2016

The Attentional Mechanisms of Active Forgetting

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THE ATTENTIONAL MECHANISMS OF ACTIVE FORGETTING

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Psychology

by
Laura Lee Heisick
B.S., Louisiana State University, 2014
May 2017

ACKNOWLEDGMENTS

The completion of this project would not have been possible without the invaluable assistance and resources of researchers at Arizona State University. I thank Steve Walenchok and Steve Goldinger for the time and effort they devoted to assisting in data collection, without which this project would not have been possible. I also thank Jenna Gibbs for her assistance in collecting additional data. Finally, I thank Megan Papesh, Jason Hicks, Melissa Beck, Juan Guevara Pinto, and Dina Acklin for their feedback, patience, and continued support throughout the current project.

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ABSTRACT

Recent work has shown that intentional forgetting of distracting, erroneous, or irrelevant information aids memory, and relies on active, effortful processes. Two experiments investigated the underlying attentional mechanisms that are active during directed forgetting (DF). Across both experiments, participants completed a modified item-method DF task, in which they received memory instructions to remember or forget individual images for a subsequent memory test. Participants studied items associated with remember or forget instructions before they were shown a subliminal presentation of target items. Finally, participants responded to probes by identifying briefly shown letters to assess how attention and item identity information are inhibited following forget instructions. In Experiment 1, after studying items, participants completed either an explicit memory test (recognition) or an implicit memory task (perceptual identification). Experiment 2 extended the findings of Experiment 1 by examining how spatial information is inhibited following instructions to forget, given spatial components in many recent investigations of DF (e.g., Fawcett & Taylor, 2008, 2010; Taylor, 2005). Although it was predicted that active forgetting would be associated with attentional inhibition linked to both item identity and spatial location, results revealed no inhibitory effects during speeded probe responses across both experiments. However, clear forgetting effects were observed, with participants exhibiting better memory for items they were cued to remember, relative to items they were cued to forget. The results of both experiments support the hypothesis that some information is lost or degraded by instructions to intentionally forget, but raise further questions about the nature of attentional withdrawal proposed to occur during a DF task.

CHAPTER 1. INTRODUCTION

Forgetting is often described as a failure of memory, the passive decay of encoded material over time, interference from competing information, or even as changes in space or context that affect accessibility of memory (for a review, see Suprenant & Neath, 2013). Since Ebbinghaus's (1913) seminal demonstrations of the forgetting curve, researchers have been interested in the relationship between learning and forgetting. Recent work has explored forgetting as an active cognitive process, and that intentional forgetting of irrelevant, distracting, or erroneous information has some benefit for memory (for reviews, see Johnson, 1994; MacLeod, 1998). Intentional forgetting is a practice that is often engaged in real-world settings; for example, many online accounts require that passwords be changed every six to eight months. Engaging in successful intentional forgetting to discard the previous password then becomes paramount to ease of accessing the account.

The benefits of forgetting were empirically demonstrated by an early study conducted by Muther (1965). In this experiment, some participants received instructions to forget a subset of presented stimuli. When participants were subsequently tested on their memory, recall performance was dependent on forgetting: When participants were instructed to forget items, recall of the remaining items improved. However, recall of remaining items (i.e., the items they were told to remember) was lower than when participants simply learned fewer items. Although this indicates that memory is not exclusively facilitated by forgetting, considerable evidence supports that forgetting facilitates memory for remaining information (MacLeod, 1998).

The evidence that forgetting may be purposeful (e.g., Muther, 1965) led to the development of laboratory paradigms designed to induce and examine forgetting. Directed forgetting (DF) paradigms can be divided into two broad categories, list-method and item-method, which differ in when DF cues are shown to participants. In typical DF experiments, participants study a series of items (usually words, but see Quinlan, Taylor, & Fawcett, 2010) for a subsequent memory test. In list-method DF paradigms, participants are told at the midpoint of the study list that the previous items will not be tested (i.e., they can forget all previous items), but that the second half of the list will be tested. In item-method DF paradigms, study items are each followed by an explicit cue instructing participants to either remember (e.g., R, remember, RRRR) or forget (e.g., F, forget, FFFF; Muther, 1965; Geiselman, Bjork, & Fishman, 1983). During test, participants either recall as many items as possible or make recognition judgments about items they were instructed to remember, items they were instructed to forget, and novel distractors. Participants are instructed to identify any item that was previously studied (i.e., both remember and forget items) as old, and only novel distractors are categorized as new, to compare memory performance for the to-be-remembered (TBR) and to-be-forgotten (TBF) items (e.g., Epstein, 1970)

DF paradigms report facilitation of items associated with remember cues (R items), relative to items associated with forget cues (F items), as well as facilitation when compared to baseline performance (i.e., no DF instructions) in explicit memory tasks, referred to as the directed forgetting effect. This advantage is especially apparent for recall (e.g., MacLeod, 1975). MacLeod (1999) also provided evidence that DF paradigms do indeed induce forgetting, rather than selective reporting of TBR items, by demonstrating that retrieval of F items was impaired even when participants were offered financial incentives to retrieve them.

While explicit memory tests show clear patterns for R and F items, the impact of DF on implicit memory tests is less understood. MacLeod (1989) documented that using an item-method DF task revealed DF effects for both explicit (e.g., recognition and free recall) and implicit (e.g., fragment completfion and lexical decision) memory tests. These results showed that participants explicitly remembered more R items compared to F items. Further, F items did not show the same implicit facilitation in a fragment completion task, with participants completing more R words than F words. A similar finding was reported by Fleck, Berch, Shear, and Strakowski (2001), who found that items associated with forget cues were judged more slowly than items associated with remember cues in a lexical decision task. However, Basden, Basden, and Gargano (1993) failed to find similar results: They showed that DF effects were easily established using both list- and item-method DF tasks that included an explicit test. Only list-method DF, however, showed DF effects in an implicit test, with F items exhibiting no priming effects. Despite mixed results, few studies have examined the impact of DF cues on implicit memory, as explicit memory tests (e.g., recall and recognition) are more common. Implicit memory tests allow for more precise investigations of whether or not a memory trace remains for to-be-forgotten items, making it an ideal method to aid investigation of the mechanisms that underlie DF effects.

Mechanisms of Forgetting

There are several underlying mechanisms proposed to explain directed forgetting effects, including selective rehearsal of R and F items (Bjork, 1970, 1972), set differentiation of R and F items (Epstein, Massaro, & Wilder, 1972), active erasure from memory (Muther 1965), and both attentional inhibition (Zacks, Radvansky, & Hasher, 1996) and retrieval inhibition (Basden & Basden, 1998). These hypotheses differ in whether they propose that differentiation (i.e., mechanisms by which R items are better remembered and F items are impaired, relative to no DF instructions) between R and F items occurs during encoding or retrieval. While many DF hypotheses exclusively discuss encoding (e.g., selective rehearsal) and retrieval (e.g., retrieval inhibition) mechanisms, recent evidence suggests that a strong attentional component is involved in DF processes (e.g., Taylor, 2005; Fawcett & Taylor, 2010; Fawcett & Taylor, 2011). This evidence has led to greater exploration of the attentional inhibition hypothesis in order to isolate the underlying attentional mechanisms of DF effects.

The most dominant explanation for item-method DF effects has been the selective rehearsal hypothesis (e.g., Basden, Basden, & Gargano, 1993; Bjork, 1970, 1972; MacLeod, 1999). According to selective rehearsal, individual items are held in working memory until the memory instruction is received. When the F or R cue is presented, participants engage in elaborative rehearsal of R items, but not F items. This selective engagement leads to more R items subsequently retrieved, while F items gradually decay from the memory set. Early studies of DF were interpreted as consistent with selective rehearsal (Bjork, 1972), and further evidence was provided by Wetzel (1975; Wetzel & Hunt, 1977), who demonstrated that manipulating post-cue rehearsal time (i.e., the time during which selective rehearsal should occur) impacted R, but not F, item performance. Specifically, with longer post-cue intervals, R item memory improved, but F item memory was unaffected (Wetzel & Hunt, 1977). In addition, when the post-cue interval contained a distractor task that prevented rehearsal, R item memory suffered without a corresponding effect on F items, essentially eliminating DF effects. These results support the hypothesis that R items are actively rehearsed, while F items passively decay from lack of rehearsal.

However, the selective rehearsal hypothesis fails to explain how to-be-forgotten (TBF) items are eliminated from the memory set, and it suggests that forgetting is a passive decay process. Forgetting as passive decay is not supported by recent behavioral and neurophysiological evidence demonstrating active cognitive mechanisms engaged during intentional forgetting (e.g., Fawcett & Taylor, 2008; 2010; Ullsperger, Mecklinger, & Müller, 2000; Wylie, Foxe, & Taylor, 2008). For instance, Fawcett and Taylor (2008) demonstrated that participants were slower to respond to dot probes following forget instructions relative to remember instructions, which they interpreted as indication that forget processes were effortful and took longer to disengage to respond to probes. Further, when compared to unintentional forgetting, which is often associated with poor encoding conditions, successful intentional forgetting has been shown to be associated with increased activation in prefrontal regions (see Wylie et al., 2008). As prefrontal regions are implicated in executive control processes, this suggests that intentionally forgetting relies on active mechanisms, and not on passive decay.

An alternative explanation for item-method DF effects is the attentional inhibition hypothesis, which proposes that active cognitive processes are engaged during encoding following remember and forget instructions. According to the attentional inhibition framework (Zacks, 1989), when items are no longer goal-relevant, attentional inhibition actively suppresses them, thereby preventing further processing. For example, when an item is followed by an F cue, it is no longer goal-relevant (i.e., because it will not be tested). According to this framework, F cues cause attention to be withdrawn from items and inhibits attention from returning. In this way, the processing of F items is suspended to prevent them from consuming limited WM resources.

The majority of the support for this hypothesis has come from studies that have examined the differences in DF across the lifespan. Although both younger and older adults show DF effects, older adults, who are less effective at inhibitory processing due to age-related cognitive declines (see Zacks & Hasher, 1994), have been shown to exhibit a smaller advantage for R items compared to F items (i.e., fewer F items are forgotten). This, alongside the fact that older adults are also more likely to report F items during test (e.g., Zacks, 1989; cf. Marks & Dulaney, 2001), suggests that a lack of attentional inhibition drives older adults' difficulty in implementing forgetting.

Recent evidence has expanded attentional effects in DF by demonstrating that attention may also be withdrawn from the spatial representation of F items (Taylor, 2005; Fawcett & Taylor, 2010). Similarly, DF paradigms have been compared to stop-signal paradigms. If remember is the default process engaged (i.e., similar to a go signal), engaging in successful forgetting is analogous to a stop signal. When an F cue is implemented, the associated item is actively inhibited (i.e., processing "stops"), resulting in fewer F items retrieved (Hourihan & Taylor, 2006). These results support the attentional inhibition framework, in which inhibition of F items at encoding suggests that F cues result in a degraded or even nonexistent representation of F items. In addition, the attentional inhibition framework does not distinguish between degradation acting upon conceptual or perceptual representations of F items, raising further questions about how inhibitory processes result in poorer memory performance for F items. Taken with evidence that has demonstrated F items tested implicitly are not associated with negative priming effects (i.e., response to F items is slower than R items, but still faster than novel items), this suggests that inhibitory processes do in fact act upon F item representations (see Fleck et al., 2001).

Evidence of Attentional Mechanisms

While previous work has demonstrated that active attentional mechanisms are involved in DF tasks (e.g., Taylor, 2005; Taylor & Fawcett, 2011), attentional inhibition following forgetting is still being investigated. Based on evidence that attention was actively inhibited or withdrawn following forget instructions, a parallel was drawn between the inhibition of return (IOR) in visual search and the inhibition of attention proposed by the attentional inhibition framework. The IOR in visual search tasks occurs when participants are slower to return to target items when they appears in the same location as preceding targets (e.g., Klein & Taylor, 1994, as cited by Zacks et al., 1996). In visual search, IOR is thought to comprise two distinct components, stimulus detection and movement production (Abrams & Dobkin, 2004). In the stimulus detection phase, observers have greater difficulty detecting a stimulus in a previously attended location, perhaps due to the mechanisms of attentional suppression. The movement production phase involves slower eye movement latencies when stimuli are presented in a previously attended region, relative to a previously unattended region. Importantly, this deficit is found even when participants are not required to respond to a cue.

The withdrawal of attention in directed forgetting has since been proposed to rely on similar mechanisms as the IOR in visual search, as recent work has revealed that items associated with forget cues also exhibit IOR (Taylor, 2005). For example, Taylor (2005) had participants study items appearing on the left- or right-hand side of the screen, followed by remember or forget instructions. After each instruction, a target dot appeared in the same (congruent) or opposite (incongruent) location as the studied item, and participants' task was to press a button as soon as they detected the dot. Taylor (2005) documented that when participants responded to a probe that appeared in the same location as an item associated with an F cue, reaction times were slower than when the probe was in the opposite location or followed an R cue. Relative to baseline performance (i.e., no DF instructions), F items yielded an increased IOR, while R items yielded a decreased IOR (see also Fawcett & Taylor, 2010). These results are consistent with the attentional inhibition hypothesis.

Evidence of Attentional Inhibition

Although IOR following forgetting has been documented, why forget cues are associated with a larger IOR than remember cues is less clear. Specifically, whether the attentional inhibition associated with forgetting is due to a withdrawal of the exogenous and/or endogenous attentional systems has recently been investigated. While the exogenous attentional system is associated with the ability to reflexively orient attention based on external stimuli, the endogenous attentional system is instead associated with voluntary and often goal-related orientation (Berger, Henik, & Rafal, 2005). Importantly, an investigation of visual cueing by Briand and Klein (1987) suggested that these systems were dissociable. Across four experiments, they combined Posner's (1980) attentional cueing task, in which participants received valid or invalid cues about the location of to-be-presented stimuli, with Treisman's feature/conjunction task (Treisman & Gelade, 1980), in which participants performed either feature search or conjunction search. This investigation demonstrated that when cues were presented peripherally, a large effect of exogenous attention was found on conjunction search, such that peripheral cueing produced larger costs for invalid cues (i.e., slower responses) and larger benefits for valid cues (i.e., faster responses). However, when cues were presented centrally, conjunction and feature search were similarly impacted by endogenous attention, with equivalent costs and benefits for both search tasks.

The likelihood that the exogenous and endogenous attentional systems are dissociated has been further supported by a large body of evidence demonstrating that central cues are associated with conscious attentional shifts, while peripheral cues are associated with more automatic orienting (for a review, see Carrasco, 2011). When these results are considered alongside the evidence that goal-directed attentional orienting (i.e., endogenous) and stimulus-driven (i.e., exogenous) attentional orienting rely on distinct neural networks and produce differential patterns of neural activity (see Corbetta & Shulman, 2002), this strongly suggests that the exogenous and endogenous systems are in fact separate.

Taylor and Fawcett (2011) investigated the impact of these two attentional systems on DF performance. Across five experiments, their results suggested that the IOR found following forget cues is a result of exogenous attentional withdrawal. More specifically, Taylor and Fawcett showed that when a memory instruction (e.g., remember or forget) was a centrally-presented cue that appeared after the target item, the abrupt onset captured exogenous attention. Equating exogenous attention (and thereby preventing any exogenous withdrawal) led to a disappearance of IOR differences following forget items when compared to remember items (Experiment 1). Further evidence came from a direct manipulation of endogenous attention through probability (Experiment 2), such that participants were informed that the majority of targets would occur at the center of the screen. Despite this endogenous orientation, an IOR was still found when memory cues were of a different modality (e.g., tones), further suggesting that the IOR for intentional forgetting relies on exogenous attention. The results of this study showed that when the memory instructions did not reorient exogenous attention, a reliable IOR difference between forget and remember items was found.

Taken as a whole, there is increasing support for the attentional inhibition hypothesis (e.g., Fawcett & Taylor, 2010; Taylor & Fawcett, 2011; Thompson, Hamm, & Taylor, 2014). While these results do clearly reveal that strong attentional processes are involved in intentional forgetting, as well as provide support for attentional inhibition, the current research investigated whether attentional suppression in DF is tied to the spatial location of a presented item, or to diagnostic identity information of an item representation. If attentional suppression in DF reflects spatial suppression, the target item should continue to capture attention if presented in a different location. The resulting attention capture should bias participants to target locations. However, if forgetting results in suppression of item identity information, target items should not as readily capture attention if presented in a different location. In this case, the inhibition of item representations should fail to bias attention to the target location. To differentiate between these possible patterns of inhibition, the current research investigated the precise nature of exogenous attentional withdrawal recently demonstrated in DF tasks (Fawcett & Taylor, 2011).

CHAPTER 2. CURRENT STUDY

While previous studies have documented clear evidence for exogenous attentional withdrawal, the current experiments focused on whether attention is withdrawn from spatial locations of peripherally presented targets, or if it is withdrawn from item representations. To investigate withdrawal from location versus from identity information, the current experiments employed images as stimuli for a DF task. Previous work investigating attentional withdrawal has used only verbal stimuli (e.g., Taylor & Fawcett, 2011), as have most studies of DF effects (see MacLeod, 1998). The few investigations of DF effects that have used pictures (e.g., Quinlan et al., 2010) have documented a clear picture superiority effect (Nickerson, 1965; Shepard, 1967), the pervasive finding that the presentation of pictures at study, relative to words, can result in extremely accurate subsequent memory. While Quinlan et al. (2010) documented that DF effects could be found for both picture and word stimuli, the magnitude of these effects was smaller for pictures than what is typically found for words (i.e., fewer F items were successfully forgotten). However, using pictures as stimuli in the current experiments allowed for participants' exogenous attention to be oriented using subliminal attention capture. This was based on evidence that has shown a peripherally presented picture can exogenously capture attention during a subliminal presentation, resulting in IOR effects (e.g., Mulckhuyse, Talsma, & Theewus, 2007). Thus, while verbal stimuli offer a more robust DF effect, the current experiments used pictures in order to more precisely investigate the impact of item identity information during a DF task.

In the current experiments, the attentional mechanisms of directed forgetting were examined. The goal was to determine how attentional processes underlying DF are mobilized (Taylor, 2005), and to investigate whether the exogenous attentional withdrawal following DF is associated with item identity information and/or spatial location (Taylor & Fawcett, 2011). Behavioral responses to speeded probe items were used to assess attentional engagement or inhibition following DF instructions (e.g., Taylor, 2005). Based on previous work that has used probe responses to assess effort (e.g., Fawcett & Taylor, 2008), the current experiments also examined the effort in intentionally forgetting information. Finally, the use of both implicit and explicit subsequent memory tests allowed for a closer examination of how target items may be inhibited following instructions to forget.

Previous research has implicated attentional processes in active forgetting (Fawcett & Taylor, 2008). The aim of the current studies was to more precisely determine how these processes are deployed, and what effect they have on real-time perception and subsequent memory. Two experiments investigated how exogenous attentional withdrawal following forgetting inhibits object identity information and spatial information, and examined subsequent memory in both explicit and implicit memory tests.

CHAPTER 3. EXPERIMENT 1

In Experiment 1, the attentional suppression of object identity information following forgetting was assessed. Evidence suggests that an exogenous withdrawal of attention is associated with intentional forgetting (e.g., Fawcett & Taylor, 2011). While previous research has provided evidence of a withdrawal of attention from spatial locations through demonstrations of the IOR (see Taylor, 2005; Fawcett & Taylor, 2010), intentional forgetting in realistic situations often does not include a spatial component. For example, when changing a password associated with an online account, intentionally forgetting the previous password involves no spatial information. Instead, to successfully inhibit the previous string, information about that specific item must be forgotten. Intentional forgetting in many applied scenarios, therefore, must rely at least in part on the suppression of identity information, such that something that was previously remembered (e.g., a previous password) is inhibited or suppressed in order to successfully encode new information (e.g., a novel password) and to prevent interference. To investigate how identity information is inhibited, Experiment 1 examined the withdrawal of attention from diagnostic identity information when spatial information is held constant. In this way, Experiment 1 investigated whether DF tasks result in complete forgetting (e.g., the item representation is no longer available) or in partial forgetting (e.g., a degraded or nonexistent explicit memory trace).

