixation cross (“+”) presented at the centre of the screen for

1500 ms. The processing question ("Is it living?") then appeared centred at the top of the screen. After 1000 ms, the study word was then presented in a box at the centre of the screen for 3000 ms (the question remained visible at the top of the screen). Participants were instructed to answer the processing question about the word by pressing the "m" key to respond "yes" and the "z" key to respond "no." The box surrounding the word disappeared when a keypress response was detected, but the word itself remained visible for 3000 ms. The word was then replaced by the memory instruction (either "RRRRR" or "FFFFF") for 2000 ms. The memory instruction and processing question were then removed from the screen, and a blank screen was presented for 1000 ms prior to the next trial.

Immediately following the study phase, participants were given instructions for the recognition test. They were asked to respond "yes" to all words that they had previously seen and answered questions about, regardless of memory instruction. The studied words (40 Remember and 40 Forget) were presented on the recognition test, along with the remaining 40 words from the pool that had not been presented at study. Presentation order was randomly determined for each participant. On each trial, the word was presented at the centre of the screen and remained visible until the participant responded "Yes" by pressing the "m" key or "No" by pressing the "z" key. A 500 ms blank preceded the next trial.

Results

Recognition performance

The mean proportions of "yes" responses on the recognition test are displayed in the third row of Table 5. A paired-samples t-test revealed a significant directed forgetting effect ($t(15) = 2.21$, $p < .05$). A one-sample t-test showed that recognition of words was significantly less than

1.0, indicating that performance was not at ceiling ($t(15) = 7.91$, $p < .001$, for Remember and $t(15) = 8.44$, $p < .001$, for Forget).

Comparison with Experiment 4A

The directed forgetting effect for Deep words was computed for both experiments by subtracting the proportion of Forget words recognized from the proportion of Remember words recognized. Opposite to the first three experiments, a t-test showed that the size of the directed forgetting effect was significantly smaller in the pure list context than in the mixed list context ($t(41) = 2.20$, $p < .05$). Also diverging from the first three experiments, separate one-sample t-tests showed that the directed forgetting effect was significantly larger than zero in both the pure list context ($t\ (15) = 2.21$, $p < .05$) and the mixed list context ($t(26) = 4.50$, $p < .001$).

Discussion

The directed forgetting effect observed in this experiment indicates that semantic processing does not prevent directed forgetting from occurring. Again, this is rather unsurprising, given that Deep processing also produced directed forgetting in Experiment 4A, when items were studied in a distinctive context. Moreover, much more highly differentiated items (pictures, imaged words) are subject to directed forgetting when studied in a non-distinctive context, so there is no reason to predict that relatively undifferentiated items would not be subject to these effects as well. Here, because all items were processed for semantic information in the same manner (i.e., determining an item’s living or non-living status), they were not differentiated—additional item information processed at encoding was not unique.

Taken together, the results of Experiments 4A and 4B demonstrate that encoding can be improved without differentiation, and that non-differentiated encodings are subject to the item selection processes invoked by the directed forgetting paradigm, even when studied in a distinctive context. This supports the claim that neither differentiation nor distinctiveness alone is sufficient to eliminate directed forgetting—only the combination of these two study list properties can override selection processes. Deep processing clearly improves memory, benefiting from distinctiveness (among other factors) in a mixed-list context, but deeply processed items can still be selectively forgotten.

General Discussion

Summary of Findings

A summary of the encoding circumstances examined and the observed pattern of directed forgetting effects is presented in Table 6. The first experiment in this dissertation examined how memory for pictures is affected by directed forgetting instructions and by study context—pictures were studied either in a pure list condition or in a mixed list condition, with words serving as the more weakly encoded background condition. It was found that pictures are subject to directed forgetting when studied in a pure list context. However, when pictures were studied in a distinctive context (i.e., in the presence of weaker, background items), directed forgetting was not found: Remember pictures and Forget pictures were recognized equally well when studied in the presence of words (which themselves displayed directed forgetting). Stimuli that are highly differentiated by nature, like pictures, apparently will not produce directed forgetting when studied in a distinctive context.

