RETRIEVAL INDUCED FORGETTING:

A CASE OF INTERFERENCE

By

Andrea D. Hughes

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B.A., University of Saskatchewan, 1996

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Name: Andrea   Hughes

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Chair: Dr. Thomas Spalek
Assistant Professor, Psychology

Dr. Bruce Whittlesea
Senior Supervisor
Professor, Psychology

Dr. John McDonald
Supervisor
Assistant Professor, Psychology

Ray Koopman
Supervisor
Professor, Psychology

Internal Examiner: Dr. Barry Beyerstein
Professor, Psychology

External Examiner: Dr. Stephen Lindsay
Professor
University Of Victoria

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Abstract

Inhibition as a psychological construct has been used to explain a wide range of cognitive behaviors including phenomena such as negative priming, inhibition of return, directed forgetting and retrieval-induced forgetting. In general, these phenomena typically show a decrement in performance, measured by accuracy or reaction time, relative to a baseline response. Such decreases in performance have been argued to reflect inhibitory processes which serve to suppress a response to a stimulus. Inhibitory models of cognition are intuitively appealing in the sense that they provide an explanation of behavior that parallels the functioning of neurons. Despite the widespread acceptance of inhibition within the domain of cognition, a number of researchers have begun to question the plausibility of such a mechanism, and instead have offered inhibition free accounts of cognitive phenomena (Neill & Mathis, 1998; Pratt, Spalek & Bradshaw, 1999; MacLeod, Dodd & Sheard, 2003). The central aim of this thesis was to examine the utility of an inhibitory account of retrieval-induced forgetting. In particular, the experiments reported here demonstrate the limitations of an inhibitory account, and instead support an interference based account of retrieval-induced forgetting.

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Chapter 1: Introduction

Inhibition has long been part of our language, both in our daily lives as well as in scientific theorizing. In a general sense the term inhibition means to withhold an impulse, or to terminate a prepotent response. From a psychological perspective, the term inhibition has two primary functions (MacLeod, Dodd, Sheard, Wilson & Bibi, 2003). The first is to explain basic neuronal behavior within the central nervous system. The second is to account for cognitive and social behaviors that involve thought processes. It is the latter function that is the central focus of this thesis. In recent years, the utility of inhibition as a cognitive mechanism has fallen into question. The goal of the present research was to examine the utility and applicability of the concept of inhibition within the domain of human memory.

Inhibition is defined as something that forbids or restricts; or, an inner impediment to free activity, expression or functioning (Webster's online dictionary). In terms of psychological processes, inhibition has been included in theory to explain a wide range of behavioral phenomenon, extending from basic reflexes all the way to complex thought processes. Indeed, psychologists have employed this term since the science was in its infancy. One of the most famous early psychologists, William James, wrote extensively on the concept of inhibition. In his <u>Principles of Psychology</u> he wrote:

> We should all be cataleptics and never stop a muscular contraction once begun, were it not that other processes simultaneously going on inhibit the contraction. Inhibition is therefore not an occasional accident; it is an essential and unremitting element of our cerebral life.
>
> (James, 1890, Vol. II, p. 583)

This quotation illustrates that inhibition has long been an integral part of theorizing within the domain of psychology. However, the concept of inhibition, though described in many different ways, pre-dates James by over a century. The following section describes a brief history of the concept of inhibition beginning with the idea of neural inhibition, followed by the construct of cognitive inhibition.

Neural Inhibition

Early philosophers such as Descartes (1650; as cited in Smith, 1992) pondered the notion of opposing forces within the nervous system. It was Descartes who studied the reflex arc and concluded that such an automatic process must arise as a result of two opposing excitatory neural impulses. Though he did not employ the term inhibition, Descartes was already thinking about reflexes in terms of opposing forces.

It was much later when the discovery of inhibition was reported. In 1863, Sechnov (as cited in MacLeod et al., 2003) demonstrated that brain structures in a frog could inhibit a spinal reflex. This observation was revolutionary in the sense that it led scientists to begin to think about neuronal activity in terms of activation and inhibition, rather than as opposing excitations. Inhibition became quite widely accepted in the physiological sciences as a result of this discovery. By 1906, Sherrington extended this work to show that inhibition was not limited to the neuronal level but that neural inhibition is integral to the organization of the central nervous system. For his work, Sherrington was awarded the Nobel Prize for Medicine in 1932 (Smith, 1992).

Around the same time that Sherrington was conducting his physiological research, the link between neural inhibition and cognitive inhibition was being developed. For

Pavlov (1928), the concept of inhibition played a central role in his theory of learning. According to Pavlov, inhibition was responsible for reducing the frequency or likelihood of producing a conditioned response. Pavlov distinguished between two different types of inhibition; external inhibition, in which a new stimulus interferes with a conditioned response, and internal inhibition in which a new response interferes with an old, unconditioned response. Clearly, Pavlov integrated the notion of inhibition into his theory of learning and conditioning, and in doing so, extended the concept of inhibition from a physiological level to a more cognitive level of analysis.

Similarly at that time, Freud (1938) was working on his own theory of mind. The notion that impulses in mind are sometimes repressed or suppressed was a central premise of Freud's theory. According to him, the mechanism by which suppression or repression occurs is inhibition. More specifically, Freud suggested that inhibition was the mechanism that served to restrain the ego and that this restraint resulted in a civilized existence in society.

This brief history demonstrates the developing role of inhibition in many aspects of scientific reasoning. Importantly, it becomes apparent that even early models of cognition were based on the physiological correlates of neuronal functioning in the brain and the rest of the central nervous system. Given this, it is not at all surprising that as cognition developed as a discipline of study, inhibition has been an integral aspect of many models of cognitive behavior.

Cognitive Inhibition

As already mentioned, the concept of cognitive inhibition emerged relatively early in the field of psychology and persisted in theorizing into the early 20th century. However, compared to the study of neuroscience, inhibition was not particularly prevalent in theories during the early 1900's (MacLeod et al., 2003). While neuroscience continued along the path of inhibition, cognitive psychologists were not necessarily faced with the need for such a mechanism. For example, cognitive phenomena such as semantic priming, as originally demonstrated by Meyer and Schvaneveldt (1976), were thought of in terms of activation and facilitation and did not rely upon the need for a construct that employed opposing forces. Gradually though, cognitive psychologists began to incorporate the concept of inhibition as a force which opposes activation, as a means of explaining a number of behavioral phenomena that showed decrements in performance as a result of interference of some sort. Over the past few decades, the term inhibition has been accepted as a reasonable description of such observations, likely due to it's analogy to the operations of neurons. In fact, Dagenbach and Carr (1994) suggest that:

> ... the desire to have what is known about the way the nervous systems works
> reflected in our cognitive models may be a relevant factor in renewed interest in
> inhibitory processes.
>
> (Dagenbach &Carr, 1994, pp. 13)

Thus, many cognitive researchers have widely accepted the concept of inhibition and there are a large number of behavioral phenomena that employ this construct as a plausible explanation of the mechanism underlying the behavior. Inhibition is often employed to explain attentional phenomena such as negative priming, inhibition of return, stroop interference and task switching, just to name a few. Similarly, memory

effects, including directed forgetting and retrieval-induced forgetting have used the concept of inhibition to account for observable behaviors.

Despite the widespread acceptance of inhibition in cognition, a small number of researchers have begun to question the need for such a mechanism to explain cognitive behavior. Part of the discontent with an inhibition explanation arises from the fact that inhibition in a cognitive sense is nothing more than a psychological construct. However, theories tend to draw parallels between the construct of inhibition in cognition and the physical reality of inhibition in neuronal functioning. Though there is no direct mapping between neural activity and cognitive behavior, researchers find a level of false security in their theorizing (MacLeod, et al; 2003). As MacLeod et al. (2003, pp. 165) stated, "…an electrochemical impulse in a neuron cannot possibly explain a thought, despite being involved intimately in providing the means for that thought to occur." At present, though still a minority, several researchers are re-examining cognitive paradigms which are predominantly using inhibition as the mechanism to explain behavior and arguing that in many cases, a more parsimonious account can be employed to account for that same behavior.

In the following sections, a number of cognitive phenomena that predominantly employ inhibition as the explanatory mechanism will be reviewed. This summary will include a description of the basic cognitive effect and an analysis of both the inhibitory account and research that has challenged that inhibition explanation. For simplicity, the research will be separated into attention related research and memory related research. As the focus of this thesis is primarily on inhibition and memory, the majority of the review will be devoted to this section.

Cognitive Inhibition and Attention

Negative Priming

Negative priming was first reported in the literature by Dalrymple-Alford and Budayr (1966). These researchers used the Stroop task and found increased interference if the ignored word on one trial became the attended word on a subsequent trial. That is, participants were slower to name the color of a word if the color corresponded to the distractor word immediately preceding it in the list. Negative priming did not receive much attention until later, when Neill (1977), Lowe (1979) and Tipper (1985) revived the effect using a variety of different paradigms which are still commonly used today.

In a typical negative priming experiment, two trials are presented rapidly one after the other, with the first being referred to as the prime trial and the second as the probe trial. On each trail the participant is cued, by font or color, as to whether they are to attend to or to ignore the stimulus. The critical probe trials are those in which the previously ignored distractor is presented as the stimulus to be attended. Typically, what is observed is that participants are much slower to respond to the probe if the attended word was an ignored word on the immediately preceding prime trial. Hence, the term negative priming, which implies that the prime serves to slow down responding to the probe target.

The predominant view of negative priming assumes that the effect is the result of an inhibitory mechanism operating on visual selective attention (Tipper, 1985, 2001). According to Tipper's account, negative priming demonstrates selective inhibition of ignored words. Specifically, ignored words on a prime trial become inhibited and in

consequence, it takes those words longer to become activated on the subsequent probe trial as compared to an unrelated word, which was not inhibited. Tipper's account gained favor and became the standard for measuring inhibition. In many ways, inhibition became synonymous with negative priming. In fact, Tipper himself stated that negative priming is a means of directly observing cognitive inhibition (Tipper, 2001).

Within this literature there has been some debate as to what exactly is being inhibited (Fox, 1995). The original argument suggested that the mental representation of the ignored stimulus initially receives some level of activation which is subsequently de-activated by an inhibitory mechanism. This theory became problematic in that it failed to account for a common finding; positive priming is often observed if an ignored distractor is followed by a probe trial that contains no distractors. If the prime stimulus is inhibited, then it is not possible that it leads to facilitation, regardless of the probe trial. To accommodate this observation, Cranston and Tipper (1985; as cited in Fox, 1995) proposed an alternate explanation. They suggested that the mental representations of an ignored distractor remain active, while the link between the representation and the response becomes inhibited. Thus, as long as a selection state is operating, inhibition will persist and negative priming will be observed. If there is no need for selection (as in the case of a probe with no distractor) then inhibition will be dropped and positive priming can occur. Despite the debates concerning how inhibition accounts for negative priming, this account has been widely accepted and few alternative, non-inhibitory explanations have been proposed.

One non-inhibitory account of negative priming, proposed by Lowe (1979), suggests that negative priming occurs as a consequence of a mismatch between features

of the ignored prime and the subsequent probe. Lowe presented color words as primes and then either another color word or a color patch as probe stimuli. As would be expected, he found negative priming when a probe word was a previously ignored prime word. However, when the probe was a color patch (rather than a color word) there was facilitation from previously ignored congruent color words. Based on this finding, Lowe argued that in the related condition the color-name is represented twice; once as an ignored distractor and again as a selected target. This double representation gives ambiguity to the color word and in consequence requires time to resolve the ambiguity. For example, if a participant responds "red" to a target associated with the identity "blue" and then on a subsequent trial is required to respond "blue" to a probe that is associated with the identity "green", there is a mismatch that requires further processing to resolve ambiguity. By this account, negative priming is the result of a mismatch between features of the ignored distractor and those of the subsequent target.

Another more recent non-inhibitory account of negative priming is based on Logan's instance theory of automaticity (1988). Neill and Mathis (1998) proposed an episodic retrieval theory of negative priming. The main premise of this account is that we frequently retrieve information from memory as a means of assisting current processing and that the most likely information to be retrieved is the most recent information. Applied to negative priming, when an individual encounters a probe that was previously an ignore trial, they are likely to retrieve an "ignore" signal that is inappropriate for the current trial. This conflict takes time to be resolved and, as a result, participants are slower to respond to a probe that was previously ignored. This episodic retrieval based account of negative priming, though quite different from an inhibitory

account, is not the only non-inhibitory explanation of priming effects. Several other researchers have adopted similar theories to account for priming effects. For example, Ratcliff and McKoon (1988) proposed a compound-cue model to account for semantic priming effects, where it is argued that retrieval of the cue combines with the target to facilitate responding on semantically related trials. In addition, Whittlesea and Jacoby (1990) demonstrated that difficult processing of a prime facilitates processing of a semantically related target. By that account, an individual relies on recent processing experiences to assist processing on the current task.

In summary, negative priming as a domain of investigation has been predominantly accounted for in terms of inhibition. There are those though, who argue for a more parsimonious account of the effect, such as episodic retrieval (Neill and Mathis, 1998). Others have also provided evidence to suggest that inhibition may not be the best account of negative priming (e.g., Milliken & Joordens, 1996). However, discussion of those theories is beyond the scope of this thesis.

Inhibition of Return

The effect that is commonly referred to as inhibition of return (IOR) was first reported by Posner and Cohen (1984) who recognized that people are biased to attend to novel, unsearched locations in their visual field. Specifically, once a stimulus has captured attention, people are biased not to return to that location, but instead tend to search new locations. The typical task for measuring IOR involves presenting two boxes in a horizontal row while the participant fixates on a crosshair in the center of the screen. Then one of the peripheral boxes is briefly illuminated and it is assumed that this

brightening reflexively draws attention to that particular location. Subsequently, one of the two boxes is filled, indicating the target, and the participant's task is to respond as quickly as possible where the target was located. On a proportion (e.g., 40%) the target appears in the cued location and with the same frequency at the uncued location (e.g., 40%). The remaining trials (e.g., 20%) are catch trials in which no target is presented. The typical finding is that for very brief cue-target asynchronies (50 or 100 msecs) the target is detected faster at the cued location than at the uncued location. However, when the cue-target asynchrony is increased (300 or 500 msecs), target detection is actually slower at the cued location than the uncued location (Posner & Cohen, 1984). It is this slowed responding that constitutes the IOR effect.

Numerous inhibition-based accounts have been proposed to explain the IOR effect. In fact, the effect has received so much attention that theories have been proposed at the perceptual level, the attentional level and at the response level, all of which are inhibitory accounts.

At the perceptual level of analysis, it has been proposed that inhibition of return slows the rate at which perceptual information accumulates at the cued location (Abrams & Dobkin, 1994; Handy, Jha & Mangun, 1999). That is, stimulation in the periphery summons attention and then inhibits the cued location. In consequence, this inhibition prevents rapid return to that particular visual region for further processing. To examine the perceptual aspects of IOR, Abrams and Dobkin (1994) measured saccadic reaction times and found that participants were slower to initiate eye movement to previously cued locations and that inhibition was greater for peripheral than for central cues. Based on these results, Abrams and Dobkin (1994) argued that at least some of the inhibition

was due to processes involved in visual stimulus detection at the perceptual level. Further support for the notion of perceptual inhibition was provided by Handy et al. (1999) who demonstrated that IOR effects can be elicited using target discrimination rather than target detection. In their studies, Handy et al. examined accuracy in target discrimination rather than reaction times and found a significant reduction in target discrimination at recently attended locations independent of speed of responding. Hence, these results provide more direct support for the argument that IOR affects the perceptual quality of visual processing.

Others have argued that the IOR effect is an attentional effect rather than a perceptual effect (Reuter-Lorenz, Jha & Rosenquist, 1996). These authors assert that rather than inhibiting the perceptual system, IOR actually inhibits attention such that the system is unable to reorient to the cued location, resulting in slower processing. These authors demonstrated that variables known to influence performance on cueing tasks (modality, target intensity etc.) also had effects on IOR. Following from this, Reuter-Lorenz et al. (1996) reasoned that because the mechanism underlying cueing performance is generally thought to be attentional, then it follows that attention is likely to be the mechanism underlying IOR.

From the response level of analysis, Klein and Taylor (1994) argued that IOR is the result of a response bias against responding to a stimulus presented at the cued location. This argument was based on the observations of Abrams and Dobkins (1994) who provided an additional cue during the task. Those authors presented an arrow on the screen directing participants to make a saccade while the target was being illuminated. Their results show IOR even with the directive arrow and thus, Klein & Taylor (1994)

suggest that the effect can not be entirely due to perceptual processing but must also involve a response bias. In particular, they suggest that IOR reflects a motor response bias that is activated by an oculomotor program to fixate at the cue.

Another inhibition account suggests that both cued locations and cued objects receive inhibitory tags (Tipper, Driver, & Weaver, 1991). Specifically, they argued that if inhibition were specific to a cue, then IOR would only be predicted when the cue and the target occurred in the same location on subsequent trials. However, Maylor and Hockey (1985) found that IOR occurs not only on back-to-back trails, but also when target 1 served as a cue for target 2, which in turn served as a cue for target 3. Thus, Tipper et al. (1991) argued that it was not just the location that was inhibited but, instead, the particular object was inhibited.

As is apparent from the discussion above, there have been many differing accounts of inhibition of return. All of these explanations assume that inhibition is responsible for the effect and have attempted to account for the data based on that assumption. Alternative accounts of IOR that do not depend on the assumption of inhibition are less common. However, those accounts have intuitive appeal.

One intriguing account of IOR suggests that the bias observed in that effect is due to an attentional momentum mechanism rather than inhibition (Pratt, Spalek & Bradshaw, 1999). According to this hypothesis, attention is reflexively drawn to the cued location and then moves back to the central fixation. However, because attention is now moving toward the uncued location, participants are quicker to respond to the uncued location and slower to stop attentional movement and return to the cued location. Pratt et al. (1999) provided support for the attentional momentum hypothesis by modifying the procedure

slightly. In their study, Pratt et al. used a four location display with three uncued locations as opposed to only one. The four locations were equal distance from a central fixation point on the display. Pratt et al. (1999) found that latency to respond to the uncued location that was opposite the cued location was faster than for either of the other 2 uncued locations that were orthogonal to the cued location. Hence, they argued that IOR results not from inhibition as the name implies but, instead, the effect is due to a bias for attention to continue to move in the initiated direction. An important point to note is that an attentional momentum account is capable of explaining IOR effects without the need to invoke any inhibitory mechanisms.

In summary, this brief review of negative priming and inhibition of return illustrates that two very common attentional phenomena, that are typically accounted for by an inhibitory theory, can be explained using non-inhibition mechanisims. The importance of such theories is that they do not require the assumptions that are required by inhibition theories. For example, the episodic retrieval account of negative priming, proposed by Neill and Mathis (1998), is not contingent upon any specific cognitive architecture. This theory explains the effect based on the observable behavior, without assumptions regarding the structure of mind or representations in mind.

In contrast, an inhibition account requires assumptions about the representations in mind and how those representations operate. For example, in the case of negative priming, it is not clear what mechanism invokes inhibition of the ignored prime. Is a simple cue sufficient to invoke inhibition? If so, this account would be in conflict with many other cognitive phenomena. Wegner et al. (1987) in their classic "white bear study", found that instructing participants not to think about white bears actually led them

to think more about white bears! This is a very simple illustration of a complex problem with inhibitory accounts. Such accounts have difficulty in providing explanations as to how inhibition works. A theory should, in principle, be able to accommodate all of the available data as well as provide an explanation of how the theoretical mechanism operates in mind.

Memory and Inhibition

Directed Forgetting

When one considers the uses of memory, it seems entirely reasonable that forgetting has certain advantages. Take for example, the situation in which an individual moves to a new home, and thus has a new address. If forgetting did not occur, people would likely make an error each time they attempted to come up with their own address. Studies of directed forgetting attempt to examine how this type of forgetting occurs within a laboratory setting.