Participants engaged in a modified item-method DF task and, importantly, engaged in one of two possible retrieval mechanisms. In Experiment 1A, participants performed a explicit recognition test, and in Experiment 1B, participants performed an implicit recognition test, during which they made perceptual identifications of studied items and novel foils. This manipulation was intended to tap into different retrieval mechanisms, and across these two experiments, the manipulation of recognition test type and use of novel foils as distractor items allowed an assessment of how item identity information may be inhibited or suppressed following intentional forgetting.

Previous research comparing explicit and implicit tests in DF tasks has shown mixed results. MacLeod (1989) and Fleck et al. (2001) documented that using an item-method DF task revealed DF effects for both an explicit (e.g., recognition and free recall) and implicit (e.g., fragment completion and lexical decision) memory test. However, Basden et al. (1993) challenged this finding and demonstrated that while DF effects could be established explicitly using both list- and item-method DF tasks, only list-method also showed DF effects in an implicit task (e.g., priming). Overall, the goal of Experiments 1A and 1B was to establish whether the exogenous attentional withdrawal associated with forgetting also impacts item identity information. If attention is withdrawn from presented items, this would provide additional evidence that object identity information is inhibited during intentional forgetting.

Method

Participants. Based on an a repeated measures a priori power analysis of Fawcett and Taylor (2008), who presented DF stimuli centrally and documented slower responses following Forget instructions, approximately 30 participants were needed for each of the current experiments. This estimate was based on $\eta_p^2 = 0.04$, and Cohen's *f* effect size of approximately 0.20 for the slowing following Forget cues. G*Power was used to conduct the analysis, with power at 80%, alpha at 0.05, no between-subjects factors, and the number of memory cue repetitions (i.e., the number of trials during which participants received either Remember or Forget cues) held at 20 (Faul, Erdfelder, Lang, & Buchner, 2007). Forty-three participants recruited from Arizona State University participated in Experiment 1A (M_{age}= 18.7; 17 female), and an additional 45 participants participated in Experiment 1B (M_{age}=18.6; 20 female) in exchange for partial course credit. All participants self-reported normal or corrected-to-normal vision and were native English speakers. Participants engaged in sessions lasting approximately 60 minutes. One participant from Experiment 1B was excluded from analyses due to failure to comply with experimental instructions during the perceptual identification task.

Stimuli. A total of 288 objects were used in the current experiment, with 96 items appearing as targets during the study phase and 96 items appearing as novel distractors during the test phase. Novel distractors included 48 semantically matched foils, and 48 were unrelated and unpresented objects. The remaining 96 items were presented subliminally; each target object was randomly paired with an unrelated and untested novel object for subliminal presentation. All presented items were drawn from the Massive Memory Object Database (Brady, Konkle, Alvarez, & Olivia, 2008), which includes every day, nameable objects. All images appeared in grayscale and were sized 250 x 250 pixels. Images presented were independently pilot-tested to ensure general agreement about the name of the object presented, with only target-foil pairs receiving 80% accurate naming or higher utilized. Pilot testing produced a set of 100 possible

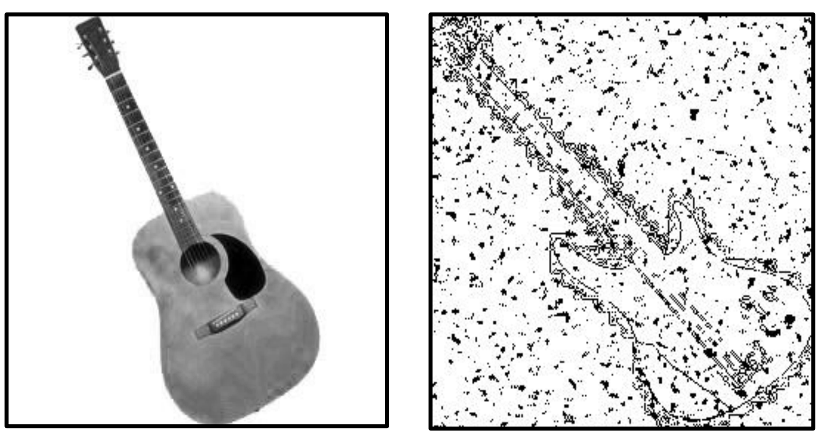

Figure 1. Sample stimuli used for perceptual identification in Experiment 1B. Participants studied one exemplar and were tested on both a degraded target and degraded matched foil.

image pairs that were used as targets in both Experiments 1A and 1B, with assignment of target and foil counterbalanced across participants. Participants studied one of each exemplar pair, and could see both exemplars during test.

In Experiment 1B, during which participants viewed degraded versions of targets and distractors, images were manipulated using Adobe Photoshop®, with all images subjected to manipulation by trace contour, with an additional Mezzotint pixilation set to coarse dots (for sample stimuli, see Figure 1). Based on pilot testing, this manipulation produced the widest range of identification response times and average accuracy[1], making it the ideal image manipulation for the current experiment.

Design. A 2 (Memory Cue: Remember, forget) x 2 (Subliminal Location: Left, right) x 2 (Probe Location: Congruent, incongruent) completely within-subjects design was used for the current experiment. The dependent variables that were examined included participants' response times to probes during study trials, and behavioral performance on the subsequent memory test.

Experiment 1A Procedure. Participants were first familiarized with the experiment procedure and the task. Specifically, before beginning the experiment, participants were familiarized with the memory instructions used throughout to ensure that participants would

[1] To establish a set of images that were quickly and easily identifiable, participants identified JPEG images of everyday objects presented in grayscale. Average accuracy for image identification was 0.948. For images that all participants correctly identified at average rates of 0.9 or higher, accuracy was significantly higher ($M = 0.98$), $t(97) = 12.72$, $p < 0.05$. This produced a set of 100 useable images for the current experiments. To establish what type of image degradation produced the widest range of both accuracy and identification times for the current experiments, participants also identified images that were subject to manipulation using Adobe Photoshop®. Response times differed by image manipulation, with participants responding slower on average to items manipulated using trace ($M = 7493$ ms, $SD = 3360$ ms), relative to other image manipulations, $F(2, 118) = 12.253$, $p < 0.01$. Given that Trace was also associated with average accurate identification and the slower and wide range of response times (1299 – 36992 ms), images manipulated using Trace were used in the current experiments.

engage in intentional forgetting. To provide remember or forget instructions, participants heard either a relatively high-pitched tone (1175 Hz) or a relatively low-pitched tone (146 Hz). Tones were used in place of visual cues based on evidence provided by Taylor and Fawcett (2011) that centrally-presented cues equate exogenous attentional withdrawal, resulting in a lack of IOR differences, and were independently pilot tested to ensure that they were perceptually distinct[2]. Assignment of memory instruction to tone was counterbalanced, such that half the participants heard high tones for R cues and low tones for F cues, and the other half of participants experienced the opposite. Participants were familiarized with the tones across ten familiarization trials, during which the tone, a verbal description of the tone, and the paired instruction (e.g., "High tone – FORGET") were presented simultaneously. The tone played for 500 ms, and the instruction was presented centrally and remained onscreen for a total of 1500 ms. Participants completed several practice trials before beginning the experiment. Participants were also tested on their understanding of which tone indicated which memory instruction. Participants were only allowed to begin once complete accuracy in identification of the tones was achieved, and once accurate responding to probe practice trials was above 80%.

During the first phase of the experiment, participants began each trial with a central fixation cross for 1000 ms. Each fixation was followed by an individual target item that remained on screen for 500 ms[3]. After the target, participants experienced a screen with only a fixation to

[2] Based on pilot data, the tones used in the current experiment were perceptually distinct. Participants rated how similar two sequentially presented tones were using a scale of 1 to 5, with 1 indicating that the tones were very different, and 5 indicating that the tones were very similar. Average similarity ratings for tones when they did not match (e.g., the high tone was played, followed by the low tone) were 1.31, which were significantly lower than similarity ratings for the tones when they did match ($M = 4.78$), $t(11) = 19.87$, $p < 0.01$.

encourage gaze to remain on-screen. During this fixation, they were presented the auditory memory instruction (i.e., remember or forget) for 400 ms. Immediately following the offset of the cue, participants experienced a variable inter-stimulus interval (ISI). This variable ISI was included to prevent participants from anticipating the appearance of the subliminal primes. The ISI was between 700 and 1200 ms, a range drawn from previous work that has been shown to produce reliable DF effects (see Taylor & Fawcett, 2011).

Following the ISI, participants were presented objects on both the left- and right-hand side of the screen for 16 ms. This presentation time has been previously demonstrated as sufficient time to capture exogenous attention and produce IOR (see Mulckhuyse et al., 2007), and was independently piloted to ensure subliminal presentation. To determine whether attention is inhibited for item identity information, one of the subliminally presented objects was always the target of the trial, and the other object was an unrelated (and untested) object. Immediately following the offset of the subliminal item presentation, participants responded to a briefly presented letter probe that appeared on one side of the screen. Most research examining IOR in DF tasks has used dot probe localization, during which participants identify the spatial location in which a dot probe appears (e.g., left or right side of the screen by pressing ‘f’ or ‘j’,

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[3] Based on pilot testing, 500 ms presentation time produced DF effects using images. Participants were shown either images or words for 500 ms prior to receiving a cue to remember or forget. This was directly compared to the results of Quinlan, Fawcett, and Taylor (2010), who presented images for 2000 ms. Using this shorter presentation time, a significant directed forgetting effect was found. During a recognition test, participants accurately identified more items associated with remember cues as old (M = .82, SD = .13) than items associated with forget cues (M = .62, SD = .22), $t(21) = -5.11$, $p < .05$. Although participants recognized more images than words associated with forget cues (M = .47, SD = .20), the difference was not reliable, $t(20) = 1.933$, $p > .05$. The results of this pilot suggest that directed forgetting using images was possible for the current experiments.

respectively). Based on pilot data utilizing the same dot probe task as previous work (Fawcett & Taylor, 2010), although probe responses following Forget cues were slightly numerically larger (*M* = 190 ms, *SE* = 13 ms), there was no reliable difference relative to probe responses following Remember cues (*M* = 187 ms, *SE* = 12 ms), $t(24) = 1.107$, $p > 0.05$[4]. To make the task more perceptually challenging and prevent participants from responding to the dot probe without actively engaging in the experimental task, the dot probe was changed to briefly shown lowercase letters (either a 'b' or a 'p') that could appear to the left or right of central fixation. Participants were instructed to keep their gaze focused on central fixation after the presentation of the target item and were instructed that if they focused on one side of the screen over the other, they would be unable to detect the letter, as they were chosen to be easily confusable.

Based on prior literature (see Taylor & Fawcett, 2011), only probe responses between 200 ms and 1500 ms were analyzed, and participants received a two-second time penalty for responding beyond 1500 ms. The probe was presented for 250 ms and consisted of a lowercase letter ‘b’ or letter ‘p’ in size 25 font, subtending a visual angle of 0.5 degrees. The probe appeared either on the same side as the subliminal target object (congruent) or the opposite (incongruent; see Figure 2 for examples). Immediately following the offset of the probe, participants indicated which letter they had seen by pressing the corresponding key. Participants’

[4] Pilot testing using dot probe localization, with probes presented for 250 ms (Fawcett & Taylor, 2011) demonstrated no reliable difference between average probe response times following Remember cues (*M* = 187 ms, *SE* = 12 ms) and Forget cues (*M* = 191 ms, *SE* = 13 ms), $t(24) = 1.107$, $p > 0.05$. Because no R < F probe response difference was found based on pilot data, the task was altered to be more perceptually difficult (described above). Although previous work has demonstrated that perceptual discrimination may not produce typical IOR observed in DF tasks (e.g., the IOR may reverse, with slower responses following R cues, relative to F cues; see Fawcett & Taylor, 2011, Experiment 7), the perceptual discrimination task utilized here was equipped with spatially compatible (and incompatible) responses intended to examine IOR using a more engaging task.

responses terminated the trial, and between each trial was a blank inter-trial interval (ITI), lasting for 1000 ms. After completing all the study trials, participants were given a three-minute break before moving on to the second and final phase of the experiment.

The final phase of the experiment was an explicit recognition and source monitoring test. Trials began with a fixation cross for 1000 ms. Tested items included images that participants were cued to forget (*n* = 48), images participants were cued to remember (*n* = 48), and novel distractors including semantically matched foils (*n* = 48) and unrelated objects (*n* = 48).

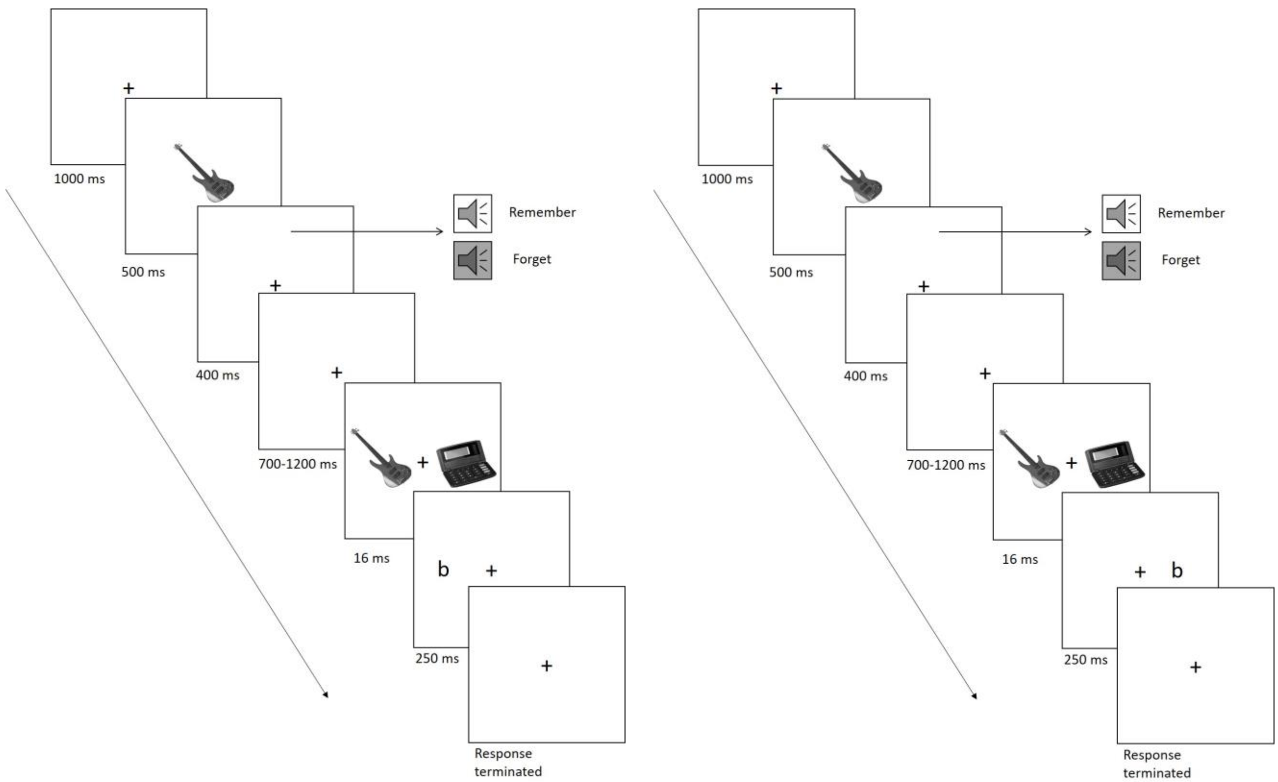

Figure 2. Trial schematic from the encoding phase of Experiment 1.

Participants were told that, although they might see similar items during test (e.g., two coffee cups), their task was to respond only to studied items. The use of matched foils allowed an examination of whether participants made more false alarms to foils of TBF items, relative to TBR items.

Participants indicated whether a presented item was old (i.e., previously studied) or new (i.e., not previously studied) by pressing the ‘f’ or ‘j’ keys, with response mapping counterbalanced across participants. Participants were further instructed that items should be called old if they was seen at all during the first phase of the study, even if an item was associated with a forget cue, using instructional language from previous research (Fawcett & Taylor, 2008). Importantly, the order in which participants saw a semantically matched foil versus the target object during test was controlled to examine whether participants made more false alarms to foil items when they were presented before the target objects.

Finally, participants made source decisions for every tested item by indicating whether items were previously associated with cues to remember or cues to forget. Source monitoring tests require that participants retrieve specific details of the encoded stimuli (Johnson, Hashtroudi, & Lindsay, 1993); this source decision was included to assess the impact of exogenous attentional withdrawal on contextual information, particularly based on evidence that source memory for R items is better than source memory for F items (e.g., MacLeod, 1975). After each item, participants experienced a 1000 ms ITI. Upon completion of the experiment, participants answered a post-experiment questionnaire that assessed whether they believed that items associated with forget cues would actually remain untested.

Experiment 1B Procedure. The procedure for Experiment 1B was identical to Experiment 1A with the following exception: After participants completed the encoding phase, during which they experienced the modified DF task described above, they performed an implicit memory test to assess their memory for studied items. In Experiment 1B, participants completed a perceptual identification task, during which they viewed degraded versions of studied items and semantically matched novel distractors (for an example, see Figure 3). Participants viewed degraded images and made object identifications by first pressing the space bar to indicate that they had identified the image, and then typing the name of the item. Speed and accuracy of identifications were stressed.

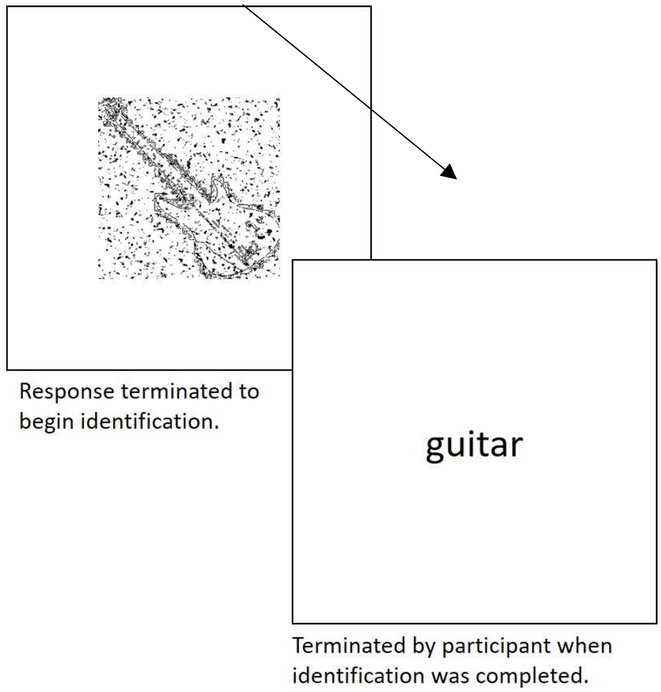

Figure 3. Sample test procedure in Experiment 1B.

Results

Alpha for significance tests was held at .05, and all multiple comparisons were Bonferroni-corrected unless stated otherwise. Because Experiments 1A and 1B differed only in the memory test administered, and analysis revealed no reliable differences between probe response times in 1A compared to 1B, $t(83) = 1.083$, $p > 0.05$, results for probe response were collapsed across test type. Prior to data analyses, outlier trials were filtered out based on prior literature (e.g., Taylor & Fawcett, 2005). For probe trials, any trial during which participants responded faster than 200 ms were dropped, and any response slower than 2.5 standard deviations above an individual subject's mean was replaced with a cutoff value. This resulted in a total of 1.1% of probe trials (160 trials out of 4,435 total) being dropped across all participants in Experiment 1A, and 1% of probe trials (154 trials out of 4,153 total) dropped in Experiment 1B. Less than 1% of trials were replaced by cutoff values in Experiment 1A (120 trials), and 2.3% were replaced in Experiment 1B (331 trials). Only correct probe responses were analyzed. This resulted in a total of 10% of trials being dropped across all participants in Experiment 1A, and 10% of trials dropped across all participants in Experiment 1B. Data from one participant in Experiment 1A and two participants from Experiment 1B were not analyzed due to error rates higher than 15% on probe trials. Data from the remaining 42 participants in Experiment 1A and 42 participants in Experiment 1B are reported below.