In the second experiment, mental imagery instructions were used to examine how processing a word in an elaborative, differentiating manner would affect directed forgetting in a distinctive vs a non-distinctive context. It was found that imaged words, like pictures, are subject to directed forgetting when studied alone in a non-distinctive, pure list context. However, when pictorial (Deep) imagery occurs in the context of letter (Shallow) imagery, Deep imaged words do not produce directed forgetting: Remember Deep and Forget Deep imaged words were recognized equally well when studied in a distinctive context.

The third experiment in this dissertation examined the production effect, an effect that, to occur in the first place, relies on distinctiveness, and serves to differentiate words only relatively weakly. Even with this relatively weaker form of item differentiation (i.e., compared to pictures or mental images), directed forgetting was not observed for Aloud words when studied in the context of weaker Silent words. When all words were studied Aloud, directed forgetting did occur. Even when item differentiation is not pictorial, differentiation in a distinctive context eliminates directed forgetting.

Finally, the fourth experiment in this dissertation examined an encoding task that improves memory without differentiating items. Level of processing improves memory, but typically does so by adding non-unique semantic information at the time of encoding (e.g., pleasantness or living/non-living status). Unlike the three other encoding tasks examined in this dissertation, level of processing does not interact with directed forgetting instructions. Because level of processing does not differentiate Deep studied items from one another, only distinctiveness was present in Experiment 4A, and thus both Deep and Shallow items displayed directed forgetting. It was not surprising that, with only Deep processing in Experiment 4B, directed forgetting persisted.

In sum, I have shown across four experiments that when differentiated items are studied in a distinctive context, the strong items are not subject to directed forgetting. Yet when these same differentiated items are studied in a non-distinctive context, directed forgetting does occur. I have shown that differentiation in the absence of distinctiveness is not sufficient to eliminate directed forgetting (Experiments 1B, 2B and 3B), nor is distinctiveness in the absence of differentiation sufficient to eliminate directed forgetting (Experiment 4A). Both encoding processes must be in place for directed forgetting to be abolished. The question remains: How does this interaction between differentiation and distinctiveness operate to eliminate directed forgetting?

How is the interaction between encoding and memory instruction produced?

As discussed in the introduction, the observation of item method directed forgetting generally is ascribed to a selective rehearsal process. Items are only maintained until the memory instruction is presented. Then, Remember items undergo further rehearsal and/or elaboration whereas Forget items are dropped from the rehearsal set. This is viewed as an active process (e.g., Fawcett & Taylor, 2008; Taylor, 2005; Wylie et al., 2008). Thus, one possibility is that we simply cannot keep track of which items are Remember and which are Forget when type of encoding varies randomly from trial to trial in the same experiment. Forget items might accidentally get rehearsed as much as Remember items if performing the different encoding tasks in a mixed list is simply confusing. This is unlikely to be the case, however, because we do not see the same pattern of results in the level of processing experiment, in which study items are not well differentiated. If it was simply a matter of confusing Remember and Forget instructions while performing different encoding tasks, we would expect the interaction pattern to be present for any two encoding manipulations; I have demonstrated that this is not the case.

An alternate possibility is that it is not differentiation per se that drives the interaction, but that strong encoding conditions demand more attention to the item at the time of encoding than do weak encoding conditions; this increased attention to items that are then Forget cued allows them to be recognized just as well as Remember items at the time of test. In the production task, for example, the strong encoding condition requires reading words aloud whereas the weak encoding condition requires reading words silently. It is clear in this case that the Aloud condition requires more processing at encoding than does the Silent condition; moreover, no explicit response is required on the Silent trials whereas a vocal response is required on Aloud trials. Pictures have more perceptual details than words do, which may attract additional attention to pictures at encoding; pictures may also spontaneously lead to semantic processing whereas words do not (e.g., Smith & Magee, 1980). Yet in the level of processing experiment, a keypress response was required on both Deep and Shallow trials, and the interaction was not produced. It may well be that it is this extra attention or the requirement to make an explicit response on a trial, rather than differentiation in a distinctive context, that eliminates directed forgetting in the strong encoding condition. This would mean that the reason that the interaction is not produced in the level of processing experiment is because a response was given on each study trial, not just on the strong encoding trials.