Typically, directed forgetting experiments involve the use of one of two different methods, referred to as the "item method" and the "list method." With the item method, participants encode a list of words, one word at a time, and are cued immediately after each word whether that word is to be remembered (R) or to be forgotten (F) (MacLeod, 1975). Alternatively, with the list method participants are cued half way through the list and again at the end of the list, indicating whether the preceding studied items are to be remembered or forgotten (Elmes, Adams & Roediger, 1970). Both procedures are typically followed by either a free recall test or a recognition memory test.

In general, using either the item method or the list method, the data reveal an advantage of R items over F items on a memory test. This directed forgetting effect has inspired numerous investigations, resulting in a debate amongst researchers as to the mechanisms underlying the forgetting effect. The earliest accounts of directed forgetting argued that the effect arises through differential rehearsal of the R and F items (Bjork, 1970). In particular, it was proposed that participants selectively rehearsed R items in favor of F items, which they believed would not be tested. In consequence, recall of R items was much higher than for F items.

However, this account was challenged later by Bjork and Geisleman (1978) who moved toward an inhibitory account of directed forgetting. These authors proposed that the forgetting effect occurred as a consequence of inhibition of the F items. It was theorized that, for both the list method and the item method, inhibition was invoked after the initial encoding. That is, when the participant became aware that they would not have to recall a specific item, or set of items, those items then became inhibited in order to facilitate remembering of the R items.

However, this account was quickly modified when Bjork (1989) found that, using the list method, the directed forgetting effect was eliminated when a recognition test preceded the recall test. In consequence, it was proposed that the list method and the item method have different underlying mechanisms (Bjork,1989). Specifically, Bjork argued that with the item method, participants engage in selective retrieval of the R items during encoding and thus show deficits in remembering F items. However, with the list method, Bjork (1989) argued that retrieval inhibition was the cause of the forgetting. In particular, he suggested that when participants were cued at the end of a list to forget a set

of items, they were susceptible to inhibition and, consequently, on a recall test those F

items were not recalled. Further, it was proposed that inhibition was lifted when those

items were presented again during a recognition task. Hence, this explains why directed

forgetting was not observed using a recognition test.

Other researchers have argued in support of the "two-methods" explanation of

directed forgetting. For example, Geiseleman & Bagheri (1985) also failed to observe

directed forgetting using a recognition test with the list method. From this and other

studies, the authors argue that successful recognition for items that participants failed to

recall suggests that the items must have been effectively encoded and, thus, must have

been inhibited during the recall test. This assertion has been taken as strong support for

an inhibition account of the directed forgetting effect and is currently the predominant

theory in this domain of study (MacLeod et al., 2003).

Whilst inhibition is the most favored account, some have argued that the selective

rehearsal account has no difficulty in explaining the list method as well as the item

method (Sheard, Dodd, Wilson & MacLeod, 2002). Sheard et al. (2002) employed the

task used by Basden and Basden (1998) in which they introduced a "warning" in the list

method. Participants were given a brief delay between the encoding and the final test

and, during this delay, half of the participants were warned that they would have to recall

all of the items, not just the R items. Basden and Basden (1998) found that the directed

forgetting effect was eliminated for the warning condition. These authors argued that this

observation supports a retrieval inhibition account of the effect. They proposed that, at

the time of recall, participants normally adopt a retrieval strategy that favors R items and

inhibits the F items. However, when a warning is provided, they argue that participants have ample time to switch retrieval strategies, allowing for recall of both R and F items.

This interpretation was challenged by the findings of Sheard et al. (2002) whose data replicated the findings of Basden and Basden (1998). Instead, Sheard et al. (2002) argued that the data can be accounted for without a need for inhibition. These authors conducted an additional analysis on their data set and found that when a median split was used to separate participants into high versus low memory groups, the effect of the warning had a differential impact on the two groups. In particular, they found that the warning manipulation had no impact on the magnitude of directed forgetting. That is, equal amounts of forgetting were observed whether these participants were warned or not. However, the warning manipulation had a clear impact on the high memory group. Those participants showed a reduction in directed forgetting with the warning, and an increase, as compared to baseline, in the amount of forgetting with no warning.

Based on this analysis, Sheard et al. (2002) concluded that a selective rehearsal account could accommodate their data. They proposed that, for the low memory group, participants likely did not engage in rehearsal of either R or F items, as the warning had no impact on this group. For the high memory group, participants who did not receive a warning selectively rehearsed R items, while participants who were warned diverted their rehearsal to include both R and F items. Thus, Sheard et al. (2002) argued that list method directed forgetting can be explained in terms of selective rehearsal, just as the item method is.

In a further experiment, Sheard et al. (2002) directly manipulated rehearsal by preventing participants from rehearsing during the delay period and found that the data

were much like the data from the low memory group in the previous study. This was taken as support for their assumption that participants in the low memory group did not engage in rehearsal during the delay period, with or without a warning. In conclusion, these authors argue that inhibition is not necessary to account for the available data in the list method of directed forgetting. Instead, they assert that the observations can be accounted for in terms of selective rehearsal.

Retrieval-Induced Forgetting

Retrieval-induced forgetting, first reported by Anderson, Bjork and Bjork (1994), refers to the observation that repeated retrieval of some members of a particular category impairs later recall of other members of that same category. This rather paradoxical phenomenon is another area of memory in which the predominant explanation is one of inhibition.

In their initial study, Anderson et al. (1994) presented category-exemplar pairs to be studied. Study lists consisted of 8 categories with 6 exemplars per category. Half of the categories contained only strongly associated exemplars and half only weakly associated exemplars. In a second phase, participants practiced retrieving half of the exemplars from half of the categories using a category plus stem-cued recall task. After the retrieval practice session, participants were provided category cues and were instructed to recall all of the studied words.

The surprising finding from this study was that recall was poorer for unpracticed items from practiced categories than for unpracticed items from entirely unpracticed categories. This observation led Anderson et al. (1994) to propose an inhibition account

of the retrieval-induced forgetting effect. They argued that during the practice session, studied items from the same category compete with each other while a search for the appropriate stem completion is ongoing. This competition requires suppression of competitors and in consequence those inhibited exemplars are forgotten on the final test.

In that same study, Anderson et al. (1994) also reported that this decrement in performance for unpracticed exemplars, relative to baseline, was only found with strongly associated exemplars. This observation was taken as support for their inhibition explanation, as they proposed that weakly associated exemplars would produce much less competition and, in consequence, not require suppression during the practice phase.

Further support for the inhibitory account came from the work of Anderson and Spellman (1995) who found the same retrieval-induced forgetting effect using independent cues at the final test. More specifically, participants studied category-exemplar pairs and then engaged in retrieval practice. However, on the final test, participants were probed with new, related cues rather than with the category word. For example, participants may have studied the pairs GREEN – lettuce, GREEN – emerald and SOUPS- mushroom. On the final recall test, the novel cue VEGETABLE was presented. Note that this cue is related to lettuce and mushroom and, thus, would be expected to probe recall of those items. Despite the change in cues, participants still showed retrieval-induced forgetting. That is, unpracticed items from practiced categories were recalled at below baseline rates, even with an independent cue. Anderson and Spellman (1995) argue that this observation provides evidence to show that the items were inhibited in memory rather than being interfered with on the final test.

Since these initial findings, the literature has exploded with research demonstrating the widespread generality of the retrieval-induced forgetting effect. Researchers have used a number of different stimuli to demonstrate the forgetting effect. For example, retrieval-induced forgetting has been found using emotional versus unemotional biographical memories as stimuli (Barnier, Hung & Conway, 2004). In that study, participants generated positive or negative memories associated with provided cues and then engaged in retrieval practice, as in the standard paradigm. Consequently, participants were below baseline at recalling unpracticed memories from categories that had been practiced. Similarly, in another study, participants were presented with 12 stimuli that were uniquely colored but belonged to one of four shape categories (Ciranni & Shimamura, 1999). During retrieval practice, participants were required to recall the colors of a subset of the items using shape as a cue. Again, retrieval-induced forgetting was observed for unpracticed items belonging to practiced categories.

Other studies have been conducted to investigate retrieval-induced forgetting involving a variety of other memory phenomena. In one experiment, participants were provided with narratives about two hypothetical burglaries, from two different houses, with the stolen items being underlined in the story (Saunders & MacLeod, 2002). After encoding the narratives, participants were asked questions about a subset of the stolen items from one of the houses. This phase was meant to constitute retrieval practice. In an additional phase, several more questions were asked about semantically related, but non-presented items. The purpose of this phase was to introduce misinformation to the participants. A multiple-choice test was used as the final memory test. The authors reported two critical findings from their data. First, they found evidence of retrieval-

induced forgetting, showing that unpracticed items from categories that received practice were recalled below baseline. The second observation was that participants who received misinformation that was semantically very similar to unpracticed items from practiced categories, were much more likely to falsely report those items as being from the initial narrative. Thus, Saunders and MacLeod (2002) concluded that retrieval-induced forgetting extends to the misinformation effect and that inhibition of related items increases the likelihood of falsely recalling misinformation on a memory test.

Eyewitness memory has also been examined using the retrieval-induced forgetting paradigm (Shaw, Bjork & Handal, 1995; MacLeod, 2002). These investigations have used variants of the standard paradigm to examine eyewitness memory. To illustrate briefly, Shaw et al. (1995) had participants view a series of slides, which contained household items from two different categories. For retrieval practice, participants were asked questions about a subset of the items from one of the categories and then were given a final recall test. Not surprisingly, retrieval-induced forgetting was observed.

Along a similar line of investigation, Starns and Hicks (2004) investigated retrieval-induced forgetting of false memories. Participants were presented with category-exemplar pairs associated with a critical, non-presented theme word and performed retrieval practice for half of the exemplars from half of the categories. A retrieval-induced forgetting effect was observed. In addition, these authors found that false recall of critical theme words associated with practiced lists was lower than for critical words associated with unpracticed lists. In conclusion, the authors argue that

false memories are subject to inhibitory forgetting mechanisms that also operate on true memories.

Investigations of retrieval-induced forgetting have also been conducted using tasks other than a recall test. For example, a recent article was published indicating that retrieval-induced forgetting can be observed when a recognition task is employed (Hicks & Starns, 2004). These authors used the standard paradigm, with the exception that in one of their experiments participants were also required to indicate whether an item they recognized as being "old" had been practiced or not during the retrieval practice phase. Along with a retrieval-induced forgetting effect, they found that participant's claims of 'not practiced' were higher for unpracticed items from non-practiced categories than for unpracticed items from practiced categories. In conclusion, Hicks and Starns (2004) argue that their results support an inhibition account of retrieval-induced forgetting.

The forgetting effect in question has also been reported under conditions in which participants are forced to semantically generate the retrieval practice items repeatedly before beginning the final test phase (Bauml, 2002). In another study, retrieval-induced forgetting was demonstrated using an indirect, lexical decision task (Veling & van Knippenberg, 2004). In that experiment, participants went through the standard study and retrieval practice phases, but instead of being asked directly about their memory, were tested using a lexical decision task. The results demonstrated that participants were slower to classify an unpracticed word from a practiced category, than to classify a word from a category that did not receive any retrieval practice. The authors of this study suggest that their results provide important support for an inhibition account of retrieval-

induced forgetting, given that this is the first demonstration of the effect using an indirect measure of memory.

In addition to the wide range of experiments that have extended the generality of the retrieval-induced forgetting effect, several investigators have examined the boundary conditions of the effect. In one rather unusual experiment, participants were asked to imagine themselves as being in one of three situations regarding the purchase of a gift (MaCrae & Roeseveare, 2002). The study phase involved lists of gifts that were either indoor or outdoor items. Following study, retrieval practice was performed for half of the items from one of the categories. Finally, participants were cued by category to report the studied items. The results of this study show that retrieval-induced forgetting was observed only when participants were taking on the role of another individual. That is, the forgetting effect was not found for the condition in which participants were asked to approach the task as "themselves" as opposed to another person. The authors concluded from these results that some processing operations are protected from the temporary forgetting induced by inhibition.

Further support for an inhibitory account comes from a demonstration that retrieval induced forgetting was observed when the final test was administered shortly after the retrieval-practice phase, but not when the delay between practice and test was extended from a few minutes to 24 hours (MacLeod & MacRae, 2001). In particular, the results of this study showed that no retrieval-induced forgetting was evident when participants were tested 24 hours after the retrieval practice phase. Based on these results, MacLeod and MacRae suggest that retrieval-induced forgetting is due to inhibition, but that inhibition is only temporary, lasting less than 24 hours.

A further boundry condition of the forgetting effect was reported by Anderson and McCulloch (1999). These investigators encouraged participants to try to make multiple connections between items on the study list. Specifically, participants were instructed to relate each subsequent study item to other items belonging to that same category on the list. Participants then engaged in retrieval practice before the final cued recall test. The instructional manipulation of inter-relating items during encoding affected recall on the final test. Specifically, participants who were instructed to inter-relate items at study did not show a retrieval-induced forgetting effect, while those who were not given this instruction did show the forgetting effect. Anderson and McCulloch (1999) argued that this resistance to retrieval-induced forgetting illustrates a limit on the effect, and also supports the age-old assertion that integration is critical to successful remembering.

It becomes apparent when reviewing the literature on retrieval-induced forgetting that the majority of experiments that have been conducted have focused not on the theoretical implications of the effect, but more on the breadth of the effect. Thus, it is not necessarily surprising to discover that most retrieval-induced forgetting studies have employed the inhibition account that was originally proposed by Anderson et al. (1994). Though limited in number, there are studies which have provided challenges to an inhibitory account of retrieval-induced forgetting.

Related to the findings of Anderson and McCulloch (1999), one investigation of the forgetting effect demonstrated that retrieval-induced forgetting is reduced when participants are encouraged to process studied items in a distinctive manner (Smith & Hunt, 2000). In one experiment, distinctive processing was induced by asking

participants to make difference judgments among the studied items during the encoding phase. In a second study, participants were instructed to make similarity judgments amongst study items. It was predicted that the similarity judgment task would produce results similar to those observed by Anderson and McCulloch (1999) with their integration task. Distinctive processing reduced the retrieval-induced forgetting effect. However, unlike the findings from Anderson and McCulloch's study, the results from the similarity task demonstrated the standard forgetting effect. Importantly, Smith and Hunt (2000) argue that the results from their studies do not support an inhibition account of retrieval-induced forgetting. In particular, an inhibition account would predict that inhibition during retrieval practice would lead to forgetting regardless of the encoding, and thus forgetting should have been observed. The results of Smith and Hunt's experiments are important because they are one of very few that do not support an inhibitory account. Unfortunately, those authors did not attempt to provide an alternative mechanism to explain the effect. Despite the lack of theory, the data do provide a limit on the retrieval-induced forgetting effect.

Recently, Williams and Zacks (2001) proposed a theoretical challenge to the inhibitory account of retrieval-induced forgetting. Specifically, Williams and Zacks attempted to replicate the original findings of Anderson et al. (1994) as well as the observations of Anderson and Spellman (1995). Across their experiments, which closely paralleled the procedures of Anderson et al. (1994) these authors failed to replicate the category strength effect as well as the independent cue effect. That is, Williams and Zacks (2001) found retrieval-induced forgetting for both strong and weak category-exemplar associations. This finding is in contrast with that of Anderson et al. (1994) who

found a forgetting effect only for strong associates. Thus, Williams and Zacks question the conclusions of Anderson et al., who argued that inhibition would predict no forgetting effect for weakly associated items.

A further challenge presented by the data from Williams and Zacks' (2001) study was the fact that they failed to replicate the findings of Anderson and Spellman (1995) using the independent cueing technique. Specifically, these authors used a procedure that was very similar to that of Anderson and Spellman, but did not observe retrieval-induced forgetting. Based on the failure to replicate, on two critical dimensions, Williams and Zacks (2001) argued that the inhibition account is questionable. Instead, they proposed that the effect is due to retrieval interference. In particular, they argue that the retrieval practice phase does not invoke inhibition, but instead creates interference at the time of recall on the final test phase.

The alternative account put forward by Williams and Zacks (2001) is the first theoretical challenge to an inhibitory account of retrieval-induced forgetting. Unlike the cognitive phenomenon of directed forgetting, few researchers have investigated the potential of a non-inhibitory account of the retrieval-induced forgetting account. In summary, the studies reported here represent a review of the memory literature involving inhibition as a theoretical account. Though this review is not exhaustive by any means, it is clear that the majority of studies that have investigated directed forgetting and retrieval-induced forgetting have resulted in explanations rooted in an inhibitory framework. As stated earlier, such accounts have difficulty in explaining how inhibition operates. Importantly, these theoretical accounts do not provide a mechanism by which inhibition is invoked, operates or is arrested. Furthermore, they do not provide the

essential assumptions regarding the nature of representations in mind. Finally, there are many inconsistencies amongst the various instantiations of inhibition. If inhibition were the mechanism responsible for many cognitive phenomena, including negative priming, inhibition of return, directed forgetting and retrieval-induced forgetting, it seems reasonable that such a mechanism would have some similarities across the different cognitive domains.

Purpose

The aim of this thesis was to challenge the construct of cognitive inhibition from within the framework of retrieval-induced forgetting. In particular, the investigations that were conducted were designed to test the inhibitory theory put forward by Anderson et al. (1994). Inhibitory theories of cognitive phenomena leave many questions unanswered, and many assumptions unstated. For example, the inhibitory account put forth by Anderson et al. (1994) does not clearly state *what* is inhibited in mind nor does it specify the mechanism by which inhibition is invoked. At a deeper level, an inhibition account would need to specify the assumptions of mind. In particular, how is mind organized? what is represented in mind? how are those representations accessed? and importantly, how do they become inhibited?

Thus, the goal of the present work was to develop an account of the retrieval-induced forgetting effect that did not rely on the construct of inhibition. Such an account would help researchers to better understand the forgetting effect, but more importantly, would add to the growing body of research that argues for non-inhibitory accounts of cognition in general.

Chapter 2: Retrieval-Induced Forgetting

The experiments described in this section were conducted in an attempt to replicate the retrieval-induced forgetting effect and to examine conditions under which the effect can be observed. The experiments reported below employed the retrieval-induced forgetting paradigm, which was first introduced by Anderson et al. (1994). The paradigm involves three critical phases. In the first phase, participants study category – exemplar pairs for a subsequent memory test. Importantly, the study set includes several exemplars from each of a number of different categories. For example, participants might see pairs such as FRUIT – apple, FRUIT – orange, ANIMALS – cat, ANIMALS – dog, along with other categories.

Following the study phase, participants engage in retrieval practice. The retrieval practice phase requires the participants to actively engage in extensive retrieval for only a subset of exemplars from half of the studied categories. This is typically accomplished by using a category plus word stem cued recall task, which is repeated a number of times. Thus, participants may see cues such as FRUIT – a_____ and ANIMALS – c_____ and are instructed to use items from the study list to complete the stems. This design allows for three critical conditions: practiced items (RP+), unpracticed items from practiced categories (RP-) and unpracticed items from unpracticed categories (NRP). After completing the retrieval practice phase, participants are given a delay for a brief amount of time.

In the final phase of the experiment, participants are given a category cued recall test. The category cue words are presented one at a time and participants are instructed to recall all of the studied exemplars belonging to that category. The interesting finding

reported by Anderson et al. (1994) is that participants are below baseline in recalling

unpracticed items from practiced categories (RP-). That is, recall performance is higher

for NRP items than for RP- items. This rather counterintuitive observation led Anderson

et al. (1994) to propose an inhibitory explanation for the effect. In brief, they argue that

retrieval of the incomplete exemplars during the practice phase requires the participant to

inhibit related competing items. This inhibition is argued to persist into the test phase

resulting in below baseline remembering of RP- items.

Study Phase	Retrieval Practice	Delay	Recall Phase
5 sec/pair 8 categories/ 6 items	10 sec/item (3X) Fragment Completion		30 sec/category Cued Recall
e.g. fruit category: FRUIT - apple FRUIT - orange FRUIT - banana FRUIT - kiwi FRUIT - pear FRUIT -strawberry	FRUIT - ap___ FRUIT - or___ FRUIT - pe___		FRUIT ANIMAL FISH DRINKS PROFESSIONS BUILDINGS WEAPONS TREES

Figure 1: General format of the retrieval practice paradigm.

Experiment 1: The Basic Effect

The purpose of Experiment 1 was to replicate the findings of Anderson et al.