Probe Response. To assess whether the exogenous attentional withdrawal associated with intentional forgetting impacts item identity information, response times to correctly identified probes were examined by a 2 (Memory Cue: Remember, forget) x 2 (Image-Probe Location: Congruent, incongruent) repeated measures (RM) ANOVA. Although previous research has shown that probe responses following Forget cues are overall slower than probe responses following Remember cues, no such difference was observed in the current experiments. Probe response times for Forget cues (M = 449 ms, SE = 11 ms), while very slightly numerically larger, did not reliably differ from probe response times for Remember cues (M = 444 ms, SE = 10 ms), $F(1, 83) = 1.836$, $p > 0.05$, $\eta^2 = .02$. Results also revealed no effect of Image-Probe Congruency; probe responses for letters that appeared congruent with the subliminal target presentation (M = 446 ms, SE = 11 ms) did not reliably differ from probe responses for letters appearing incongruently with the subliminal presentation (M = 447 ms, SE = 11 ms), $F(1, 83) = 0.495$, $p > 0.05$, $\eta^2 = .003$. The interaction between Memory Cue and Image-Probe Congruency was also not reliable, $F(1, 83) = 0.018$, $p > .05$, $\eta^2 = .00$, illustrated in Figure

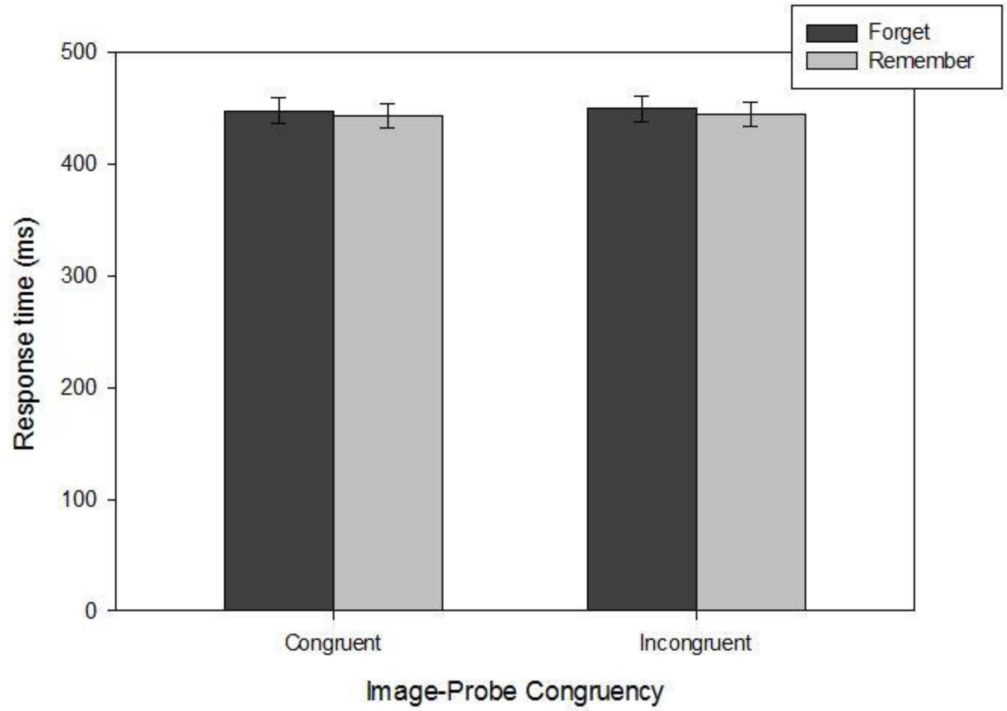

Figure 4. Probe RTs during Experiment 1A and 1B when the subliminal target and probe were congruent versus incongruent following cues to Remember or Forget.

4. This result is inconsistent with prior work demonstrating IOR effects for probe items following Forget cue, and potential explanations for the lack of IOR observed in the current experiment can be found in the General Discussion.

To determine whether IOR differences were observed based on the successful implementation of intentional forgetting, an additional 2 (Memory Cue) x 2 (Subsequent Memory: Forgotten, remembered) RM ANOVA was conducted on probe response times, illustrated in Figure 5. Because only Experiment 1A explicitly tested participants' memory for target items, this analysis excluded probe responses during Experiment 1B. Results revealed no effect of Memory Cue, with no reliable difference in probe response speed between items associated with Remember cues (M = 438 ms, SE = 17 ms) and Forget cues (M = 440 ms, SE = 17 ms), $F(1, 41) = .067$, $p > .05$, $\eta^2 = .002$. In addition, there was no difference in probe response speed between items that were subsequently remembered (i.e., associated with accurate old/new recognition; *M* = 438 ms, *SE* = 17 ms) and items that were subsequently forgotten (*M* = 440 ms, *SE* = 17 ms), $F(1, 41) = .339$, $p > 0.05$, $\eta^2 = .008$. However, results revealed a significant

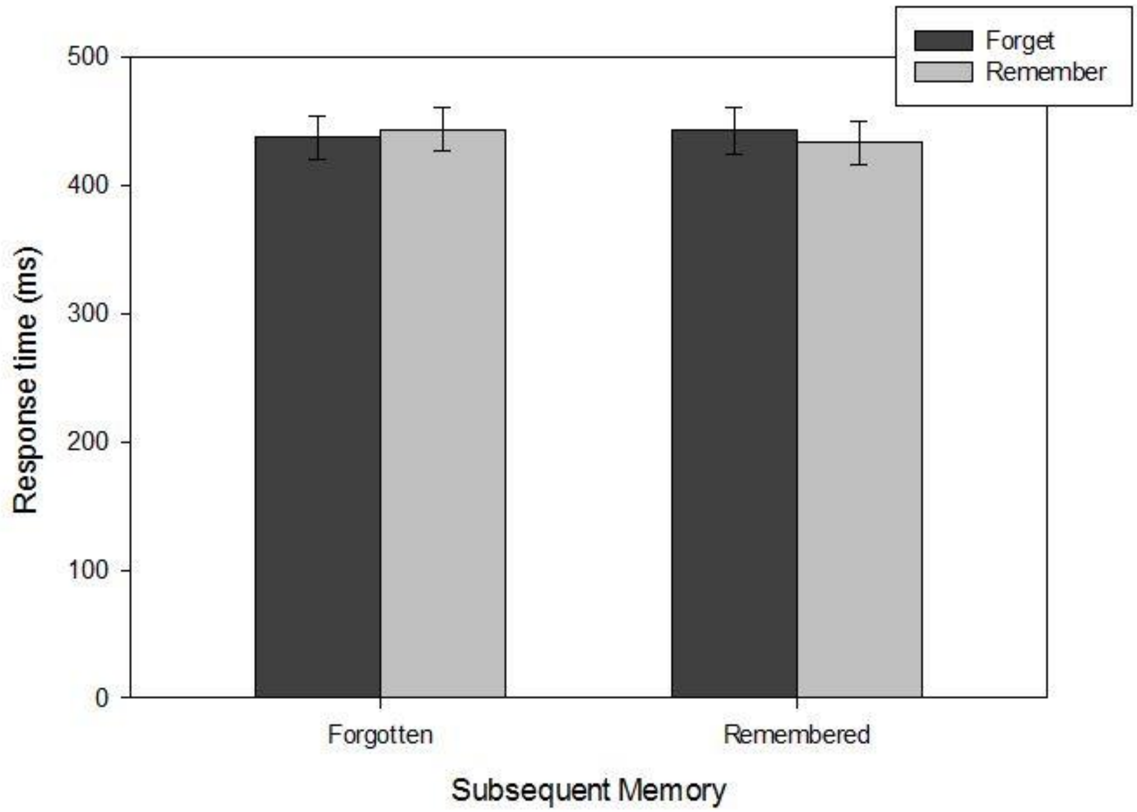

Figure 5. Probe RTs during Experiment 1A by participants' subsequent memory.

interaction: Images associated with Remember cues during study that were subsequently remembered were also associated with faster probe responses (*M* = 433 ms, *SE* = 17 ms) than images that were associated with Forget cues and subsequently remembered (*M* = 443 ms, *SE* = 18 ms), $F(1, 41) = 4.167$, $p < 0.05$, $\eta^2 = .094$; see Figure 5. Although the difference observed is not numerically large, this interaction has interesting implications. If, as previous work has suggested, DF tasks share similarity with stop-signal paradigms (Hourihan & Taylor, 2006), this finding might suggest that Remember cues are indeed participants "default," and if that process is interrupted or disturbed in some way (e.g., by a Forget cue), the additional resources required to overcome a stop signal may be responsible for slower probe responses. However, because participants did not experience any baseline (i.e., no DF instruction) conditions, a comparison between baseline and probe responses are not possible; therefore, it is not possible to demonstrate whether successful Remember probe responses were associated with facilitation.

Experiment 1A: Recognition Performance. First, to determine whether DF effects were observed in the current experiment, participants' recognition accuracy (defined as hits for studied items) was analyzed by a 2 (Memory Cue: Forget, remember) factor RM ANOVA. Based on pilot tests that suggested that DF effects (more R items retrieved and fewer F items retrieved) using picture stimuli was possible, I predicted the same effect would be found in the current study. The analysis revealed a significant effect of memory instruction, with target items associated with Remember cues recognized with higher accuracy ($M = .64$, $SE = .02$) than targets associated with Forget cues ($M = .52$, $SE = .02$), $t(41) = -5.835$, $p < 0.01$, $\eta^2 = .45$. An additional analysis of Forget items revealed that recognition performance did not reliably differ from chance (i.e., 50% accuracy), $t(41) = .924$, $p > 0.05$. These results support the predicted DF effect,

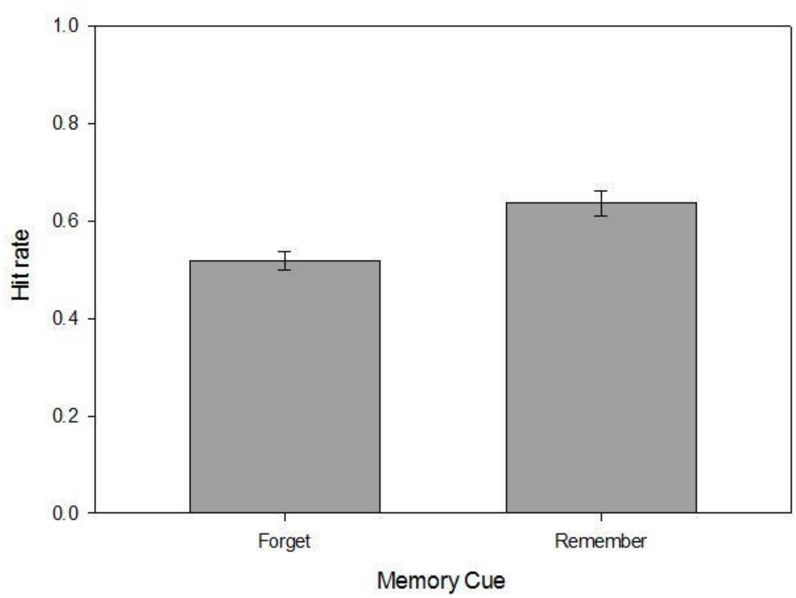

Figure 6. Recognition accuracy (hits for target items) in Experiment 1A.

and replicate prior work that has shown that items associated with Forget cues are typically recognized at lower rates than items associated with Remember cues (see Figure 6). Further, these results provide a novel contribution in that the DF effect established in the current experiments used image stimuli, which have previously produced very weak DF effects (possibly due to the picture superiority effect; see Quinlan, Fawcett, & Taylor, 2010).

An additional analysis was conducted on recognition accuracy for foils. To determine whether participants falsely recognized matched foils of target items more often than unmatched foils, false alarms to semantically matched foils were assessed by a paired samples *t*-test between the two types of foils (i.e., matched foils and unrelated foils). It was predicted that if participants retain a memory trace for intentionally forgotten items, they would exhibit higher false alarm rates for semantically matched foils during recognition, relative to novel foils. Results revealed a significant difference in false alarms between foil types, with false alarm rates for matched foils significanty higher (M = .58, SE = .02) than false alarm rates for unrelated foils (M = .19, SE = .03), $t(41) = 8.84$, $p < 0.01$, $\eta^2 = 0.66$. To compare false alarm rates across foils associated with memory instructions, a 3 (Foil Type: Forget foil, remember foil, novel foil) factor RM ANOVA was conducted. False alarm rates for foils of TBF (M = .40, SE = .03) and TBR (M = .45, SE = .02) items were both significantly higher than false alarms for novel, unrelated items (M = .19, SE = .03). However, false alarm rates for TBF and TBR foils did not reliably differ from each other, $F(2, 82) = 29.12$, $p < 0.01$, $\eta^2 = 0.42$; see Figure 7. As predicted, this difference suggests that the item representation of Forget items is only partially degraded but not nonexistent. Further, the fact that participants exhibited more false alarms for TBF items, relative to novel foils, implies that participants have some memory trace available during retrieval, but this memory trace does not contain enough diagnostic identity information to correctly identify a

TBF item. The fact that false alarm rates for TBF and TBR items were not reliably different further suggests that attentional inhibition may not be the most viable underlying mechanism to explain DF effects; a more detailed discussion of potential alternative explanations can be found in the General Discussion.

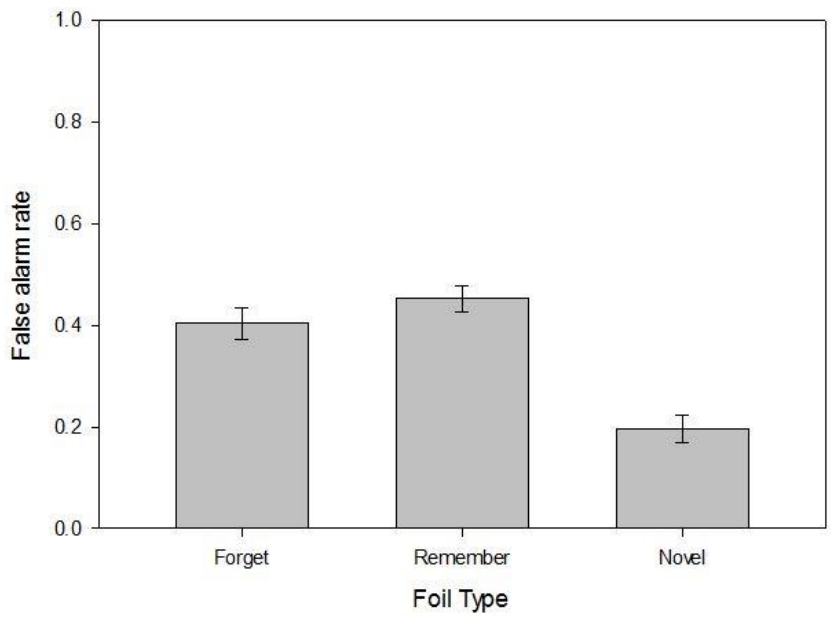

Figure 7. False alarm rates by whether the item was the foil of a TBR target, TBF target, or an unrelated foil.

To determine whether recognition accuracy differed on the basis of the order in which participants were shown a semantically matched foil and target item during test, separate 2 (Memory Cue) x 2 (Test Order: Target tested first, foil tested first) RM ANOVA were conducted on participants recognition decision accuracy (defined as hits for studied items and false alarms to semantically matched foils). To extend the results of the first analysis, only novel contributions are discussed. For target items, an effect of Test Order was observed, with overall recognition accuracy higher when the target item was presented first during the memory test (*M* = .64, *SE* = .02) relative to when the matched foil was presented first during the memory test (*M*

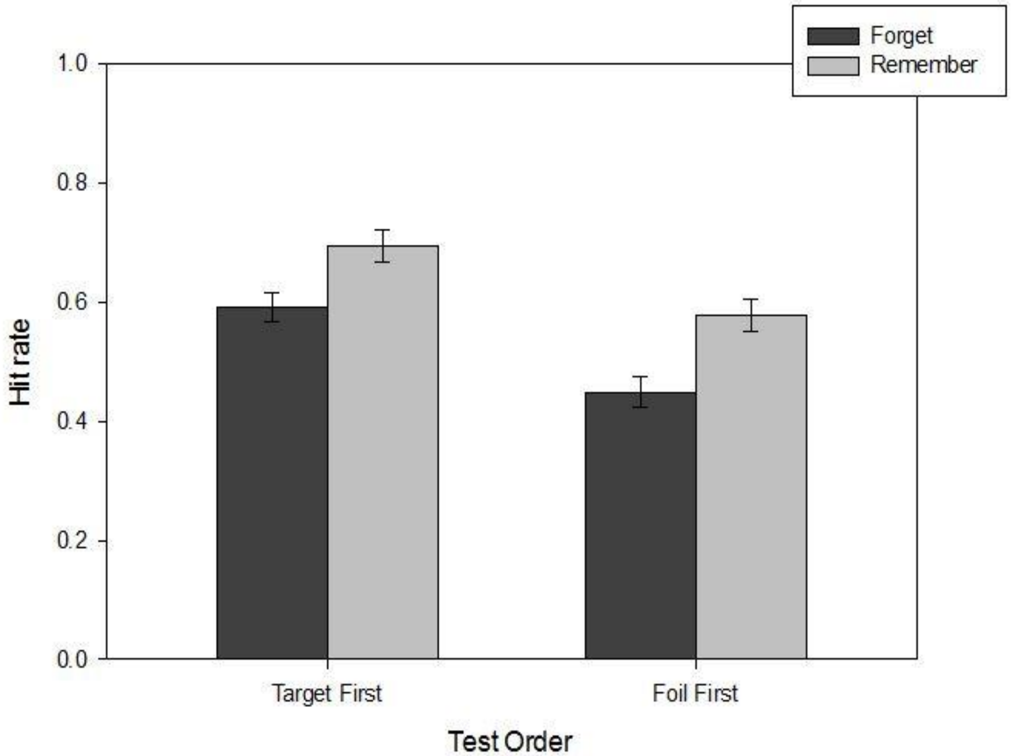

Figure 8. Hit rate for target items by Memory Cue and Test Order.

= .51, *SE* = .01), $F(1, 41) = 41.094$, $p < 0.01$, $\eta^2 = 0.50$; see Figure 8. The interaction between Memory Cue and Test Order was not statistically reliable, $F(1, 41) = .677$, $p > 0.05$, $\eta^2 = .016$. For foils, the effects of Memory Cue and Test Order were marginal, $F(1, 41) = 3.617$, $p = .064$, $\eta^2 = .077$, and $F(1, 41) = 3.818$, $p = .058$, $\eta^2 = .085$, respectively. Although marginal, there was a trend toward lower false alarm rates for TBF foils (*M* = .403, *SE* = .03), relative to TBR foils (*M* = .443, *SE* = .02), and a trend for higher false alarm rates when the matched foil was presented first during test (*M* = .45, *SE* = .02), relative to when the target was presented first during test (*M* = .40, *SE* = .03). A significant interaction was observed, with false alarm rates highest when TBR foils were tested before their matched targets (*M* = .501, *SE* = .03) and lowest when TBR foils were tested after their matched targets (*M* = .384, *SE* = .03), $F(1, 41) = 8.451$, $p < 0.01$, $\eta^2 = .172$; see Figure 9. This pattern of results suggests that while the memory trace for Remember items may be overall stronger, some memory trace is still available for items that participants are instructed to forget, given the fact that comparable false alarm rates were observed for both TBR and TBF foils.