Again, however, this is unlikely to be the reason why differentiated encoding does not produce directed forgetting effects in a distinctive context. Experiment 2A examined mental imagery, and both the Deep and Shallow imagery tasks required very similar processes: formation of a mental image. The Deep task required a mental image of the presented word that was pictorial in nature whereas the Shallow task required an image of the presented word in only a slightly transformed manner. Both tasks also required a keypress response, and there was no difference in the amount of time that it took participants to complete the two different imagery tasks. Yet the highly differentiated pictorial images were not subject to directed forgetting when studied in the context of the less differentiated word images. The key difference between the tasks in Experiments 2A and 4A is that pictorial mental images serve to differentiate items uniquely from one another whereas the additional living/non-living information is consistent across items, and therefore does not add unique information. Both tasks require an overt response to each studied word, but only imagery encourages differentiation. Therefore, it is not likely to be the case that additional attention or the requirement of an explicit response at encoding are responsible for the observed interaction.

Having examined and rejected two possible ways in which this effect might occur, I will now describe two complementary alternative explanations for the fact that differentiated items do not produce directed forgetting when studied in a distinctive context. These explanations share the feature that, before the memory instruction is presented, a differentiated item in a distinctive context is simply very well learned. As alluded to throughout this dissertation, these two explanations differ on whether these well learned items are simply not rehearsed further, or whether the rehearsal processes operate, but are ineffective at differentially improving memory.

First, it may be that participants do not choose to further rehearse words when they are learned very well. That is, the process of differentiating a study item in a distinctive context may subjectively feel like the item is optimally learned, and that no further rehearsal is necessary. This is not to say that Remember items might not improve from additional rehearsal following the memory instruction, but that participants think that Remember items will not improve from further rehearsal, and thus focus their mental resources on completing the encoding task and selectively rehearsing the weak Remember items that they think will improve from further rehearsal. Because Forget items received the same processing as Remember items pre-instruction, and then they receive no further processing following the instruction, no directed forgetting is observed. To look at it another way, memory for the strong Remember items is reduced to the level of the strong Forget items because participants do not rehearse strong Remember items to their potential level of memorability. In essence, the strength of the Remember items is overestimated.

Second, it may be that participants do selectively rehearse the strong Remember items, but that the rehearsal that takes place is ineffective at improving memory beyond its current state. That is, the process of differentiating a study item in a distinctive context produces a form of encoding that actually is optimally learned, and thus further rehearsal cannot improve memory. In this case, normal selective rehearsal processes take place, but they are only effective at improving memory in the weak encoding condition. Rehearsal itself may be taking a very shallow, repetitive form that does improve memory, but only for weak encodings. Under this account, Remember items are rehearsed whereas Forget items are not rehearsed, but the circumstances of the initial encoding of strong items are such that they do not require further rehearsal to be very well remembered. To look at it another way, memory for the strong Forget items is improved to the level of the strong Remember items because the initial processing (differentiation in a distinctive context) actually produced optimal encoding.

This second explanation is favoured because it seems unlikely that most participants would truly be assessing the "need for rehearsal" on a trial-by-trial basis, and then using this metamemorial information to determine which of the Remember items should or should not receive further rehearsal. It is much more likely that participants attempt to employ a strategy of rehearsing all (and only) Remember items, and not rehearsing Forget items, but that the strong Forget items are so well encoded already that they are recognized as well as the strong Remember items even without further rehearsal. Admittedly, it is not entirely clear from the data which of these two possible explanations is actually taking place, but both explanations converge on the fact that differentiation in a distinctive context produces very good learning. What is critical is that these items are actually so well learned that they countermand our usual item selection processes.