(1994), using the standard retrieval-induced forgetting paradigm. In accordance with

Anderson et al.'s findings, it was predicted that recall performance would be very high

for items that received retrieval practice. More importantly, it was expected that recall

performance would be higher for unpracticed items from non-practiced categories (NRP),

as compared to unpracticed items from practiced categories (RP-). This pattern of data

would be a successful demonstration of the retrieval-induced forgetting effect.

Method

Participants. Fourteen Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were a modified version of those used by Anderson et al. (1994). Prior to conducting the experiment proper, a pilot study was run to collect norms for the categories used by Anderson et al. (1994). This was done out of concern that participants at Simon Fraser University may not be familiar with exemplars such as Bluegill or Muskie as members of the FISH category.

The pilot study involved having participants generate all of the exemplars that they could come up with for each of ten categories. The selected categories included the eight categories used by Anderson et al. (DRINKS, WEAPONS, FISH, FRUITS, PROFESSIONS, METALS, TREES & INSECTS), as well as two other categories (BUILDINGS & ANIMALS) which were taken from Perfect et al. (2002).

The pilot data were collected from 75 participants. Each participant was instructed to list as many exemplars for each category as he or she could generate. The most frequently occurring six examples for each category were chosen as stimuli. However, for the purposes of the stem cued retrieval practice phase, it was necessary that no two exemplars, from any category, began with the same two first letters. Thus, if an exemplar overlapped with another exemplar in terms of the first two letters, the next frequently occurring item from that category was chosen. The final stimulus set consisted of ten categories with six exemplars per category (see Appendix A for the complete stimulus set).

Eight of the ten categories and their associated exemplars were randomly selected to be critical experimental items. The remaining two categories were used as filler items. Four of the eight experimental categories were randomly assigned to the retrieval practice condition and the remaining four to the non-practiced condition. Thus, half of the categories were practiced and half were non-practiced. For each category in the retrieval practice condition, half of the exemplars were designated to be practiced items (RP+) and half to be unpracticed items (RP-). As a result of this design, there were 12 practiced items (RP+), 12 unpracticed items from practiced categories (RP-) and 24 unpracticed items from non-practiced categories (NRP). Assignment of categories and exemplars to conditions was freshly randomized for each participant.

Procedure. Participants were tested individually in a quiet testing room. They were informed that they would be participating in a memory experiment and were given examples of the types of category – exemplar pairs that they would study. Prior to beginning the study phase, participants were instructed to encode the word pairs for a later memory test.

During the study phase, participants saw a total of 60 category – exemplar pairs. Study items were presented in 16 point font on a Power Macintosh G3 computer. Category words were presented in upper case and exemplars were presented in lower case. All pairs were presented for 5 seconds each with a 1 second interval between items. The first and last six study pairs were filler items taken from two categories. The remaining forty-eight study pairs were the critical experimental items and were presented in random order in the center of the computer screen.

After completing the study phase, participants were familiarized with the retrieval practice phase. They were told that they would be doing a fill-in-the-blanks test, where they would see the category word along with part of the exemplar word, for some of the studied items. Participants were instructed to come up with the incomplete word and to write it down on the provided sheet. For example, if they saw "FRUIT – ap____", they were to write down "apple." Furthermore, they were informed that they may encounter the same incomplete item more than once and that they were to use the same completion each time that item occurred. During the retrieval practice phase, RP+ items were presented, one at a time, at the center of the computer screen for 10 seconds, with a 1 second interval between each item. The twelve RP+ items were presented a total of three times each, with the set being re-randomized for each presentation. After completing the retrieval practice phase, the experimenter removed their response sheets and engaged the participant in conversation for five minutes before moving onto the final test phase. In order to ensure that the participant did not engage in any rehearsal, the experimenter discussed the current weather conditions and current events on campus.

For the final test phase of the experiment, participants were given the task of recalling all of the exemplars from each of the experimental categories that had been studied in the first phase of the experiment. Memory was tested using a category cued recall task. For each of the eight experimental categories, the category word was presented on the screen for a duration of 30 seconds. Participants were provided with response sheets on which they were asked to write down as many of the six studied exemplars as they could. After the 30 second limit, the next category word appeared on

screen and participants were instructed to move on and not return to previous test categories.

Results and Discussion.

In the retrieval practice phase of the experiment, participants were very successful in completing the word stems. Accuracy for stem completion was 94%. This finding is very similar to that of Anderson et al. (1994), who reported approximately 90% success for participants in the retrieval practice task.

Recall data were analyzed using a repeated measures analysis of variance (ANOVA). In the present, and all subsequent experiments, two planned comparisons were conducted. The first compared recall performance between RP+ items and NRP (baseline) items in order to examine the effects of retrieval practice. The second, and more theoretically relevant, comparison was between RP- items and NRP items. This second comparison allows for an examination of the retrieval-induced forgetting effect.

Figure 2 shows the percentages of correctly recalled items for each of the three experimental conditions. Not surprisingly, repeatedly retrieving members of a category improved recall of those items (RP+ = 85%) relative to baseline (NRP = 61%) on the final recall test [F (1,13) = 21.31, p = .000, MSE = .02, η^2 = .625]. This retrieval practice effect is consistent with the findings of Anderson et al. (1994) who also reported a recall advantage for items that were repeatedly retrieved prior to the final recall test.
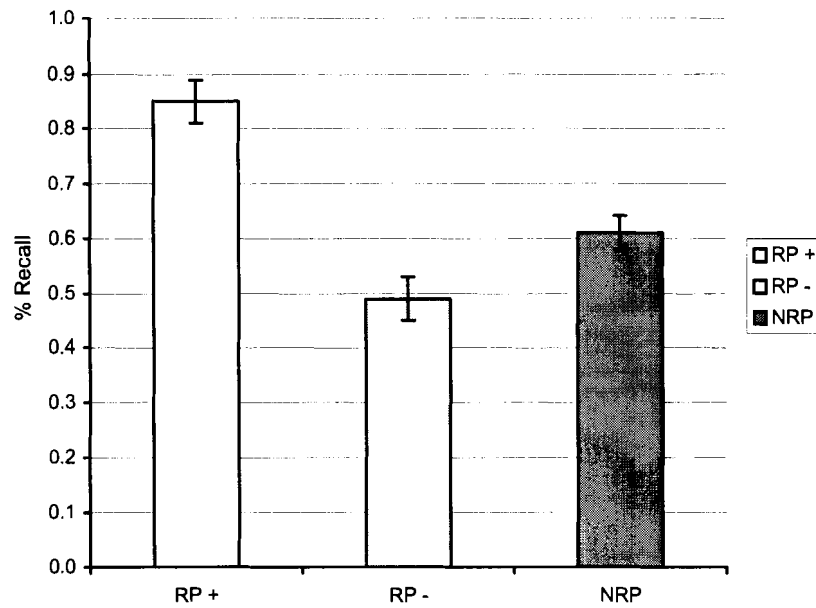
Figure 2: Percentage recall as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

More importantly, a reliable difference was found when comparing RP- items to NRP items on the final recall test. That is, unpracticed items from practiced categories (RP- = 49%) were recalled at a lower rate than baseline (NRP = 61%), on the delayed final recall test [F = 6.18, p = .027, MSE = .0, η^2 = .321]. This reduced ability to recall RP- items, compared to baseline, is in accord with the findings of Anderson et al. (1994).

These data demonstrate the retrieval-induced forgetting effect. As would be expected the items from the RP+ condition were very well recalled. After engaging in multiple retrieval episodes, participants are much more likely to recall those retrieved items. More importantly, the RP- items showed poor recall when compared to the baseline condition (NRP). It is this finding that is of particular theoretical interest. Specifically, Anderson et al. (1994) proposed that this below-baseline performance is the

consequence of selective inhibition of competing members of a class. One question that arises from this finding is whether participants are even aware of their decrement in performance for items that do not receive extra retrieval. This question will be addressed in the following two experiments.

The data of Experiment 1 replicate of the work of Anderson et al. (1994). Aside from the fact that a replication has been demonstrated, these results attest to the fact that the stimuli used in this experiment are not in any way biased against the effect. As a result, the same stimulus set was used in the remainder of the experiments reported in this thesis.

Experiment 2: Participant's Awareness

The results of Experiment 1 demonstrate the retrieval-induced forgetting effect. That is, participants have difficulty recalling unpracticed items from practiced categories relative to baseline. This forgetting effect has been attributed to an inhibitory process that serves to minimize internal distraction (Anderson et al., 1994; Anderson & Bell, 2001). According to this account, the retrieval process is met with competition from related memories and successful remembering is achieved through suppression of those competitors. This suppression is argued to persist and lead to later forgetting of those competing memories. Importantly, this account places emphasis on the role of attentional control mechanisms associated with the retrieval process (Anderson & Bell, 2001). That is, inhibition of competitors requires some degree of attentional control. If this assumption is correct, then it may be the case that participants have some awareness of their retrieval processing experience.

The aim of Experiment 2 was to examine the extent to which participants can be aware of their cognitive functions. In particular, participants in this study were asked to provide a qualitative description of their ability to recall each item on the final memory test. Though no specific predictions were made, it was reasoned that if participants are able, at least to some extent, to control their retrieval, then one might observe differences in their confidence of retrieving under the different experimental conditions.

Method

Participants. Twenty-two Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in Experiment 1 (see Appendix A for stimuli).

Procedure. The procedure for Experiment 2 differed from Experiment 1 only in the final test phase of the study. Participants studied 60 category – exemplar pairs (12 filler and 48 experimental) in the first phase. Subsequently, participants engaged in retrieval practice for half of the items from half of the categories. Retrieval practice was induced using a category plus cued stem recall task. Following the retrieval practice phase, participants were delayed by 5 minutes with conversation.

The test phase was very similar to that of Experiment 1. Participants viewed a category word on the computer screen for 30 seconds. During that time, participants were asked to recall all of the studied items from that category as well as providing a qualitative response regarding their memory. For each item that was recalled, participants were asked to indicate whether they felt that they were "remembering" or

"guessing." It was assumed that this measurement would provide some indication as to how participants viewed their own remembering performance. If participants were made aware of their ability or inability to recall, through this measure, then it may be possible for participants to overcome the retrieval-induced forgetting effect.

Results and Discussion.

Similar to the observation in Experiment 1, participants performed very well in the retrieval practice phase of the experiment, and successfully completed word stems 95% of the time.

Data from the final recall test were analyzed using a repeated measures ANOVA. The recall accuracy data were examined for both the effects of retrieval practice (RP+ vs. NRP) and for retrieval-induced forgetting (RP- vs. NRP). The same comparisons were conducted for the qualitative responses. That is, ANOVA's were conducted for the claims of remembering data as well as for the claims of guessing data.

Figure 3 shows the percentages of correctly recalled items for each of the three experimental conditions. As in Experiment 1, items that were repeatedly retrieved during the retrieval practice phase (RP+ = 87%) were better recalled than baseline items (NRP = 70%) on the final test [F (1,21) = 23.54, p = .000, MSE = .01, η^2 = .563].

The data also show a clear pattern of retrieval-induced forgetting. Recall for RP- items (60%) was reliably lower than recall for NRP items (70%) [F(1,22) = 12.75, p = .002, MSE = .01, η^2 = .378]. Thus, the data for Experiment 2 still provide evidence of retrieval-induced forgetting.
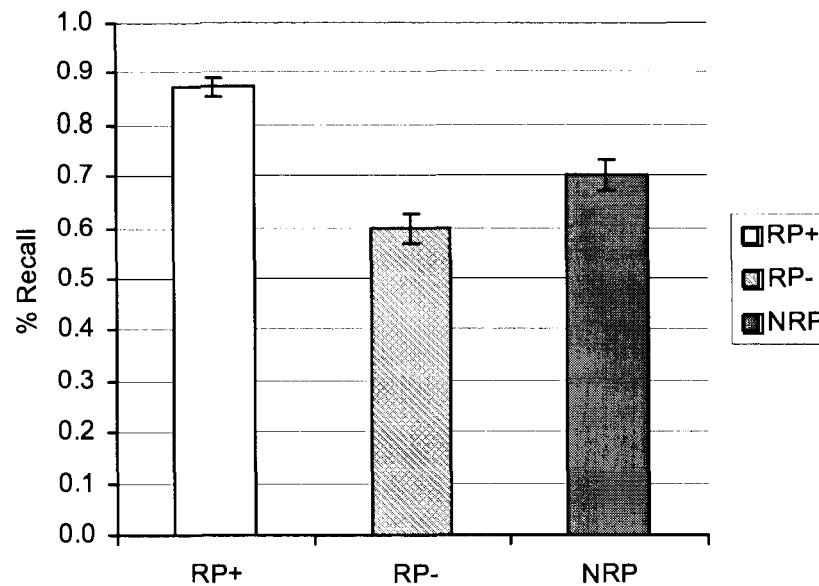
Figure 3:Percentage recall as a function of experimental condition. RP+ = retrieval
practiced items, RP- = unpracticed items from practiced categories, NRP =
unpracticed items from non-practiced categories.

The qualitative data for Experiment 2 are shown in Figure 4. These data represent

the percentage claims of remembering and guessing for each of the three experimental

conditions. It should be mentioned that some of the participants, despite instructions,

occasionally failed to provide a qualitative response along with their recall and in

consequence the total number of remembers and guesses do not add to 100%.

As would be expected, participants reported higher claims of remembering for

retrieval practiced items (RP+ = 79%) than for the RP- (47%) or NRP (60%) items

$[F(2,42) = 19.94, p = .000, MSE = .03, \eta^2 = .487]$. Further analyses revealed that

participants indicate higher claims of remembering for NRP items than for RP- items [F

$(1,21) = 12.75, p = .002, MSE = .01, \eta^2 = .378]$. This suggests that participants are more

confident in their recall accuracy for unpracticed items from unpracticed categories than

for unpracticed items from practiced categories. This observation is consistent with the

retrieval-induced forgetting effect; lower recall for RP- items is accompanied by fewer

claims of remembering.

The analysis of qualitative claims of guessing, demonstrated that participants

claimed to be guessing at a higher rate for RP- items (13%) than for either RP+ items

(4%) or for NRP items (10%) [F (2,42) = 6.66, p = .003, MSE = .01, η^2 = .244].

However, the source of this interaction appears to be primarily due to the low rate of

guess claims for the RP+ condition, as RP- items and NRP items did not differ

significantly [F (1,21) <1] from one another. In contrast, RP + items differed from both

RP- items [F (1,21) = 7.87, p = .011, MSE = .01, η^2 = .273], and from NRP items [F

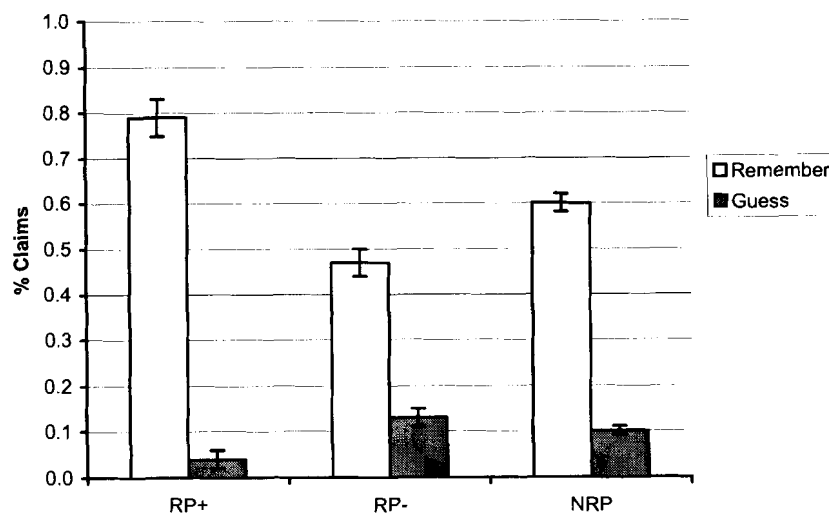(1,21) = 14.74, p = .001, MSE = .00, η^2 = .417].

Figure 4: Percentage claims of remember versus guesses as a function of experimental
condition. RP+ = retrieval practiced items, RP- = unpracticed items from
practiced categories, NRP = unpracticed items from non-practiced categories.

The results of Experiment 2 demonstrate that even though participants are somewhat aware of their cognitive processing at the time of recall, this awareness does not help them to overcome the retrieval-induced forgetting effect. Participants' claims of remembering closely corresponded to their accuracy in all conditions, while claims of guessing did not discriminate between RP- and NRP items. Despite this, a clear pattern of retrieval-induced forgetting was observed. This suggests that being aware of one's processing does not necessarily assist remembering in this task. Indeed, these data do not contradict Anderson et al.'s (1994) inhibitory account. By that explanation, inhibition is an automatic and necessary consequence of performing retrieval practice. That is, selective retrieval of some items belonging to a particular category invokes response competition from other members of that same category, and in consequence inhibition is necessary if one is to be successful in retrieving the target. However, if participants were able to overcome the retrieval-induced forgetting effect through awareness of their processing, the automaticity assumption of Anderson et al. (1994) would be seriously challenged. The following experiment addresses this possibility.

Experiment 3: Robustness

In the previous experiment, retrieval-induced forgetting was observed despite the fact that participants were somewhat aware of their retrieval processes. This finding suggests that the retrieval-induced forgetting effect is robust to awareness. That is, knowledge of one's processing experience does not assist in overcoming forgetting. However, in that experiment it may have been the case that participants were only vaguely aware of their processing. This is supported by the fact that participants' claims

of remembering paralleled their accuracy in the different experimental conditions, while claims of guessing did not distinguish between conditions. Further, it may be the case that simple awareness of one's confidence in recall is not sufficient to overcome the forgetting effect. In Experiment 3, participants were explicitly forewarned of the retrieval-induced forgetting effect. It was expected that this manipulation would encourage participants to adopt a strategy through which they could overcome the retrieval-induced forgetting effect.

Method

Participants. Nineteen Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in Experiment 1 (see Appendix A for stimuli).

Procedure. The procedure for Experiment 3 differed from Experiment 1 only in terms of the instructions for the retrieval practice phase and the final test phase of the study.

Participants studied 60 category – exemplar pairs (12 filler and 48 experimental) in the first phase. Prior to beginning the retrieval practice, participants were told about the retrieval-induced forgetting effect. Specifically, they were told that many people get tricked by the retrieval practice and, as a result, fail to recall other items from those practiced categories. Participants were encouraged to be aware of this during the retrieval practice. Again, a category plus cued stem recall task was used in the retrieval

practice phase. Following the retrieval practice phase, participants were delayed by 5 minutes with conversation.

The test phase was identical to that of Experiment 1, with one instructional exception: participants were warned that the retrieval practice phase may make the final test very difficult, and to be aware of this when trying to recall all of the items from the study phase. Participants viewed a category word on the computer screen for 30 seconds. During that time, participants were asked to recall all of the studied items from that category, and to write down recalled words on a response sheet.

Results and Discussion.

Participants performed well in the retrieval practice phase of the experiment. The word stems were accurately completed 92% of the tine.

The final recall data are presented in Figure 5. A retrieval practice effect was again observed with RP+ items being accurately recalled at a higher rate than baseline NRP items (85% versus 65% respectively) [F (1,18) = 35.58, p = .000, MSE = .01, η^2 = .661]. This finding illustrates the benefit of additional retrieval on later recall.

