# The Effects of Associative Priming on Retroactive Interference

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Abstract

We depend on our memory for events to inform the decisions we make in the moment. Whether you are trying to remember the name attached to a face you have only just meant, or trying to give crucial evidence to police about the events of a crime you witnessed, being able to remember the information is only part of it, this information needs to be accurate as well. Unfortunately, it has been consistently shown that newly learned material can cause people to forget events, or to provide inaccurate information when trying to recall an event in a phenomenon referred to as retroactive interference. This study seeks to shed light upon the mechanisms responsible for retroactive interference by associatively priming participants towards either the originally learned or newly learned information. A series of two experiments consistently showed that priming towards originally learned information prior to recall increased participants' recall accuracy. However, no effects were found when participants were primed towards 'newly learned', (interfering), information.

Day after day we are constantly bombarded with information. Meetings we must attend, facts we have to memorize, the expression of a face, or a clever turn of phrase. We internalize huge swaths of our lives with the understanding that we will be able to use this information to inform our decisions in the future. When faced with a challenge or question, we turn our minds inward, hoping to pick out the one memory in millions that contains the necessary information. The huge amount of data we are able to perceive and store comes with a price though. For over a century now, it has been shown that we learn new information, in part, by sacrificing the relevancy and strength of older memories causing us to forget them, or in more extreme cases, to conflate the new memories with the old in a phenomenon known as *retroactive interference* (RI).The goal of the current study was to determine what effect, if any, associative priming would have on retroactive interference, and from that , to see if it was possible to reach conclusions about the cognitive processes behind retroactive interference.

Although interference effects in memory had been studied as far back as the early 20th century, (Kline & Owens, 1913), it was McGeoch's intuitive proposal that interference arose due to memories sharing a single retrieval cue, (McGeoch, 1936, 1942) that spurs much of the current retroactive interference research. The idea behind this is that when you tryto remember something, say what you had for breakfast this morning, you aren't simply remembering a list of items like 'egg, toast, coffee with two creams', but instead are remembering those items within a certain context. When you are asked "What did you have for breakfast this morning?" you will probably remember yourself sitting at your table, perhaps reading a paper, and of course, the contents of your breakfast. Now imagine that you have sat in the same spot for breakfast for the past twenty years. Someone comes up to you and asks, "What did you have for breakfastyesterday?" you imagine yourself sitting at your table, and suddenly you can't

remember whether you had eggs and toast today, or yesterday. In this case the question can be thought of as a cue, (bringing to mind 'this morning', and specifically interval in which you ate breakfast), and because the contexts of both memories are so similar, rather than leading you straight to the contents you seek, the cue providedbrings multiple memory items to mind making the targeted item ambiguous.

The conceptual importance of cue-target relationships in studying and understanding retroactive interference is apparent in the widely used *paired-associate* associate paradigm. In this paradigm, participants study unrelated pairs of words for a later memory test, (knight – octopus for instance). For each pair, one word is designated as a cue, and the other as a target, and on the memory test the subject is presented with a cue, (knight), and must produce the target, which in this case would be octopus. To study retroactive interference, and make its effects more pronounced, the A-B, A-D paradigm was created. In this paradigm participants study a list of unrelated 'A-B' word pairs, (knight – octopus), and subsequently study a list of 'A-D' word pairs which share the same cue, but have a different target, (e.g. knight – boron). When presented with the cue, participants are instructed to provide the target studied in the 'A-B' study phase, but because they now must choose between two feasible targets, participants' recall accuracy is hampered by retroactive interference. This effect is extremely robust, and a huge amount of literature has shown that participants' memory of the 'A-B' list suffers greatly after presentation of the 'A-D' list causing overall memory accuracy to sharply decline, (Goggin, 1969; Thune & Underwood, 1943; Keppel &Rauch, 1966, to name just a few).

While retroactive interference has been extensively studied in the laboratory, the mechanisms behind retroactive interference remain occluded. Multiple feasible accounts have been put forward trying to explain this phenomenon including *the unlearning hypothesis*,

(Melton & Irwin, 1940), and *variable stimulus encoding*,(VSE), (Martin, 1968). The unlearning hypothesis posits that when a memory item is associated with a cue, and a later item becomes associated with the same cue, that the strength of association between the cue and newer memory item is strengthened while simultaneously weakening the link between the cue and original memory item. Variable stimulus encoding, (VSE), on the other hand, states that targets cannot share an identical cue. Instead, two different versions of the cue are stored. Presentation of the cue in this case would, in turn, activate both cues, and possibly cause participants to retrieve the target associated with the incorrect cue.

Strong support for the unlearning hypothesis comes from a Melton & von Lackum study, (1941) which tested the relative magnitude of retroactive and proactive interference in participants. They found that retroactive interference effects were generally much more robust than proactive interference effects. They attributed this to the fact that proactive interference should only be dependent on occlusion, (when interference occurs because one memory item partially covers, or occults, another memory item), whereas retroactive interference would be subject to both occlusion and unlearning. Further support provided for the unlearning hypothesis came from Barnes & Underwood, (1959) who showed that retroactive interference is also exhibited when participants are given a *modified modified free recall test*, (MMFR). In an MMFR test, participants are asked to provide as many targets as they can that were studied in relation to the given cue. The fact that participants still exhibited retroactive interference, even when they were given ample time to provide responses, supports the idea that the forgetting caused by retroactive interference is in part driven by a weakening of the association between the cue word and original target. However, contradictory experimental findings, (Postman and Stark, 1969), fail to exhibit retroactive interference in recognition tasks. The importance of this is that

recognition tests should eliminate the occlusion aspect of retroactive interference by providing participants with all possible responses. This would ostensibly leave unlearning as the primary mechanism causing retroactive interference. The fact that postman & Stark, (1969), were unable to find an interference effect in this case casts uncertainty on the feasibility of the unlearning hypothesis.

VSE, as I have mentioned earlier, is centered on the idea that two targets cannot share an identical cue. For example, when studying A-B and A-D word-pairs, VSE stipulates that the second instance of the cue, (A-D) is actually encoded in memory as a completely separate cue, (*A'*). In this model, the forgetting effects of retroactive interference arenot caused by occlusion or unlearning, but instead because participants are choosing the incorrect cue at retrieval. Support for this theory is provided by Chandler and Gargano, (1995). In this study participants study lists of paired associates. At the testing stage, they were presented with the cue and a fragment of the target after studying the cue in relation to one of two additional targets. Either participants studied an additional cue-target pairing in which the secondary target was semantically associated with the original target, or they studied an alternate cue-target pair in which the secondary target was completely unrelated to the original target, (in these alternate cue-target pairs, the cues remain identical to the original study phase). Compared to a control condition, where participants studied only a single target in relation to a cue, participants who studied the alternate unrelated target showed significant retroactive interference effects and had difficulty remembering the original target. On the other hand, participants who studied the related alternate target showed facilitation in recall at the final test phase. The experimenters propose that this is due to variable encoding of the cue word. In other words, when the secondary target was related to the original one, it strengthened the association between the cue-

target pair learned during the first study session allowing participants to easily pick out the correct cue. In cases where the alternate target is not related to the original a new cue is encoded with completely different association criteria. Chandler and Gargano, (1995), argue that this inappropriate encoding of the cue caused participants to have a strong alternative to the originally learned cue-target pair, which resulted in retroactive interference.