Item selection processes

Throughout this dissertation, I have referred to the fact that item method directed forgetting results from our intentional item selection processes for memory. I have argued that differentiation in a distinctive context countermands our intentional item selection processes, thus resulting in equal memory for selected (Remember) and unselected (Forget) items. What remains to be developed more precisely is the meaning of "item selection processes," beyond stating that they are active rather than passive. This omission was intentional. The goal of this dissertation was to explore how various encoding or contextual manipulations affect our ability to select items for memory, not to describe the process of how items are selected. A full delineation of item selection processes is therefore beyond the scope of this dissertation, but a brief description of possibilities follows.

Item selection may simply involve rote rehearsal (e.g., Waugh & Norman, 1965; Shiffrin & Atkinson, 1969; Rundus & Atkinson, 1970; Woodward & Bjork, 1971). That is, when given Remember and Forget instructions, we repeat the Remember items over and over but do not repeat the Forget items. This is a relatively shallow manner of selecting items, but one that is effective and readily available to implement. More elaborate forms of rehearsal, such as item-chaining (e.g., Hasher & Zacks, 1979), may well be used by those who are aware of these more effective rehearsal techniques. Regardless of the form of repetition (whether item-based or in association with other list items), rehearsal is likely the most common way of improving memory for the selected items. In the present experiments, strong Remember words were recognized better than weak Remember words, so the form of rehearsal employed did not serve to overcome the encoding manipulation (i.e., memory for the weak Remember words was not augmented to the level of the strong Remember words by rehearsal).

Specifically in the context of item method directed forgetting, attentional inhibition has been proposed to play a role in item selection processes (e.g., Zacks et al., 1996). According to Zacks et al., dropping Forget items from the rehearsal set is accomplished via inhibition of the item itself, such that it is rapidly removed from working memory and not permitted quick re-entry. Older adults have reduced inhibitory control (relative to younger adults), and therefore show smaller directed forgetting effects because they cannot sufficiently inhibit the Forget items. However, this inhibitory account was not supported by Marks and Dulaney (2001) who showed that Remember and Forget items do not differ in terms of semantic priming; inhibiting an item should reduce, eliminate, or reverse semantic priming. Thus, inhibition does not seem to have a role in explaining item method directed forgetting; even Zacks et al. (1996) admit that their results could also have been caused by older adults' reduced ability to keep track of each item's memory instruction, leading to increased accidental rehearsal of Forget items, and therefore smaller directed forgetting effects.

As stated earlier, however, the processes that take place when a Forget instruction is received do appear to be active rather than passive. Forget instructions produce different spatial attention after-effects than Remember instructions (Taylor, 2005), and produce different patterns of brain activation than do Remember instructions, even for Remember items that are later forgotten (Wylie et al., 2008). Item selection processes in the context of directed forgetting are not clearly understood, so there certainly is work to be done to delineate these processes. For the purpose of this dissertation, however, it is only important to realize that we are capable of selecting some items as more important than other items in memory, and of course that there are many circumstances that affect our ability to use these processes effectively.

Implications for distinctiveness

Research in the area of distinctiveness effects in memory (for reviews, see the recent book by Worthen & Hunt, 2006) has already provided us with the useful discrimination between event-based distinctiveness (referred to as "distinctiveness" throughout this dissertation), wherein a set of items stand out against a common background set, and item-based distinctiveness (referred to as “differentiation” throughout this dissertation), wherein a single item stands out from its background because it is processed in a manner that highlights unique information about that item (e.g., Hunt, 2006). Although they are not by any means a perfect match, differentiation and distinctiveness can be roughly mapped onto the concepts of item-specific and relational processing, respectively (Hunt & Einstein, 1981). Item-specific processing, as its name implies, involves processing information that is unique to that item, and thus relates very well to the concept of differentiation (although item-specific processing could technically be performed on a single item, and thus without a background against which to be differentiated). Relational processing refers to the encoding of similarities among a set of items, and thus a distinctive set of items must be processed relationally to notice the commonalities of this set. Note that the weaker background items may well also be processed in a relational manner, if only in terms of being members of “the other items” on the study list.