It was predicted that, if participants were made aware of the effects of retrieval practice on later recall of unpracticed items, they might be able to overcome the typical forgetting effect. However, as is evident from Figure 5, retrieval-induced forgetting was observed. Participants showed a clear disadvantage for RP- items (51%) when compared with baseline NRP items (65%) [F (1,18) = 13.72, p = .002, MSE = .01, η^2 = .435].
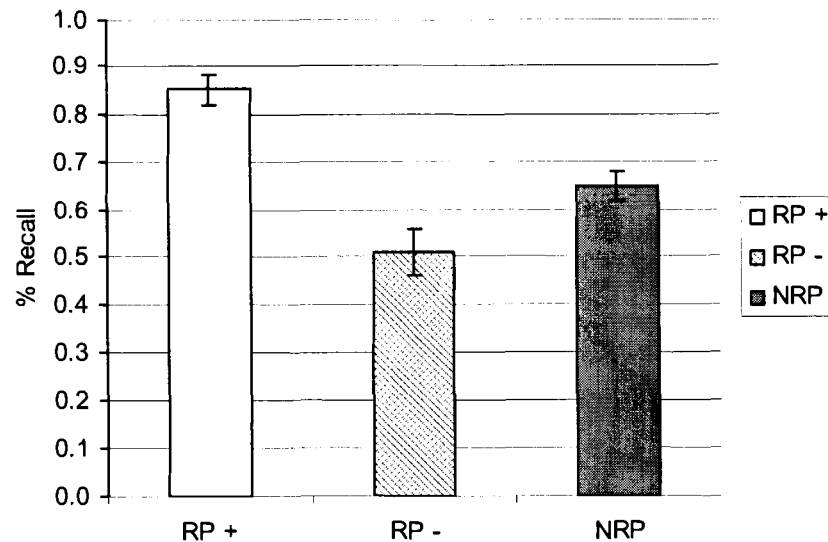
Figure 5: Percentage recall as a function of experimental condition. RP+ = retrieval
practiced items, RP- = unpracticed items from practiced categories, NRP =
unpracticed items from non-practiced categories.

The pattern of data found in Experiment 3 is nearly identical to that of Experiment

1, which suggests that the explicit warning manipulation had no effect on participants.

Clearly, encouraging participants to develop a strategy did nothing to assist them in

remembering unpracticed items from practiced categories (RP-). By all appearances, it

seems as though the retrieval-induced forgetting effect is cognitively impenetrable.

Knowledge of the forgetting effect does not prevent the forgetting from occurring.

Indeed, Anderson and Green (2001) suggested that participants are, for the most part,

powerless to prevent retrieval-induced forgetting, even when they are highly motivated to

do so. In their study, participants were rewarded with money for accurate responses, and

still showed retrieval-induced forgetting. This observation lends support to Anderson et

al.'s (1994) account suggesting that inhibition is an automatic consequence of engaging

in retrieval practice.

Summary

In conclusion, the experiments reported in this section clearly demonstrate the retrieval-induced forgetting effect. In three experiments, retrieval-induced forgetting was observed, and in consequence, one can be certain that the stimulus materials and procedure used are not in any way biased against the effect. In addition, the effects reported are very similar in magnitude to those found by Anderson et al. (1994).

Furthermore, these experiments demonstrate that retrieval-induced forgetting, as a cognitive phenomenon, is a robust effect. Despite the observation that participants have some degree of awareness of their remembering accuracy, forgetting is observed. Likewise, explicitly warning participants of the forgetting effect did not improve recall performance in any way.

Taken together, the results reported in this section do not necessarily challenge an inhibitory account of retrieval-induced forgetting. However, these observations do not provide any evidence as to why an inhibitory mechanism is needed to explain the effect, nor do they explain how that mechanism might work. To illustrate, Anderson and Bell (2001) argue that an inhibitory mechanism is needed to suppress competing related memories when one is attempting to retrieve a target memory. This type of theoretical account naturally leads to the question: how does such an inhibitory mechanism discriminate between targets and competitors? It seems that the response to such a question could become very complex. For example, it could be argued that memory is arranged in some type of network fashion and that a target will become active during retrieval. If that activation of the target exceeds the activation level of competing memories, then discrimination of the target from competitors would be relatively trivial

for the system. However, following from this argument, the need for inhibition is eliminated, as the target could be selected simply on the basis of higher activation.

An alternative explanation could be that target items are selected on the basis of attention. In fact, Anderson and Bell (2001) argue that attentional processing is central to the inhibition account. They suggest that it is the process of attending to a specific target that invokes the suppression of competing memories. The difficulty with this conclusion is that the authors provide no explanation as to which items are competitors, nor why they interfere with target selection. That is, what is the mechanism that leads to response competition? Furthermore, it is not clear how an automatic inhibitory process requires attention in order to operate.

The remainder of the experiments reported in this thesis were a further examination of the circumstances under which retrieval-induced forgetting is observed. The goal of this work was to outline the boundaries of retrieval-induced forgetting and to attempt to provide a parsimonious explanation of the data.

Chapter 3: Capacity Limitations

In the previous chapter, retrieval-induced forgetting was examined using the standard paradigm developed by Anderson et al. (1994). Using that paradigm, clear evidence of forgetting was found in several experiments. The results of these studies suggest that retrieval-induced forgetting is a robust effect, in that it is observed even when participants are explicitly encouraged to overcome the forgetting effect. Indeed, these experiments do not pose any challenge to an inhibitory account of the effect. However, they do raise questions as to how inhibition operates on memory to produce item specific forgetting. The studies reported in the present chapter were conducted in order to further examine the experimental conditions under which retrieval-induced forgetting is observed and to develop a clearer understanding of the cognitive mechanisms responsible for the effect.

Experiment 4: Effects of Generation

The predominant theory of retrieval-induced forgetting is an inhibitory account (Anderson et al., 1994, Anderson & Spellman, 1995; Anderson & Bell, 2001; Anderson, 2003; Anderson, 2005; MacLeod & Macrae, 2001; MacLeod, 2002). According to this explanation, selective retrieval of a target requires inhibition of related items in that same class. This inhibition is argued to persist for up to twenty four hours, resulting in forgetting of items that are strongly associated to the retrieved target item (Anderson et al., 1994; MacLeod & Macrae, 2001).

Experiment 4 was conducted to test the inhibition account of retrieval-induced forgetting. In brief, that account argues that retrieval practice of a subset of items from a

particular class will result in suppression of other episodically encoded items from that same class. Following from this argument, it would be expected that participants would fail to realize that they had recently encoded unpracticed items from the practiced categories. This is typically the result that is found using a standard category cued recall test.

The present experiment tested the inhibition hypothesis in an alternative way. Specifically, prior to engaging in the final recall task, participants were asked to generate new items for each of the studied categories. It was reasoned that if, in fact, the unpracticed items from practiced categories (RP-) were inhibited, then participants would likely generate those items, erroneously, as new items. This logic follows from the findings of Anderson et al. (1994) who demonstrated that the magnitude of the retrieval-induced forgetting effect is related to the strength of association between exemplars. They found that exemplars that were strongly associated with a category (e.g., APPLE with the FRUIT category) showed more retrieval-induced forgetting than weakly associated exemplars (e.g., GUAVA). All of the experiments reported in this thesis used strongly associated exemplars, and thus it should be expected that RP- items in this study should receive a relatively large amount of inhibition.

Method

Participants. Seventeen Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in Experiment 1 (see Appendix A for stimuli).

Procedure. The procedure for Experiment 4 differed from the standard procedure of Anderson et al. (1994) only in the final test phase of the study. In the first phase, participants studied 60 category – exemplar pairs (12 filler and 48 experimental). Retrieval practice involved a category plus stem cued recall task for half of the items from half of the studied categories, which was completed three times for each item. Following the retrieval practice phase, participants were delayed by 5 minutes with conversation.

The test phase was very similar to that of Experiment 1. Participants viewed a category word on the computer screen and were prompted to generate 3 new, unstudied items belonging to that category. They were told that three common items belonging to each category had been left out of the initial study list, and that they should try to come up with those items. After generating new items, participants were then instructed to recall all 6 studied items from that category. Further, they were asked to indicate for each recalled item, whether they felt that they were remembering or guessing. All responses were written on booklets provided and participants worked at their own pace. After completing each category, they were instructed to press a button on a button box in order to move to the next category.

Results and Discussion.

Similar to the observation in Experiment 1, participants performed very well in the retrieval practice phase of the experiment, and successfully completed word stems 94% of the time.

The data from the generation task are reported in Figure 6. These data reflect the mean number of new and old items generated for practiced (RP+ & RP-) and unpracticed categories (NRP). Note that generation of an old item constitutes an error, as participants were only to list new, unstudied items on this task. From an inhibition perspective, it was predicted that participants would have difficulty generating new items for practiced categories. That is, the most typical exemplars, which were the RP- items, should have been inhibited and, in consequence, it was expected that participants would erroneously generate those items as new items. However, as is evident from Figure 6, participants had no difficulty in generating new items for practiced categories (10.94/12 = 91.2%). Occasionally participants failed to generate three items for each category and thus, the total of new and old generated items does not add up to 100%.

All data in this experiment were analyzed using repeated measures ANOVA. In contrast to the predicted outcome, participants were actually able to generate more new items for practiced (91.2%) than unpracticed categories (10.06/12 = 84.3%) [$F(1,16) =$ 5.61, p = .031, MSE =.01, $\eta^2 = .278$]. In addition, participants were less likely to make an error (e.g., generate an old studied item) for practiced categories (6.8%) than for unpracticed categories (11.3%) [F (1,16) = 4.7, p = .046, MSE =.00, $\eta^2 = .250$]. Overall, the results for the generation task do not support the inhibition account and, instead, suggest that participants have not necessarily inhibited unpracticed items, but possibly can not access them during the final recall test in the standard paradigm.
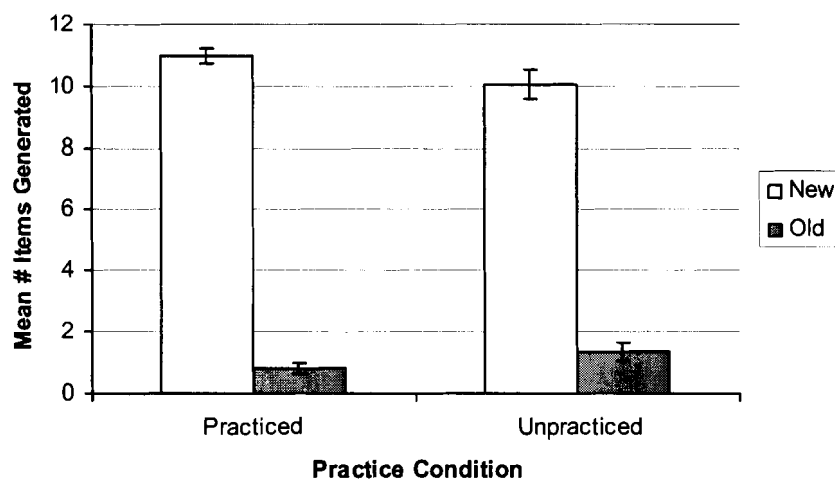
Figure 6: Mean number of new and old items generated as a function of practiced (RP+ & RP-) or unpracticed (NRP) category. Note: maximum number of responses is 12. New exemplars are accurate responses and old exemplars are errors.

The results of the final recall data are illustrated in Figure 7. Not surprisingly, there was an effect of retrieval practice. Previously retrieved items (RP+ = 93%) were better recalled on the final recall test than baseline items (NRP = 72%) [F (1,16) = 59.65, p = .000, MSE =.01, η^2 = .782]. The more interesting result was that there was no evidence of retrieval-induced forgetting. That is, participants were equally as likely to recall RP- items (73%) as NRP items (72%) on the final recall test [F <1]. Given that the modifications in test procedure were relatively minimal, this failure to find forgetting suggests that retrieval-induced forgetting may not be a highly robust effect.

Figure 7: Percentage recall as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

The data for percentage claims of remembering and guessing are shown in Figure 8. Analysis of the qualitative data for Experiment 4 revealed a reliable difference in claims of remembering. Participants claimed to be recalling more often for RP+ items (92%) than for either RP- (57%) or for NRP (63%) items [F (2,32) = 40.13, p =.000, MSE =.01, η^2 = .715]. However, claims of recall were not different for RP- and NRP items [F<1]. Similarly, the only difference observed for claims of guessing was due to the low rate of guesses for RP+ items (1%) which were reliably lower than for RP- (15%) or NRP (9%) items [F (2,32) = 13.92, p =.000, MSE =.01, η^2 = .459]. Again, RP- and NRP conditions did not differ in terms of claims of guessing [F<1].
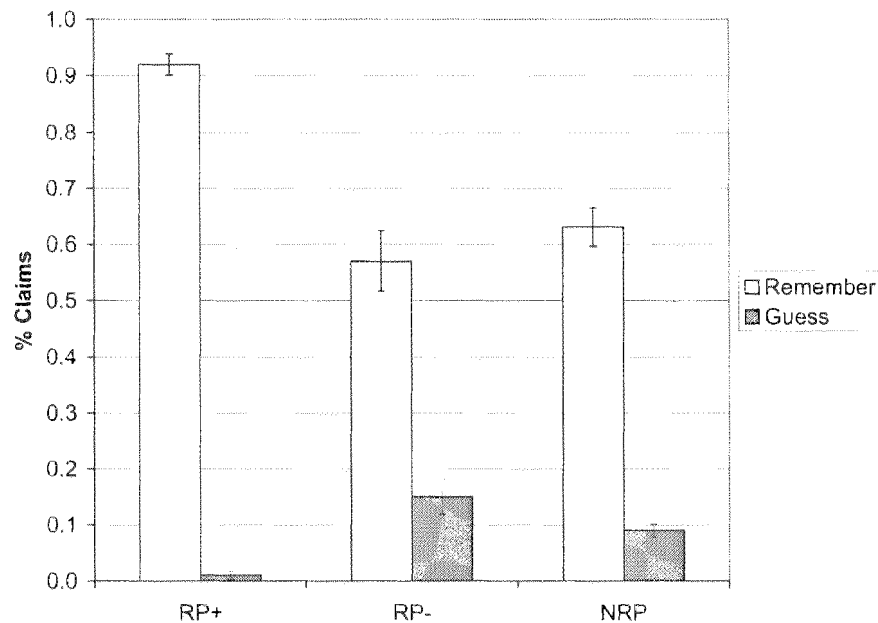
Figure 8: Percentage claims of remember versus guesses as a function of
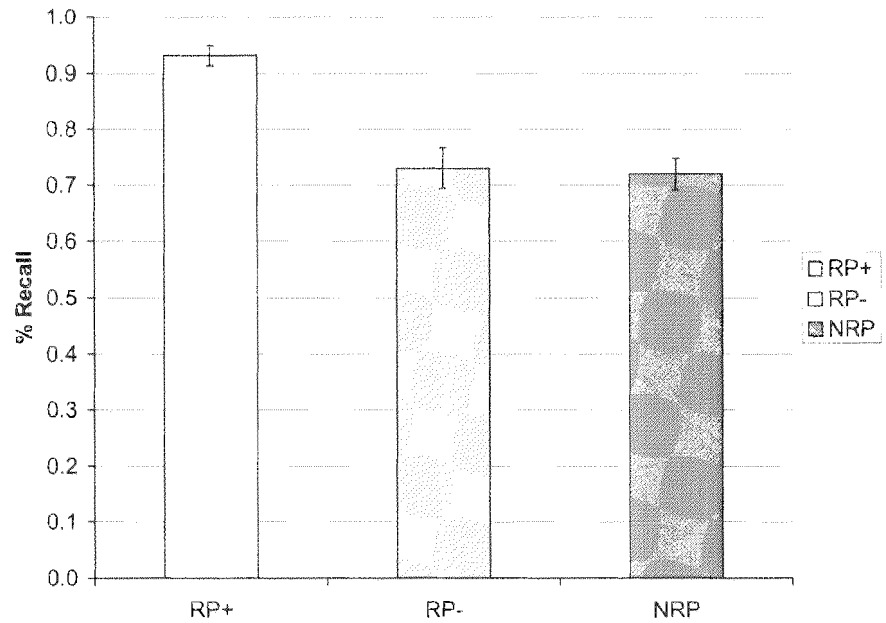experimental condition. RP+ = retrieval practiced items, RP- =
unpracticed items from practiced categories, NRP = unpracticed items
from non-practiced categories.

The results of Experiment 4 cast some doubt on the inhibition account of

retrieval-induced forgetting. Inhibition would predict that participants would fail to have

episodic awareness of the fact that they had recently encoded RP- items. That is, the

retrieval practice phase should have inhibited competitors to the target items and, in

consequence, one would have expected participants to mistakenly generate those items as

being new. However, the data from the generate task indicate that participants were able

to recognize that they had recently encountered these items and were quite able to

generate novel items. In fact, only rarely did individuals erroneously generate studied

items as being new. Furthermore, no retrieval-induced forgetting was observed in the

final recall data. This result was somewhat surprising, given that the effect was thought to be robust to manipulations in procedure.

According to Anderson (2001; see also Anderson & Green, 2001; Levy & Anderson, 2002; Anderson, Anderson, Ochsner, Khul, Cooper, Robertson, Gabrieli, Glover & Gabrieli, 2004; Anderson, 2005), the inhibitory mechanism that underlies retrieval-induced forgetting in the laboratory, is that same mechanism that guides intentional forgetting in our daily lives. These authors have proposed that inhibition is responsible for intentional forgetting, ranging from forgetting an argument with a good friend, all the way to complete suppression of childhood sexual abuse. If this proposed mechanism is so powerful that it can induce forgetting of such traumatic events, then one would expect that inhibition of this sort should be quite robust to slight modifications in laboratory procedure.

The fact that retrieval-induced forgetting was not observed in the present experiment suggests that deviation from the original paradigm, developed by Anderson et al. (1994) may influence the effect. It is difficult, though, to determine why the effect was not observed in the present study, as there were several slight modifications in procedure that may have influenced participants' remembering behavior.

First, in Experiment 4, participants were asked to generate new items for each category, prior to engaging in recall. This is not usually done in the standard paradigm and may have influenced the forgetting effect. Retrieval-induced forgetting has been previously demonstrated using a generation task (Bauml, 2002). In that experiment, participants studied only RP+ items in the initial list. Subsequently, they were asked to generate semantic associates for the studied categories; these generated items constituted

the RP- items. Following the retrieval practice phase, participants recalled fewer RP-items than a baseline condition. Thus, it was concluded that retrieval-induced forgetting can be observed even when the unpracticed items from practiced categories (RP-) are generated by the participants.

The procedure used by Bauml (2002) differs slightly from that of Experiment 4 in that the semantic generation phase was quite separate from the final recall phase. In Experiment 4, the generation phase was completed immediately prior to the recall test for each category. Though it is not apparent why this difference would lead to a difference in remembering performance, it can not be eliminated as a possibility and it certainly does not demonstrate conclusive evidence for or against the inhibition account. For example, it could be argued that having participants engage in semantic generation immediately prior to recall leads to a disinhibition of previously suppressed items. That is, forcing participants to actively focus on a set of items belonging to a particular class, may cause activation which in turn releases any previous inhibition. A similar argument has been proposed by Bjork (1989) to account for failure to observe directed forgetting effects. Bjork suggested that failure to observe directed forgetting using a recognition memory test was due to disinhibition. It was argued that, when the "forget" item was presented for discrimination on the recognition test, that item receives some level of activation and, as a result, is no longer inhibited by previous instructions. Following from this, it is possible that the generation task in Experiment 4 served to release any inhibition that was invoked during the retrieval practice phase.

A second deviation from the standard paradigm was that the procedure in Experiment 4 required participants to indicate their qualitative evaluation of their

retrieval processing. Though this may have had an influence, it is unlikely that this factor alone was responsible for the failure to observe retrieval-induced forgetting. This is supported by the fact that participants in Experiment 2 were also asked to provide remember or guess assessments along with their recall and, in that study, retrieval-induced forgetting was observed.

A third and final deviation from the standard paradigm was that Experiment 4 permitted participants to work at their own pace on the generation task, as well as the final recall task. The standard paradigm limits recall to thirty seconds per category and, thus, the present experiment allowed for much more variability in retrieval processing time. Despite this difference, previous research has demonstrated that the effects of inhibition on recall can be observed up to 24 hours after the retrieval practice phase (MacLeod & Macrae, 2001). Thus, it seems reasonable to expect that allowing participants more than thirty seconds to recall six items for each category should not influence performance too drastically.

Based on the discussion above, it seems most likely that the failure to observe retrieval-induced forgetting in Experiment 4 was related to the generation task. Neither the qualitative reporting, nor the extended time factor, have particularly compelling arguments to suggest they may have caused the forgetting effect to be eliminated. Thus, in the following experiment, the generation task was excluded in an attempt to isolate the source that eliminated the retrieval-induced forgetting effect.