The theories outlined above, could be consistent with expecting an effect of associative priming on retroactive interference. This, of course makes several assumptions. First of all, it assumes that the originally learned material is still accessible even after interfering information has been learned which is consistent with both VSE and unlearning hypothesis, (at least in the earliest stages of unlearning), models of retroactive interference. It also assumes that these cue-target associations are placed within the context of a participant's semantic knowledge, which is not explicitly stated by either theory, but which does not contradict them either. Finally, it would also assume that priming these semantic associations would bring the associated target to mind in a manner similar to cue presentation, wherein activation of the prime would propagate from the semantic representation of the prime to the target in much the same way classical theories of interference posit that presentation of a studied cue would bring a given associated target to mind.

Most of the studies outlined above show, quite clearly, the effects of retroactive interference on memory, and laid the groundwork for further research not only in the domain of interference, but also in the organization of memory itself. However, the existence of support for multiple theories of interference leavesits actual cause a subject of continuing debate.

Some of the most telling research pertaining to retroactive interference has been performed under a subset of retroactive interference known as the *misinformation effect*. The misinformation effect refers to the phenomenon in which participants' memory of an event is

altered after misleading information about the event is presented, (Loftus, 1991). For example, let's say that you see a mugging during which the victim is stabbed in the arm. As a potential witness, you are brought in and questioned by police who ask you to "tell them everything you remember about the night the victim was stabbed in the chest". Later, you try to recall the event, and erroneously remember the victim being stabbed in the chest. This effect has been observed countless times, (Loftus et al., 1978; Loftus and Hoffman, 1989), and under a variety of different conditions, (Assefi& Garry 2002), all of which showed that participants who were introduced to misleading information following the learning of information performed significantly worse on memory tests pertaining to that information then their control group counterparts, and often provided misleading information in responses rather than the accurate, or originally learned, information.

To understand how the misinformation effect can be thought of as analogous to retroactive interference it is helpful to view the previous example in terms of cue-target pairing, and the A-B, A-D paradigm specifically. In this case 'the events on the night of the mugging' can be thought of as the cue, (A), and 'the victim was stabbed in the arm' would represent the originally learned target, (B). The misleading information, 'the victim was stabbed in the chest', is analogous to the interfering target, (D). It is easy to see that when presented with the cue, there are now two possible contradictory accounts of the events on that night: one of which contains the originally learned information, while the othercontains the misleading, or interfering, information. Although differences do exist between the misinformation paradigm and the classical retroactive interference paradigm, in that participants are intentionally misled in one but not the other, because the misinformation effect is a subset of retroactive interference, theories

and findings pertaining to misinformation effect are applicable to understanding retroactive interference.

Interestingly, some of the most insightful studies into retroactive interference aren't supported by the presence of interference at recall, but by its absence under certain conditions.One of the earlier proposed causes of the misinformation effect is the *destructive-updating hypothesis*, (Loftus, Schooler, & Wagner, 1985) which suggests that previously stored memories are completely overwritten by the presentation of post-event information. In this model, the misleading information replaces the originally learned, or accurate, information leaving it completely inaccessible. While this hypothesis is attractive, McCloskey and Zaragoza, (1985), showed that participants actually can access originally learned information. In their study, participants learned information, were presented with misinformation, and then took a test in which they were presented with possible answers. However, rather than presenting the misleading response, participants were shown a novel foil item. What they found was that participants in this condition performed just as well as participants in the control condition who were not exposed to misinformation, implying that originally learned information is not permanently altered or eliminated by the subsequent presentation of misleading information, a finding which has been replicated in multiple similar studies, (Belli, 1993; Ceci, Ross, &Toglia, 1987).

Clearly, even in extreme cases of retroactive interference the originally learned information still exists in conjunction with the interfering information so the question remains of why participants still experience the effects of retroactive interference so routinely. One commonly proposed cause is *retrieval fluency*.Retrieval fluency is, simply put, the ease with which a memory comes to mind, (Baddeley, 1982; Jacoby & Dallas, 1981). In cases of

retroactive interference, participants have multiple possible responses associated with a single retrieval cue. If a subject's response is based on retrieval fluency, one could imagine that one of the possible responses would come to mind first. The ease with which an answer flows to mind, and the fact that it came to mind first, may influence participants to select that answer even if it is incorrect or interfering information. Furthermore, fluency is consistent with proposed causes of interference including the unlearning hypothesis, and it has been used to explain the effects of testing on the misinformation effect. Thomas, Bulevich, and Chan, (2010), put retrieval fluency forward as a possible explanation for the findings of their *retrieval-enhanced suggestibility paradigm*. This paradigm refers to their finding that testing participants directly after learning the events of a scene increases participants' susceptibility to misinformation. In this paper, the experimenters suggest that the initial testing phase causes participants to attend more closely to the subsequent study phase where misinformation is presented, because of this the misinformation is more strongly encoded than the original information. As participants took the final memory test, better encoded responses would come to mind first, (misleading responses in this case), encouraging participants to respond with misleading information. More importantly, Thomas, Bulevich, and Chan showed that this effect could be eliminated by giving participants a strong warning about the presence of information suggesting that with the proper prompt participants would depend less upon retrieval fluency in formulating a response, and would engage in more stringent source discrimination techniques instead.Further support for retrieval fluency at recall is found in Benjamin, Bjork, & Schwartz, (1998), and it is thought that participants depend disproportionally onthis feeling of fluency rather than examining the source of a possible response which is consistent with the findings of Thomas et al., (2010).

Although the preceding studies provide some evidence for retrieval fluency being at least partially responsible for the misinformation effect, it is hard to determine whether the effects seen in phenomena such as RES are due to retrieval fluency. Other studies have suggested that warnings can improve participants performance either by limiting participants' range of response, (Echterhoff, Groll, &Hirst, 2007), or that a warning implicating misleading narratives as untrustworthy may cause participants to disregard or forget the narrative which would reduce the accessibility of misinformation.