Research examining how item-specific and relational processing affect memory has demonstrated that, although each type of processing benefits memory on its own, combining the two types of processing improves memory even more (e.g., Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt, 2003). Moreover, relational processing seems to improve memory by increasing the ability to reject distracters, whereas item-specific processing improves memory by increasing the ability to recognize targets (Hunt, 2003). Again, memory is most accurate when both types of processing are involved. These findings clearly fit well with this dissertation, in which combining differentiation and distinctiveness produced optimal encoding, such that intentional selection processes could not further improve on item memory. Thus, this dissertation has added the unique contribution that the improved memory resulting from differentiation in a distinctive context (or item-specific plus relational processing) is in fact so memorable that it does not matter whether we select that item or not—it will be very well remembered.

The principal theoretical claim of this dissertation meshes nicely with McDaniel and Bugg’s (2008) very recent item-order account of why various encoding manipulations produce different patterns of free recall depending upon list structure. Their account begins by assuming that both item-specific encoding (roughly mapping onto differentiation) and item-order information (referring to temporal order of presentation) contribute to free recall performance. Critically, the relative contributions of these two types of information differ when a particular encoding condition occurs in a pure list context as opposed to a mixed-list context. McDaniel and Bugg use generation, word frequency, enactment, bizarreness, and perceptual interference as examples of encoding manipulations that produce very different patterns of recall when studied in pure lists vs mixed lists. According to their theory, unusual items (roughly mapping onto strong encoding) generally benefit from item-specific encoding, but suffer in terms of item-order information when studied in pure lists; the opposite is true for common items (roughly mapping onto weak encoding). This is why pure list designs tend to show recall benefits for common items. However, in mixed list designs, unusual items benefit from additional item-order information, and the item-order information emphasized when common items appear in pure lists is reduced. This results in the elimination or reversal of the effect seen with pure lists: Mixed lists produce either no difference between common and unusual items, or they produce a memory benefit for unusual items. Based on McDaniel and Bugg’s account, a strong prediction for the present dissertation would be that any of the weak encoding conditions should produce superior order memory in recall relative to the strong encoding conditions, despite recognition performance indicating inferior item-specific memory.

Implications for directed forgetting

Item method directed forgetting effects are well described with a selective rehearsal account: Following the memory instruction, Remember items are selected for further rehearsal because they are important for memory and Forget items are not selected for rehearsal. The ability to select some information as more important for memory than other information via selective rehearsal is evident in the fact that directed forgetting effects are generally quite robust (see MacLeod, 1998, for a review). One example of circumstances under which this selection process is ineffective is the combination of item differentiation in a distinctive context, as demonstrated in this dissertation. Although we can select and rehearse more weakly encoded items to improve the memory for some items (Remember items) over other items (Forget items), when items are sufficiently encoded to begin with, then rehearsal does little to improve memory beyond its initial strong encoding.

Thus, for directed forgetting research in general, the explanation put forth in this dissertation would predict that any encoding task that serves to improve memory via differentiation would not be subject to directed forgetting when studied in a distinctive context. One example is already available in the literature: word generation (Slamecka & Graf, 1970). One accepted explanation of the generation effect is that generating a word is a distinctive process (i.e., item-specific distinctiveness or differentiation), and that this underlies the generated items being much more memorable than the items simply read at the time of study (e.g., Begg, Snider, Foley, & Goddard, 1989; but see Schmidt, 1982). MacLeod and Daniels (2000) had participants study a list of words in an item method directed forgetting paradigm by either reading them (weak encoding) or by generating them from a meaningful cue (strong encoding). The usual robust generation effect was observed, but it interacted with memory instruction:

Whereas read words showed directed forgetting, generated words did not. MacLeod and Daniels attributed this interaction to differential strength favouring the generated items, but their result also fits well with the account offered in this dissertation: When items are differentiated (i.e., via generation) in a distinctive context (i.e., the read words), item selection processes are ineffective at improving memory beyond its optimal initial encoding.