Experiment 5: Elimination of Generation Task

The purpose of Experiment 5 was to examine more closely those factors that may contribute to the retrieval-induced forgetting effect. It was demonstrated in Experiment 4 that deviations from the standard paradigm in terms of procedure abolished the effect. However, it is not clear which of those changes in procedure was responsible for the failure to observe retrieval-induced forgetting. From an inhibition perspective, it could be argued that the semantic generation task used in Experiment 4 led to disinhibition of the competing exemplars (RP- items) and, thus, no forgetting was observed. Experiment 5 was conducted to test this argument. Specifically, if the generation task (but not the other procedural changes) lead to disinhibition, then it can be predicted that retrieval-induced forgetting would be observed in the absence of that task.

Method

Participants. Seventeen Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in Experiment 1 (see Appendix A for stimuli).

Procedure. The procedure for Experiment 5 differed from Experiment 4 only in the final test phase of the study. In the study phase, 60 category – exemplar pairs (12 filler and 48 experimental) were presented. Retrieval practice involved a category plus stem cued recall task for half of the items from half of the studied categories, which was completed three times for each item. Following the retrieval practice phase, participants were delayed by 5 minutes with conversation.

The test phase was very similar to that of Experiment 4, with the exception that participants were not asked to generate any new items. Thus, participants viewed a category word on the computer screen and were instructed to recall all 6 studied items from that category. As well, they were asked to indicate for each recalled item, whether they felt that they were remembering of guessing. All responses were written on booklets provided and participants worked at their own pace. After completing each category, they were instructed to press a button on a button box in order to move to the next category.

Results and Discussion.

As has been observed in all of the reported experiments so far, performance on the retrieval practice phase was very high. Participants successfully completed word stems 95% of the time.

The final recall data are illustrated in Figure 9 which shows the percentages of correctly recalled items for each of the three experimental conditions. All analyses in this experiment were conducted using a repeated measures ANOVA.

Participants were very successful in recalling items that were repeatedly retrieved during the retrieval practice phase. Again, a retrieval practice effect was observed with RP+ items (91%) being recalled at a much higher rate than baseline (NRP = 77%) [F $(1,16)$ = 19.82, p =.000, MSE =.01, η^2 = .556]. Surprisingly, when comparing recall rates for items in the RP- condition to items in the NRP condition, no reliable difference was observed [F <1]. As is apparent from Figure 9, there was virtually no difference in recall rates for RP- items (76%) and NRP items (77%). Thus, retrieval-induced forgetting was

not observed in this experiment. It was predicted that the exclusion of the generation task

in the present experiment would result in retrieval-induced forgetting. However, there is

no evidence for the predicted effect in Experiment 5. This suggests that the failure to

observe retrieval-induced forgetting in Experiment 4 was not due to the semantic

generation task but, instead, due to some other factor.

Figure 9: Percentage recall as a function of experimental condition. RP+ = retrieval
practiced items, RP- = unpracticed items from practiced categories, NRP =
unpracticed items from non-practiced categories.

The qualitative data for percentage claims of remembering and guessing are

shown in Figure 10. Participants claimed to be recalling at a higher rate for RP+ items

(89%) than for either RP- items (62%) or for NRP items (67%) [F (2,32) = 22.77, p

=.000, MSE =.02, η^2 = .586]. Participants were no more likely to claim to be

remembering for RP- items than for NRP items [F<1]. Likewise, participants claimed to

be guessing at a lower rate for RP+ items (2%) than for either RP- items (14%) or for

NRP items (11%) [F (2,32) = 9.79, p =.000, MSE =.01, η^2 = .382]. Again, the source of

the observed interaction appears to be due to the relatively high confidence ratings for the

RP+ items, as the RP- and NRP conditions did not differ in terms of claims of guessing

[F<1]. Together, the qualitative results of the present experiment are similar to the

reports of remembering and guessing for both Experiments 2 and 4 reported earlier. In

particular, the only reliable differences observed in the three experiments seem to arise

from the high confidence level that participants have in recalling items that have been

given extensive practice in the retrieval practice phase.
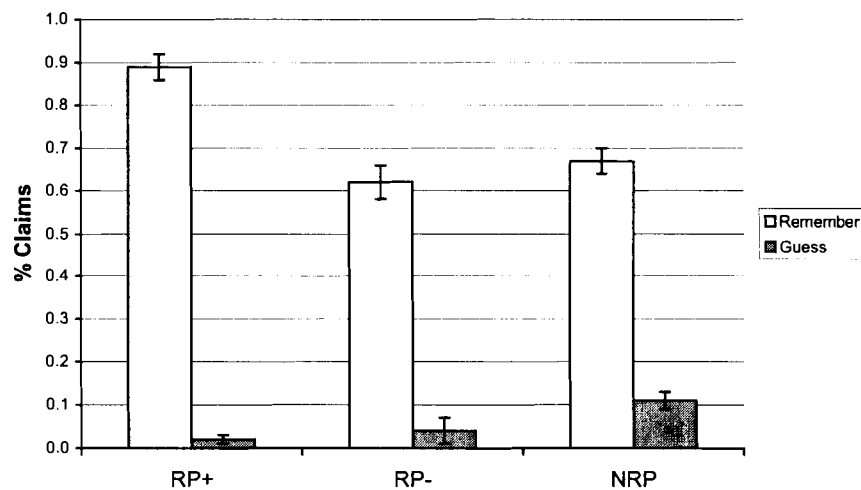
Figure 10. Percentage claims of remember versus guesses as a function of experimental
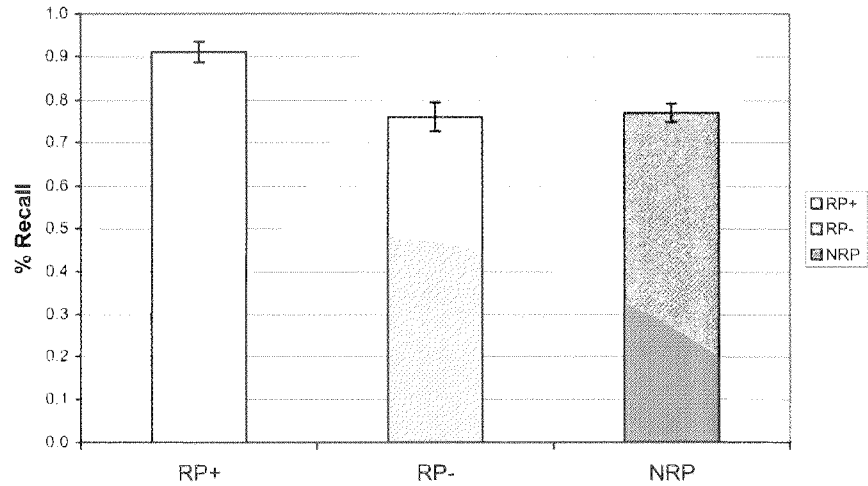condition. RP+ = retrieval practiced items, RP- = unpracticed items from
practiced categories, NRP = unpracticed items from non-practiced categories.

Retrieval-induced forgetting was not observed in Experiment 5. From an

inhibition standpoint, it was hypothesized that omission of the semantic generation task

would result in retrieval-induced forgetting. In particular, it was assumed that any

deviation the standard procedure may have eliminated the retrieval-induced forgetting effect in earlier studies, and thus, elimination of task differences would re-invoke the forgetting effect. From that perspective, it may have been the case that the act of generation would lead to disinhibition of the RP- items. Given that retrieval-induced forgetting was not found in the present experiment, it can be argued that the semantic generation task used in Experiment 4 was not responsible for the failure to observe the effect. Together, these experiments provide some insight into the factors that influence the retrieval-induced forgetting effect and suggest that inhibition may not be the source of the effect. Despite this insight, these experiments do not illuminate clearly the cognitive mechanisms underlying the retrieval-induced forgetting effect.

As mentioned earlier, Experiment 4 differed from the standard procedure in several ways. It was hypothesized that the generation procedure used in that study may have been responsible for failing to observe the retrieval-induced forgetting effect. However, it is clear from the results of Experiment 5 that the generation task was not the critical departure from procedure that resulted in no forgetting.

The results of the qualitative data from Experiment 5 suggest that the task of assessing one's confidence in their recall is not of central importance to the effect. Specifically, the data from Experiment 5 are very similar to those of Experiment 2 in the sense that in neither case did the claims of remembering or guessing discriminate between RP- and NRP items. Given that the data are very similar between these two experiments, and that retrieval-induced forgetting was observed in Experiment 2, it is unlikely that the qualitative task used in the present study was responsible for failing to observe the effect.

Instead, it may be that the retrieval-induced forgetting effect is related to the amount of time that participants are given to recall studied items. Specifically, in Experiments 4 and 5, the final recall task was self-paced, such that participants faced no time constraints. This stands in contrast to the standard paradigm, in which participants are limited to thirty seconds to recall all six exemplars for each category. It was thought unlikely that this was a critical deviation, given that previous investigations of retrieval-induced forgetting have demonstrated that inhibition of the RP- items can persist for up to 24 hours (MacLeod & MacRae, 2001). However, in that particular study, participants were only given 30 seconds to recall at the time of test. Therefore it may be the case that allowing unlimited time during the test phase is an important factor in the retrieval-induced forgetting paradigm. The following experiment examines the possibility that time to recall has a critical influence on retrieval-induced forgetting.

Experiment 6: Effects of Time to Retrieve

In the discussion above, it was proposed that the reason retrieval-induced forgetting was not observed in the previous two experiments may have been related to the amount of time that participants were given to recall studied exemplars for each category. In those two studies, the recall test was self-paced and, thus, participants were free to take as long as they wished to come up with the exemplars. It is possible that this unlimited retrieval time was responsible for the elimination of the forgetting effect.

The purpose of Experiment 6 was to examine the influence of retrieval time on the forgetting effect. Specifically, the present experiment was an investigation of

retrieval time in the absence of any other procedural changes. Thus, Experiment 6 was

virtually identical in procedure to that of Experiment 1 with the exception that the amount

of time given to recall on the final test was limited. If time to recall is a critical factor in

the retrieval-induced forgetting effect, then it could be argued that the effect itself is

somewhat determined by the characteristics of the task, rather than an automatic

inhibitory mechanism that governs remembering behavior in general.

Method

Participants. Thirty-eight Simon Fraser University students participated in this

experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in all

previous experiments (see Appendix A for stimuli).

Procedure. The study phase consisted of 60 category – exemplar pairs (12 filler

and 48 experimental) were presented on the center of a computer screen. Immediately

following the study phase, participants engaged in retrieval practice. As in all previous

reported studies, retrieval practice was induced using a category plus stem cued recall

task for half of the items from half of the studied categories. Each stem was completed

three times for each item. Following the retrieval practice phase, participants were

delayed by 5 minutes with conversation.

The test phase of Experiment 6 differed in procedure from the standard paradigm

only in the amount of time that participants were given to recall studied exemplars.

Participants viewed category words at the center of a computer screen and were

instructed to recall all 6 studied items from that category. Unlike the standard procedure,

participants were given two minutes, as opposed to 30 seconds, per category to recall studied exemplars. After two minutes, participants were alerted by a beep from the computer, indicating that they were to move on to the next page on the provided booklet. Following a brief (5 second) delay, the next category word was presented.

In Experiments 4 and 5 participants were self-paced on the final recall task and, in both studies, retrieval-induced forgetting was observed. The present experiment limited recall time to two minutes per category and, thus, participants were somewhat constrained. However, they still had ample time to recall six exemplars. It was expected that if participants were not able to recall within the two minute limit, then it was unlikely that they would ever recall accurately. The rationale for the two minute limit was that this limit greatly exceeds 30 seconds but does not permit a wide range of variability across participants in terms of recall time. If the retrieval-induced forgetting effect is dependent upon the participants being somewhat hurried in their final recall, then it could be predicted that no retrieval-induced forgetting would be observed with the extended time limit. However, if the effect is not time dependent, then retrieval-induced forgetting should be observed.

Results and Discussion.

In accordance with the observations of Anderson et al. (1994), as well as all of the experiments reported in this thesis, participants performed well on the retrieval practice phase, successfully completing word stems 95% of the time.

The data for the final recall test are illustrated in Figure 11, showing the percentages of recalled items for each of the three experimental conditions. As could be

expected, based on previous experiments, an effect of retrieval practice was found. That

is, repeatedly practiced items were recalled at a higher rate (RP+ = 90%) than were

baseline (NRP = 66%) items [F (1,37) = 78.03, p = .000, MSE =.01, η^2 = .677]. More

theoretically relevant was that no retrieval-induced forgetting was observed. That is, RP-

items were recalled (64%) just as well as NRP items (66%) [F <1].
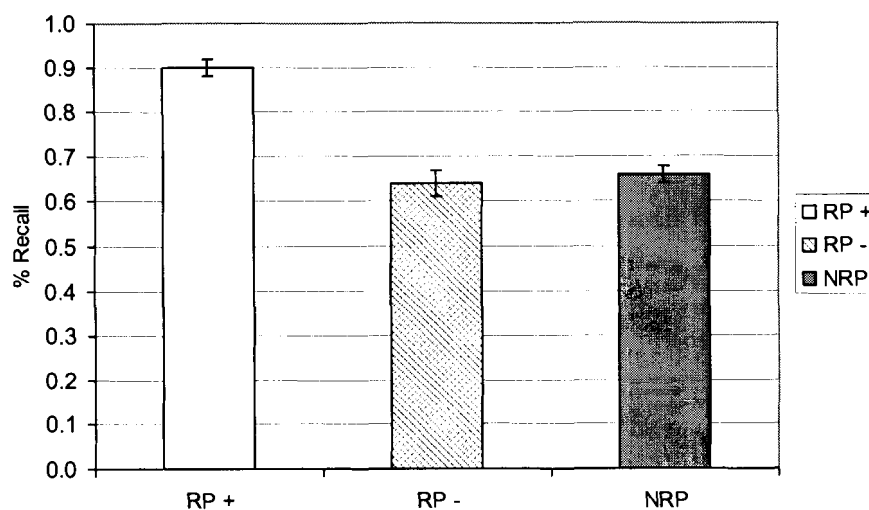
Figure 11: Percentage recall as a function of experimental condition. RP+ = retrieval
practiced items, RP- = unpracticed items from practiced categories, NRP =
unpracticed items from non-practiced categories.

The results of Experiment 6 suggest that the retrieval-induced forgetting effect is

dependent upon the amount of time that participants are given to recall studied items on

the final recall test. Specifically, when participants are constrained to a time limit, but

that limit allows ample retrieval time, the forgetting effect is not observed. Furthermore,

the results of the present experiment suggest that the failure to find retrieval-induced

forgetting in Experiments 4 and 5 was not due to either a generation task nor to the

qualitative assessment of remembering task. Instead, these data provide evidence to support the hypothesis that the effect is, at least in part, determined by the demands of the task. When pressed for time, participants show difficulty in recalling unpracticed items from unpracticed categories (RP-). However, when given unlimited time, or even just extended time to retrieve, the forgetting effect is not observed.

In terms of theory, these data pose a challenge to the inhibition account of retrieval-induced forgetting. If the forgetting effect were a result of an automatic inhibitory mechanism that is capable of suppressing traumatic life experiences, then it would be reasonable to expect that the effect would be robust to modifications of the task. In opposition to an inhibition account, these data suggest that the retrieval-induced forgetting effect may be the result of a limitation of capacity.

Rather than employing an inhibition account, the data thus far can be explained in terms of processing capacity. That is, the retrieval-induced forgetting effect may occur as a result of the time limitations of the paradigm. After repeatedly practicing a subset of items from a category, it is plausible that at the time of recall, those items would be predominant in memory and may "pop" into mind with each attempt at retrieval. In consequence, the practiced items are competing with the unpracticed items. With time limitations the practiced items that persist in mind will win out in terms of successful recall.

From this perspective, the retrieval-induced forgetting effect could be argued to be an interference effect, rather than an inhibition effect. That is, instead of RP- items being suppressed, RP+ items are the first that come to mind at the time of recall, and in

consequence, those items tend to over-ride the RP- items initially. This persistence of RP+ items creates interference, which can only be overcome with time. When participants are given adequate time to sort out which items were included in the retrieval practice phase, and which were not, they can do so quite readily. This argument is supported by the data of Experiments 4, 5 and 6, which demonstrated that the provision of additional retrieval time on the final test eliminated the forgetting effect.

Together, these studies support the notion that retrieval-induced forgetting can be explained in terms of limited capacity. More directly, these data show that participants are capable of overcoming the forgetting effect if they are given sufficient time to recall studied items. These observations suggest that, at least in part, the retrieval-induced forgetting effect is driven by the circumstances of the task. Extending time to recall on the final test phase from 30 seconds to two minutes eliminated the effect. Clearly, this time extension had a dramatic impact on the retrieval-induced forgetting effect. One potential criticism is that this large increase in time to retrieve may have allowed participants too much time to reflect on the category and its exemplars. That is, two minutes provides ample time for thinking about the category and thus, rather than retrieving studied items, participants may have simply generated likely candidates. Though participants were instructed only to recall items from the study list, this possibility remains and was tested in a subsequent experiment.

Experiment 7: Effects of Reducing Time to Retrieve

In the previous section it was argued that retrieval-induced forgetting as a phenomenon may be more parsimoniously explained in terms of limited capacity to

retrieve information. More specifically, it was proposed that the forgetting effect is strongly influenced by the demands of the task, and that those task demands determine the magnitude of the forgetting effect. By that argument, retrieval-induced forgetting would be expected only when the demands of the task exceed processing capacity.

The purpose of Experiment 7 was to further examine the effects of time to recall on retrieval-induced forgetting. In the previous experiment, retrieval-induced forgetting was not observed when participants were given ample time (2 minutes per category) to retrieve studied items on the final recall task. In the present experiment, the amount of time to retrieve was reduced from two minutes to one minute per category. It was reasoned that one minute should be sufficient time to recall although only half of the time allotted in Experiment 6. This one minute limit would also allow for examination of time boundries for the retrieval-induced forgetting effect.

Method

Participants. Nineteen Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in all previous experiments (see Appendix A for stimuli).

Procedure. The study phase of Experiment 7 was identical to all of the previously reported experiments. Sixty category – exemplar pairs (12 filler and 48 experimental) were presented at the center of a computer screen. This was followed by the retrieval practice phase, which involved category plus stem cued recall for half of the

items from half of the studied categories. Each stem was completed three times for each item. After retrieval practice, there was a 5 minute delay period.

The test phase of Experiment 7 differed in procedure from that of Experiment 6 only in the amount of time that participants were given to recall studied exemplars. Participants viewed category words at the center of a computer screen and were instructed to recall all 6 studied items from that category. Participants were given one minute per category to recall studied exemplars. After one minute, participants were alerted by a beep from the computer, indicating that they were to move on to the next page of the provided booklet. Following a brief (5 second) delay, the next category word was presented.

Results and Discussion.

The data from the retrieval practice phase indicate that participants were successful in completing the word stems accurately 94% of the time. This observation is consistent with that of previous studies.

The data for the final recall test are illustrated in Figure 12. The data are illustrated in terms of the percentages of recalled items for each of the three experimental conditions. A retrieval practice effect was found, with repeatedly practiced items being recalled at a higher rate (RP+ = 89%) than unpracticed items from non-practiced categories (NRP = 64%) items [F (1,18) = 42.13, p = .000, MSE =.01, η^2 = .700].