Several studies have sought to manipulate retrieval fluency directly through priming protocols. Jacoby, (1999) showed that priming could be used to introduce misinformation. In this study, participants studied a list of related word pairs and then were given a cued-recall test. In the test phase they were presented with a cue and a fragment of the target. Priming occurred before each test trial with misleading prime words being orthographically similar to the originally studied target, and semantically related to both the cue, and the originally learned target. Jacoby found that priming with these misleading targets caused participants to produce the misleading primes in the test phase, lowering their overall recall accuracy when compared to baseline and congruent prime groups, (In congruent trials, participants were primed with the originally learned target. In baseline trials, they were primed with a string of ampersands.) Furthermore, older adults showed a much greater deficit on misleading trials than their younger counterparts. Jacoby suggests that this is due to accessibility bias being greater in older than in younger adults. The idea of accessibility bias is closely related to retrieval fluency, and simply states that memory items which are more easily accessible, or which come more easily to mind are more likely to be viewed as correct. Older adults would be more susceptible to this bias because of a decreased ability to recollect the events of the learning phase, (Jacoby, 1991, 1998).

He proposes that accessibility bias is a "basis of responding that is independent of recollection", (Jacoby, 1999). In other words, while accessibility is a determining factor when choosing a target in relation to some cue, ability to remember possible learning phases, and subsequent examination of those phases by participants dictates the extent to which accessibility bias inform the participants' responses. This is consistent with studies seeking to attribute retrieval fluency to the RES effect where a warning about the nature of misleading material can boost participants' performance on a memory test, effectively reducing the misinformation effect (Thomas et al., 2010). Additionally, since it seems plausible that bias, or fluency, is a process which is independent of recollection, that providing participants with information which is implicitly related to target information may be able to influence participants' responses.

Although Jacoby's study, (1999), provides strong support for the effects of fluency on memory recall, several factors reduce the strength of his argument. The fact that incongruent primes were so closely related to the original target both orthographically and semantically may simply be constraining participants responses too much. Thus, it is not completely clear whether the increase in misinformation experienced by participants in misleading trials were basing their response on processes independent of recall, such as accessibility bias or fluency, or if participants were engaged in a source discrimination task, and due to the similarity of the targets, experienced increased difficulty in separating the source of the two competing targets.

A more recent study attempted not only to support the role of fluency in recollection, but to also place fluency within a spreading-activation model of memory, (Gordon & Shapiro, 2012). In this experiment, participants were asked to study a narrative. On a second study phase participants were instructed to read a misleading narrative in which some of the facts from the first narrative had been changed. Prior to the test phase participants were asked to provide

pleasantness ratings for individual words. What they weren't told was that, in some cases, these words were strongly semantically associated with the originally learned information. The experimenters found when participants rated words which were strongly associated with originally learned information, they performed much better on the final recall test. Gordon & Shapiro posit that this data can be explained via a spreading-activation network. In a spreading activation network individual words or concepts can be thought of as nodes which share excitatory or inhibitory connections with one another. As one node becomes active, this activity is propagated down through these associative connections eventually leading to the activation of other related nodes, (Collins & Loftus, 1975). By priming participants with semantically related words, Gordon and Shapiro believe that activation of the prime-word's node would spread to the originally learned information, causing it to become more active than other plausible nodes, and thus increasing the fluency with which it comes to mind and leading participantsto select the correct response over the misleading one.

The current study attempts to build upon previous experiments which propose the importance of retrieval fluency in selection between two possible targets. Also, rather than looking specifically at cases of misinformation, this study aims to examine the possible effects of associative priming within a more general retroactive interference paradigm using the classical A-B, A-D paradigm. If associative priming does indeed work upon participants' response criteria via spreading activation, and if determination of a response is partially dependent upon non-recollection based processes, then we would expect associative priming of originally learned information to boost participants' performance on a final memory test. Furthermore, if fluency is responsible for participants' responses then we might expect to see an interaction between encoding strength and priming wherein those items which were more strongly encoded at study

would benefit less from congruent associative priming. The logic behind this is that these targets would already show higher levels of retrieval fluency, and so the proportional increase in fluency would be smaller than for less well encoded items.

## Experiment 1

Experiment 1 seeks to achieve several goals. First of all, we hope to find analogous results to Gordon & Shapiro, (2012) on our novel procedure in order to validate both its design and to determine whether the effects of associative priming shown in previous misinformation literature are applicable to the phenomenon of retroactive interference. We also wish to determine, if possible, the extent to which retrieval fluency informs participants' answers in the final test phase of the experiment. We hypothesize that associatively priming participants towards originally learned information will improve recall accuracy of that information in a forced-cued recall task. Furthermore, if retrieval fluency is the primary mechanism behind participants' responses, then we might expect an interaction between associative priming and how well encoded an item is, wherein participants will show less benefit of priming towards original information as the strength of encoding for an item increases. This is because well encoded items should already show higher levels of retrieval fluency, and so the proportional increase in fluency would be smaller.

### Method

### Participants

Young adults (31 women, 27 men, $M_{age}$ = 19.08, age range: 18 – 22) were recruited via their enrollment in introductory Psychology courses at Tufts University. Participants received

course credit for their participation. Participants with English as a second language were identified due to the highly verbal nature of the task.

**Materials**

Thirty-two unrelated A-B word pairs and thirty-two unrelated A-D word pairs were created for this experiment (i.e., knight – octopus). Word pair association was ascertained using the University of South Florida Free Association Norms (Nelson, D. L., McEvoy, C. L., & Schreiber, T. A., 1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.) Additionally, 36 prime words were also selected, one for each target from list 1, (for some examples of word-pairs and their associative primes, refer to table 3). A word was considered a prime for a given target when there was a forward associative strength greater than .4 from the prime to the target word, (i.e. knight – octopus, prime: squid).

**Procedure**

The task consists of two study phases and one test phase. In Phase 1, participants were asked to study a list of 36 A-B word pairs, (list 1), which had a cue on the left and a target on the right. Each pair was presented for 2 seconds as white text with a black background in the center of a computer monitor. Participants were instructed to study the word pairs so that they could provide the appropriate target when they saw its corresponding cue word alone in a later test phase. The 36 A-B pairs, (i.e.knight – octopus), were divided into three experimental conditions. Twelve pairs served in the control condition, twelve served in the inconsistent presentation condition, and twelve served in the consistent presentation condition. While not relevant for Phase 1 presentation, these conditions were important for Phase 2 presentation.

After completing the first study phase participants engaged in a 6 minute non-verbal retention interval task which in this case consisted of playing the popular puzzle game Sudoku. Afterwards they were given a second study phase, this time containing 12 inconsistent A-D pairs, (pairs that have the same cue as a pair shown in the first study phase, but a different target), and 12 consistent pairs, again, each pair was presented for 2 seconds. Following the second study phase participants engaged in 20 more minutes of Sudoku. A-B/A-D pair conditions were counterbalanced such that all A-B pairs served in all three conditions.