Conclusion

As demonstrated in this dissertation, we are capable of selecting some information to be more important for memory than other information presented in the same context. Experimentally, we can usually selectively rehearse items that we are told are important to remember, and we later remember those items better than items we were told to forget—the directed forgetting effect. However, I have demonstrated that these selection processes are ineffective for optimally encoded items: differentiated items studied in a distinctive context. Pictures, imaged words, and produced words are subject to directed forgetting effects only when studied on their own. In sharp contrast, when a weaker background context is included at study, these differentiated items are not subject to directed forgetting. I have further shown that neither distinctiveness nor differentiation alone is sufficient to overcome directed forgetting: Only the combination of these two factors will eliminate directed forgetting for the strong encoding condition. We certainly can and do select items as priority in memory, but our selections can easily be overridden by context.

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Appendix A: Words used in Experiment 1A

account
address
afternoon
amount
answer
attention
attitude
author
avenue
beauty
border
budget
business
campaign
capital
career
century
clean
command
danger
daughter
debate
degree
department
design
direction
distance
duty
education
election
entrance
event
fashion
file
foundation
friend
furniture
future
gravity
growth
guardian
health
history
holiday
industry
invention
invitation
journey
justice
kingdom
knock
language
laugh
lesson
measure
merchant
message
mind
minute
morning
neighbour
nephew
partner
pattern
peace
position
powder
product
public
quarrel
quarter
quick
range
reach
reason
record
reward
rise
scene
shadow
sight
signal
speech
stand
state
station
surface
system
task
text
travel
uncle
unit
vacation
valley
victory
voice
whisper
world
year

Appendix B: Words used in Experiments 2A and 2B

Words used in Experiment 2B

anchor
arrow
baby
ball
barn
barrel
basket
beach
beer
bell
bench
blanket
blood
board
book
boot
bottle
brain
bread
brush
bubble
bush
cake
camera
candle
chain
chicken
child
church
city
clay
clock
cloud
coffee
desk
dinner
doctor
door
dust
face
farm
feet
fire
flag
floor
forest
frame
garden
glass
gold
grass
hair
hand
head
heart
hotel
house
island
jacket
judge
king
knife
lamp
library
lime
mail
market
milk
missile
money
moon
motor
music
mustard
needle
nest
night
palace
paper
park
path
pencil
phone
piano
pill
plane
plant
pocket
pool
porch
purse
radio
rain
rice
ring
road
rock
rope
rose
salt
school
shell
ship
smile
snake
snow
soap
soldier
star
stove
suit
teacher
teeth
tent
train
tree
truck
water
wheel
wine

Additional words added to Experiment 2A

apple
bath
beard
beetle
bridge
broom
cane
canoe
cave
chair
chin
cigar
cork
corn
crown
deer
drum
duck
fence
fish
flask
frog
golf
gorilla
grave
hammer
harp
hill
horse
jail
jeep
kite
lion
lizard
lobster
mirror
mouse
neck
nose
ocean
onion
orange
pants
peach
pickle
pony
river
shore
shrimp
skunk
soup
sunset
thorn
trumpet
tulip
violin
volcano
whale
wolf
zipper