When comparing recall performance for RP- items (59%) and NRP items (64%), no reliable difference was found [F <1]. Thus, the data show that retrieval-induced

forgetting was not observed in the present experiment, despite the reduction (in comparison to that of Experiment 6) in time to recall.
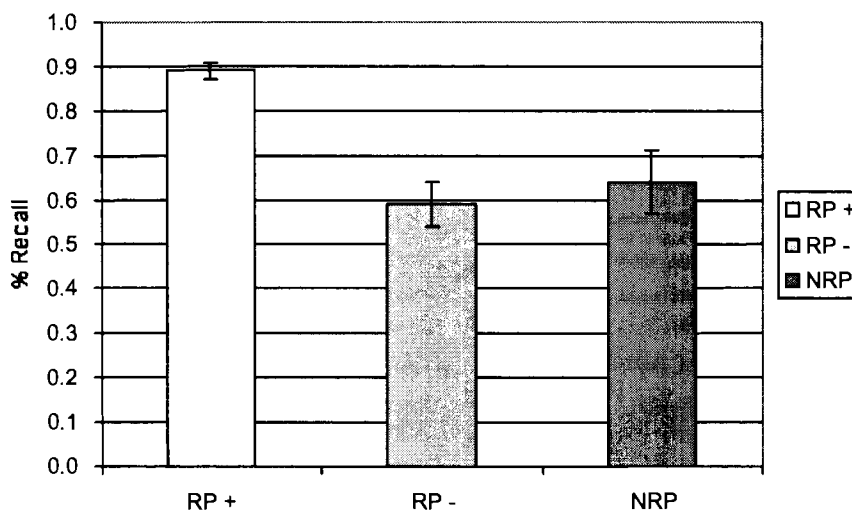
Figure 12: Percentage recall as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

Experiment 7 was conducted to examine the circumstances under which retrieval-induced forgetting can be observed. In particular, this experiment sought to determine whether the forgetting effect can be observed when participants are given more time than the standard paradigm allows to retrieve studied items on the final recall test. Interestingly, retrieval-induced forgetting was not observed in Experiment 7. Thus, based on Experiments 6 and 7, it appears that the effect is limited to the very short term (e.g., 30 seconds). This lends credence to the suggestion that retrieval-induced forgetting, as a cognitive phenomenon, is somewhat driven by the demands of the task. Further, the

results of Experiment 7 support the notion that the effect can be explained in terms of limited capacity. With only 30 seconds to recall, participants have a great deal of difficulty coming up with RP- items, but with one or two minutes they show no evidence of forgetting. The implication of these results is that participants need time to overcome the retrieval-induced forgetting effect. When pressed for time, participants do not have the capacity to sort out any interference that may occur during the retrieval process, but with more time they can do so quite readily. A further implication of these studies is that the retrieval-induced forgetting effect is limited to retrieval time of less than two minutes.

Summary

The experiments reported in this chapter pose a challenge to the inhibition account of retrieval-induced forgetting effect in a number of ways. First, it was demonstrated in Experiment 4 that participants were able to generate new exemplars from retrieval-practiced categories with very little difficulty. If inhibition were responsible for the forgetting effect, it would have been expected that generated items would have been the more typical exemplars, which were the unpracticed items from practiced categories (RP-). According to an inhibition account, repeated retrieval of some members of a category leads to suppression of other, non-practiced items from that same category. If inhibition had occurred, one would have predicted that the most typical exemplars be suppressed and, in consequence, would be thought to be new items for that category. However, this was not the case. Participants were quite able to generate new items for practiced categories.

A further challenge to the inhibition account arises from the finding that retrieval-induced forgetting was not observed when participants were given more time to recall items during the final test phase. More specifically, retrieval-induced forgetting was not observed when participants were permitted to recall at their own pace, when they were limited to two minutes per category or limited to only one minute per category. Given that previous studies have established that inhibition should last for up to 24 hours, it is not clear how small increases in recall time should result in abolition of the effect. Furthermore, if this inhibitory effect is thought to be responsible for everyday intentional forgetting, it seems implausible that the forgetting must be established in less than one minute.

Taken together, the experiments reported in this chapter can arguably support one of two theoretical accounts. In particular, retrieval-induced forgetting can be explained in terms of inhibition, but only if that account assumes that the inhibition will persist only up until an individual attempts to re-access a category. This assumption is necessary to account for the data reported in Experiments 4, 5, 6, and 7, all of which demonstrate that extending the time to recall eliminates the forgetting effect. If inhibition is responsible for retrieval-induced forgetting, then it must be the case that permitting extra time to recall allows the individual to re-examine the category and, in consequence, disinhibits any suppression that had occurred. Such an account has questionable utility, in the sense that any attempt to think about a concept related to an intentionally forgotten concept will result in recall of the forgotten memory.

An alternative account suggests that retrieval-induced forgetting, as a cognitive phenomenon, reflects a limitation in retrieval processing ability. Clearly, the experiments

reported in this chapter demonstrate that the forgetting effect is dependent upon the amount of time that an individual is given to remember on the final recall task. If the retrieval-induced forgetting effect truly reflects the type of intentional forgetting that takes place in daily life, it seems unlikely that a 30 second window is a realistic time frame for the forgetting to take place.

To illustrate, Anderson (2003; 2005) suggested that retrieval-induced forgetting in the laboratory parallels the intentional forgetting of an argument with a friend. By Anderson's account, each time we retrieve a concept associated with the friend in question, we intentionally suppress the argument and, in consequence, it is forgotten. However, the data from the experiments reported in this section complicate that explanation. In particular, retrieval-induced forgetting was not observed when participants were given ample time to retrieve on the final recall test. Following from Anderson's example, the forgetting of the argument with the friend must occur only when the individual attempts to retrieve related concepts very quickly. More clearly stated, the data from the experiments above suggest that people will not forget the argument if they take their time in retrieving other, more positive, concepts surrounding the particular friend. From this perspective, it seems unlikely that this is how intentional forgetting occurs in daily life, in the sense that the majority of remembering is completely self-paced in nature. It is only very rarely that we are forced to remember something under highly constrained time pressure.

In conclusion, the experiments reported in this chapter illustrate that the retrieval-induced forgetting effect is not a robust effect and, instead, is quite sensitive to manipulations in procedure. If this forgetting effect is supposedly reflective of an

automatic inhibitory process that guides daily behavior, it could be expected that the effect be fairly robust to modest changes in procedure.

The evidence reported in this section demonstrates that an inhibitory account can explain the data only if a very specific set of assumptions is adopted. A more parsimonious account of the effect is one of capacity limitations. This explanation readily accounts for all of the data reported thus far. A limited capacity system can overcome internal interference with the assistance of extra time. Following from this type of account, it can be predicted that manipulations of strategy may aid participants in overcoming interference and, in consequence, to overcome the forgetting effect. This prediction will be the focus of the following chapter.

Chapter 4: Retrieval Efficiency

In Chapter 3, it was proposed that the retrieval induced forgetting effect could be accounted for in terms of processing limitations. Specifically, it was argued that the forgetting effect occurs not because of an automatic inhibitory mechanism, but instead because the task demands at the time of retrieval exceed the individual's capacity for resolving interference. That is, using the standard paradigm, retrieval induced forgetting is observed, not due to inhibition, but instead because participants are required to respond at a rate that does not permit them to overcome interference. When more time is permitted, participants are able to overcome the persistence of the retrieval-practiced items and successfully recall the unpracticed items as well.

Following from this argument, more efficient processing may assist individuals in overcoming the retrieval induced forgetting effect. If the effect is due to an inability to resolve interference, then it is possible that more efficient processing could serve to reduce the interference. The experiments reported in the present chapter were conducted to examine this possibility. It was predicted, from a limited capacity perspective, that manipulations of strategy could invoke more efficient processing and, consequenctly, reduce the amount of retrieval induced forgetting observed.

Experiment 8: Effects of Test Strategy

The purpose of Experiment 8 was to examine the effects of test strategy on the retrieval induced forgetting effect. Above, it was proposed that the forgetting effect is the result of limited processing capacity and that more efficient processing may help individuals to overcome the effect. In Experiment 8, efficiency was examined by

manipulating individuals' test strategies. In particular, strategy was manipulated by eliminating the delay period between the retrieval practice phase and the test phase. Furthermore, participants were not aware of the difference between retrieval practice and the final test. It was reasoned that participants might adopt different strategies when approaching the two different tasks. The retrieval practice phase places relatively low pressure on participants, in comparison to the test phase. Often, people feel that they have a poor memory and this subjective feeling, or low confidence, may influence their ability to recall on the final test. In the present experiment, participants were not aware of the test phase and it was predicted that this approach to the recall task might influence remembering behavior. In particular, if participants were not aware that there was a "test," they might be more likely to successfully recall unpracticed items from practiced categories.

Method

Participants. Twenty-nine Simon Fraser University students participated in this experiment for course credit.

Stimuli. The stimuli used in this experiment were identical to those used in all previous experiments (see Appendix A for stimuli).

Procedure. The study phase of Experiment 8 was identical to all of the previously reported experiments. Sixty category – exemplar pairs (12 filler and 48 experimental) were presented at the center of a computer screen. This was followed by the retrieval practice phase, which involved category plus stem cued recall for half of the

items from half of the studied categories. Unlike the previous experiments, there was no delay between the retrieval practice phase and the final test phase.

The test phase of Experiment 8 differed in procedure from that of previous experiments in several other ways. Rather than category cued recall, the final test employed the same category plus stem cued recall task as the retrieval practice phase. The reason for this modification in procedure was to ensure that participants could not distinguish between the retrieval practice phase and the final test phase.

Participants viewed the category plus stem at the center of a computer screen and were instructed to recall from the study list the appropriate completion to the stem. As participants stated the completion word, they were instructed to press a button on a button box. This button press recorded the reaction time of participants' responses. After the subject reported the word aloud, the experimenter entered a code as to whether the participant response was accurate or inaccurate. An accurate response was counted only when the participant reported the word that had been seen on the training set. Responses that were either non-studied words or a failure to come up with a response constituted an inaccurate response. Each category-plus stem remained on screen until the participant responded. The inter-trial interval was 1 second. After completing all test trials, participants were debriefed and given credit for their participation.

Though the procedure used in Experiment 8 differed from the standard paradigm used by Anderson et al. (1994), it was assumed that if any evidence of inhibition was present it could be detected in one of two different measures. With the standard task, retrieval-induced forgetting is measured in terms of recall accuracy. The present experiment measured both accuracy and reaction time. Though previous investigations

of retrieval-induced forgetting have not used reaction time as a dependant measure, it is reasonable to expect that if any inhibition were to occur it would be as likely to be detected by reaction time as by recall accuracy. Indeed, reaction time is typically used to measure other cognitive phenomenoa, that are thought to be governed by inhibition. To name a few, negative priming (Neill, 1977), inhibition of return (Posner & Cohen, 1984), the Stroop effect (Stroop, 1935), and lexical decision tasks (Meyer & Schvaneveldt, 1976; Ratcliff & McKoon, 1995) are all cognitive effects that typically use reaction time as a dependent measure.

Results and Discussion.

The data from the retrieval practice phase indicate that participants were successful in completing the word stems accurately 93 % of the time. This observation is consistent with that of previous studies.

The accuracy data for the final recall test are illustrated in Figure 13, which shows the percentages of recalled items for each of the three experimental conditions. A retrieval practice effect was found, with repeatedly practiced items being recalled at a higher rate (RP+ = 93%) than unpracticed items from non-practiced categories (NRP = 86%) [F (1,28) = 9.30, p = .005, MSE =.01, η^2 = .238].

The interesting finding from these data was that no retrieval-induced forgetting effect was observed. When comparing recall performance for RP- items (90%) and NRP items (86%), no reliable difference was found [F (1,28) = 2.14, p = .154, MSE =. 01, η^2 = .071]. Thus, the data show that retrieval-induced forgetting was not observed in the present experiment.

One point to note is that, in general, the accuracy scores for all conditions in Experiment 8 were higher than for any of the experiments reported previously in this thesis. This increase in accuracy is likely due to the type of task used for the final recall test. In all prior studies, a category cued recall test was used. However, in the present experiment, the final test employed a category plus stem cued recall test which is presumably an easier task than simple recall. This difference in task difficulty likely accounts for the increase in accuracy for all of the experimental conditions.
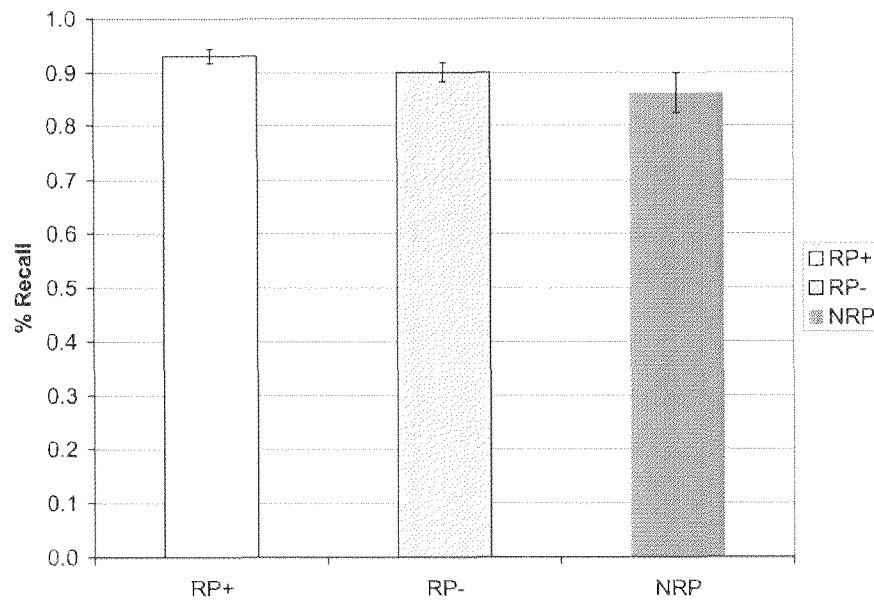

Figure 13: Percentage recall as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

Reaction time data were analyzed using a repeated measures ANOVA. Figure 14 shows the means of median reaction times as a function of experimental condition. Only

accurate responses were included in the reaction time analysis. The reaction time data

show a very similar pattern to the accuracy data of Experiment 8. As can be seen in

Figure 14, participants were faster to respond to retrieval practiced items (986.0 msecs)

than to items in the baseline NRP condition (1352.5 msecs) [F (1,28) = 66.6, p = .000,

MSE =29247.03, η^2 = .704]. Thus, like the accuracy data, the reaction time data

demonstrate a retrieval practice effect.

When comparing RP- items and NRP items in terms of reaction times, no retrieval

induced forgetting was observed. In particular, reaction times to recall RP- items (1267.5

msecs) did not differ significantly from reaction times to recall NRP items (1352.5

msecs) [F (1,28) = 2.42, p = .131, MSE =43186.53, η^2 = .079]. The results of these

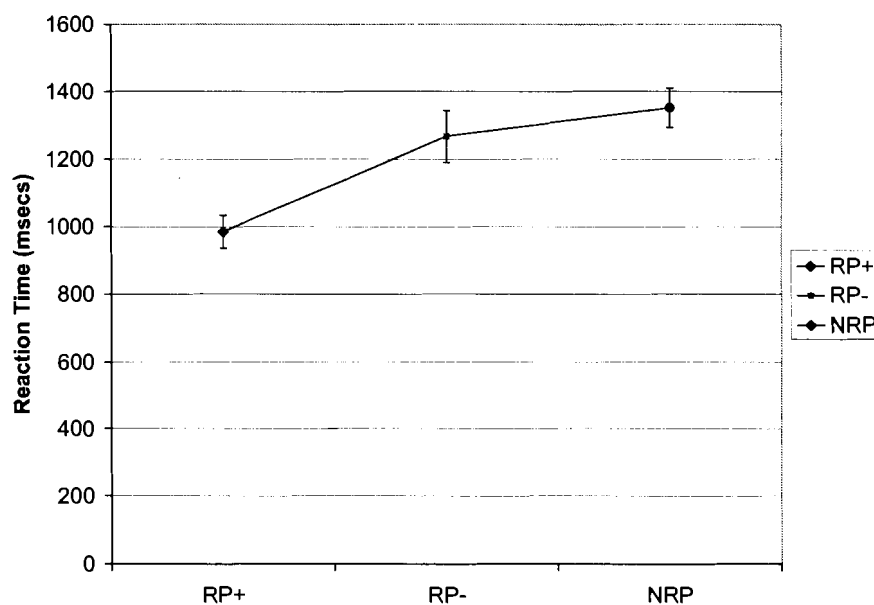reaction time data closely parallel the accuracy data for this experiment.

Figure 14: Average median reaction time as a function of experimental condition. RP+ =
    retrieval practiced items, RP- = unpracticed items from practiced categories,
    NRP = unpracticed items from non-practiced categories.

To summarize, the data from Experiment 8 demonstrate a clear retrieval practice effect, but fail to show retrieval-induced forgetting. Both dependent measures, accuracy and reaction time, show the same pattern. That is, no reliable differences were found between RP- and NRP items. It was predicted that eliminating the distinction between the retrieval practice phase and the final recall phase would result in less retrieval-induced forgetting. The main purpose for conducting this study was to examine whether the strategy that a participant adopts towards the final test phase plays a role in the forgetting effect. In particular, it was expected that a reduction in pressure to recall might have reduced the amount of interference that a participant experienced at the time of recall. Clearly the data show no indication of retrieval-induced forgetting. However, it is not obvious why this manipulation eliminated the effect. One possibility is that the category plus stem cued recall test reduced the overall amount of interference that the individual experienced during recall. From an interference perspective, this explanation makes good sense. However, from an inhibition point of view, this account is more difficult to accommodate.

An inhibitory account of retrieval induced forgetting would predict a forgetting effect similar to that found using the standard category cued recall task in the final test phase of the experiment. Indeed, Anderson et al. (1994) reported using a category plus stem cued recall task and found evidence of retrieval-induced forgetting. Given this, it seems likely that the manipulation of strategy did have an influence on remembering performance. Taken together, these observations support the notion that the retrieval-induced forgetting effect is a consequence of interference during a forced output at the time of recall effect, rather than an inhibitory effect. More directly stated, the retrieval-

induced forgetting effect can readily be explained in terms of the processing experience of the individual. When forced to recall at a quick pace, participants are unable to overcome the interference between the practiced items and studied items from that same category. However, when participants are not explicitly attempting to recall a specific set of items from a particular category, they are quite able to successfully complete word stems for RP- items just as well as for NRP items. These observations support the suggestion that the retrieval-induced forgetting effect is the result of an inability to overcome interference within a limited capacity cognitive system. Furthermore, these data argue that strategic approaches to the final recall task may influence the forgetting effect.

Previously, it was argued that a limited capacity system might be assisted by means of manipulating strategy. The data from Experiment 8 support this assertion to a certain extent. However, this study does not provide conclusive evidence that the forgetting effect is due to interference during retrieval at the final test phase. The following experiment was conducted to investigate the role of strategic approach to the test and the retrieval-induced forgetting effect.

Experiment 9: Controlled Output at Test

It was argued above that retrieval-induced forgetting results not from an inhibitory mechanism, but rather from interference that can not be resolved in a very short period of time. Furthermore, it was proposed that a limited capacity system might benefit from strategic manipulations that minimize interference at the time of recall. The results of Experiment 8 support this argument. It was found that participants did not

show a retrieval-induced forgetting effect when they were not informed that they were engaged in a recall task. Inhibition would predict a forgetting effect regardless of an individual's awareness of the task. Thus, these data argue against inhibition and support the notion of interference as the source of the retrieval induced forgetting effect. However, it is not clear how the strategic manipulation in Experiment 8 eliminated the forgetting effect. It was postulated that participants might have approached the task differently as a result of reduced performance anxiety, however, the data do not provide definitive support for that argument.

The central aim of Experiment 9 was to investigate retrieval strategy in an entirely different way. In particular, the interference account was examined by manipulating output order on the final recall test. From an interference perspective, it was hypothesized that encouraging retrieval of RP- items prior to retrieval of RP+ items would eliminate, or at least reduce, the retrieval-induced forgetting effect. In contrast, an inhibition account would argue that retrieval-induced forgetting should be observed irrespective of output order.

Method

Participants. Forty-nine Simon Fraser University students participated in this experiment for course credit. As this was a between participants experiment, twenty-three participated in one condition and twenty-six in the other.

Stimuli. The stimuli used in this experiment were identical to those used in all previous experiments (see Appendix A for stimuli).

Procedure. The study phase of Experiment 9 was identical to the previously reported experiments. Sixty category – exemplar pairs (12 filler and 48 experimental) were presented at the center of a computer screen. The retrieval practice phase employed a category plus stem cued recall for half of the items from half of the studied categories. There was a five-minute delay between the retrieval practice phase and the final test phase.

The test phase of Experiment 9 was very similar to that of Experiment 8. The final test employed the same category plus stem cued recall task as the retrieval practice phase. This allowed for control of output order and as well as recording of reaction times.