After completing the second retention interval participants were given a forced cued recall test. Each "question" in the test began with a fixation cross appearing for 1 second in the center of the screen. The fixation cross was then replaced with either a prime word which corresponded to the upcoming cue – target completion task, (original-prime), or a neutral string of ampersands. Recall that the prime word was highly related to the original B target. The prime was presented for 50 ms. Following the prime participants were presented with a cue and had to provide the target associated with that cue during the first study phase by typing it in and pressing 'enter', thus beginning the next cued recall trial. For the test phase participants were instructed to answer with the target from the first study phase only. That is, participants were instructed to provide 'B' targets that were presented in Phase 1. Participants were told to ignore Phase 2 study. They were also told that they must provide an answer for every cue, and that that answer must be an English word. With regard to the prime, participants were told that the prime was not related to the upcoming test phase, but to pay attention as it may be important at some later point in the experiment. Participants were given as much time as they needed to provide a target for each given cue.

**Results**

Analysis focuses on participants' recall accuracy in the forced cued recall test segment of the experiment. Recall accuracy was analyzed across item-type and prime-type with mean recall accuracy, (the percentage of targets from list 1 that participants successfully provided), being calculated for each participant's performance on each of the six prime-type x item-type conditions. The differences in recall accuracy were then examined with a 2 x 3, (prime-type [original, none], item-type [consistent, control, inconsistent]), repeated measures analysis of variance (ANOVA). This ANOVA revealed a significant main effect of item-type, $F(2, 114) = 58.94, MSE = 1.584, p < .001$, and a main effect of prime-type, $F(1, 57) = 5.816, MSE = .241, p = .019$, with participants exhibiting higher recall accuracy on trials where they were primed towards list 1 targets than on trials where they received no prime, (see figure 1, table 1 for details). Finally, a significant interaction was not found between item-type and prime-type, $F(2, 114) = 1.291, MSE = .027, p = .279$, meaning that the advantage priming provided on participants' recall accuracy did not differ significantly across item-type conditions.

The results outlined above suggest, consistent with one of our hypotheses, that priming towards originally learned information does, in fact, increase participants' recall accuracy on the forced-cued recall task. These findings help affirm that originally learned information is still accessible even after the introduction of interfering information, and that these learned associations are placed within the broader context of a participants semantic knowledge, and can be brought to mind through implicit activation. In regards to fluency, because we failed to show a significant reaction between prime-type and item-type, this experiment neither provides extra support for the role of retrieval fluency in cued recall, nor does it contradict the fluency based hypotheses seen in Jacoby, (1999) or Gordon & Shapiro, (2012). Thus, although we see a clear

effect of priming on participants' recall, definitive conclusions cannot be reached at this point with regards to the mechanisms responsible for participants' recall when presented with a cue.

**Discussion**

As outlined earlier, we wished to see if associatively priming participants towards originally learned information prior to recall would improve overall performance in a forced cued recall task. Furthermore, we wanted to examine the magnitude of the role of retrieval fluency in participants' decision making process when they provide a response.Thus, we hypothesized that there would be a main effect of prime-type, with participants performing better on test trials where they had received an associative prime towards the list 1 target then on trials where they received no prime. Furthermore, if fluency were the primary factor in participants' decision making processes, we hypothesized an interaction between prime-type and item-type with a smaller performance increase of list 1 associative priming on consistent trials than on control or inconsistent trials. The results provide clear support for the first of our hypotheses via the main-effect of prime-type on recall accuracy. However, the lack of a significant interaction between prime-type and item-type fails to support our second hypothesis.

Taken at face value, the results of this experiment seem to support earlier findings by Jacoby, (1999), and Gordon & Shapiro, (2012), which use the effects of priming to support the importance of retrieval based fluency in interference. The fact that priming towards originally learned information increases participants' performance also implies that memorized events are not encoded in isolation in a subject's mind as a single, biographical event, but instead are stored in association with the broader semantic knowledge that a participant has accumulated over the course of their lifetimes. The fact that this semantic knowledge could be used to implicitly improve participants' memory helps to support the spreading activation model of memory, (see

concluding discussion for details). This is consistent with Gordon & Shapiro, (2012), who hypothesized that this increase in activation caused by associative priming would, in turn, increase the retrieval fluency of the associated target. In the case of this experiment, it could be this increase in retrieval fluency which influenced participants to recall the correct target.

While this experiment did not explicitly support a fluency-based hypothesis, it did not discount one either. This leaves the possibility open that, rather than priming increasing implicit decision making processes in participants, that priming is in some way inducing participants to engage in more stringent source-discrimination techniques. The thought behind this is that perhaps being primed towards a target does not just spread activation to the target, butin doing so helps participants to recall both targets relating to a given cue. This might influence participants to examine both possible targets for a given cue and to determine whether they were presented in the list 1 or list 2 study phase. In essence, this engagement in more stringent source discrimination techniques would improve their performance on the forced cued recall task. Experiment 2 seeks to dissociate fluency and source discrimination techniques at recall through procedural modifications to experiment 1.

## Experiment 2

As previously mentioned, experiment 2 was performed in an attempt to dissociate whether priming induced greater fluency or source discrimination techniques at recall for participants.This was tested by adding ‘interfering’ and ‘neutral’ prime-types. ‘Interfering-primes’ were those which were strongly semantically associated to the list 2, or inconsistent, target. Neutral-primes were words which had no semantic association with either the cue, or its two possible targets. We hypothesized that if priming is affecting participants recall primarily through retrieval fluency, then the ‘original-prime’ condition will still improve recall accuracy

across all three item-type conditions, that the 'neutral-prime' condition will show no effect on performance, or that it will slightly inhibit recall accuracy due to proactive interference, and finally that the 'interfering-prime' condition would inhibit participants' recall accuracy across all three item-type conditions. On the other hand, we hypothesized that if priming was increasing participants' performance in experiment 1 by inducing more stringent source discrimination techniques,then we would expect the same effects of the 'original-prime' and 'neutral-prime' condition, but we hypothesizedthat the 'interfering-prime' condition would improve participants' recall accuracy as well. The justification for this is that if the prime is simply increasing the retrieval fluency of its associated target, then in the 'interfering-prime' condition retrieval fluency would be increasing for the interfering target making it come to the participants' mind more easily and causing them to either recall the interfering target, or simply be unable to recall the original target. If priming is bringing both study sessions to mind by propagating activation backwards from the target to the original cue, then regardless of whether the prime is towards the original or interfering target priming would improve participants' ability to engage in source discrimination and select the correct target, thus improving their recall accuracy as long as the prime is actually related to one of the two study phases.

## Method

### Participants

Once again, young adults (40 women, 35 men, $M_{age}$ = 19.12, age range: 18 – 22) were recruited via their enrollment in introductory Psychology courses at Tufts University. Participants received course credit for their participation. Participants with English as a second language were identified due to the highly verbal nature of the task.