Appendix C: Words used in Experiments 3A and 3B

forest
judge
vacation
pebble
kingdom
pocket
ticket
clothes
speech
river
traffic
account
partner
thread
meadow
leather
uniform
foundation
distance
nephew
lesson
teacher
stream
summer
message
language
handle
sailor
factory
ocean
branch
answer
garden
knock
arrow
invention
package
kettle
valley
holiday
station
quarrel
winter
guardian
turnip
history
captain
beauty
attitude
department
village
trousers
queen
wheat
island
treasure
attention
border
furniture
entrance
theatre
shoulder
avenue
whisper
journey
wagon
afternoon
evening
reward
ladder
minute
election
painting
daughter
shadow
direction
resort
gravity
building
porch
century
laugh
friend
steam
castle
battery
uncle
machine
powder
merchant
amount
market
engine
neighbour
kitchen
record
capital
basket
travel
orchard
debate
industry
office
peace
quarter
wheel
school
plate
harbour
justice
address
dinner
campaign
author
envelope
invitation
fashion
education
victory
glass

Appendix D: Words used in Experiments 4A and 4B

farmer
butterfly
secretary
lobster
pearl
vase
toaster
pliers
pigeon
wrench
dog
mosquito
clarinet
cup
lily
crab
salmon
clam
penguin
lamp
husband
elephant
cottage
pansy
son
desk
zinc
plumber
carnation
bowl
robin
brother
chisel
ant
hat
violet
bee
spider
whale
mouse
crow
castle
nephew
dresser
trailer
tin
herring
iron
tent
carpenter
wasp
engineer
plane
trout
trombone
harp
sheep
diamond
bull
pillow
lilac
coat
stove
dress
sink
tulip
dish
worm
dentist
gold
ruby
lion
glass
dove
shark
stool
chair
beetle
giraffe
flute
hawk
wife
pan
emerald
rose
lawyer
banker
ostrich
opal
piano
shrimp
chicken
doctor
bronze
aunt
cardinal
mansion
bed
owl
mitten
shirt
minnow
sock
skillet
tuna
amethyst
clerk
house
glove
brass
deer
sofa
father
pig
daisy
orchid
cow
eagle
scarf
cod
sapphire
bear
sweater
flea
spatula
violin
teacher
pelican
drill
canary
dandelion
kangaroo
tuba
silver
radio
knife
cave
hammer
rock
scissors
cabinet
hotel
oboe
turtle
apartment
nickel
igloo
drum
copper
daughter
moth
rug
microphone
sunflower
ruler
saw
marigold
cabin
cousin
guitar

Footnote

[1] Prior to the recognition test, participants completed an implicit speeded reading task. Twenty of the words that had been studied in each colour (10 Remember and 10 Forget), together with 20 words not shown at study, were assigned to this implicit test, where they were presented in a new random order. The two tests used entirely non-overlapping sets of stimuli, thereby preventing contamination. The results of the implicit test are not relevant to this dissertation, and therefore are not discussed.

Table 1

Summary of Encoding Manipulations and Predicted Directed Forgetting Effects for Distinctive (mixed list) and Non-Distinctive (pure list) Study Contexts

Manipulation	**Pictures: Experiment 1**	**Imagery: Experiment 2**	**Production: Experiment 3**	**Deep Processing: Experiment 4**
How encoding improves memory	Differentiation: each item is perceptually and semantically unique	Differentiation: each pictorial image formed is unique	Differentiation: each item has unique pronunciation information associated	No Differentiation: each item is processed for the same, non-unique semantic information
Example	Study a picture of an elephant	Imagine a picture of “elephant”	Read aloud the word “elephant”	Is “elephant” a living thing?
Prediction for distinctive study context (*mixed list*)	No Directed Forgetting	No Directed Forgetting	No Directed Forgetting	Directed Forgetting
Prediction for non-distinctive study context (*pure list*)	Directed Forgetting	Directed Forgetting	Directed Forgetting	Directed Forgetting

Table 2

Experiments 1A and 1B: Proportions of "Yes" Responses in Recognition (SE in parentheses) as a Function of Study-Test Condition and Memory Instruction

	Pictures			**Words**		
Condition	**Remember**	**Forget**	**New**	**Remember**	**Forget**	**New**
Experiment 1A:	.87	.87	.05	.74	.62	.28
Distinctive Context	(.04)	(.02)	(.01)	(.03)	(.04)	(.03)
Experiment 1B:	.86	.70	.04	---	---	---
Non-Distinctive Context	(.022)	(.032)	(.015)			

Note: Proportions of "Yes" responses in recognition represent hits for Remember and Forget items and false alarms for New items.