Output order was manipulated between participants. Practiced categories and unpracticed categories were interleaved on the final test phase, such that half of the participants retrieved a practiced category first on the final test phase and half of the participants received an unpracticed category first. Subsequent trials alternated between practiced and unpracticed categories.

For practiced categories, half of the participants completed stems for retrieval-practiced items (RP+) first on the final recall test and the other half completed unpracticed items from practiced categories (RP-) first on the final test phase. It was predicted that participants who received RP+ items first would show a retrieval-induced forgetting effect, while participants who received RP- items first would not show the forgetting effect. Such an observation would support the assertion that retrieval-induced forgetting results from interference that occurs in a limited capacity system.

Participants viewed the category plus stem at the center of a computer screen and were instructed to recall the appropriate completion for the stem. As participants stated the completion word, they were to press a button on a button box. The button press recorded the reaction time of participant responses. The experimenter entered a code as to whether the participant response was accurate or inaccurate. Accurate responses were counted only when the participant reported the word that had been seen on the training set. Responses that were either non-studied words or a failure to come up with a response constituted an inaccurate response. Each category-plus stem remained on screen until the participant responded. The inter-trial interval was 1 second. After completing all test trials, participants were debriefed and given credit for their participation.

Results and Discussion.

The data from the retrieval practice phase indicate that participants were successful in completing the word stems accurately 89% of the time. This observation is quite similar to the accuracy data from previous studies.

The accuracy data for the final category plus stem cued recall test are depicted in Figure 15, which shows the percentages of recalled items for each of the three experimental conditions and for the two different output order groups. A retrieval practice effect was found for both output order conditions. For the RP+ output first condition, participants successfully retrieved more RP+ items (91%) than NRP items (75%) [F (1,22) = 17.07, p = .000, MSE = .02, η^2 = .435]. A similar pattern was

observed for the RP- output first condition, with RP+ items (92%) being retrieved at a higher rate than the NRP items (71%) [F $(1,25) = 93.13$, p = .000, MSE = .01, $\eta^2 = .910$].

In addition, a retrieval-induced forgetting effect was found for the RP+ output first condition. That is, participants recalled fewer RP- items (66%) than NRP items (75%) [F $(1,22) = 6.33$, p = .02, MSE =.01, $\eta^2 =.225$]. However, this pattern was not observed for the RP- output first condition. Participants recalled more RP- items (78%) than NRP items (71%) in this condition [F $(1,25) = 7.85$, p = .01, MSE =.01, $\eta^2 = .240$].
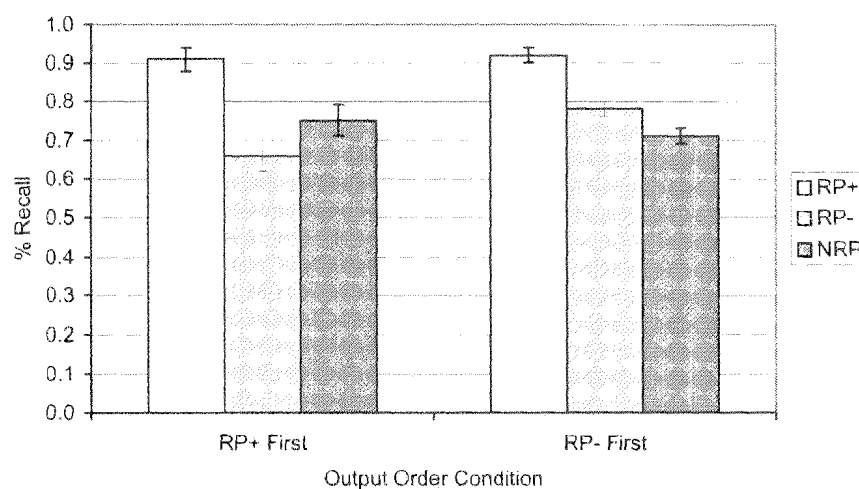
Figure 15: Percentage recall as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories. Note: 23 participants were in the RP+ first condition and 26 were in the RP- first condition.

The reaction time data from Experiment 9 are illustrated in Figure 16. These data reflect the mean of the medians across participants. A repeated measures ANOVA revealed a reliable retrieval practice effect for both output order conditions. Participants in the RP+ first output condition were faster to retrieve RP+ items (737.10 msecs) than to retrieve NRP items (1026.18 msecs) [F $(1,22) = 74.48$, p = .000, MSE =12903.63, $\eta^2 =$

.772]. Similarly, RP+ items (788.05 msecs) were retrieved more quickly than NRP

items (1057.42 msecs) for the RP- first output condition [F (1,25) = 110.31, p = .000,

MSE =8551.03, η^2 = .815].

As would be predicted by either an inhibition or an interference account, retrieval-

induced forgetting was observed for the RP+ first output condition. Participants were

reliably slower to retrieve RP- items (1189.36 msecs) than NRP items (1026.18 msecs) [F

(1,22) = 8.76, p = .007, MSE =34957.09, η^2 = .285].

The more theoretically interesting observation was that no retrieval-induced

forgetting was observed for the RP- first output condition. In fact, participants were

reliably faster to retrieve RP- items (921.92 msecs) than NRP items (1057.42 msecs) [F

(1,25) = 24.26, p = .000, MSE =9836.65, η^2 = .492]. The finding that participants in this

condition were faster to retrieve RP- items than NRP items is not of central concern in

that no interaction was predicted. Instead the finding that no retrieval-induced forgetting

was observed lends support to an interference explanation of retrieval induced forgetting.

Whereas an inhibition account would predict a forgetting effect regardless of order of

output, an interference account would predict that when participants are encouraged to

output RP- items first, they can overcome interference from the RP+ items.

A simple factorial ANOVA revealed that the only reliable difference between the

two output order conditions was for the RP- items. That is, participants in the RP- first

output condition, responded faster to RP- items than did participants in the RP+ first

output condition [F (1,47) = 13.79, p = .003, MSE =872843.82, η^2 = .227]. There were

no differences between output conditions for either RP+ items or for NRP items. This

supports the suggestion that the retrieval-induced forgetting effect is due to interference

at the time of retrieval. Participants who were permitted to recall RP- items first had the advantage of avoiding or overcoming interference with RP+ items. The fact that output order had no influence on RP+ or NRP items, in terms of time to recall, further supports this argument. It would not be expected that either of those conditions would benefit or suffer from a manipulation in output order, as it is very unlikely that either of those conditions accumulated any interference prior to or during the test phase of the experiment. From an interference perspective, RP+ items should be recalled well due to the extensive retrieval practice in the previous phase. Furthermore, NRP items should not be influenced by output order, as those items belong to other categories and no interference should occur.
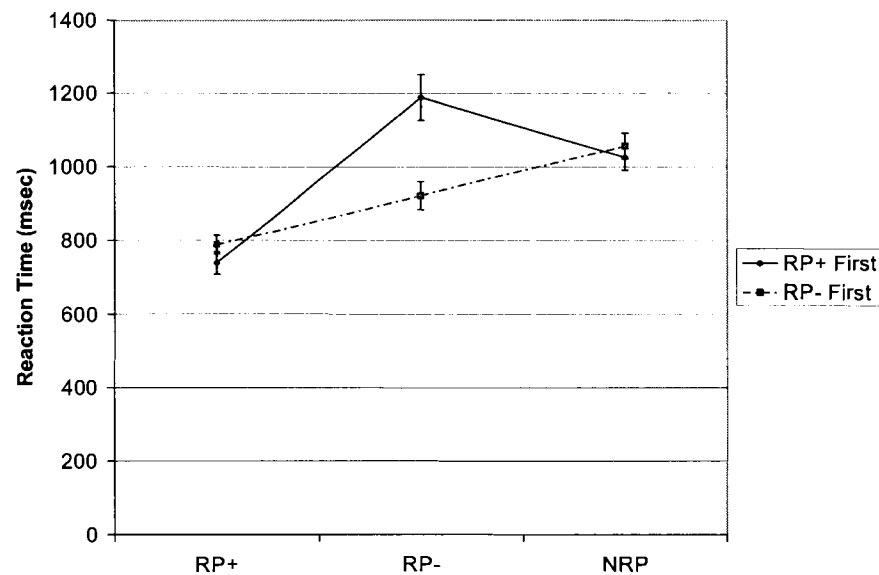

Figure 16: Average median reaction time as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

The results of Experiment 9 support an interference account of the retrieval-induced forgetting effect. In particular, it was demonstrated that retrieval-induced forgetting was observed only when participants were forced to output retrieval-practiced items before unpracticed items for the practiced categories. In contrast, when participants had to output the RP- items first on the final test, no forgetting was observed. These data support the idea that the retrieval-induced forgetting effect results from interference that occurs at the time of retrieval. Earlier, it was postulated that the forgetting effect arises due to persistence of retrieval-practiced items that prevent participants from retrieving unpracticed items in a short period of time. In the present study, it was found that when participants were forced to retrieve RP- items, they could do so quite readily. Thus, it appears that assistance in overcoming interference at the time of recall aids in reducing the retrieval-induced forgetting effect.

Moreover, the observations reported in Experiment 9 challenge an inhibitory account of retrieval-induced forgetting. By that account, order of output at the time of retrieval should not reduce or eliminate the forgetting effect. Inhibition would predict that the retrieval practice phase would lead to suppression of competing items from that same category and, in consequently, those items should be forgotten at the time of test, regardless of which items are reported first on the test. In fact, Anderson et al. (1994) manipulated output order on the final recall test, using the same category plus stem cued recall task as that used in the present study, and observed retrieval-induced forgetting regardless of output order condition.

At first glance, it is not clear why the results of Experiment 9 stand in direct contrast to the findings of Anderson et al. (1994). However, closer analysis of Anderson

et al.'s (1994) procedure may explain why those authors concluded that output

interference does not play a role in retrieval-induced forgetting. Specifically, in

Experiment 2 of Anderson et al.'s paper, they included an additional factor; i.e., they

manipulated strength of the exemplar to the category. The data reported by those authors

indicated that retrieval-induced forgetting was observed regardless of output order and, in

conclusion, they argued that output interference is not responsible for the forgetting

effect. However, that conclusion was based on an analysis that collapsed across the

strength of association variable. Looking at the overall effect of output order, Anderson

et al. reported that strong exemplars that were recalled first were recalled better than

strong exemplars that were recalled second, whereas order of output had no effect on

recall of weak category exemplars. Furthermore, they reported that recall of RP- items

was impaired, even when reported first. However, this report did not take strength of

association into account. In fact, Anderson et al. mention briefly that, even though the

main effect of testing position did not reveal any advantages, there was a marginal

interaction with category composition (i.e., strength of association). Thus, when all of

the data are considered in full, it may be the case that Anderson et al.'s participants may

have been influenced, to some extent, by the output position manipulation. In addition, it

may have been that the additional factor of category composition led Anderson et al.

(1994) to arrive at a different conclusion than that implied by the data from Experiment 9.

In summary, the data from Experiment 9 support the assertion that retrieval-

induced forgetting results from interference that arises at the time of retrieval rather than

inhibition that arises at the time of retrieval practice. When permitted to retrieve

unpracticed items first, participants do not show the forgetting effect, whereas outputting

practiced items first, or free recalling items (as in previous experiments), results in retrieval-induced forgetting. Taken together with earlier experiments, it appears that the retrieval-induced forgetting phenomenon is not a robust effect and is likely driven by the demands of the task at hand.

In particular, the experiments reported in this dissertation have demonstrated that modifications to procedure can have dramatic effects on the forgetting phenomenon. Importantly, all of these experiments have focused on manipulations in procedure during the final test phase of the experiment. These studies, as well as those reported by many other authors have held the assumption that the retrieval practice phase will influence remembering performance as is measured by the final test. However, it is possible that the initial study phase may play a role on the retrieval-induced forgetting effect. According to an inhibition account, repeated practice of some members invokes inhibition of studied items from that category that do not receive any additional practice. This account assumes that the inhibition flows from the practice phase to the study phase and inhibits competitors. Thus, the study phase is a critical aspect of the retrieval-induced forgetting effect. In the following experiment, the role of the study phase on retrieval-induced forgetting is examined more closely.

Experiment 10: Effects of Eliminating the Study Phase

Experiment 10 was conducted to examine the role of the study phase on the retrieval-induced forgetting effect. As mentioned above, the inhibition account put forward by Anderson et al. (1994) asserts that suppression occurs during the retrieval practice phase. This suppression serves to inhibit studied exemplars from that same

category that did not receive extra practice. Based on this account, the study phase is a necessary aspect of a retrieval induced forgetting experiment. That is, episodic inhibition of recently studied exemplars could not occur if one had not recently encountered those exemplars.

However, an interference explanation of the forgetting effect does not necessarily require that participants engage in a study episode prior to the retrieval practice phase. That is, interference is thought to occur at the time of retrieval on the final recall test, as a result of persistence of the repeatedly practiced items. Thus, by this account, the study phase plays a very small role in the forgetting effect. Anecdotally, it was noted in the previous two experiments that participants may not have actually been "remembering" from the study phase when completing the final test items. Logically, it seems entirely reasonable that participants could be successful on the final test without actually recalling anything from the study phase. Take for example the following test item, FRUIT – ap_____; successful completion of this word stem need not depend upon having seen a recent study list.

Thus, the goal of Experiment 10 was to examine whether retrieval-induced forgetting would be observed in the absence of a study phase. From an inhibition perspective, it would be predicted that no retrieval-induced forgetting be observed. Alternatively, if an interference account holds true, it would be predicted that the same type of retrieval-induced forgetting observed in previous experiments should occur.

Method

Participants. Thirty Simon Fraser University students participated in this experiment for course credit. Fourteen participated in one experimental condition, and sixteen in another experimental condition.

Stimuli. The stimuli used in this experiment were identical to those used in all previous experiments (see Appendix A for stimuli).

Procedure. The procedure of Experiment 10 was identical to that of Experiment 9 with the exception that the study phase was eliminated completely.

Thus, participants began the experiment by engaging in a category plus stem cued recall task for half of the items from half of the categories in the stimulus set. This was completed three times for each item and order of items was randomly refreshed for each of the three trials. After completing the retrieval practice phase, participants were delayed for 5 minutes by engaging in conversation with the experimenter.

The test phase of Experiment 10 was identical to that of Experiment 9. The final test employed the same category plus stem cued recall task as the retrieval practice phase. This allowed for control of output order as well as recording of reaction times.

Output order was manipulated between participants. Practiced categories and unpracticed categories were interleaved on the final test phase. For practiced trials, half of the participants completed stems for retrieval practiced items (RP+) first on the final recall test and the other half completed unpracticed items from practiced categories (RP-) first on the final test phase. Participants viewed the category plus stem on the center of a computer screen and were instructed to complete the stem with an appropriate word. As participants stated the completion word, they pressed a button on a button box. The

experimenter entered a code as to whether the participant response was accurate or inaccurate. Accurate responses were counted only when the participant reported an English word that completed the stem and was associated with the category cue. Each category-plus stem remained on screen until the participant responded. The inter-trial interval was 1 second. After completing all test trials, participants were debriefed and given credit for their participation.

Results and Discussion.

In accordance with all of the studies reported previously, the data from the retrieval practice phase indicate that participants were successful in completing the word stems. Stems were completed accurately 82% of the time.

Due to an error in following the experimental procedure, the accuracy data were not correctly recorded for Experiment 10 and thus, the data will discussed only in terms of reaction time analyses. It was reasoned that this analysis would suffice, as the accuracy data and reaction time data showed very similar effects in the previous two experiments. The reaction time data from Experiment 10 are illustrated in Figure 17. These data show the means of the medians across participants. A repeated measures ANOVA was conducted on the data. In general, the data for Experiment 10 appear to be very similar to the data of Experiment 9, with the exception that reaction times are noticeably longer in Experiment 10. However, this is not surprising, given that participants did not have the advantage of a study episode in Experiment 10.

As in all previous studies, a retrieval practice effect was observed in Experiment 10. The effect was reliable for both the RP+ first output condition [$F (1,13) = 49.97$, $p =$

.000, MSE =31675.97, η^2 = .794] and the RP- first output condition [F (1,15) = 18.10, p

= .001, MSE =128756.33, η^2 = .626]. Thus, despite the lack of a study phase,

participants showed a clear advantage from having engaged in retrieval practice prior to

the test phase.

A repeated measures ANOVA revealed a reliable retrieval-induced forgetting

effect for the RP+ first output condition. That is, when participants were forced to output

RP+ items first on the final test, they were slower to retrieve RP- items (1946.49 msecs)

than to retrieve NRP items (1420.71 msecs) [F (1,13) = 5.66, p = .033, MSE =341817.82,

η^2 = .303]. This result is not surprising, and would be predicted by either an inhibition

account or an interference account of retrieval-induced forgetting.

However, the more important finding from the results of Experiment 10 was that,

there was a slight reaction time advantage for RP- items (1380.56 msecs) as compared to

NRP items (1643.24 msecs) for the RP- first output condition. This observation was

marginal and not reliable at the .05 significance level [F (1,15) = 4.34, p = .055, MSE =

127326.85, η^2 = .224]. Though this advantage was not a statistically reliable finding, it

does lend some support to an interference account of retrieval-induced forgetting. That

is, interference does not predict any difference between RP- and NRP items in terms of

recall. In contrast, inhibition would predict faster recall of NRP items than RP- items.

From the persepective of an interference account, it was predicted that permitting

participants to recall RP- items first on the final test would assist them in overcoming any

interference with RP+ items. Such an account would not predict that recall of RP-

necessarily be faster than recall of NRP items, but instead that they would be roughly the
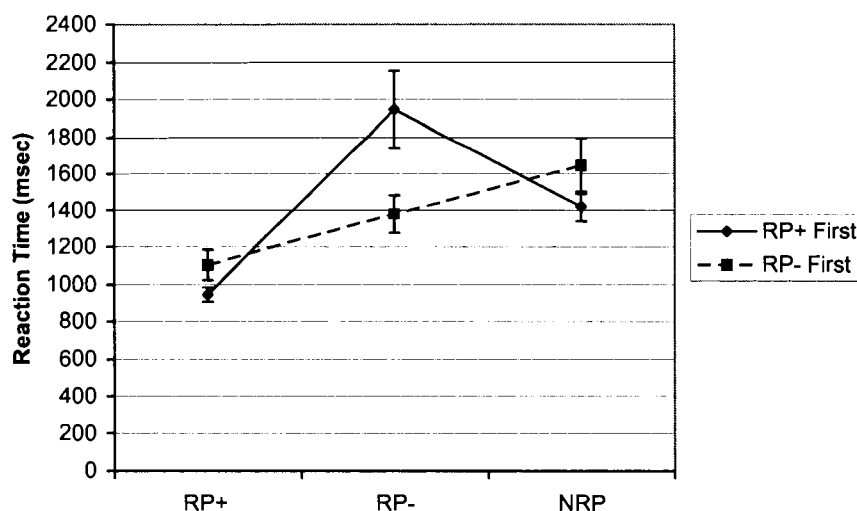
same.

Figure 17: Average median reaction time as a function of experimental condition. RP+ = retrieval practiced items, RP- = unpracticed items from practiced categories, NRP = unpracticed items from non-practiced categories.

The data from Experiment 10 clearly challenge an inhibition account of retrieval-induced forgetting. In particular, the data from this study show a pattern that is almost identical to that observed in Experiment 9, suggesting that the process underlying the forgetting effect is similar between the two experiments. This parallel in the data pattern between the two experiments implies that participants are not necessarily "remembering" on the final recall test, but instead are generating the most appropriate completion to the word stem. The finding that participants need not be recalling from the study phase, poses a challenge to an inhibitory account of retrieval induced forgetting.

Retrieval-induced forgetting was observed when participants were required to output retrieval practiced items first on the final test. However, no forgetting was found when participants were permitted to retrieve unpracticed items from practiced categories first on the test. This pattern suggests that the order of output at the time of recall is critical to the forgetting effect.