### Materials

The materials for experiment 2 were identical to experiment 1 with two main exceptions. A second list of 36 prime words was produced. The difference between this list of prime words, and the one used in experiment 1 is that these prime words were strongly related to the interfering target which participants learned in the second study phase on inconsistent trials these are referred to as 'interfering-primes'. A third list of prime words was also generated wherein the words had no associative strength with any given cue or either of its two possible targets, these are referred to as 'neutral-primes'. The original prime list from experiment 1, as well as the 36 unrelated word pairs and their possible unrelated interfering targets were all kept consistent from experiment 1 for their use in experiment 2.

**Procedure**

The procedure for experiment 2 was identical to experiment 1 with two major exceptions. Rather than testing all prime-types as a within participants, repeated measure, the experiment was split into two between participants 'prime-groups', ('original' and 'interfering'), which determined which set of possible primes participants would be exposed to prior to recall on the forced cued recall task. In the 'original' prime-group participants are exposed to either an 'original' prime for the given cue-target pair from experiment 1, a neutral-prime, or no prime, (a string of ampersands). In the 'interfering' prime-group, participants are exposed to an interfering-prime, neutral-prime, or no prime prior to recall on the forced-cued recall task.

**Results**

Analyses again focus on participants' recall accuracy in the forced cued recall test segment of the experiment. Recall accuracy was analyzed across item-type, prime-type, and prime-group with mean recall accuracy, (the percentage of targets from list 1 that participants successfully provided), being calculated for each participant's performance on each of the 18

prime-type x item-type x prime-group conditions. The differences in recall accuracy were then initially examined with a 3 x 3 x 2, (prime-type [[original/interfering], none, neutral], item-type [consistent, control, inconsistent], prime-group [original, interfering]), multivariate measures analysis of variance (ANOVA). This ANOVA failed to reveal significant measures, (see table 2, figures 2 & 3 for details). While these results were initially disappointing, it drove us to perform analyses breaking the data into its constituent parts in order to answer several questions. First, we were curious as to whether the 'true-prime' condition of the 'true' prime-group replicated results from experiment 1. To test this we examined recall accuracy with a 3 x 3, (prime-type [true, none, neutral], item-type[consistent, control, inconsistent]), repeated measures ANOVA. This ANOVA revealed both a main effect of item-type, $F(2, 76) = 26.91, MSE = 1.379, p < .001$, and a main effect of prime-type, $F(2,76) = 5.833, MSE = .204, p = .005$, (see figure 4 for details). These results are consistent with results from experiment 1, and show that participants performed significantly better in terms of recall accuracy when associatively primed towards the originally learned target.Next, we tested the interferingprime-group separately to see what effect the interfering-prime had on participants' recall. To test this we examined recall accuracy with another 3 x 3, (prime-type [interfering, none, neutral], item-type[consistent, control, inconsistent]), repeated measures ANOVA which only revealed a main effect of item-type, $F(2, 62) = 15.89, MSE = .770, p < .001$, (see figure 3 for details), but not of prime-type. Finally, we compared participants' recall accuracy between the 'original' and false prime-groups. We tested this measure using a 2 x 3 ANOVA, (prime-group [original, interfering], item-type [consistent, control, inconsistent]). Although this test did not show a statistically significant difference between groups, there is evidence that it is trending towards significance, with participants in the original prime-group, unsurprisingly, performing better than participants in the interfering-prime

group across item-type conditions, (see figure 6 for details). In terms of the neutral-prime conditions, although some of the measures were statistically significant, they could not be explained in terms of our hypotheses, especially considering that the neutral prime acted differently in our between participants prime-group condition, driving confusing, and in some cases contradictory marginal interactions.

The results previously outlined satisfy some, but not all of our hypotheses. While it was shown that the original-prime acted as expected by boosting recall accuracy, the false-prime seemed to have zero effect on participants' performance on the memory test. This is contrary to both the hypothesis concerning fluency, wherein it was predicted that participants recall accuracy would be inhibited by the interfering-prime condition, and the hypothesis concerning source discrimination, wherein it was predicted that participants' recall accuracy would improve in the interfering-prime condition. Unfortunately, because of this it is not possible to dissociate retrieval-fluency from source discrimination as the primary mechanism driving participants' responses on the forced cued recall task.

**Discussion**

The goal of experiment 2 was to see if we could determine the primary process behind participants' responses on the forced-cued recall task. This experiment reiterated results from experiment 1, showing that priming towards originally learned information has a beneficial effect on participants' memory. However, the most important measure, (the effect of the interfering--prime on participants' recall accuracy), did not provide any significant measurements, leaving any predictions about participants' rationale behind their responses inconclusive.It is possible that on interfering-prime trials participants would be more likely to provide the target from list 2 as a response even though it didn't reduce participants' overall

recall accuracy. If this were the case, it would provide further support, not only for retrieval fluency, but also for spreading activation models of memory. In future analyses, the number of times participants provide interfering targets should be included.

Although the lack of statistical significance in the interfering-prime seem to counter the findings of Jacoby, (1999), it is important to remember that in his study, misinformation was introduced through priming rather than manipulating the salience of misinformation through priming. That being said, these results are consistent with the findings of Gordon & Shapiro, (2012) who also failed to find a significant effect of associatively priming towards interfering information within their experiment. One possibility is that the prime is, in fact, increasing the retrieval fluency of the target it is associated with, but that once the associated target comes to mind participants are able to accept or reject the answer which comes to mind without fully recalling both possible targets. This is still consistent with the process of source discrimination, which posits that source discrimination only reduces interference if participants are still able to access the original information. This means that while source discrimination is still a potential candidate for the effects of priming on retroactive interference, this study did not provide definitive proof.

Testing whether or not participants' benefit, (or lack thereof), from a specific prime-type is due to the interaction of conscious, (recall dependent), and implicit, (recall independent), decision making processes could be done in many ways. One possibility could be to record participants' confidence, or feeling-of-knowing ratings for each target they provide. If participants are actively validating or rejecting the increase in retrieval fluency caused by priming, then we would expect participants to be significantly more confident on trials where they received an original-prime than after receiving no prime. We might also expect confidence

to be the same or lower on trials where they received an interfering-prime then no prime. Another way of testing this would be to give participants a time limit on their responses. If participants are depending both on retrieval fluency as well as conscious decision making processes to inform their response, then we would expect a time limit to force them to rely wholly on fluency. This would be consistent with Lindsay & Johnson, (1985), who posited that source discrimination processes take more time than fluency based ones. If this is the case, then we would expect original-primes to boost performance compared to trials where they did not receive a prime, and for interfering-primes to inhibit performance. Clearly, though, more experiments need to be performed before anything definitive can be stated about the underlying mental processes which drive participants' responses.