Table 3

Experiments 2A and 2B: Proportion of "Yes" Responses in Recognition (SE in parentheses) as a Function of Study-Test Condition and Memory Instruction

	Deep imagery		**Shallow imagery**		**New**
	Remember	**Forget**	**Remember**	**Forget**	
Experiment 2A:					
Distinctive Context					
Overall	.86	.84	.71	.62	.11
	(.030)	(.026)	(.038)	(.028)	(.018)
"good" imagers only	.88	.88	.71	.63	.12
	(.036)	(.029)	(.049)	(.038)	(.024)
Experiment 2B:					
Non-Distinctive Context					
Overall	.85	.74	---	---	.18
	(.022)	(.034)			(.031)
Imaged as Read					
	.85	.80	---	---	.20
	(.031)	(.036)			(.049)
Imaged after Instruction					
	.85	.66	---	---	.15
	(.033)	(.057)			(.028)

Note: Proportions of "Yes" responses in recognition represent hits for Remember and Forget items and false alarms for New items.

Table 4

Experiments 3A and 3B: Proportions of "Yes" Responses in Recognition (SE in parentheses) as a Function of Study-Test Condition and Memory Instruction

	Studied aloud		**Studied silently**		**Unstudied**
Measure	**Remember**	**Forget**	**Remember**	**Forget**	**New**
Experiment 3A:	.80	.77	.70	.61	.23
Distinctive Context	(.022)	(.022)	(.025)	(.022)	(.016)
Experiment 3B:	.83	.70	---	---	.16
Non-Distinctive Context	(.028)	(.037)			(.031)

Note: Proportions of "Yes" responses in recognition represent hits for Remember and Forget items and false alarms for New items.

Table 5

Experiments 4A and 4B: Proportions of "Yes" Responses in Recognition (SE in parentheses) as a Function of Study-Test Condition and Memory Instruction

	Deep processing		**Shallow processing**		**Unstudied**
Measure	**Remember**	**Forget**	**Remember**	**Forget**	**New**
Experiment 4A:	.79	.61	.72	.48	.10
Distinctive Context	(.032)	(.038)	(.035)	(.048)	(.016)
Experiment 4B:	.83	.77	---	---	.12
Non-Distinctive Context	(.022)	(.027)			(.025)

Note: Proportions of "Yes" responses in recognition represent hits for Remember and Forget items and false alarms for New items.

Table 6

Summary of Encoding Manipulations and Observed Directed Forgetting Effects (Remember – Forget proportion recognized; SE in parentheses) for Distinctive (mixed list) and Non-Distinctive (pure list) Study Contexts

Manipulation	**Pictures: Experiment 1**	**Imagery: Experiment 2**	**Production: Experiment 3**	**Deep Processing: Experiment 4**
How encoding improves memory	Differentiation: each item is perceptually and semantically unique	Differentiation: each pictorial image formed is unique	Differentiation: each item has unique pronunciation information associated	No Differentiation: each item is processed for the same, non-unique semantic information
Example	Study a picture of an elephant	Imagine a picture of "elephant"	Read aloud the word "elephant"	Is "elephant" a living thing?
DF Effect for distinctive study context (*mixed list*)	.00 (.019)	.02 (.015)	.03 (.025)	.18* (.039)
DF Effect for non-distinctive study context (*pure list*)	.16* (.027)	.11* (.018)	.14* (.034)	.06* (.025)

Note: DF = Directed Forgetting; * = significantly different from zero