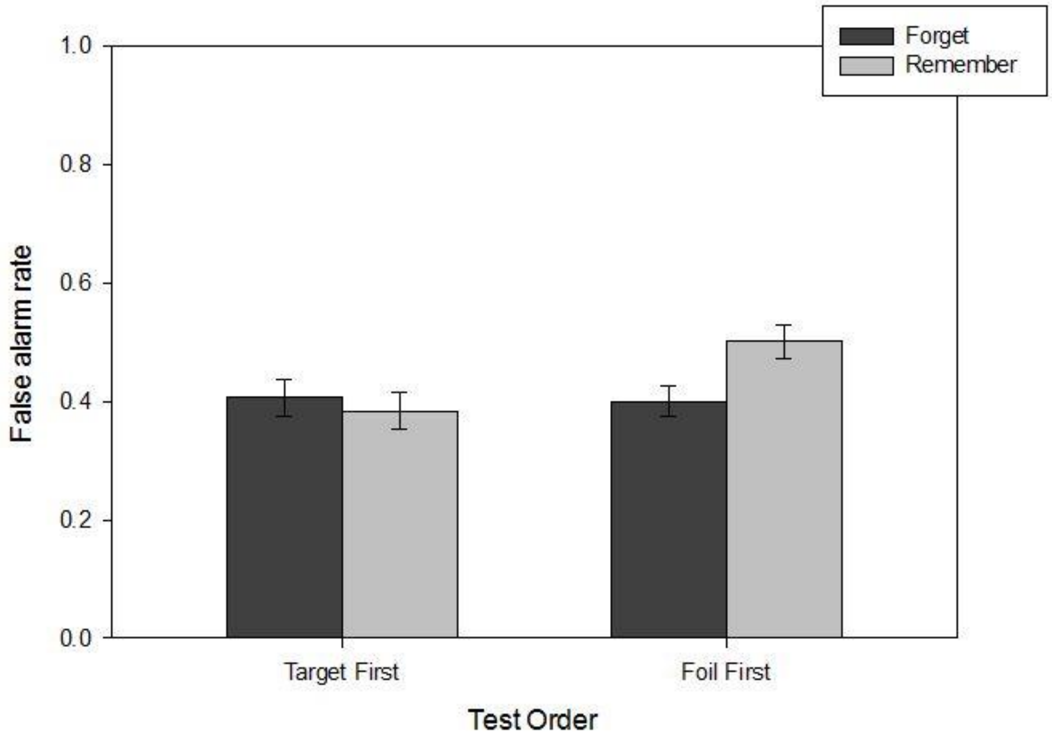

Figure 9. False alarm rate for foils by Memory Cue and Test Order.

Participants' source monitoring decisions for target items were also examined using a 2 (Memory Cue) x 2 (Recognition Decision: Correct, incorrect) RM ANOVA. Results revealed an effect of Memory Cue, such that source information (the Memory Cue from the study phase) was accurately identified more often for items associated with Forget cues (M = .71, SE = .03) than for items associated with Remember cues (M = .48, SE = .02), $F(1, 41) = 38.43$, $p < 0.01$, $\eta^2 = 0.48$. There was also an effect of Recognition Decision, with source information correctly identified more often for targets that were correctly identified as old (M = .66, SE = .02) than targets that were incorrectly identified (M = .54, SE = .01), $F(1, 41) = 28.44$, $p < 0.01$, $\eta^2 = 0.41$. There was also a significant interaction between Memory Cue and Recognition Decision, demonstrating that forgotten targets associated with Forget instructions had the highest source accuracy (*M* = .83, *SE* = .03), while forgotten targets associated with Remember instructions had the lowest source accuracy (*M* = .23, *SE* = .04), $F(1, 41) = 93.70$, $p < 0.01$, $\eta^2 = 0.70$; see Figure 10. Although the main effects of Memory Cue was predicted, this interaction may provide insight into source decisions are made during a DF task. This pattern of results suggests that if participants fail to correctly identify a target item, they may be making their decisions on the

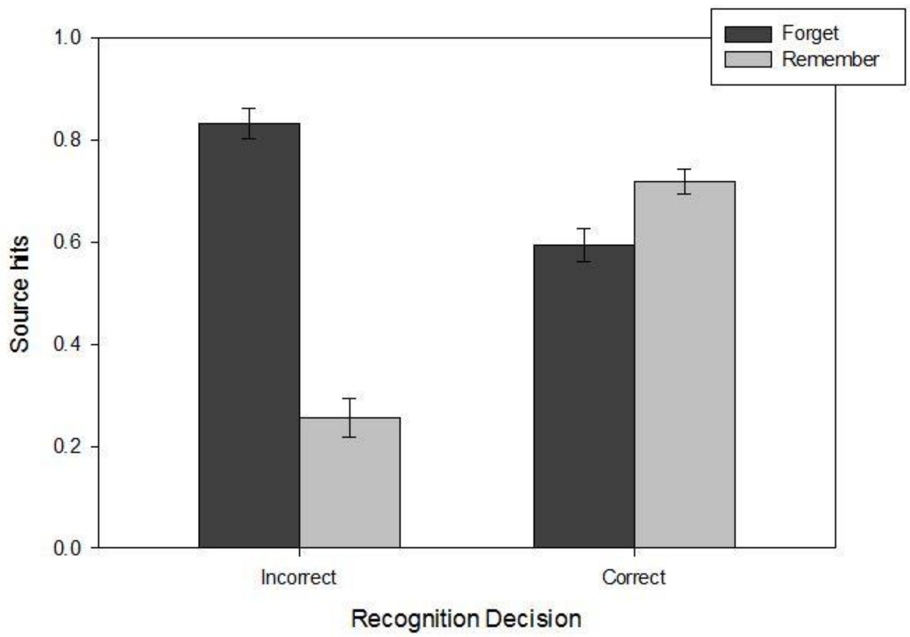

Figure 10. Source identification accuracy (hits for targets) in Experiment 1A.

basis of familiarity. If an item feels at all familiar, it is possible that participants will be more inclined to select “forget” as the associated memory instruction because they are unable to retrieve strong evidence that the tested item was indeed presented at study. The fact that source accuracy was lowest for a TBR target that was incorrectly identified suggests that if a Remember target is *unintentionally* forgotten, the source information associated with that memory trace may also be forgotten, leading participants to attribute the weak or nonexistent memory trace to Forget instructions during the study phase of the experiment and an incorrect source decision.

However, the fact that source information was more accurate for target items when they were associated with Forget cues does not support my predictions, nor does it support previous work suggesting that Forget items are associated with less accurate source information (e.g., MacLeod, 1975; Goernert et al., 2006).

A similar analysis was conducted on participants' source accuracy for semantically matched foils to determine whether a correct recognition decision impacted participants' source decisions. A 2 (Memory Cue) x 2 (Recognition Decision) RM ANOVA was conducted on source accuracy for matched foils (defined as whether the memory instruction chosen matched the instruction associated with the target). The same pattern of results as target source accuracy was found, with participants more accurate at identifying the source TBF foils (M = .71, SE = .03), relative to the source of TBR foils (M = .48, SE = .03), $F(1, 41) = 28.16$, $p < 0.01$, $\eta^2 = .41$.

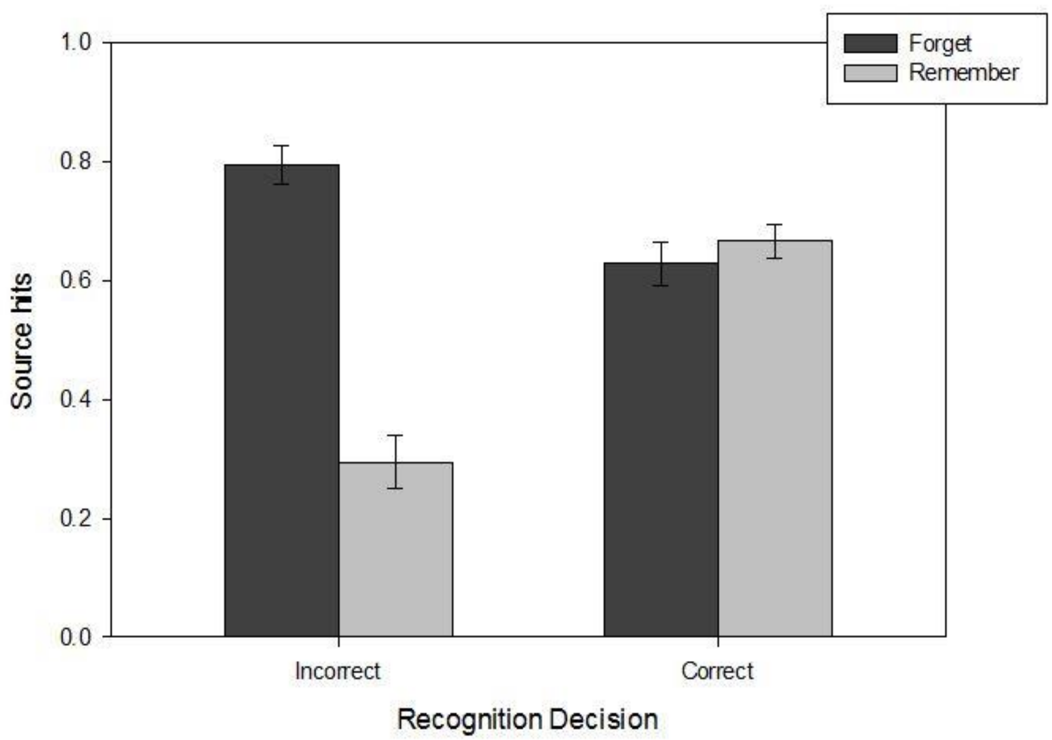

Figure 11. Source accuracy (defined as matching source identifications for foils).

Overall, participants were more accurate when the foil was correctly identified (*M* = .65, *SE* = .03) than when the foil was incorrectly identified (*M* = .54, *SE* = .02), $F(1, 41) = 13.18$, $p < 0.05$, $\eta^2 = .24$. A significant interaction was also observed, with participants exhibiting the highest source accuracy for TBF foils that were incorrectly identified (*M* = .79, *SE* = .03) and lowest accuracy for TBR foils that were incorrectly identified (*M* = .29, *SE* = .05), $F(1, 41) = 54.53$, $p < 0.01$, $\eta^2 = .57$; see Figure 11.

Finally, signal detection indices of sensitivity (*d'*) and bias (*c*) were computed for each participant based on their behavioral response (i.e., hits and false alarms) during the recognition test. Separate paired sample *t* tests were conducted on sensitivity and bias, comparing both indices on the basis of whether items were associated with Remember cues or Forget cues. Analyses revealed no reliable difference in sensitivity across TBR and TBF targets and foils, $t(24) = -1.183$, $p > 0.05$, with participants exhibiting comparable albeit low sensitivity for TBR items (*M* = .58, *SE* = .10) and TBF items (*M* = .80, *SE* = .15). However, participants' exhibited a more conservative bias for TBF items (*M* = .17, *SE* = .04), relative to TBR items (*M* = -.08, *SE* = .08), $t(24) = 2.562$, $p < 0.05$, Cohen's $d = -0.242$; see Figure 12. This finding is consistent with

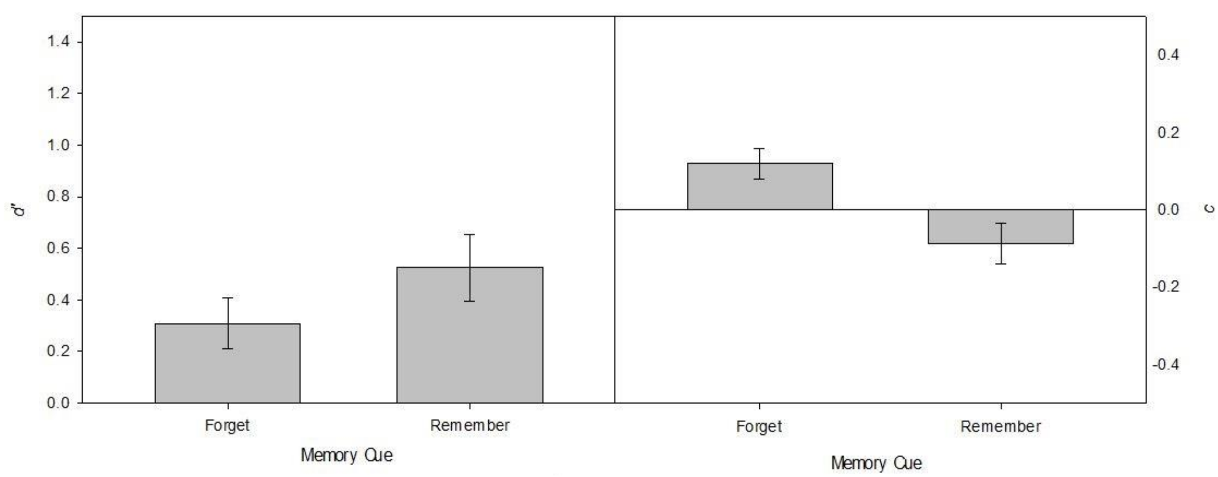

Figure 12. Signal detection indices of d' and c for recognition memory performance.

the DF effects described above; participants exhibited conservative biases for TBF items, showing that they were less likely indicate that images associated with Forget cues were previously studied.

Experiment 1B: Perceptual Identification. Because Experiment 1B included an implicit memory test (perceptual identification), participants' response times in making identifications of studied items and semantically matched foils were analyzed by a 2 (Memory Cue) x 2 (Item Type: Target, foil) RM ANOVA. I predicted that participants should exhibit a main effect of Memory Cue, such that participants should make faster identifications of items associated with Remember instructions, relative to items associated with Forget instructions. However, no effect of Memory Cue was observed; while response times for items associated with Remember cues were numerically smaller (*M* = 2810 ms, *SE* = 127 ms), there was no reliable difference between Remember items and Forget items (*M* = 2851 ms, *SE* = 122 ms), *F*(1, 41) = .330., $p > 0.05$, $\eta^2 = .005$. There was also no effect of Item Type, with no reliable

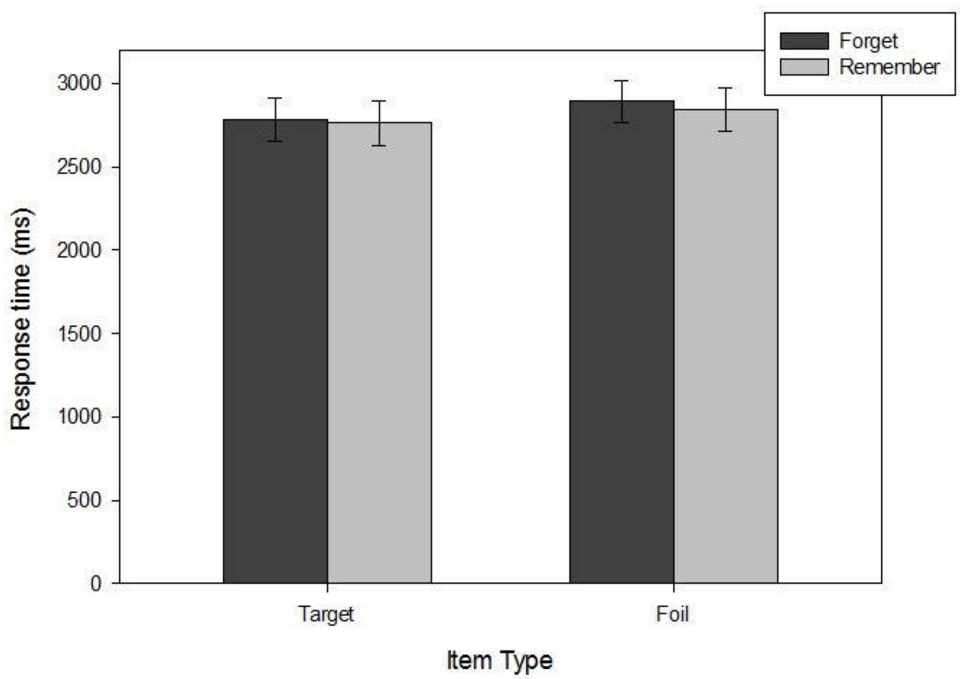

Figure 13. Perceptual identification response times (ms).

difference in response times between target images (*M* = 2785 ms, *SE* = 128 ms) and foil images (*M* = 2876 ms, *SE* = 120 ms), *F*(1, 41) = .330, $p > 0.05$, $\eta^2 = .046$; see Figure 13. If participants are slower to identify items that were associated with Forget cues, relative to their matched foils, this would suggest that active inhibition of item information occurs during encoding. However, the interaction between Memory Cue and Item Type also failed to reach significance, *F*(1, 41) = 1.776, $p > 0.05$, $\eta^2 = .004$. Participants response times for identification of target items associated with Forget cues (*M* = 2802 ms, *SE* = 131 ms) did not reliably differ from response times for identification of matched foils (*M* = 2900 ms, *SE* = 125 ms). Additionally, response times for targets associated with Remember cues (*M* = 2768 ms, *SE* = 136 ms) did not reliably differ from response times for identification of matched foils (*M* = 2852 ms, *SE* = 131 ms). Although I predicted that participants would respond slower to identify images associated with Forget cues, this effect was not observed. The fact that response times to identify target stimuli, regardless of the Memory Cue associated, were numerically smaller than response times to identify semantically matched foils might suggest that the memorability of picture stimuli resulted in faster target identifications, although the difference was not statistically reliable.

An additional 2 (Memory Cue) x 2 (Item Type) RM ANOVA was conducted on accuracy of perceptual identifications to determine whether participants were more accurate in identifying previously studied versus semantically matched novel items (defined as correct identifications for targets and foils). Again, there was no effect of Memory Cue, with no reliable difference between accuracy for items associated with Remember instructions (*M* = .50, *SE* = .02) and items associated with Forget instructions (*M* = .52, *SE* = .02), *F*(1, 41) = 1.663, $p > 0.05$, $\eta^2 = .046$, and no reliable difference based on Item Type. Comparable accuracy for targets (*M* = .52, *SE* = .02) and foils (*M* = .49, *SE* = .02) was observed, *F*(1, 41) = 2.118, $p > 0.05$, $\eta^2 = .038$. In addition, there was no reliable interaction, $F(1, 41) = .775$, $p > 0.05$, $\eta^2 = .016$; see Figure 14. Although the results of Experiment 1A suggested that Forget cues result in inhibition of item identity information that is clearly reflected in a task relying on explicit memory processes (e.g.,

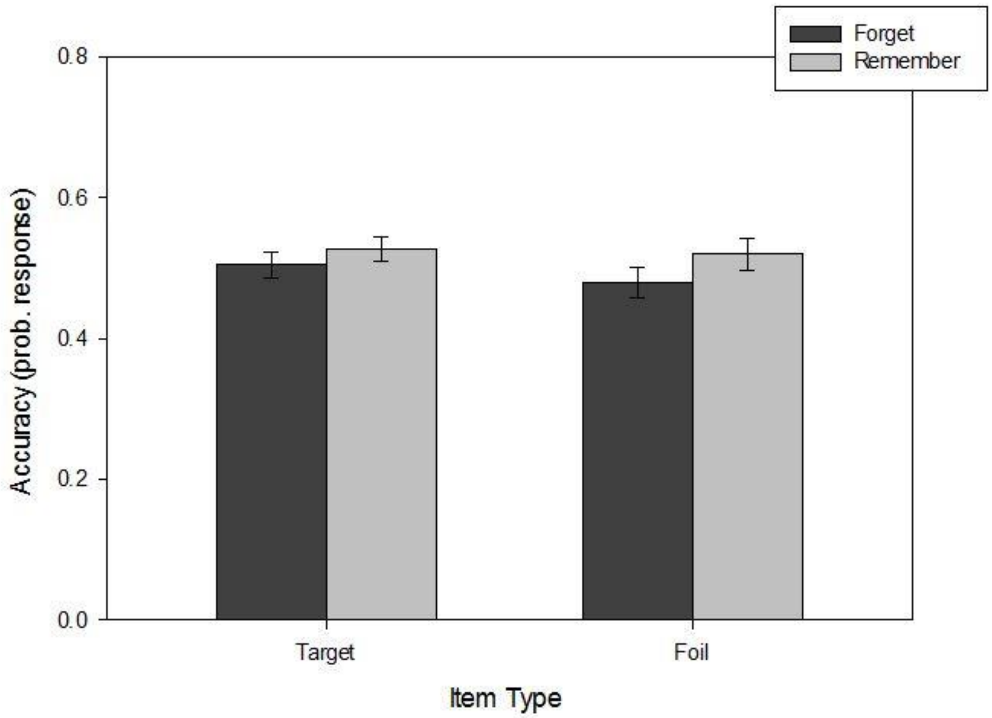

Figure 14. Perceptual identification accuracy in Experiment 1B.

recognition), these results suggest that no such effect is observable in a task relying on implicit memory processes (e.g., perceptual identification).