## Summary and Concluding Discussion

Gordon & Shapiro, (2012), determined the efficacy of priming towards originally learned material in eliminating the misinformation effect and improving participants' memory for a narrative. They attributed this finding to the prime increasing retrieval fluency for the originally learned information. The two previously outlined experiments attempted to apply this explanation to retroactive interference. Our hypothesis that associative priming could boost participants' performance in cases where the prime is related to the correct response was consistently fulfilled. However, our experiment 1 hypothesis that the original-prime would show less of an influence on consistent item-types was not fulfilled. Furthermore, our experiment 2 hypotheses that the interfering-prime would inhibit recall of inconsistent word pair targets consistent with retrieval fluency and Jacoby's findings, (1999), or that the same prime would boost recall of these targets consistent with a source-discrimination decision-making process were not fulfilled. That being said, the data from this study can be used to support either of these

hypotheses, and with post-hoc analysis determining the rate of production of interfering primes, or minor procedural changes to the experiment, we should be able to more clearly determine what decision-making processes participants are depending upon at recall, the feasibility of a spreading activation models of memory, and to provide support for classical models of retroactive interference such as VSE. Furthermore, the data pertaining to original-prime conditions adds to a growing body of literature, (Frost & Weaver, 1997; Parker, Buckley &Dagnall, 2009; Ecker, Lewandowsky, & Tang, 2010), showing that originally learned information is still accessible after the introduction of interfering information, which directly contradicts trace-overwrite/alteration accounts of interference, (Loftus, 1975).

The spreading-activation semantic network model of memory, (Anderson 1976, 1983; Reder& Gordon, 1997), posits that information is stored in memory as a vast web of concepts attached by their semantic associations, and also the contexts under which they are learned. Each individual concept is referred to as a 'node', and it is the activation level of the node which determines whether or not it will be recalled, with an item only being recalled if it surpasses some threshold level of activation. The associations between nodes can carry activation between concepts, so as a single concept becomes activated this activation propagates outward to other semantically or contextually related concepts thus bringing them to mind. This model has been used to explain a variety of memory related phenomena such as associative priming, (Ratcliff and Mckoon, 1981), and retrieval fluency, (Gordon & Shapiro, 2012). This is also the model which I will use to explain how data from this study, as well as future experiments can help to determine the role of decision making processes such as source discrimination and retrieval fluency in retroactive interference, and the effects of associative priming on these processes.

Retrieval fluency refers to the ease with which a memory item comes to mind. In terms of a spreading activation model, the memory item with the highest level of retrieval fluency, (i.e. that item which initially comes to mind), would also have the highest level of activation, or at least would have crossed its activation threshold first. Gordon & Shapiro, (2012), proposed that associative priming would decrease misinformation effects by raising the activation level of originally learned information above threshold, thus making it the memory item with the highest retrieval fluency. This increased fluency would then lead subjects to answer with the most fluently recalled item in an effect known as accessibility bias, (Lustig et al., 2004; Jacoby, 1999). The results concurrent with our hypotheses that associative priming towards originally learned information would boost participants' recall accuracy. However, the fact that participants' recall accuracy was not inhibited by priming towards interfering targets could be viewed as contradictory to retrieval-fluency and accessibility bias, but as I stated in the experiment 2 discussion, additional analysis concerning the rates at which participants provide the interfering target at recall would help us take a more definitive stance on these related theories.

By measuring the rates at which participants provide interfering targets as responses, a significant difference in these measurements or lack thereof could have concrete implications in regards to retrieval fluency and accessibility bias. If participants who receive an interfering-prime on inconsistent trials produced the interfering target more often than in other prime conditions then this would provide support for Jacoby's theory of accessibility bias, and would provide data that was analogous with the results of his 1999 study. On the other hand, if a difference is not found between prime-types in regards to production of interfering targets, then it would imply that another mechanism such as source monitoring, (also known as source discrimination), should be considered as possible alternatives to accessibility bias.

Source monitoring, (Lindsay & Johnson, 1987), states that the misinformation effect occurs when recall conditions cause participants to remember information from the incorrect source. According to source monitoring, if participants are encouraged in some way to inspect the source of their decision, then there would be a reduction in the misinformation effect provided that the original source information can be accessed. In experiment 2 we hypothesized the possibility that associative priming towards either target would boost participants' recall accuracy. The logic behind this was that by increasing a target's activation level, this activation would propagate backwards to the cue, and assuming that the cue is associated with both targets, would spur participants to examine the source of both possible targets and be able to select the target associated with the cue in the first study phase. In fact, Bower & Mann, (1992), found that by providing a cue to help participants distinguish interfering information reduced interference effects. They argued that the cue's relation to features exclusive to interfering information allowed participants to 'reorganize' this information, effectively segregating originally learned and interfering information. In the case of this study, however, participants would not be aware of which study phase the prime was related to, and so any source monitoring would occur due to spreading activation. However, the data from experiment 2 failed to support this hypothesis, but this finding could be explained, in part, through Martin's theory of VSE.

As I had outlined previously, VSE is based on the assumption that different memory items cannot be associated to an identical retrieval cue. In this view, the two cues would not be associated with each other, but instead would be associated with the target learned with each cue in that cue's study phase. In this case it is possible that, via spreading activation, interfering-primes would be bringing the interfering target to mind, but the fact that the target is associated with the cue from the second study phase may be causing participants to reject the target which

comes to mind. This rejection, combined with the fact that the original target exists in association with an unrelated cue from the first study phase would mean that while participants are able to reject the target that comes to mind, they are not able to remember the target from the first study phase. In other words, associative priming of the interfering target would spread activation from the prime to the target, and from the target to its associated cue, but because this cue is unassociated with the other cue, that activation would fail to spread to the original target. This would be concurrent with the results of experiment 2 which failed to show a significant difference between the no-prime, interfering, and neutral prime-types on inconsistent trials.

VSE contradicts the notion proposed by McGeoch, (1936, 1942), that interference is caused by multiple memory items sharing an identical retrieval cue. Although VSE seems like a likely candidate for the results in experiment 2, these results are not contradictory to McGeoch's theory. One can imagine activation levels of a given target as the probability of recall. If we take this view then it is possible that priming is indeed spreading activation to its associated target, and from there to a common cue shared by both targets. In interfering-prime trials it is possible then, that the interfering target would not only be receiving activation from the prime itself, but from the reactivation of the cue as well, whereas the original target would only be receive activation from reactivation of the cue. If participants did indeed provide interfering targets at a higher rate when provided with an interfering-prime then this would provide evidence that the interfering target was receiving more activation from its associated prime. McGeoch's proposal and VSE could then be further dissociated by changing the nature of the memory test from a forced-cued recall task to a modified modified free recall, (MMFR), test. In an MMFR, participants are instructed to provide any target that they think is related to the provided cue. In the case of interfering targets sharing an identical retrieval cue we would expect priming of both

original and interfering information to improve odds of recalling both possible targets when compared to neutral or no-prime conditions. However, in the case of VSE we would expect priming to only increase recall of the target which is directly associated with the provided prime-word.