Taken together, these observations provide support to the suggestion that the retrieval-induced forgetting effect is an interference effect, rather than an inhibitory effect. Interference would predict a forgetting effect, even in the absence of a study phase. That is because the interference occurs at the time of retrieval rather than suppression of study items at the time of retrieval practice. In addition, the finding that retrieval-induced forgetting is not observed when participants are required to output RP-items first on the final test provides further support for an interference explanation of the effect. When participants are assisted, through testing order manipulation, to overcome interference they are able to perform better. However, when RP+ items are recalled first on the final test, the forgetting effect is observed. Though this factor was manipulated in the present study, it is very likely that in a free recall test, participants would recall RP+ items as well. Thus, the results of the present experiment may be extended to the effect in general and it may be argued that it is the persistence of RP+ exemplars, during a short time period, that interferes with recall of RP- items.

Summary

The experiments reported in this Chapter were conducted to investigate the effects of retrieval strategy on the retrieval-induced forgetting effect. Earlier, it was proposed that the forgetting effect occurs as a result of interference, rather than due to inhibition in memory. In particular, the interference account suggests that the retrieval-induced forgetting effect comes about at the time of retrieval. Retrieval practiced items remain salient in mind and interfere at the time of test with unpracticed items from the same category. In a very short period of time, participants are unable to overcome this

interference and thus forgetting occurs. In general, it was predicted that, if the forgetting effect is due to interference as opposed to inhibition, then manipulations that allow for more efficient processing may alleviate the effect.

The data reported in this section provide support for an interference explanation of retrieval induced forgetting. In addition, they provide serious challenges to an inhibition account of the effect. For example, in Experiment 8 participants were unaware of the test phase and no retrieval induced forgetting was found with respect to overall accuracy or at reaction times. According to Anderson and Green (2001; see also Anderson & Spellman, 1995), inhibition is a relatively automatic mechanism that occurs rapidly when one attempts to retrieve information from memory. It is not clear why awareness of the test should influence this automatic process. From an interference perspective, these data are quite easily accounted for. That is, when participants are not trying to recall for the purposes of a test, they likely do not experience much interference in the sense that they are simply coming up with an appropriate completion to the stem word. Thus, no forgetting should be observed in this situation.

A further complication for an inhibitory account of retrieval-induced forgetting was the observation that retrieval-induced forgetting was only observed when, in two experiments, participants were forced to recall retrieval-practiced items prior to unpracticed items. This is problematic for an inhibition account because the inhibition is thought to last for at least 10 minutes (Anderson et al., 1994) and up to twenty-four hours (MacLeod & MacRae, 2001). Thus, it is unlikely that inhibition has "decayed" or reduced over the short time span of the task. It could be argued that the category plus stem cued recall task used in these experiments released any inhibition that had occurred.

That is, when the participant visually experienced part of the stimulus for a second time this second activation alleviated the inhibition. Though this explanation may be plausible, it is unlikely given that Anderson et al. (1994) used the same retrieval task and found retrieval-induced forgetting.

The data from Experiments 9 and 10 can be accounted for by employing an interference explanation. When participants engage in retrieval, shortly after a retrieval practice phase, the practiced items remain salient in mind and, thus, they are unable to overcome this interference. However, when participants are given the opportunity to retrieve unpracticed items first, they can do so because they are not trying to over-ride the persistence of the practiced items at the time. For example, if a participant performed retrieval practice on the pair FRUIT – ap___ three times, it is likely at the test that "apple" will come to mind, possibly several times and in consequence the individual can not stop thinking of "apple" in order to come up with "orange". However, if at the time of test, participants encounter FRUIT – or___, it is unlikely that they will have to compete with "apple" to complete the stem.

Finally, and perhaps most importantly, it was observed that retrieval-induced forgetting was found in Experiment 10 in the absence of a study phase. According to Anderson et al. (1994; and Anderson & Bell, 2001), the inhibition that occurs in the retrieval-induced forgetting paradigm is suppression of a specific episodic representation. By that explanation, inhibition is invoked during the retrieval practice phase and, in consequence, all unpracticed but studied exemplars will be suppressed. However, in Experiment 10 there could not have been any episodic representations to suppress, as

there was no study episode. Thus, we must ask what was being inhibited if inhibition is the mechanism underlying the forgetting effect?

A simpler account would suggest that the mechanism responsible for retrieval-induced forgetting is not inhibition, but instead the demands of the task. When there is interference at the time of retrieval, forgetting will be observed. When the task is such that the participants have the resources necessary to complete the task, they can do so quite well. Thus, providing a retrieval strategy, manipulating output order, or allowing more time to retrieve, as in the previous chapter, will eliminate the forgetting effect.

Taken together, these results support the notion that the retrieval-induced forgetting effect is driven by the demands of the task. When the task at hand exceeds the capacity of the individual, forgetting will be observed. Conversely, when the task is designed to support a limited capacity system, forgetting will not be found.

Chapter 5: General Discussion

The construct of inhibition as a cognitive mechanism has enjoyed widespread

acceptance within the domain of psychology. Researchers have employed inhibition as

an explanation for a range of cognitive phenomena including memory processing and

forgetting behavior. Despite the pervasive usage of this construct, a number of

researchers have begun to question the utility of inhibition, arguing that an inhibition-free

explanation provides a more parsimonious account of the observable behaviors.

The experiments reported in this thesis examined the memory phenomenon

referred to as retrieval-induced forgetting and questioned the effectiveness of an

inhibitory explanation for that effect. Based on the observations of the present body of

research, it has become apparent that even though inhibition may explain some of the

available data, such an account is neither necessary nor sufficient in accounting for the

wide variety of ways in which remembering and forgetting can occur.

In particular, the experiments reported in this thesis demonstrate that the retrieval-

induced forgetting effect can be eliminated by simply allowing participants more time to

retrieve on the final recall test. This observation supports the hypothesis that the

retrieval-induced forgetting effect may arise not because of an automatic inhibitory

mechanism, but instead as a function of the demands of the task. Within the standard

retrieval-induced forgetting paradigm, participants are forced to rapidly recall a number

of items shortly after having repeatedly rehearsed several competing items belonging to

that same category. Thus, the task demands exceed the limited capacity available for

resolving interference. This hypothesis is supported by the observation that with

additional time participants did not have difficulty in recalling unpracticed items from

practiced categories and retrieval-induced forgetting was not observed. These findings can readily be accounted for in terms of interference at the time of retrieval, which can be overcome with additional time.

In contrast, an inhibition account has difficulty in explaining why additional retrieval time would eliminate the forgetting effect. According to that account, inhibition is invoked during the retrieval practice phase of the experiment and this automatic suppression is argued to persist for up to twenty-four hours (MacLeod & MacRae, 2001). Thus, from an inhibitory perspective, retrieval-induced forgetting would be predicted even when retrieval time is extended from 30 seconds to one or two minutes.

A similar difficulty arises in attempting to apply an inhibition explanation to the data reported in Chapter 4. In that section, it was proposed that if retrieval-induced forgetting was due to interference within a limited capacity system, then the effect could be overcome with more efficient processing. Indeed the data support this notion. In one experiment, strategy was manipulated by eliminating the instructions to treat the final test as a memory test. In that study, no retrieval-induced forgetting was found with respect to either accuracy or at reaction times.

These data can readily be explained by an account that argues for a limited capacity system which can be assisted by more efficient processing. When the task was manipulated such that participants were not aware of the distinction between the retrieval practice phase and the final recall test, they showed no evidence of retrieval-induced forgetting. It is possible that this manipulation influenced participants in one of two ways. First, it may have been the case that the elimination of a "memory test" reduced the pressure to be successful and, in consequence, participants were able to perform

better. This type of argument follows from the notion of limited capacity processing which assumes that pressure, whether it be performance-based or time-based, could influence one's ability to recall. A second, and more intuitive reason why this strategic manipulation might have eliminated the forgetting effect is that participants were not directly recalling on the final test but, instead, completing the stems with the most likely candidates. Following from this, retrieval-induced forgetting was not found because participants were not actually retrieving from memory. One might argue that the use of a category plus stem cued recall task relieved participants of the need to actually recall and thus it is not measuring retrieval-induced forgetting. However, this same task has been used in the literature and the forgetting effect has been observed with this type of final test (Anderson et al., 1994; Anderson & Spellman, 1995).

The inhibition account proposed by Anderson et al. (1994) would predict retrieval-induced forgetting regardless of retrieval strategy. According to these authors, inhibition is automatically invoked as a means of successfully retrieving items during the retrieval practice phase. Following from this, competing items (e.g., RP- items) should be suppressed irrespective of how the participant interprets the final recall task. That forgetting was not observed is somewhat of a challenge to the inhibition account.

In another experiment, output order was manipulated on the final test, such that participants output either retrieval practiced items, or unpracticed items first on the final test. In this study, retrieval-induced forgetting was only observed when participants were required to output the retrieval practiced items first on the final test. However, when they were permitted to output unpracticed items from practiced categories first, no forgetting effect was observed for either dependant measure. Again, a limited capacity system

approach can accommodate these findings. In particular, it can be argued that when participants are required to output retrieval practiced items first, these items come to mind easily as a result of the previous practice phase but persist beyond the brief time period allotted for the recall of the unpracticed items, resulting in a forgetting effect. In the other condition, where participants are forced to output unpracticed items first on the test, they are being assisted by the task to overcome any interference from the practiced items and, thus, no forgetting effect is observed. In other words, when participants are provided with the resources to assist them with more efficient processing, retrieval-induced forgetting is not observed.

The results of this study are not easily explained from an inhibitory standpoint. According to that account, RP- items are inhibited during the retrieval practice phase and remain so during the test phase. This inhibition would be expected to prevent episodic recall of the unpracticed items from practiced categories, regardless of when they were output on the final test. Thus far, the data from the present research challenges the inhibition account of retrieval-induced forgetting. In particular, the inhibition explanation would predict a forgetting effect even when test strategy and output order are manipulated, as the inhibition is thought to occur early in the retrieval practice phase and should persist well into the test phase, regardless of manipulations at the time of test.

Though these challenges are not minimal, the strongest evidence against the inhibition account comes from the final experiment in which a retrieval-induced forgetting pattern was observed in the absence of an initial study phase. In this critical experiment, output order was again manipulated, as in the previous experiment. Despite the dramatic change in procedure, the pattern of data was the same as when the study

phase was included (in the previous study). This suggests that the retrieval-induced forgetting effect may not be a forgetting effect at all. Specifically, the data showed a retrieval-induced forgetting effect when participants were forced to output retrieval practiced items (RP+) first on the final test, yet no forgetting was found when unpracticed items (RP-) from practiced categories were output first on the final test.

These observations are consistent with the assertion that the retrieval-induced forgetting effect arises as a result of interference that occurs at the time of retrieval. When participants were permitted to report unpracticed items (RP-) from practiced categories prior to practiced items (RP+), no forgetting was observed. This suggests that the RP+ items, which are dominant in mind as the individual enters the test phase, create interference with other members of that same category which will result in forgetting if those items are output first. However, if the task is such that the RP- items are output first, the interference from RP+ items can be overcome by the demands of the test task. By this explanation, the study phase is to some extent irrelevant with respect to whether or not the forgetting effect will be observed. This is because the source of the retrieval-induced forgetting effect is interference, which is argued to occur at the time of test as a result of the practice phase of the experiment.

The findings from this experiment present a rather difficult challenge for an inhibitory account of the retrieval-induced forgetting effect. According to Anderson et al. (1994; see also Anderson & Spellman, 1995; Anderson & Green, 2001), the source of the forgetting effect is inhibition of episodically studied items which is invoked during the retrieval practice phase. That is, while repeatedly recalling items during the retrieval practice, inhibition works to suppress other studied items belonging to that same

category. Following the same logic, retrieval-induced forgetting should only be observed when there are episodically studied items available to be inhibited. The finding that a retrieval-induced forgetting pattern was observed in the absence of a study phase is inconsistent with an inhibitory account of the effect and suggests that the effect does not reflect a forgetting process, per se, but rather a decrement in performance as a result of interference at the time of output, whether that output be the result of recalling or stem completion.

Taken together, the experiments reported in this thesis provide a compelling set of arguments for an interference-based account of retrieval-induced forgetting, rather than an inhibitory account. In several experiments, the inhibition account proposed by Anderson et al. (1994) fails to explain the observed data. Though modifications to that account may allow for accommodation of the observations reported here, it seems that a simpler explanation that can readily account for all of the data would be the more logical option.

If one assumes that individuals have limited capacity for processing, each of the experiments reported here can be explained in terms of availability of resources with which to overcome interference that occurs at the time of recall. When participants were allotted more retrieval time, provided with strategic support, or given more efficient processing tasks, the retrieval-induced forgetting effect disappeared. Based on these observations, it seems reasonable to conclude that the effect itself arises from interference that can be overcome with additional processing resources.

In fact, a similar argument has been proposed by Williams and Zachs (2001). These authors failed to replicate the list strength effect reported by Anderson et al.

(1994). In addition, they failed to replicate the independent cue effect demonstrated by Anderson and Spellman (1995). Despite these failures, Williams and Zachs (2001) were able to replicate the basic retrieval-induced forgetting effect, and from their data, they concluded that an inhibitory account is insufficient to explain the effect. Instead, they argued that the forgetting effect is due to interference that results from the retrieval practice aspect of the paradigm. Taken together with the results reported in this thesis, it appears that simple interference can explain what has been taken as an intriguingly paradoxical inhibitory effect.

The observations reported here provide several important contributions to our knowledge of retrieval-induced forgetting and to cognition in general. The experiments in this thesis demonstrate a range of conditions under which the retrieval-induced forgetting effect is not observed. Though null effects are often disregarded, they provide critical information that aids in the development of theories that can more accurately reflect the true nature of the underlying mechanisms of the behavior. Within the realm of retrieval-induced forgetting, very few authors have deviated from the standard paradigm developed by Anderson et al. (1994), and even fewer have challenged the inhibition account of the effect. In this sense, the data reported here provide valuable insights into the nature of the retrieval-induced forgetting effect and point to a theoretical revision, which can more readily explain all of the data. This theoretical account extends our knowledge of the forgetting effect.

In a more general sense, the theory proposed in this thesis contributes to a growing body of literature which argues for inhibition-free accounts of cognitive behavior. As mentioned earlier, a number of cognitive phenomena that were once

thought to have been governed by inhibitory mechanisms are now being explained by inhibition-free accounts of mind (MacLeod et al., 2003).

Currently, non-inhibitory theoretical explanations have been proposed to account for negative priming, inhibition of return, directed forgetting and retrieval-induced forgetting, as well as other effects. Though still in the minority, such accounts are gaining appeal as many become aware of the limitations of inhibition-based theories of cognitive behavior.

One obvious problem with the construct of inhibition as applied to cognition is the widely varying use of the term. Researchers have employed the term "inhibition" to refer to psychological processes in a number of different ways and, consequently, it becomes very difficult to discern which use of the term is intended. For example, some authors use the term inhibition to refer to specific causal processes, whereas others use the term to describe functional relationships between one aspect of experience and another, without directly implying a causal relation (Whittlesea & Hughes, 2005; MacLeod et al., 2003). In fact, the term has become so common that researchers tend to use the word inhibition interchangeably with the term interference and decreased performance (Whittlesea & Hughes, 2005). Multiple interpretations of the term are problematic in the sense that any decrease in performance (relative to a baseline) can be interpreted as reflecting inhibition. Is it reasonable to accept a decrease in performance as evidence of inhibition? If so, it becomes very unclear as to what is meant by inhibition. To complicate the picture even further, inhibition has been used to describe relations between nerves in the brain, between the brain and the mind, and between different aspects of the cognitive mind (Smith, 1992). Given the state of the term

inhibition, it has become very difficult to interpret what any particular authors intended meaning actually is.

Beyond the issue of terminology, inhibition as a cognitive mechanism has been used to explain a wide range of behaviors, with little consistency across those accounts. Inhibition as a mechanism seems to have different roles, depending upon the nature of the observed behavior. For example, within the domain of memory and forgetting, inhibition is invoked in a number of different ways. In directed-forgetting studies, inhibition is thought to be a controlled process that serves to enhance remembering of target items. In contrast, the inhibition hypothesized to account for retrieval-induced forgetting effects is argued to be an automatic process that has the capacity to discern targets from competitors. If cognition is governed to some extent by an inhibitory mechanism, it would seem reasonable that the mechanism operates under a relatively constrained set of principles. Without a defined set of principles by which a particular mechanism can operate, it seems plausible that a different form of inhibition could be proposed to account for every different behavior that is observed.

An additional problem with inhibitory accounts of cognitive performance lies in the inconsistent usage of the construct to explain some effects but not others. A simple example of this comes from studies of directed forgetting. Inhibition was hypothesized to be the cause of the directed forgetting effect, using either the list or the item method of instruction (Bjork, 1989). However, when he failed to find the effect using a recognition test with the item method, an alternative mechanism was proposed to account for that specific set of data (Bjork, 1989). As a result, it was argued that inhibition was responsible for the forgetting effect with the list method, while selective rehearsal was the

mechanism underlying forgetting with the item method of instruction. Clearly, there are problems with this type of selective application of a construct. More to the point, if an effect truly reflects a cognitive mechanism such as inhibition, then that effect should be relatively resistant to modifications in procedure and should also stand up to tests of convergence.

Finally, one of the primary drawbacks with inhibitory accounts of cognition is the inherent reliance upon structural models of mind. That is, if inhibition and its necessary counterpart activation are the mechanisms by which cognitive processing occurs, then mind must be organized in an architectural fashion. Concepts are related to one another through specific connections and associations with variable strengths of relationships. Though such theories allow for modeling in a way that can specify processing in concrete units, they can become infinitely complex when one attempts to understand observable cognitive behaviors. More of a concern, though, is the fact that researchers often disregard the assumptions that are required to make their inhibitory theories plausible. Take, for example, the case of retrieval-induced forgetting. Though not explicitly stated, mind must be organized in terms of degree of relatedness between concepts. This assumption is required to account for the findings of Anderson et al. (1994) who reported that retrieval-induced forgetting effects are largest for strongly associated exemplars within a category. In addition, that account also requires the assumption that there is a very high degree of interconnectivity across categories, given that the effect can be observed using independent cues (Anderson & Spellman, 1995). Even further, there needs to be a mechanism to account for how inhibition actually operates within such a system. It is not clear how inhibition is readily able to determine targets from

competitors, how long that inhibition will last, and what types of processing experiences can alleviate the effects of the inhibition. This is a simple example, meant only to illustrate the high level of complexity involved in structural-based theories of cognition and mind. Even if the assumptions required to account for all of the intricacies of mind could be spelled out, models such as these leave out a critical aspect of cognition. That is, there is no direct means of incorporating the vast range of experiences within a model.

Though structural models and inhibition have appeal as explanatory constructs, they lack the ability to account for the highly variable processing that the mind is capable of. As demonstrated by the experiments reported in this thesis, inhibition can not provide an adequate account of all of the available data. Instead, a simpler account, such as interference within a limited capacity system, is proposed to explain the retrieval-induced forgetting effect. Such an account requires far fewer assumptions regarding the nature of mind and representation. Rather than relying upon a detailed architecture, this account suggests that remembering performance is determined by the demands of the task. When the task is such that it allows for efficient processing, successful remembering will occur. Alternatively, when the task demands exceed the capacity of the individual, performance will decline resulting in poorer remembering.

> Successful performance will be observed to the extent that
> prior processing experiences sufficiently prepare the
> individual for the current processing demands of the task.
>
> (Whittlesea, 2002)

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Appendix A

Stimuli used in Experiments 1 through 10, including category words (uppercase) and their six associated exemplars (lowercase).

DRINKS: water, soda, juice, milk, lemonade, wine

WEAPONS: gun, sword, knife, club, bomb, rifle

FISH: salmon, tuna, shark, halibut, trout, snapper

FRUITS: apple, orange, banana, pear, kiwi, strawberry

PROFESSIONS: doctor, lawyer, teacher, nurse, engineer, dentist

METALS: iron, gold, silver, nickel, copper, aluminum

TREES: pine, oak, fir, maple, birch, cedar

INSECTS: fly, beetle, ant, spider, mosquito, grasshopper

BUILDINGS: house, school, tower, library, museum, church

ANIMALS: cat, tiger, rabbit, dog, elephant, giraffe