Finally, a 5 factor (Identification Type: Novel, forget target, remember target, forget foil, remember foil) RM ANOVA was conducted on identification accuracy to determine whether items associated with memory instructions differed from novel items. A main effect of Identification Type was observed, $F(4, 38) = 3.219$, $p < 0.05$, $\eta^2 =.07$. Pairwise comparisons revealed that novel items were identified with significantly higher accuracy ($M = .55$, $SE = .01$) than foil images associated with forget cues ($M = .48$, $SE = .02$), $p < .01$. While not reliable, novel items were also identified with higher accuracy than targets associated with forget cues (M

= .50, *SE* = .01), $p = 0.08$; see Figure 15. No other pairwise comparisons of identification accuracy were reliable, $p > 0.05$. A similar 5 factor (Identification Type) RM ANOVA was conducted on identification response times but revealed no significant differences, $F(4, 38) =$

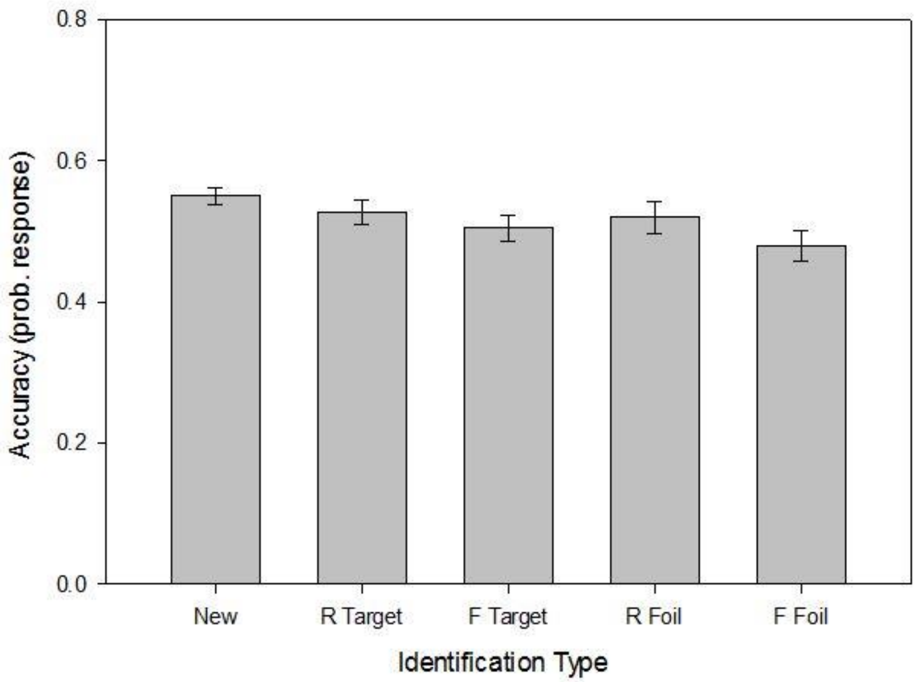

Figure 15. Perceptual identification accuracy.

.629, $p > 0.05$, $\eta^2 = .014$. Although it was predicted that TBF images would be associated with slower response times, this was not observed. However, the pattern of results demonstrating that images associated with Forget cues were identified with lower accuracy than novel images provides additional support for the hypothesis that item identity information is suppressed following instructions to forget.

Discussion

Experiment 1A demonstrated that while the letter probe task did not reflect IOR differences indicative of effortful processing, Forget cues did result in lower recognition accuracy and lower source accuracy for target items. These data suggest that while the letter probe task may not have been an accurate reflection of participants' effortful cognitive processes, intentional forgetting may involve inhibition of item identity information and can be observed using image stimuli. A similar effect was observed for matched foils, with higher false alarm rates for matched foils, relative to unrelated foils. Importantly, false alarm rates for matched foils were particularly high when the foils were tested before the matched target. Taken together, these results suggest that the memory trace for Forget items may be degraded, but not absent.

This conclusion is further supported by the results of Experiment 1B, given that target items, regardless of the memory instruction they were associated with, were identified faster than novel items. However, given the nature of the perceptual identification task, it is also possible that the results demonstrated support an alternative hypothesis. Based on evidence in retrieval-induced forgetting paradigms using implicit memory tests (Perfect, Moulin, Conway, & Perry, 2002), these DF effects may instead be indicative of retrieval inhibition, discussed in greater detail in the General Discussion.

Unlike Experiment 1, many investigations of intentional forgetting have included spatial components for target presentations, which has greatly contributed to the identification of IOR effects associated with Forget cues. While Experiments 1A and 1B suggest that item *identity* may be suppressed when the item is associated with instructions to Forget, these experiments do not speak to inhibition of spatial location and spatial identity information. No IOR effects were observed in Experiments 1A or 1B. Based on the fact that target items were presented at center, potentially equating exogenous attentional withdrawal despite the fact that there was no abrupt onset to re-orient attention later in the trial, it is possible that the central presentation prevented IOR effects from being observed. To build on the results of Experiment 1, an additional experiment was conducted to examine whether attention is inhibited for the spatial location in which an item was presented, or whether attention is inhibited for item identity information only.

CHAPTER 4. EXPERIMENT 2

Experiment 2 investigated attentional inhibition in conjunction with spatial information. Similar to Experiment 1, participants' subsequent memory for source information was also examined. In this experiment, source information referred to the target item location. Previous work examining source decisions in intentional forgetting has shown that source memory is better for R items than for F items (e.g., MacLeod, 1975). Recent work has demonstrated that participants may use the strength of a memory trace to identify whether an item was previously associated with an R or F cue (Goernert, Widner, & Otani, 2006, 2007), with strongly retrieved items classified as R items, and weak items as F items. The present experiment explored whether exogenous attentional withdrawal also inhibits other source information (e.g., spatial location).

Participants completed a modified item-method DF task with several key manipulations. Target items associated with remember or forget cues were presented either to the left or right of a central fixation. Like Experiment 1, participants were also shown subliminal items, one of which was the target of the trial, to orient attention to a particular side of the screen. Participants' responses to speeded probes allowed an assessment of the inhibition of spatial location and of object identity information to determine if exogenous attentional withdrawal occurs for source information (see Taylor & Fawcett, 2011). The goal of this experiment was to extend Experiment 1 by investigating whether the exogenous attentional withdrawal following forget instructions is associated with spatial location, item identity information, or both types of information.

Method

Participants. Based on an a repeated measures a priori power analysis of Taylor and Fawcett (2011), who demonstrated that DF tasks are associated with exogenous attentional withdrawal, approximately 35 participants were needed for the current experiment. This estimate was based on $\eta_p^2 = 0.03$ and an approximate Cohen's f effect size of 0.18 for the IOR effects documented by Taylor and Fawcett when stimuli were presented to the left or right of central fixation, with 80% power and alpha held at 0.05. G*Power was again used to conduct the analysis, with no between-subjects factors, and the number of memory cue repetitions used to elicit IOR effects held at 25 (Faul et al., 2007). Forty-five participants ($M_{age} = 19$; 17 female) from Arizona State University who did not participate in Experiment 1 participated in exchange for partial course credit. All participants self-reported normal or corrected-to-normal vision and were native English speakers. Participants engaged in individual sessions lasting approximately 60 minutes. Data from one participant were not analyzed due to failure to follow experimental instructions.

Stimuli. The same 288 objects from Experiment 1 were used in Experiment 2, with 96 appearing as targets during the study phase, 96 appearing as novel distractors (including 48 semantically matched foils and 48 novel images), and the remaining 96 paired randomly with a target for subliminal presentation. All images appeared in grayscale and were sized 250 x 250 pixels.

Design. A 2 (Memory Cue: Remember, forget) x 2 (Target Location: Left, right) x 2 (Subliminal Location: Congruent, incongruent) x 2 (Probe Location: Congruent with subliminal target, incongruent with subliminal target) completely within-subjects design was used for the current experiment. The dependent variables that were examined included participants' response times to probes during study trials and behavioral performance on the subsequent memory test.

Procedure. Before beginning the experiment, participants were familiarized with the memory instructions used throughout using the same procedure as described in Experiment 1. The first phase of Experiment 2 was identical to the procedure of Experiment 1 with the following exception: Instead of target items appearing centrally, targets appeared on either the left- or right-hand side of central fixation, subtending approximately 7.5 degrees of visual angle. Following the offset of the target item, participants viewed only central fixation for 500 ms to allow them sufficient time to return their eyes to the center of the screen. All other elements of the experiment were identical to Experiment 1. Because target items were presented to the left or right of central fixation, the subliminal presentation of target objects could appear either on the same side (congruent) or the opposite side (incongruent). The probe also appeared either on the same side as the subliminal target object (congruent) or the opposite (incongruent; see Figure 16 for examples). The manipulation of target location, subliminal target location, and probe location allowed for several types of trials depending on whether the subliminal target and probe were congruent with the original target presentation, or incongruent with the target presentation.

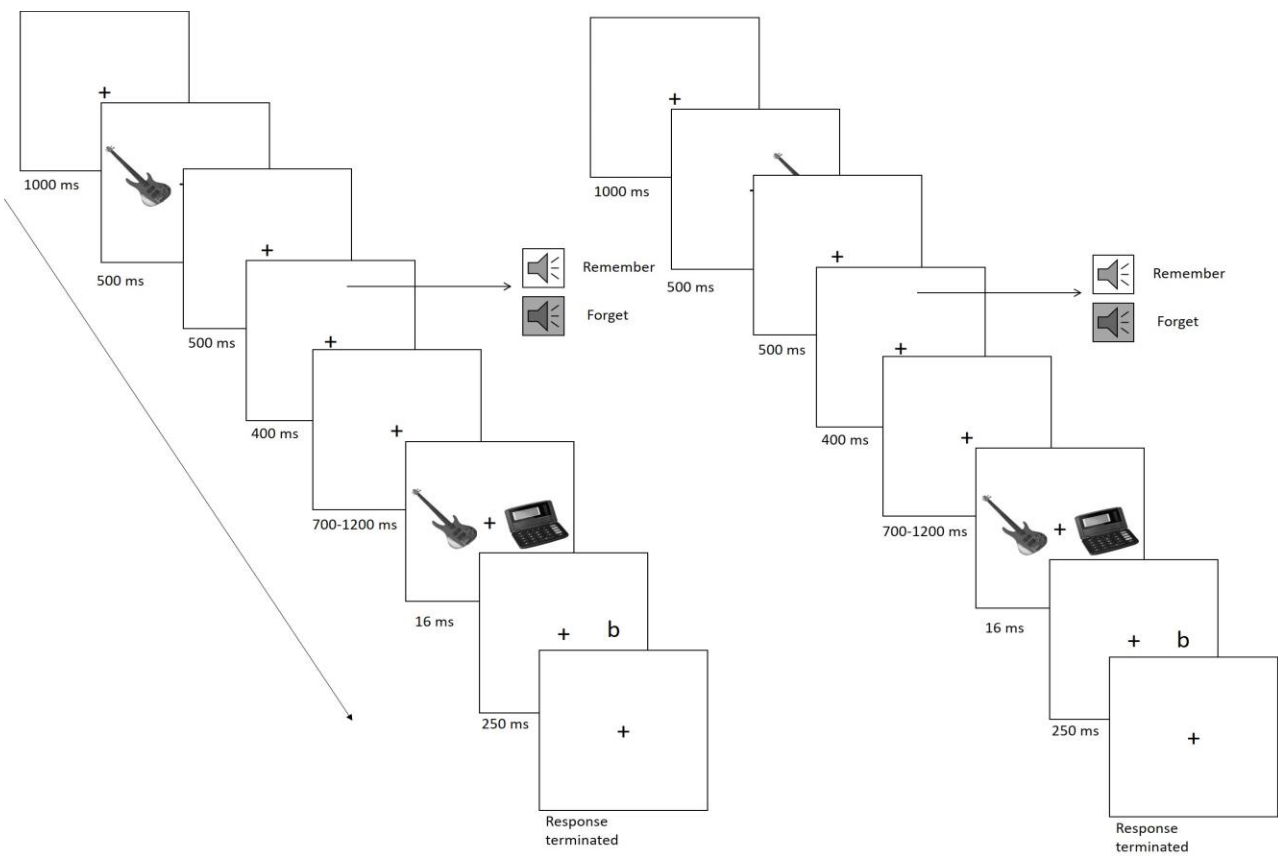

Figure 16. Trial schematics of Experiment 2.

The second and final phase of the experiment was identical to the procedure for Experiment 1A with the exception of source decisions, described below. Participants completed a recognition and source monitoring test, and tested items included images participants were cued to forget, images participants were cued to remember, and novel distractors. Like Experiment 1A, the use of matched foils allowed for an examination of whether participants made more false alarms to foils of TBF items, relative to TBR items. After indicating whether an item was old (previously studied) or novel, participants made source decisions about all items during which they indicated if items were studied on the left- or right-hand side of the screen. Source monitoring decisions were included to assess the impact of exogenous attentional withdrawal on spatial information, particularly based on evidence that source memory for R items is better than source memory for F items (e.g., MacLeod, 1975). If the exogenous attentional withdrawal following forget instructions differentially impacts spatial information, it was predicted that there would be observable differences in available source information.

Results

Analyses were conducted in a similar manner to Experiment 1 unless stated otherwise. Outlier trials were filtered the same way as in Experiment 1, which resulted in a total of 1.8% of trials being dropped (273 trials out of 4,418 total), and 3.1% of trials replaced with cutoff values (473 trials out of 4,418 total). Only correct probe responses were analyzed. This resulted in a total of 10% of trials being dropped across all participants in Experiment 2. Two participants were dropped from analysis for having greater than 20% error rates during probe trials; data below are reported from the remaining 42 participants.

Probe Response. To assess whether participants were slower to respond following instructions to forget, and whether the location of the subliminally presented target impacted attentional engagement, response times to correct letter probe decisions were examined by a 2 (Memory Cue: Remember, forget) x 2 (Subliminal Location: Congruent with target, incongruent with target) x 2 (Probe Location: Congruent with target, incongruent with target) repeated measures (RM) ANOVA. Based on the body of work that has found slower response times following Forget instructions (e.g., Fawcett & Taylor, 2008, 2010), I hypothesized that participants would exhibit a main effect of Memory Cue, with faster response times following R cues, relative to F cues. This effect was not observed, as there was no reliable difference between probe response times for images that were associated with Remember cues (*M* = 461 ms, *SE* = 14 ms; see Figure 17) and images that were associated with Forget cues (*M* = 457 ms, *SE* = 13 ms; see Figure 18), $F(1, 41) = .388$, $p > 0.05$, $\eta^2 = .009$.

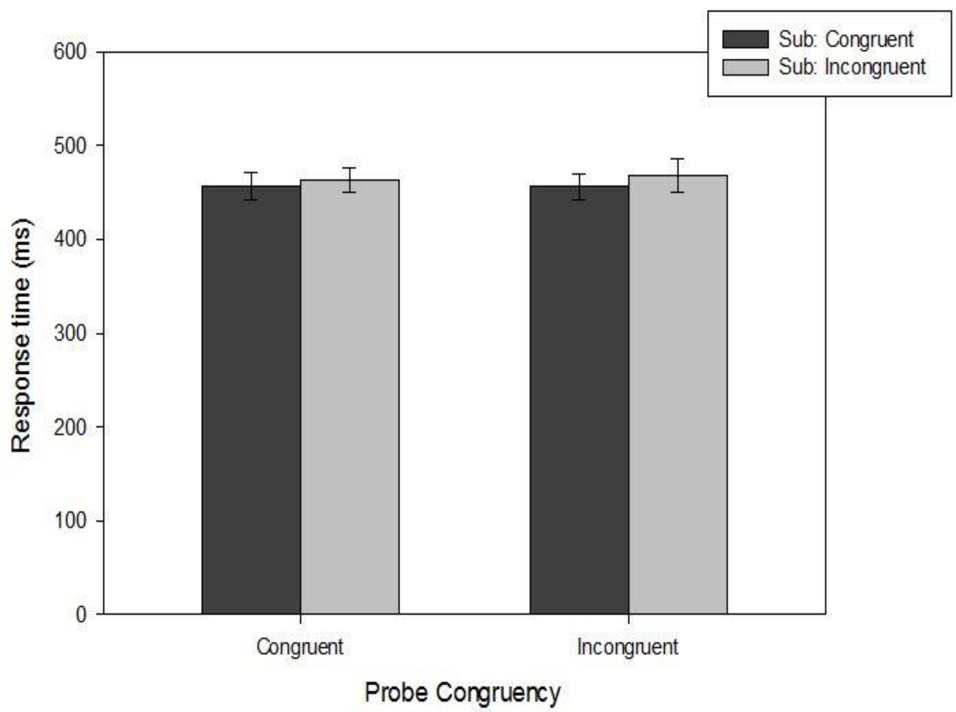

Figure 17. Probe response times (ms) in Experiment 2 following Remember cues.

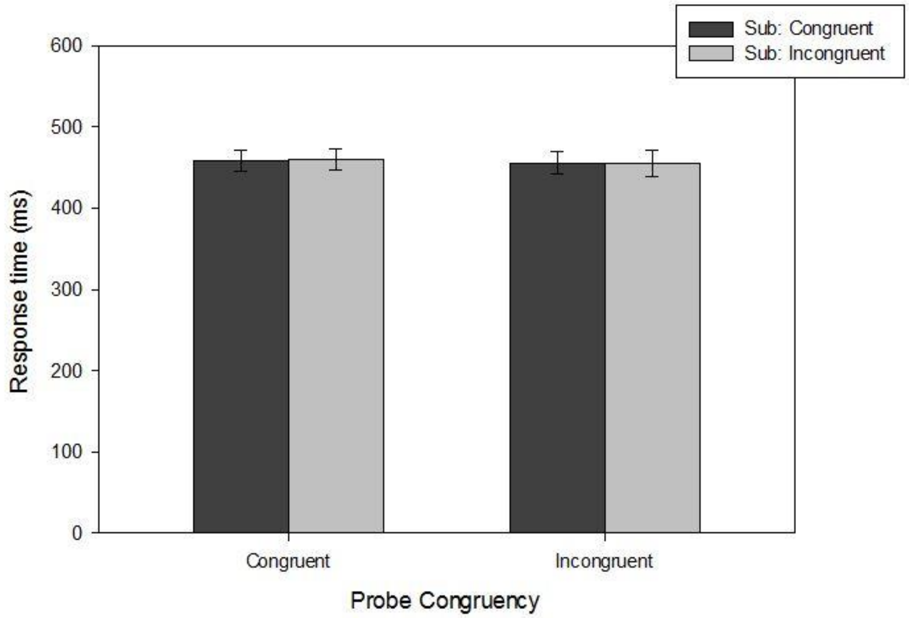

Figure 18. Probe response times (ms) in Experiment 2 following Forget cues.