Due to the somewhat limited data collected from our experiments, it is impossible to say that the results provide definitive support for the theories outlined above. The study does provide support against altered trace theories of retroactive interference such as the destructive-updating hypothesis, (Loftus et al., 1985), and the unlearning hypothesis, (Melton & Irwin, 1940), both of which depend on the alteration of the original memory trace in retroactive interference, with the destructive-updating hypothesis making the stronger claim that interfering information actually overwrites originally learned information rendering it inaccessible. This study clearly provides evidence against trace alteration, and is consistent with many other studies showing that interference can be reduced given proper cueing, or a modified recall test, (Bowman & Zaragoza, 1989).

In essence, although only one of our hypotheses, (that associatively priming for originally learned material would benefit participants' memory of that information), was supported, the fact that this hypothesis was supported provides insights into potential causes of interference as well as participants' decision making processes at recall. Furthermore, this study provides a solid foundation for future studies and post-hoc analysis which could provide definitive support for existing theories of retroactive interference. Since interference, and especially the misinformation effect, has far reaching implications in important real-life scenarios such as eye-witness memory, (Eakin, Schreiber, et al., 2003; Zaragoza & Belli, 2006; Roebers& Schneider, 2000), the importance of such research is clear. By performing follow-up experiments

concerning the effect of priming on interference effects, (such as those outlined in the discussion of experiment 2), we should not only be able to more fully understand the cognitive processes that lead to interference, but also better understand how we can reduce or eliminate interference effects, making the memories that we need to recall more robust, and well, more memorable.

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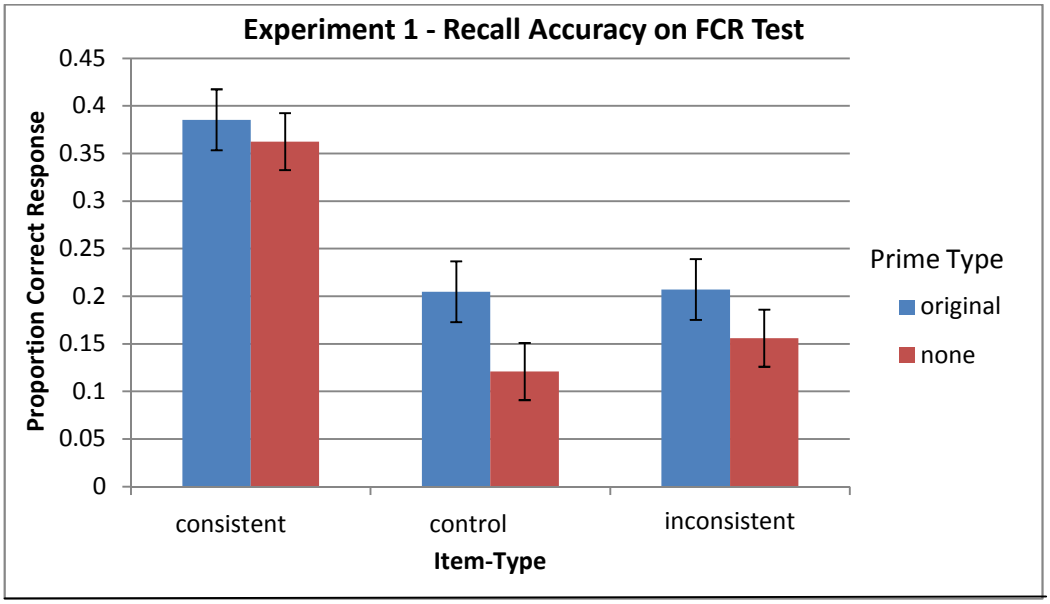
**Table 1**

*The Effects of Prime-Type on Participants' Recall Accuracy – Experiment 1*

| | **Consistent** | **Control** | **Inconsistent** |
|---|---|---|---|
| **Original-Prime** | .385 | .205 | .207 |
| **No-Prime** | .362 | .121 | .156 |

Note. n = 58. Values represent participants' mean proportion of correct answers on the forced-cued recall task. A main effect of item-type, ($F(2, 114) = 58.94$, $MSE = 1.584$, $p < .001$) and prime-type, ($F(1, 57) = 5.816$, $MSE = .241$, $p = .019$), was found.

**Figure 1**



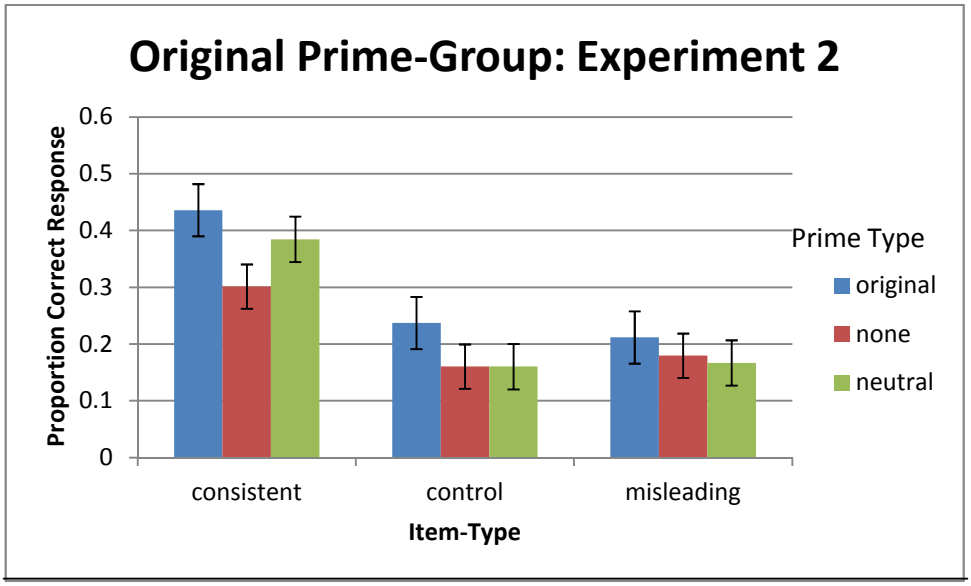

Note. This graph represents the values presented in table 1.