The predicted effects of the subliminal target location and probe location were unclear based on previous work; however, I predicted an interaction between Subliminal Location and Probe Location, such that when incongruent subliminally presented targets were paired with probes that were congruent with target items, response times would be faster. If, on the other hand, participants engaged in attentional suppression for the spatial location of objects, a main effect of Subliminal Location, Probe Location, and an interaction between them were predicted. If spatial location is inhibited during DF tasks, participants should be slowest to respond to a subliminal target-probe pair that are both congruent with the location of the target object (i.e., all presentations appear on the same side of the screen), and fastest to respond to a congruent subliminal object paired with an incongruent probe (e.g., a target presented on the left and a probe presented on the right. Results revealed no effect of Subliminal Location, with response times failing to reliably differ when subliminal targets were congruent with target presentations (*M* = 457 ms, *SE* = 13 ms) relative to when the subliminal target was incongruent with target presentations (*M* = 462 ms, *SE* = 14 ms), *F*(1, 41) = 1.512, $p > 0.05$, η^2 =.034. Similarly, there was no effect of Probe Location, with response times to probes that appeared congruently with subliminal targets (*M* = 460 ms, *SE* = 13 ms) not reliably different from response times to probes that appeared incongruently with subliminal targets (*M* = 459 ms, *SE* = 14), *F*(1, 41) = .060, $p > 0.05$, η^2 = .001. Interactions between Memory Cue and Subliminal Location, *F*(1, 41) = 2.101, Memory Cue and Probe Location, *F*(1, 41) = .882, and Subliminal Location and Probe Location, *F*(1, 41) = .022, all failed to reliably differ, $p > 0.056$. The three-way interaction between Memory Cue, Subliminal Location, and Probe Location was also not reliable, *F*(1, 41) = .107, $p > 0.05$, η^2 = .002. Given that there were no significant differences in probe response times across any condition, the prediction that spatial location information would be inhibited, resulting in IOR effects (e.g., Taylor & Fawcett, 2005; Fawcett & Taylor, 2011), was not supported. In addition, the lack of IOR effects fails to replicate previous work that has shown slowing following Forget instructions.

Similar to Experiment 1, an additional analysis was conducted on probe response times to determine whether successful implementation of memory cues was associated with slower probe responses. A 2 (Memory Cue) x 2 (Subsequent Memory: Remembered, forgotten) RM ANOVA was conducted on probe response times. Unlike Experiment 1A, there was no effect of Subsequent Memory, with probe response times for forgotten items (*M* = 416 ms, *SE* = 13 ms) not reliably different from remembered items (*M* = 416 ms, *SE* = 13 ms), *F*(1, 41) = .626, $p > 0.05$, η^2 = .015. The interaction between Memory Cue and Subsequent Memory was also not reliable, *F*(1, 41) = .460, $p > 0.05$, η^2 = .011. Overall, these results fail to support previous research that has shown that when participants engage in intentional forgetting following a Forget cue, response time to speeded probes are slowed.

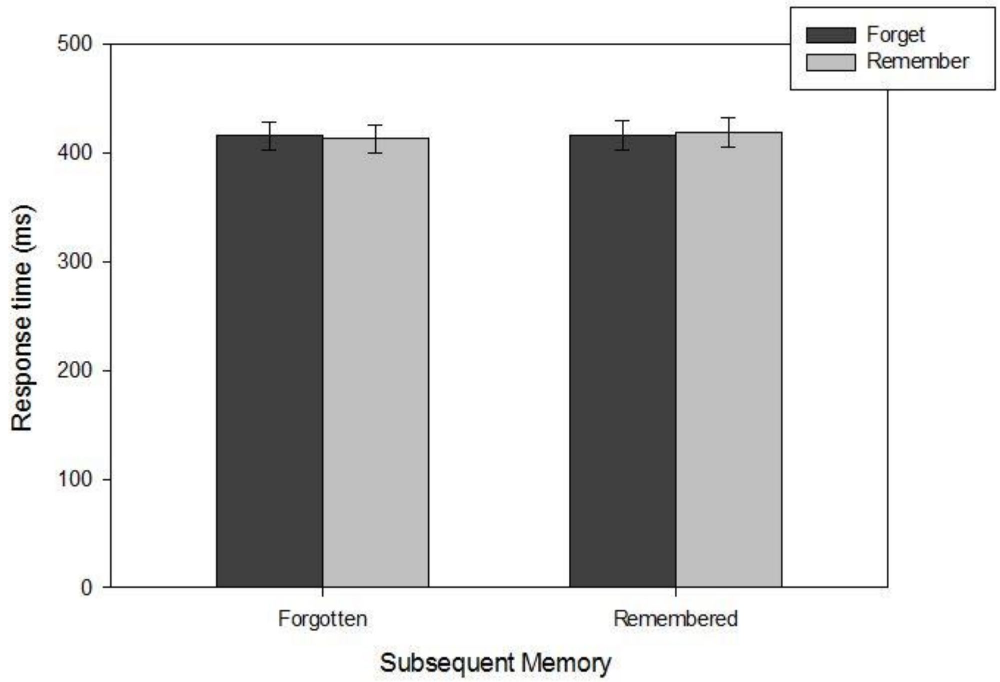

Figure 19. Response times (ms) by subsequent memory.

Recognition Performance. To determine whether participants' subsequent recognition accuracy (defined as hits for studied items) was impacted by memory cues, a 2 (Memory Cue) factor RM ANOVA was conducted comparing recognition accuracy for Forget targets to recognition accuracy for Remember targets. I hypothesized that participants should exhibit a main effect of Memory Cue, with more R items subsequently recognized than F items (i.e., standard DF effects). The analysis revealed a significant difference between Forget targets and Remember targets, with fewer Forget items accurately recognized (M = .56, SE = .03) than Remember items (M = .62, SE = .03), $F(1, 41) = 15.80$, $p < .01$, $\eta^2 = 0.28$; see Figure 20. This replicates previous work and Experiment 1A, showing a DF effect. Unlike Experiment 1A, additional analysis revealed that accuracy for Forget items reliably differed from chance, $t(41) = 2.264$, $p < 0.05$, $\eta^2 = 0.11$.

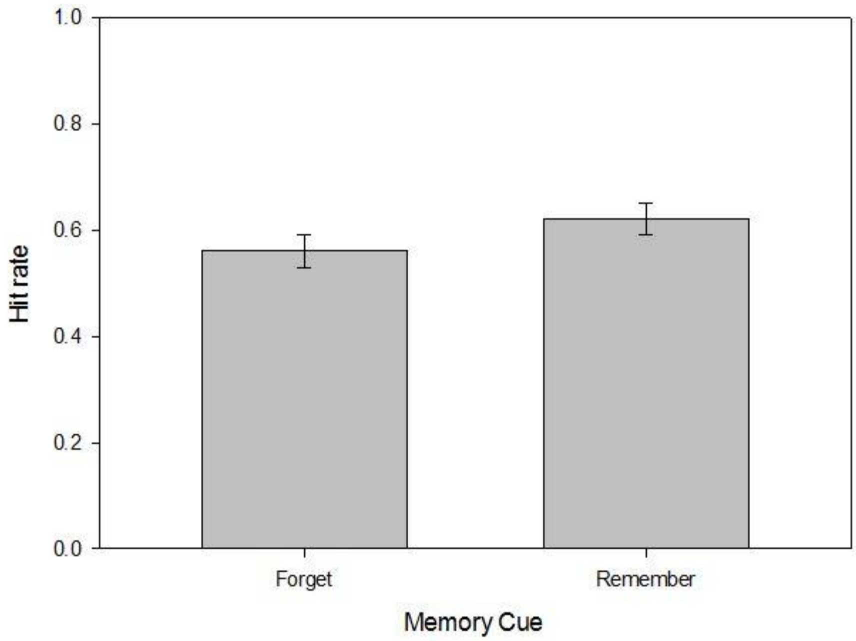

Figure 20. Accuracy (hits for target items) by Memory Cue.

Participants' recognition performance for novel items was also assessed. To determine whether participants falsely recognized matched foils more often than novel foils, false alarm rates were assessed by a paired sample *t*-test between the two foil types. Analysis revealed that false alarm rates for matched foils were indeed higher (M = .43, SE = .02) than false alarm rates for unrelated foils (M = .21, SE = .02), $t(41) = 11.53$, $p < 0.01$, $\eta^2 = 0.76$. An additional 3 (Foil Type: Forget foil, remember foil, novel foil) factor RM ANOVA revealed that false alarms for TBR foils were highest (M = .46, SE = .02), followed by TBF foils (M = .41, SE = .03), and lowest for novel foils (M = .21, SE = .02), $F(1, 41) = 73.36$, $p < 0.01$, $\eta^2 = .65$; see Figure 21. The higher false alarm rates for TBF foils, relative to novel foils, again lends support to the hypothesis that item identity information is degraded, but not nonexistent, for representations of target items participants were cued to forget. The higher false alarm rates for TBR foils, however, does not support this same conclusion, nor does it support the results of Experiment 1.

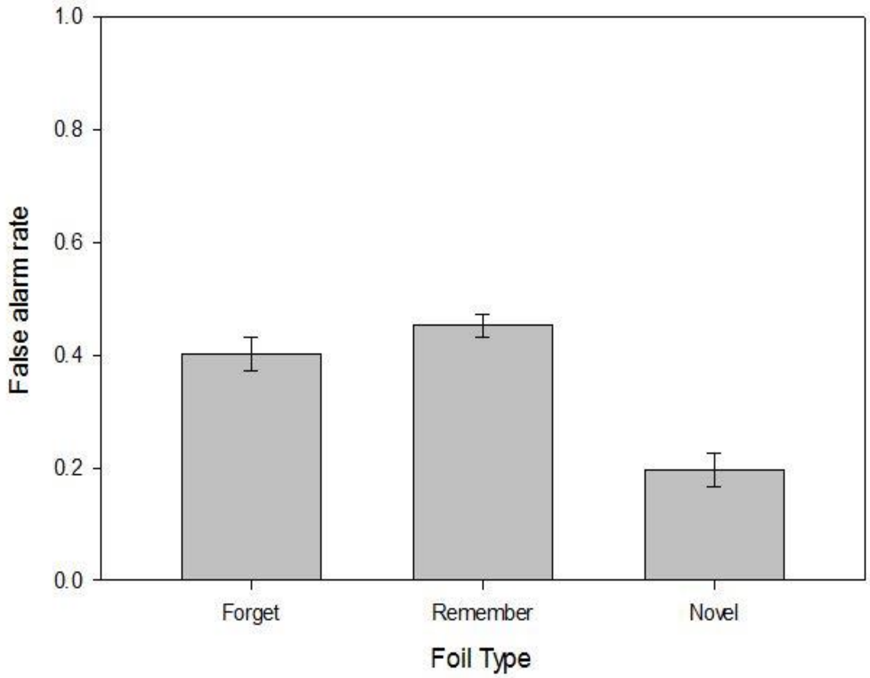

Figure 21. False alarm rates for matched foils of TBF items, TBR items, and novel items.

Next, the order in which participants were shown novel foils versus targets was also examined. If exogenous attentional withdrawal results in a degraded version of a target representation, it is possible that a semantically matched foil of a Forget item would be recognized on the basis of familiarity (Goernert et al., 2006, 2007), resulting in higher false alarm rates for matched foils when they are presented first during test. To determine whether test order impacted recognition performance (defined again as hits for target items and false alarms to novel foil), separate 2 (Memory Cue) x 2 (Test Order: Target tested first, foil tested first) RM ANOVAs were conducted. Like Experiment 1, only novel contributions are discussed. For targets, there was no reliable effect of Test Order, with comparable accuracy overall when targets were presented first during test (M = .61, SE = .03) as when matched foils were presented first (M = .57, SE = .03), $F(1, 41) = 2.912$, $p > 0.05$, $\eta^2 = .065$; see Figure 22. The interaction between Memory Cue and Test Order was also not reliable, $F(1, 41) = .071$, $p > 0.05$, $\eta^2 = .002$. For foils, there was no reliable effect of Memory Cue, with comparable false alarms to foils associated with TBF targets (*M* = .42, *SE* = .02), relative to foils associated with TBR targets (*M* = .44, *SE* = .02), *F*(1, 41) = 1.31, $p > 0.05$, $\eta^2 = .03$. There was no effect of Test Order for foils, with comparable false alarms when targets were tested first (*M* = .43, SE = .03) as when foils were

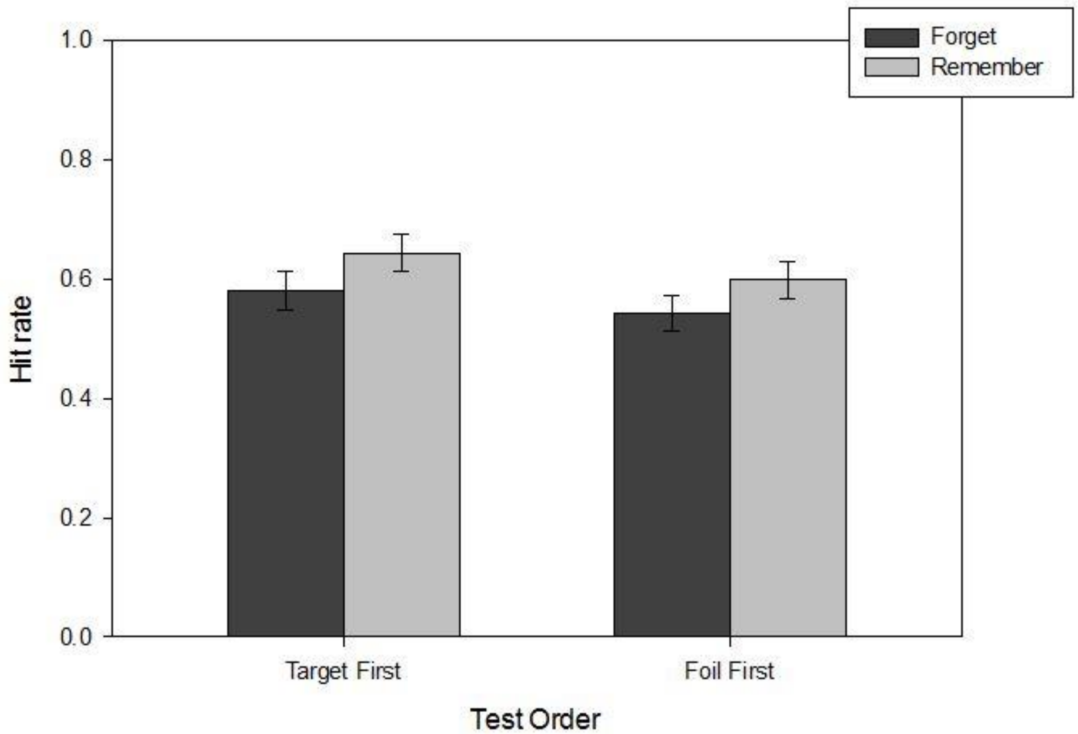

Figure 22. Recognition performance for targets.

tested first (*M* = .43, *SE* = .03), *F*(1, 41) = 0.0, $p > 0.05$, $\eta^2 = .00$. A significant interaction between Memory Cue and Test Order was observed for foils, with participants exhibiting lower false alarm rates for foils of TBF taargets when the foil was tested first (*M* = .383, *SE* = .04), and higher false alarm rates for foils of TBR targets when the foil was tested first (*M* = .48, *SE* = .03), *F*(1, 41) = 12.48, $p < 0.01$, $\eta^2 = .233$; see Figure 23. Overall, this pattern of results does not mirror that of Experiment 1. Although this pattern suggests that the basis of participants'

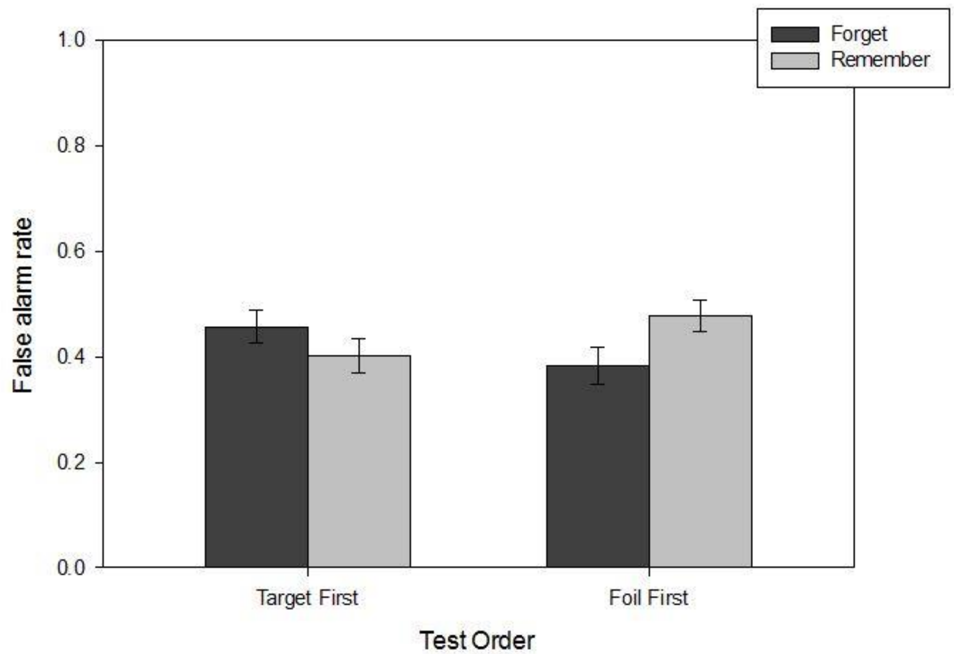

Figure 23. Recognition performance for foils.

recognition decisions may change depending on when target objects are presented and what memory instruction is associated, conclusions about whether Remember items are associated with recollection and Forget items associated with familiarity are not possible based on current manipulations and results.

To determine how DF instructions impacted memory for source material, participants' source monitoring accuracy (defined as correct source identifications for target items, and matching source identifications for matched foils) were also examined using separate 2 (Memory Cue) x 2 (Recognition Decision: Correct, incorrect) RM ANOVAs. In Experiment 2, source material referred to the spatial location in which items were presented during study; I predicted a main effect of Memory Cue for target items, such that source accuracy should be higher following instructions to remember, relative to instructions to forget. No reliable effect of Memory Cue was observed, with source accuracy comparable for Remember items (M = .61, SE = .02), relative to source accuracy for Forget items (M = .60, SE = .02), $F(1, 41) = .054$, $p >$

0.05, $\eta^2 = .00$. An effect of Recognition Decision was observed, such that target items were associated with higher source accuracy if they were correctly recognized ($M = .67$, $SE = .02$) than if they were incorrectly identified ($M = .54$, $SE = .01$), $F(1, 41) = 35.31$, $p < 0.01$, $\eta^2 = 0.46$. There was no reliable interaction between Memory Cue and Recognition Decision, $F(1, 41) = 1.36$, $p > 0.05$, $\eta^2 = .46$. Because Memory Cues did not impact source accuracy, this suggests that spatial information may not be inhibited following Forget instructions (see Figure 24). Again, given brief presentation times, it is possible that 500 ms was not sufficient time to effectively encode source material related to spatial location in the current experiment.

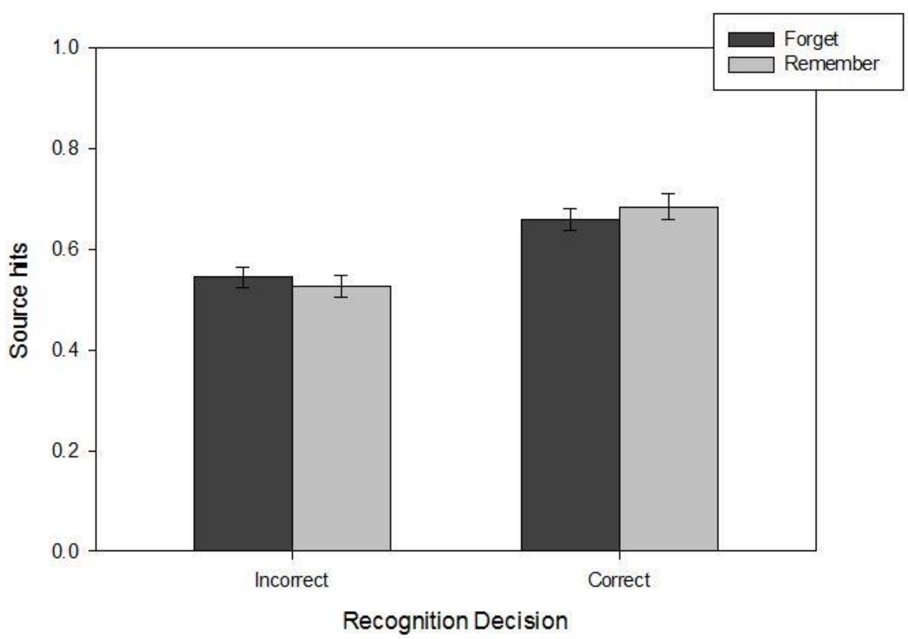

Figure 24. Source accuracy (defined as hits for target items).

For foil items, a main effect of Memory Cue was observed, with TBF foils associated with lower source accuracy ($M = .54$, $SE = .02$) than TBR foils ($M = .58$, $SE = .02$), $F(1, 41) = 4.33$, $p < 0.05$, $\eta^2 = .01$. There was also a reliable difference in source accuracy between correctly identified foils ($M = .50$, $SE = .02$) and incorrectly identified foils ($M = .62$, $SE = .02$), $F(1, 41) = 15.42$, $p < 0.05$, $\eta^2 = .27$. A reliable interaction was also observed, with source accuracy most often matching the targets' location for TBR foils that were incorrectly identified (*M* = .67, *SE* = .03) and lowest for TBR foils that were correctly identified (*M* = .50, *SE* = .02), *F*(1, 41) = 7.264, $p < 0.05$, $\eta^2 = .15$; see Figure 25. Although this pattern of results does not mirror the pattern for targets, it does suggest that source information for Remember targets is the most preserved at retrieval. If participants mistakenly identify matched foils as previously studied (i.e., incorrect recognition decisions), this suggests that the source information associated with targets is preserved, leading to higher source accuracy despite the misrecognition. However, as suggested above, these results might also indicate that participants may have failed to strongly encode Remember items and were making decisions on the basis of familiarity; when a TBR foil was mistakenly identified as previously studied, participants' source decision most often matched that of the target item. This suggests either that participants did not encode Remember targets as strongly as Experiment 1, or that spatial information may be generally weaker contextual information in a DF task.

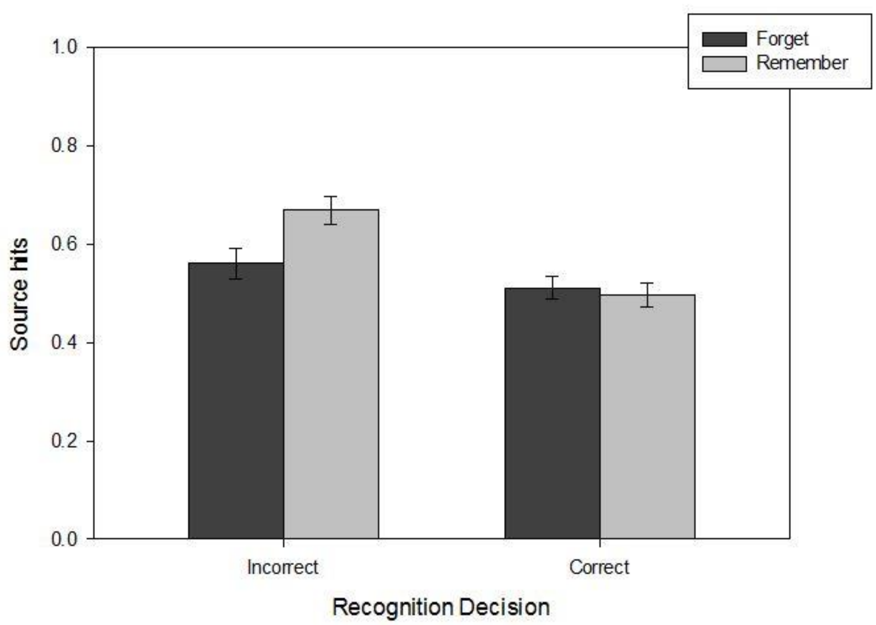

Figure 25. Source accuracy (defined as a matching source identification for foil items).

Signal detection indices (i.e., *d'* and *c*) were again computed for each participant based on behavioral response (hits and false alarms) during the recognition test. Separate paired sample *t* tests were conducted on sensitivity and bias, comparing both indices across items' associated memory cue. Fourteen participants were excluded from analysis based on lack of perceptual sensitivity (as indexed by sensitivity values less than zero); sensitivity and bias were analyzed from the remaining 28 participants. Analyses revealed no reliable difference in sensitivity across TBR and TBF targets and foils, $t(27) = -1.183$, $p > 0.05$, with participants again exhibiting comparable albeit low sensitivity for TBR items ($M = .75$, $SE = .11$) and TBF items ($M = .64$, $SE = .08$). Unlike Experiment 1A, participants' exhibited more liberal bias for TBR items ($M = -.22$, $SE = .06$), relative to TBF items ($M = -.05$, $SE = .04$), $t(27) = 3.13$, $p < 0.01$, Cohen's $d = .62$; see Figure 26. The *d'* values are again consistent with the DF effects described above, in particular that participants recognition memory was generally poorer than other literature examining

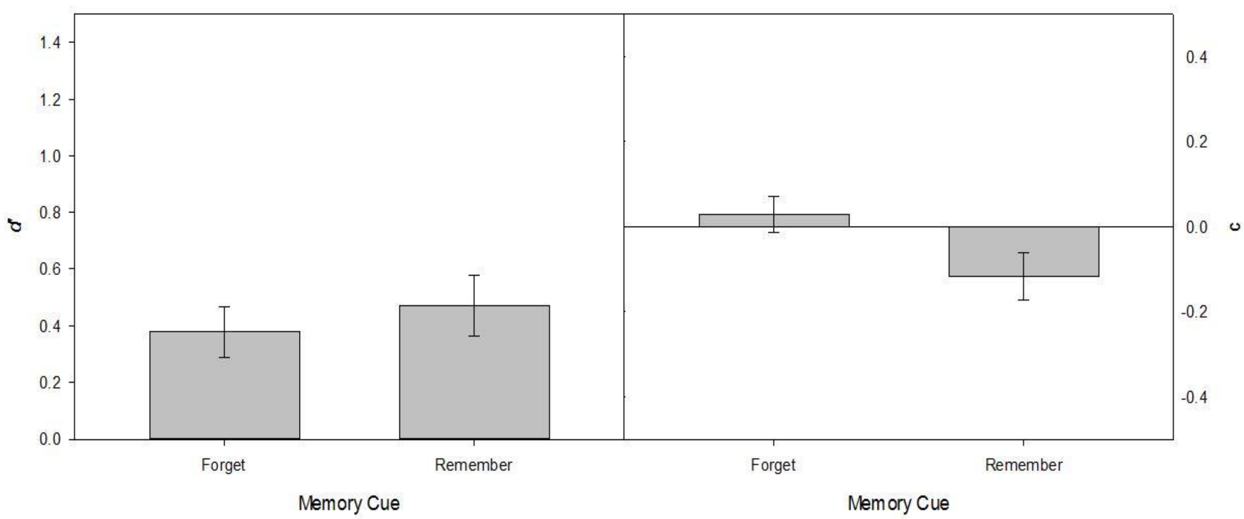

Figure 26. Signal detection indices of d' and c by Memory Cue.

memory for pictures (e.g., Quinlan et al., 2010; Shephard, 1967). The fact that participants exhibited a liberal bias for TBR items may also explain increased false alarm rates for TBR foils because participants were more likely to call test exemplars old, relative to a more conservative bias. However, these results do not explain why participants were overall less accurate in identifying studied images, relative to Experiment 1A, nor does it explain why participants exhibited lack of IOR effects.

Discussion

The results of Experiment 2 replicate and extend the results of Experiment 1. IOR effects were again not observed, with participants exhibiting comparable response speed for probes following Forget cues and for probes following Remember cues, similar to the results of Experiment 1. Participants showed higher recognition accuracy for targets associated with Remember cues, relative to targets that were associated with Forget cues. In addition, participants were most accurate when identifying items associated with Remember cues when the target was tested first, or when items were targets associated with a Remember cue. These results speak to the fact that items associated with Remember cues should also be associated with the strongest memory trace, and, by extension, the highest accuracy. The fact that participants were most accurate in identifying target items associated with Remember cues may speak to the strength of the memory trace, although it does not precisely reveal the mechanism by which Remember items are preferentially maintained.

Overall, these results suggest that while participants may retain some diagnostic information about studied items associated with Forget instructions (e.g., a coffee cup) during a directed forgetting task, the withdrawal of exogenous attention may prevent the retention of a more detailed memory trace (e.g., the specific studied coffee cup). Because participants' source memory for items associated with Forget cues was also poor, this result also suggests that withdraw of exogenous attention might also prevent the retention of spatial information, in this case, the side of the screen on which the target item appeared, and this in turn prevents source context information from bolstering the memory representation of a Forget item. However, because mixed results were obtained across Experiments 1 and 2, firm conclusions regarding the nature of attentional inhibition in DF tasks cannot be made based solely on the results of Experiment 2.

CHAPTER 5. GENERAL DISCUSSION

The current experiments examined the underlying attentional mechanisms of DF effects by using an item-method DF task and assessing behavioral response through reaction time and both implicit and explicit recognition memory metrics. Experiment 1 investigated whether the exogenous attentional withdrawal hypothesized to occur following instructions to intentionally forget resulted in a degraded memory trace, specifically by examining whether item identity information suffered for items associated with Forget instructions. Participants experienced an item-method DF task, during which they were instructed to remember or forget individual images. Based on prior work that has demonstrated forgetting is an effortful cognitive process as opposed to passive, participants also responded to probes following memory instructions by identifying a briefly presented letter. Importantly, participants were shown subliminal primes prior to responding to probes, intended to reveal whether item identity information was inhibited by the withdrawal of exogenous attention following instructions to forget. In Experiment 1A, participants next completed a subsequent recognition and source monitoring test indicating whether images were associated with Remember or Forget instructions, and in Experiment 1B, participants completed an implicit memory test (a version of perceptual identification). Results revealed no IOR, but replicated DF effects. Additionally, Experiment 1 demonstrated effective DF of images, as well as that source information did indeed suffer after attentional withdrawal. Experiment 1B demonstrated mixed results: While response times for all studied items were faster, regardless of whether items were associated with Remember or Forget cues, accuracy in identification of degraded images associated with Forget cues was lower than accuracy for identification of novel items.

Experiment 2 extended the findings of Experiment 1 by investigating whether a similar inhibition of spatial information could be observed following instructions to forget. Instead of presenting images at center, participants studied images to the left and right of central fixation, and during a subsequent recognition and source monitoring test, indicated whether images had been studied on the left- or right-hand side of the screen. Although no IOR effects were observed again in Experiment 2, DF effects for studied images were demonstrated. Source monitoring results were similar to Experiment 1, with participants more accurate at identifying the spatial location of previously studied items that were correctly recognized during test, although no effect of memory instructions were documented. The false alarm rates of semantically matched foils mirrored Experiment 1, with participants more likely to falsely identify matched foils than unrelated foils.

Taken together, the results of both experiments demonstrate that DF effects can be established using images, and that related source information may be inhibited or even not encoded for items associated with Forget instructions. The lack of IOR observed, however, is unlike previous work using dot probes (Fawcett & Taylor, 2008, 2010; Taylor, 2005, Taylor & Fawcett, 2011). Both Experiments 1 and 2 used a more complex probe (letter probe identification) intended to produce larger effects and engage participants in a more effortful task. However, this manipulation failed to produce any significant slowing following either cue type, regardless of if the probe and subliminal target presentation were congruent or incongruent with each other (Experiment 1), or in any combination with the target item (Experiment 2). It is possible that the lack of IOR observed in Experiment 1 was because of the central presentation of target items. Although previous work has shown that while participants do exhibit slower responses to dot probes following central target presentation (Taylor & Fawcett, 2008), there is also evidence suggesting that subliminal presentation of spatial information is sufficient to produce IOR (Mulckhuyse et al., 2007). However, no IOR was observed in Experiment 1 when a DF task was combined with subliminal item presentation and subsequent probe discrimination. Given that no IOR was observed in the current experiment, it is possible that subliminal presentation was not sufficient to capture attention in a DF task, leading to lack of IOR but consistent DF effects. Further, because participants' eye movements were neither constrained nor tracked, it is possible that participants simply directed their gaze off screen following the item presentation. This explanation seems unlikely given that participants' error rate in probe identification across all experiments was significantly lower than chance ($M = .10$, $SE = .01$), $t(125) = -71.20$, $p < 0.05$. The most likely explanation for Experiment 1 is twofold: That participants were shown all images at center, and that subliminal item presentation failed to capture attention. IOR in DF tasks relies on a spatially compatible response. Because there was no spatial information associated with the target presentations, this could explain why no IOR was observed.

Because no IOR was observed again in Experiment 2, it is also possible that because the task used did not require participants to engage in any processing and required only single, perceptually-based decisions (i.e., deciding what letter had been presented), participants did not need to disengage from memory instructions to respond. If participants failed to disengage from forget processes, no IOR effects would have been observed. This explanation also seems unlikely given that previous work has used even more simplistic tasks (simple dot probe localization decisions) and shown small albeit robust IOR effects. Previous work examining IOR using perceptual discrimination have shown that participants may not exhibit IOR in the same direction as probe localization (e.g., responses following Remember cues may be slower than responses following Forget cues; Taylor & Fawcett, 2011), but no reliable differences were observed across either memory cue in the current experiments. The departure from previous work utilizing probe localization may be partially responsible; specifically, Taylor and Fawcett (2011) argued that spatially compatible (or incompatible) responses are required to exhibit IOR. Although the task utilized in the current experiments did include spatial responses (e.g., participants were instructed to maintain their index fingers of each hand on one of the two required buttons throughout the experiment), no IOR was observed based on any combination of subliminal, probe, or response locations. Finally, it is possible that because every trial was followed by probe decisions, participants viewed their primary task as responding to probes, and not to engaging memory cues. However, this explanation is not supported by the DF effects observed across both Experiment 1 and 2. Given that forgetting effects were observed, but no IOR was associated with either Experiment 1 or 2, this suggests that IOR in DF tasks may be linked only to spatial information, as indexed by localization tasks, and may not be detectable using discrimination or simple detection (Taylor & Fawcett, 2011).

A similar potential alternative is that that because the current study directed participants to maintain their gaze at central fixation (intended to both prevent participants from detecting subliminal primes, and from focusing on one side of the screen and failing to detect probes), lack of IOR might have been due to participants' attention directed to center. Experiments 1 and 2 relied on subliminal primes to examine whether item identity information would continue to capture attention after cues to forget. It is possible that this method (and its requirement that participants return their gaze to center) was not ideal to investigate withdrawal of exogenous attention. An alternative method of investigation might be to replace the dot probes with repetitions of target images; for example, participants could make localization decisions about briefly presented images of targets or unrelated distractors. In this way, the subliminal primes could be eliminated, and participants would no longer be explicitly required to return their gaze to center. If participants inhibit item identity information, IOR should be observed for "target probes," relative to unrelated probe images. If, on the other hand, only spatial information is inhibited, spatially congruent probes should exhibit the slowest response times, relative to incongruent probes. Given the influence of repetition priming, however, utilizing target images as probes would risk minimizing or even eliminating DF effects. To combat repetition priming, probe presentation times would either need to be very brief (i.e., less than 250 ms, as has been used in prior literature; Fawcett & Taylor, 2008; Taylor & Fawcett, 2010, 2011), or probe images would need to be presented in an altered format (e.g., partial images as opposed to the entire image, or matched foil images). These methods would potentially allow for a more precise documentation of whether item identity or spatial location is inhibited during exogenous attentional withdrawal.

Further, the results of the current experiments do not demonstrate long-term effects of attentional inhibition. To determine whether participants' attention is subsequently inhibited for items that are supposedly forgotten, future investigations might combine item-method DF tasks (e.g., as described above) with a visual search task, during which Forget items might serve as search targets or distractors. If participants' attention is inhibited by the presence of items previously associated with Forget cues, or if their search times (i.e., time to locate targets) or target verification times (i.e., time needed to identify fixated objects as targets; see Malcolm & Henderson, 2009) are longer for targets previously associated with Forget cues, this would provide further evidence that item representations are inhibited for F items. Few studies have used images in item-method DF tasks (cf. Quinlan et al., 2010; Goernert, Corenblum, & Otani, 2011), as such, there is little literature describing how forgotten images affect subsequent attentional processes (excluding research investigating visual working memory processes; e.g., Williams & Woodman, 2012; Williams, Hong, Kang, Carlisle, & Woodman, 2013). An investigation of this nature might also provide evidence for the retrieval inhibition hypothesis, discussed in greater detail below.

Importantly, the lack of IOR effects in the current study also fail to demonstrate effort involved in successful forgetting. Participants did not differ in response speeds to probe items across both experiments, although participants did exhibit faster probe responses following Remember cues if the target was subsequently remembered (Experiment 1). This result has interesting implications, given that typical IOR effects in DF tasks are not accompanied by facilitation following Remember cues (see Taylor & Fawcett, 2011). The fact that participants were faster to respond to probes following Remember cues when the target was subsequently remembered, relative to probes following Forget cues when the target was subsequently remembered, suggests that DF processes may share similarities with stop-signal inhibition (Hourihan & Taylor, 2006). If, as previous work has suggested, remember instructions are considered participants "default," this pattern of response times might suggest that if participants are unsuccessful in implementing Forget cues, default processes persist, and items are subsequently remembered. To examine more specifically whether DF methods resemble stop-signal paradigms, future investigations might examine participants' recognition accuracy when they are interrupted during implementation of memory instructions. If participants are interrupted while engaging Remember instructions, it is possible that recognition accuracy would remain unchanged if remembering is a "default" process that requires fewer cognitive resources to engage (cf. Wetzel & Hunt, 1977).

The lack of demonstrable effort involved in forgetting in the current experiments could be due to several methodological departures from previous work. For one, the probe task differed from previous work; however, as stated above, the likelihood that making the probe task more difficult also prevented participants from exhibiting IOR effects seems unlikely. If anything, the current experiments' probes should have produced greater IOR effects, given that it was a more effortful task than simple dot probes. An alternative explanation could be that the timing used across both experiments was too long, and participants had already completed implementation of the memory cue by the time the subliminal object and probe were presented. However, this also seems unlikely, as the range of ISIs used across both experiments were drawn from time courses shown to produce reliable DF and IOR effects (Taylor & Fawcett, 2011). The results of the current experiments do not speak to the effortful nature of forgetting; as such, future investigations could more directly examine attentional withdrawal by documenting participants' eye movement patterns during a DF task. In addition, future investigations utilizing objective indices of effort (e.g., pupil dilation) could examine whether successful intentional forgetting is associated with more effort than unsuccessful forgetting. Relatedly, an investigation examining objective indices of effort could document whether more effort to engage in a Forget instruction also results in loss of more identity (or other source) information. To more effectively isolate effortful processes, future investigations could combine paradigms designed to elicit IOR with eye-tracking to precisely determine whether participants' attention (as indexed, for example, by eye movements) is inhibited from specific items, spatial locations, or a combination of both.

In addition, previous work has suggested that active attentional inhibition is responsible for either removing TBF items from working memory, or preventing attention from returning to TBF items. To investigate whether participants require active working memory processes to inhibit attention to TBF items, participants could be given a working memory load (e.g., a list of digits) before completing item-method DF trials. If participants are less effective at implementing Forget cues while working memory resources are occupied (as evidenced by higher recognition accuracy for TBF items during subsequent recognition), this would provide more evidence that forgetting is an active cognitive process and requires attentional control. Alternatively, interrupting participants' implementation of Forget cues by having participants engage in tasks intended to occupy working memory resources might also reveal whether attentional inhibition requires active working memory processes. To investigate this question, the probe localization (or identification) decision could be replaced with a simple task designed to engage working memory (e.g., a math problem). If participants are slower to complete a working memory task following a Forget cue, this would provide similar evidence that attentional inhibition relies on active working memory resources. Previous research utilizing interruption following memory cues has interpreted DF effects as evidence supportive of selective rehearsal (e.g., if participants are interrupted after receiving memory cues, R item memory is impaired, but F item memory remains unchanged; Wetzel & Hunt, 1977). However, it is also possible that these patterns of results may instead be reflective of attentional inhibition, and reliance on active working memory processes (e.g., Basden et al., 1993),

Many recent studies examining working memory processes in DF tasks have focused on visual working memory using tasks such as change detection (e.g., Williams & Woodman, 2012; Williams et al., 2013; see also Woodman & Luck, 2007). For example, Williams and Woodman (2012) demonstrated superior change detection performance when participants were cued to forget part of memory displays, relative to when participants maintained entire displays. Other recent work has examined performance when participants are told to prioritize particular objects within a display and demonstrated that prioritized objects may be protected from subsequent competing information, while de-prioritized objects (i.e., similar to TBF items) may be actively removed from the memory set (Maxcey-Richard & Hollingworth, 2013). Across these investigations, there are few discussions of more long-term memory DF tasks or processes, and results are interpreted as supporting differential encoding or maintenance, rather than differential attentional processes. Future investigations could look toward combining these hypotheses to better understand what processes actually underlie DF effects, and whether there are similarities between visual working memory DF tasks and more long-term memory DF tasks (e.g., item- or list-method DF).

In both Experiments 1 and 2, participants were more accurate at identifying target items associated with Remember cues, relative to targets associated with Forget cues. These results were accompanied by higher false alarm rates for semantically matched foils, relative to unrelated foils. Source accuracy for targets demonstrated an interesting pattern: When participants were incorrect in their recognition decision for F items (i.e., they failed to recognize F items as previously studied), they were also more accurate in their source decisions. The opposite was true for R items that were incorrectly recognized. However, source accuracy for foils did not mirror recognition accuracy across both experiments: In Experiment 1, participants were more accurate at identifying the source of Forget foils, and in Experiment 2, participants were more accurate at identifying the source of Remember foils. Despite the different patterns of results, these both support the hypothesis that Forget items may be identified on the basis of familiarity instead of recollection (MacLeod, 1975; Goernert et al., 2006, 2007). These source data might also be reflective of a simpler explanation, specifically that participants may have exhibited response bias for Forget identifications in Experiment 1A, but not in Experiment 2.

These explanations are not mutually exclusive; previous work has suggested that when participants make DF source decisions, they do so on the basis of strength-based memory criteria (Goernert et al., 2006, 2007, 2011). For example, participants were more likely to respond that faces were associated with Forget cues if they were identified (correctly or incorrectly) as new (Goernert et al., 2011). This is similar to the pattern observed in Experiment 1A and could indicate that items participants feel are novel are automatically classified as previously associated with Forget cues, which would lead to a clear response bias. However, in the current experiments, because participants made only one recognition decision and one source decision, these data do not reveal any novel information about the basis of participants' decisions, and whether participants were identifying items on the basis of memory strength.

To investigate this further, future investigations could combine similar item-method DF paradigms with Remember-Know (RK) paradigms, or paradigms intended to precisely examine how participants decide an item is old or new instead of only asking for a dichotomous recognition decision (e.g., confidence-based recognition decisions). A similar investigation could involve participants identifying the source of only items identified as old to combat the development of potential response biases. Although participants did not exhibit better perceptual discrimination for R items, relative to F items, as indexed by d' in Experiment 1A and 2, previous work suggests that DF effects do rely on varying memory strength.Based on evidence that participants use strength-based criteria and exhibit better perceptual discrimination for R items, relative to F items (Goernert et al., 2011), I would expect that DF decisions would show a clear pattern, with more R items classified as "remember" and more F items classified as "know" (see also Basden & Basden, 1996), or as high and low confidence, respectively.

To more precisely investigate DF processes, future research could examine how DF effects might change when memory strength is manipulated at encoding (e.g., Ullspurger et al., 2000) or at test in combination with overt measures of effort. The retrieval inhibition hypothesis suggests that participants must "release" F items from inhibition at retrieval in order to accurately identify them (Basden & Basden, 1998); if strongly retrieved F items are associated with greater effort than strongly retrieved R items, this would provide evidence that retrieval inhibition is indeed acting upon forgotten items. If an investigation of this nature was combined with an investigation of inhibition during encoding, it might be possible to determine whether a combination of inhibition at encoding (i.e., attentional inhibition) and retrieval (i.e., retrieval inhibition) are responsible for DF effects.

In addition, Experiment 1B failed to produce any evidence that intentional forgetting produces effects on implicit memory retrieval, as evidenced by the fact that participants' response times during a perceptual identification task were no different across Remember and Forget targets. Similar investigations of forgetting have also reported mixed results when examining forgotten items using implicit measures. For example, Perfect et al. (2002) investigated retrieval-induced forgetting (RIF) and documented that although some implicit tasks showed RIF effects, others did not. In RIF tasks, participants typically exhibit poorer memory for studied but unpracticed items, relative to studied and practiced items (for a review, see Storm & Levy, 2012). When participants are given implicit memory tests following RIF tasks, tests that rely on conceptual representations (e.g., cued recall, category generation, category verification) show reliable effects, with forgotten items failing to exhibit typical implicit benefits (e.g., cued recall performance is impaired for studied but unpracticed items). In tests that tap into perceptual representations (e.g., similar to the perceptual identification task utilized here), no effects are observed. Perfect et al. (2002) argued that this is due to the nature of the implicit tasks, and suggested that tasks during which items are forgotten result in inhibition during retrieval for specific items, but that the item representations remains unchanged. It is possible that DF effects are reflected only in conceptual, and not in perceptual, representations of items. Because the current experiments utilized only an implicit task that relied on perceptual identification (i.e., perceptual implicit memory), it is possible that alternative measures that rely on conceptual implicit memory (e.g., category generation) are necessary to document DF effects, and would potentially reveal important information about how item representations may be altered following instructions to forget.

Generally, participants were poor at perceptual identification as presented in Experiment 1B, with poor identification of targets (M = .51, SE = .02), foils (M = .50, SE = .02), and novel tested items (M = .55, SE = .01). Response times were also long for an identification task, with slow identifications of targets (M = 2866 ms, SE = 118 ms), foils (M = 2771 ms, SE = 125 ms), and novel items (M = 2828 ms, SE = 145 ms). As discussed previously, participants identified targets, foils, and novel images from the Massive Memory Object Database (MMOD; Brade et al., 2008). While the MMOD contains upward of 4,000 images, pilot testing identified 100 image pairs to be used as targets and foils in the current experiments. The limited number of target-foil pairs suggests that there was potential for the images themselves to be responsible for inaccurate identifications and slow responses, relative to a different set of 100 image pairs. Although pilot testing revealed a set of images with “average” (around 50%) accuracy and the widest range of response times, it is possible that individual differences across target-foil pairs (e.g., some pairs were easier than others to identify), and differences between pairs and novel images (e.g., some novel images may have been easier to identify) might have contributed to the rate of accurate identifications, specifically the finding that participants were more accurate to identify novel images, relative to studied images. It is also possible that the image manipulation utilized (image manipulation details go here) might have contributed to participants' difficulty in identifying degraded images. To address this, future investigations could use greater numbers of target-foil pairs and perhaps identify other image manipulations to encourage more accurate responding.

Retrieval inhibition, while not directly tested in the current experiment, is also supported by evidence from visual working memory studies examining implicit memory for forgotten objects (e.g., during a change detection task). Busch (2013) documented that although participants often had no explicit memory trace for objects that had changed during a change detection ask, event-related potential (ERP) activity showed a reliable difference between old and new items. Similar to Perfect et al. (2002), Busch suggested that failure to retrieve an item representation, and not failure to encode the item, was responsible for participants performance. Given the relevance of retrieval inhibition to DF effects, it is possible that a similar explanation could apply to the current studies.

Although the retrieval inhibition hypothesis provides potential explanatory power to the results found in the current experiments, it is in stark contrast to the attentional inhibition hypothesis. Because only one implicit test was used in the current experiment, future research will be needed to definitively state what happens to an item representation after instructions to forget. The use of alternative implicit measures (e.g., cued recall, category generation, etc.) could reveal DF effects and would provide greater evidence for retrieval inhibition, attentional inhibition, or some combination working in tandem to produce memory deficits for TBF items. An additional avenue of investigation could be to present participants with target images and associated memory cues during test and have participants indicate whether the pairings are correct or incorrect; a manipulation of this nature might reveal additional information about how memory cues are associated with studied items, similar to source monitoring, by examining participants' accuracy and decision speed. However, many implicit tasks that tap into conceptual representations rely on verbal processes (e.g., cued recall, stem completion, etc.) and might necessitate different stimuli than used in the current experiments.

In summary, the current experiments represent an investigation of what specific information is inhibited during intentional forgetting. Specifically, by examining exogenous attentional withdrawal proposed by the attentional inhibition hypothesis (Zacks, 1989), both experiments investigated whether item identity information and/or spatial information are inhibited during a DF task. Across two experiments, clear forgetting effects were observed, with participants exhibiting better memory for items they were instructed to remember, relative to items they were instructed to forget. However, no inhibitory effects were observed, raising further questions about how attention is inhibited following instructions to intentionally forget information, and what specific information attentional withdrawal inhibits. Future research will examine these questions in greater detail to determine the specific attentional mechanisms that underlie active and effortful forgetting processes.

REFERENCES

Abrams, R. A., & Dobkin, R. S. (1994). Inhibition of return: effects of attentional cuing on eye movement latencies. *Journal of Experimental Psychology: Human Perception and Performance*, *20*(3), 467-477.

Basden, B. H., & Basden, D. R. (1998). Directed forgetting: A contrast of methods and interpretations. In J. M. Golding & C. M. MacLeod (Eds.), Intentional forgetting: Interdisciplinary approaches (pp. 139–172). Mahwah: Erlbaum.

Basden, B. H., Basden, D. R., & Gargano, G. J. (1993). Directed forgetting in implicit and explicit memory tests: A comparison of methods. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(3), 603-616.

Berger, A., Henik, A., & Rafal, R. (2005). Competition between endogenous and exogenous orienting of visual attention. *Journal of Experimental Psychology: General*, *134*(2), 207-221.

Bjork, R.A. (1970). Positive forgetting: The non-interference of items intentionally forgotten. *Journal of Verbal Learning and Verbal Behavior*, *9*, 255-268.

Bjork, R.A. (1972). Theoretical implications of directed forgetting. In A.W. Melton & E. Martin (Eds.), *Coding processes in human memory* (pp. 217-235). Washington DC: Winston.

Brady, T. F., Konkle, T., Alvarez, G.A., & Oliva, A. (2008). Visual long-term memory has a massive storage capacity for object details. *Proceedings of the National Academy of Sciences, U. S. A.*, 105 (38), 14325-14329.

Briand, K. A., & Klein, R. M. (1987). Is Posner's" beam" the same as Treisman's" glue"?: On the relation between visual orienting and feature integration theory. *Journal of Experimental Psychology: Human Perception and Performance*, *13*(2), 228-241.

Busch, N. A. (2013). The fate of object memory traces under change detection and change blindness. *Brain Research*, *1520*, 107-115.

Carrasco, M. (2011). Visual attention: The past 25 years. *Vision research*, *51*(13), 1484-1525.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, *3*(3), 201-215.

Ebbinghaus, H. (1913). *Memory: A contribution to experimental psychology* (No. 3). University Microfilms.

Epstein, W. (1970). Facilitation of retrieval resulting from post-input exclusion of part of the input. *Journal of Experimental Psychology*, *86*(2), 190-195.

Epstein, W., Massaro, D. W., & Wilder, L. (1972). Selective search in directed forgetting. *Journal of Experimental Psychology*, *94*(1), 18-24.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191.

Fawcett, J. M., & Taylor, T. L. (2008). Forgetting is effortful: Evidence from reaction time probes in an item-method directed forgetting task. *Memory & Cognition, 36,* 1168–1181.

Fawcett, J. M., & Taylor, T. L. (2010). Directed forgetting shares mechanisms with attentional withdrawal but not with stop-signal inhibition. *Memory & Cognition, 38,* 797–808.

Fleck, D. E., Berch, D. B., Shear, P. K., & Strakowski, S. M. (2001). Directed forgetting in explicit and implicit memory: The role of encoding and retrieval mechanisms. *The Psychological Record*, *51*(2), 207.

Geiselman, R. E., Bjork, R. A., & Fishman, D. L. (1983). Disrupted retrieval in directed forgetting: a link with posthypnotic amnesia. *Journal of Experimental Psychology: General*, *112*(1), 58-72.

Goernert, P. N., Widner, R. L., & Otani, H. (2006). Segregation accuracy in item-method directed forgetting across multiple tests. *British Journal of Psychology*, *97*(2), 245-258.

Goernert, P. N., Widner Jr, R. L., & Otani, H. (2007). Classification accuracy across multiple tests following item method directed forgetting. *The Quarterly Journal of Experimental Psychology, 60*(9), 1178-1186.

Hourihan, K. L., & Taylor, T. L. (2006). Cease remembering: control processes in directed forgetting. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(6), 1354-1395.

Johnson, H. M. (1994). Processes of successful intentional forgetting. *Psychological Bulletin*, *116*(2), 274-292.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3-28.

MacLeod, C. M. (1975). Long-term recognition and recall following directed forgetting. *Journal of Experimental Psychology: Human Learning and Memory*, *1*(3), 271-279.

MacLeod, C.M. (1989). Directed forgetting affects both direct and indirect tests of memory. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15,* 13-21.

MacLeod, C. M. (1998). Directed forgetting. In J. M. Golding & C. M. MacLeod (Eds.), Intentional forgetting: Interdisciplinary approaches (pp. 1–57). Mahwah: Erlbaum.

MacLeod, C. M. (1999). The item and list methods of directed forgetting: Test differences and the role of demand characteristics. *Psychonomic Bulletin & Review*, *6*, 123–129.

Malcolm, G. L., & Henderson, J. M. (2009). The effects of target template specificity on visual search in real-world scenes: Evidence from eye movements. *Journal of Vision*, *9*(11), 8-8.

Marks, W., & Dulaney, C. L. (2001). Encoding processes and attentional inhibition in directed forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*(6), 1464-1473.

Maxcey-Richard, A. M., & Hollingworth, A. (2013). The strategic retention of task-relevant objects in visual working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(3), 760.

Mulckhuyse, M., Talsma, D., & Theeuwes, J. (2007). Grabbing attention without knowing: Automatic capture of attention by subliminal spatial cues. *Visual Cognition*, *15*(7), 779-788.

Muther, W. S. (1965). Erasure or partitioning in short-term memory. *Psychonomic Science*, *3*(1-12), 429-430.

Nickerson, R. S. (1965). Short-term memory for complex meaningful visual configurations: A demonstration of capacity. *Canadian Journal of Psychology*, *19*(2), 155-160.

Perfect, T. J., Moulin, C. J., Conway, M. A., & Perry, E. (2002). Assessing the inhibitory account of retrieval-induced forgetting with implicit-memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(6), 1111.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32*(1), 3-25.

Quinlan, C. K., Taylor, T. L., & Fawcett, J. M. (2010). Directed forgetting: Comparing pictures and words. *Canadian Journal of Experimental Psychology, 64*, 41–46.

Reitman, W., Malin, J.T., Bjork, R.A., & Higman, B. (1973). Strategy control and directed forgetting. *Journal of Verbal Learning and Verbal Behavior, 12*, 140-149.

Shepard, R. N. (1967). Recognition memory for words, sentences, and pictures. *Journal of Verbal Learning and Verbal Behavior*, *6*(1), 156-163.

Surprenant, A. M., & Neath, I. (2013). *Principles of Memory*. Psychology Press.

Taylor, T. L. (2005). Inhibition of return following instructions to remember and forget. *Quarterly Journal of Experimental Psychology, 58A*, 613–629.

Taylor, T. L., & Fawcett, J. M. (2011). Larger IOR effects following forget than following remember instructions depend on exogenous attentional withdrawal and target localization. *Attention, Perception, & Psychophysics*, *73*(6), 1790-1814.

Thompson, K. M., Hamm, J. P., & Taylor, T. L. (2014). Effects of memory instruction on attention and information processing: Further investigation of inhibition of return in item-method directed forgetting. *Attention, Perception, & Psychophysics*, *76*(2), 322-334.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*, *12*(1), 97-136.

Ullsperger, M., Mecklinger, A., & Müller, U. (2000). An electrophysiological test of directed forgetting: The role of retrieval inhibition. *Journal of Cognitive Neuroscience*, *12*, 924–940.

Weiner, B., & Reed, H. (1969). Effects of the instructional sets to remember and to forget on short-term retention: Studies of rehearsal control and retrieval inhibition (repression). *Journal of Experimental Psychology*, *79*(2), 226-232.

Wetzel, C. D. (1975). Effect of orienting tasks and cue timing on the free recall of remember-and forget-cued words. *Journal of Experimental Psychology: Human Learning and Memory*, *1*(5), 556-566.

Wetzel, C. D., & Hunt, R. E. (1977). Cue delay and the role of rehearsal in directed forgetting. *Journal of Experimental Psychology: Human Learning and Memory*, *3*(2), 233-245.

Williams, M., Hong, S. W., Kang, M. S., Carlisle, N. B., & Woodman, G. F. (2013). The benefit of forgetting. *Psychonomic Bulletin & Review*, *20*(2), 348-355.

Williams, M., & Woodman, G. F. (2012). Directed forgetting and directed remembering in visual working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(5), 1206.

Woodman, G. F., & Luck, S. J. (2007). Do the contents of visual working memory automatically influence attentional selection during visual search? *Journal of Experimental Psychology: Human Perception and Performance*, *33*(2), 363.

Wylie, G. R., Foxe, J. J., & Taylor, T. L. (2008). Forgetting as an active process: An FMRI investigation of item-method-directed forgetting. *Cerebral Cortex*, *18*, 670–682.

Zacks, R. T. (1989). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation*, *22*(22), 193-225.

Zacks, R.T., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 241-264). San Diego, CA: Academic Press.

Zacks, R. T., Radvansky, G., & Hasher, L. (1996). Studies of directed forgetting in older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 143-156.

APPENDIX A

Institutional Review Board Approval

ACTION ON EXEMPTION APPROVAL REQUEST

LSU

Institutional Review Board
Dr. Dennis Landin, Chair
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TO: Megan Papesh
Psychology

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: November 18, 2015

RE: IRB# E9663

TITLE: The cognitive mechanisms of intentional forgetting

New Protocol/Modification/Continuation: New Protocol

Review Date: 11/18/2015

Approved X **Disapproved** ________

Approval Date: 11/18/2015 **Approval Expiration Date:** 11/17/2018

Exemption Category/Paragraph: 2b

Signed Consent Waived?: No

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman ________

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE:**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

APPENDIX B

Approved Consent Form

Consent Form

1. Study title: The cognitive mechanisms of intentional forgetting

2. Performance site: Louisiana State University

3. Investigator: Dr. Megan Papesh (mpapesh@lsu.edu); Laura Heisick (lheisi1@lsu.edu)

4. Purpose of the Study: The purpose of this research project is to establish the underlying cognitive and attentional mechanisms of intentional forgetting. Although previous research has shown that forgetting benefits memory performance, this research investigates what relationship exists between cognition, attention, and directed forgetting.

5. Subject Inclusion: Individuals between the ages of 18 and 65 with normal or corrected-to-normal vision and normal color vision.

6. Number of subjects: 150

7. Study Procedures: The study will take between 45 and 60 minutes. Participants in this study will study a series of items and will receive instructions about which items will be presented on the memory test. Some participants will respond to a probe. All participants will take a memory test, during which they will make memory decisions.

8. Benefits: The data from this study will further research on human memory.

9. Risks: There are no known risks from participating in the current study.

10. Right to Refuse: Subjects may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled.

11. Privacy: Results of this study may be published, but no names or identifying information will be included in publication. Subject identity will remain confidential unless disclosure is required by law.

12. Financial information: You will receive no financial compensation for participating in this study. You will receive one experimental credit for each half hour of participation.

13. Withdrawal: Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled.

14. Removal: You can be removed from the experiment for behavior that is disruptive or harmful to others.

15. Signatures: The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Dennis Landin, Institutional Review Board, (225) 578-2916. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Signature of subject **Date**

____________________________________ _______________

VITA

Laura Heisick received her Bachelor's Degree in Psychology from Louisiana State University (LSU). She was accepted into the LSU Cognitive and Brain Sciences doctoral program and is currently in her third year of study. Her research interests include memory, attentional processes, eye movements, and face perception. She anticipates graduating with her M.A. degree in May 2017 and plans to continue pursuing her Ph.D. in Cognitive Psychology.