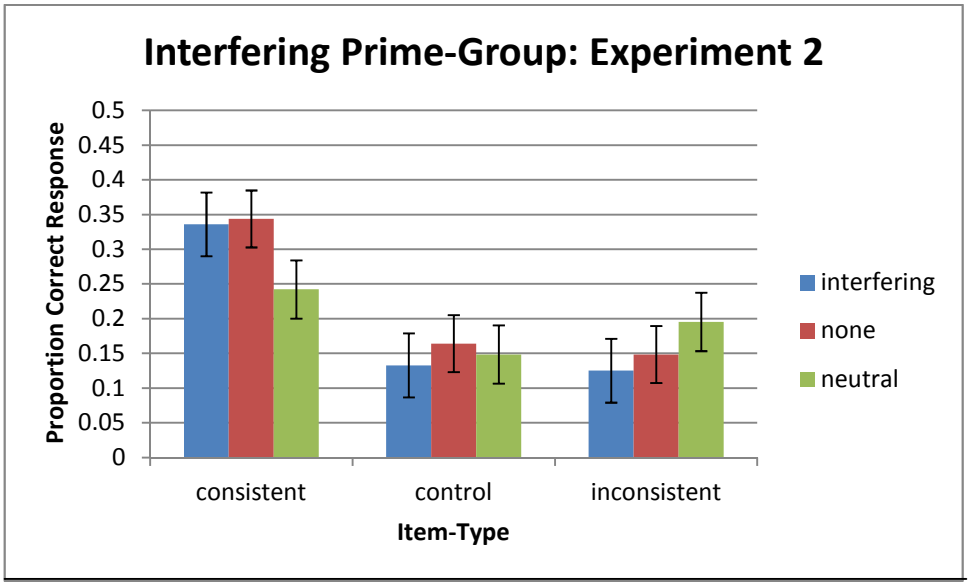
**Table 2**

| | **Consistent** | **Control** | **Inconsistent** |
|---|---|---|---|
| **Original-Prime** | .435 | .237 | .212 |
| **No-Prime** | .301 | .160 | .179 |
| **Neutral-Prime** | .384 | .160 | .167 |
| **Interfering-Prime** | .336 | .132 | .125 |
| **No-Prime** | .343 | .164 | .148 |
| **Neutral-Prime** | .242 | .148 | .195 |

Note. Values in rows 1-3 represent the mean proportion of correct responses on the forced-cued recall task in the 'original' prime-group, for this group n = 39. Values in rows 4-6 represent the mean proportion of correct responses on the forced-cued recall task in the 'interfering' prime-group, for this group n = 32. As stated in results, no statistically significant data was drawn from the holistic analysis of this data.

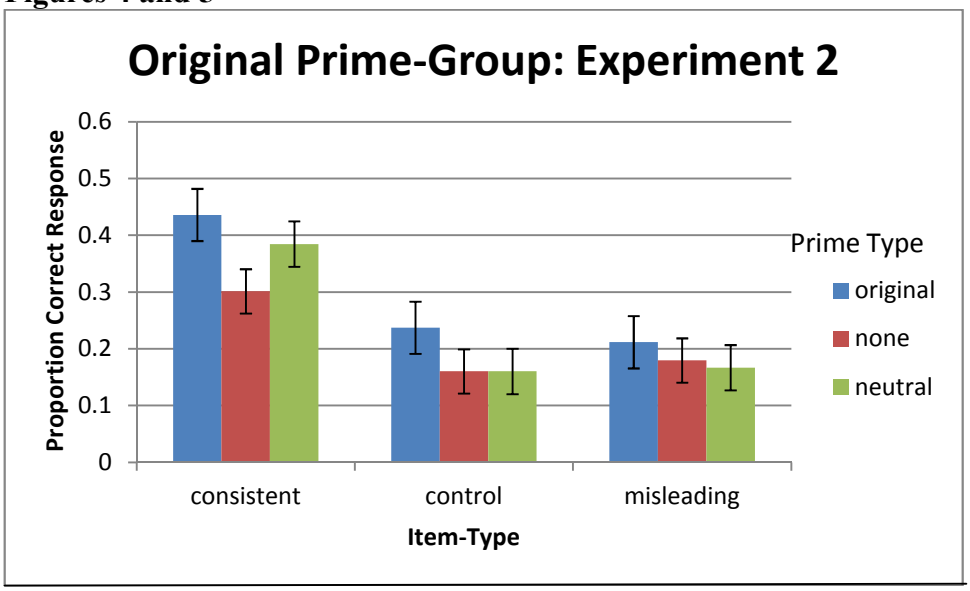
**Figures 2 and 3**

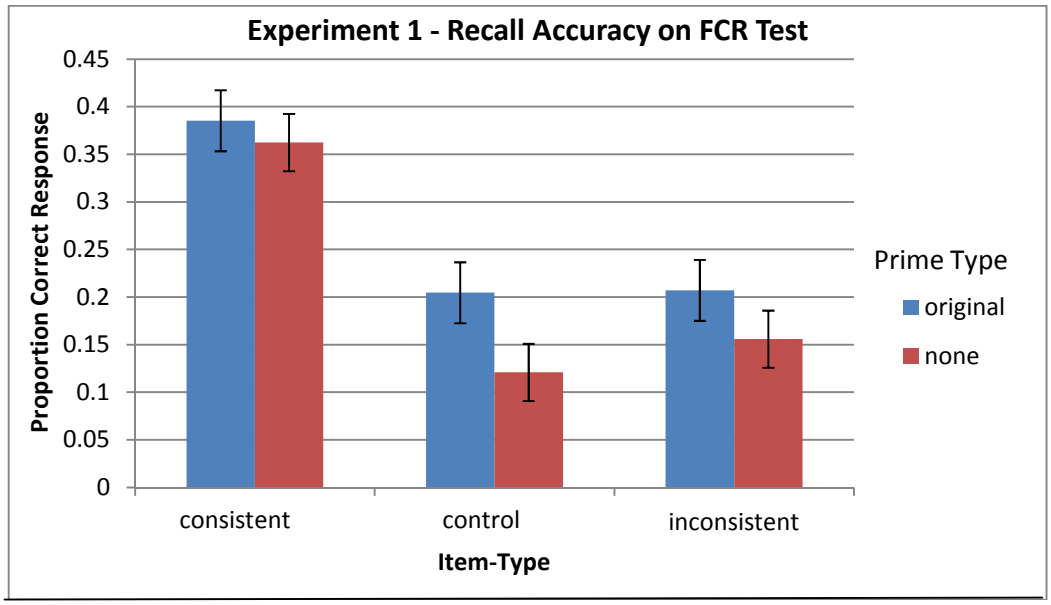



Note. Values in figure 2 represent the mean proportion of correct responses on the forced-cued recall task in the 'original' prime-group, for this group n = 39. Values in rows figure 3 represent the mean proportion of correct responses on the forced-cued recall task in the 'interfering' prime-group, for this group n = 32. Refer to Table 2 for exact values.

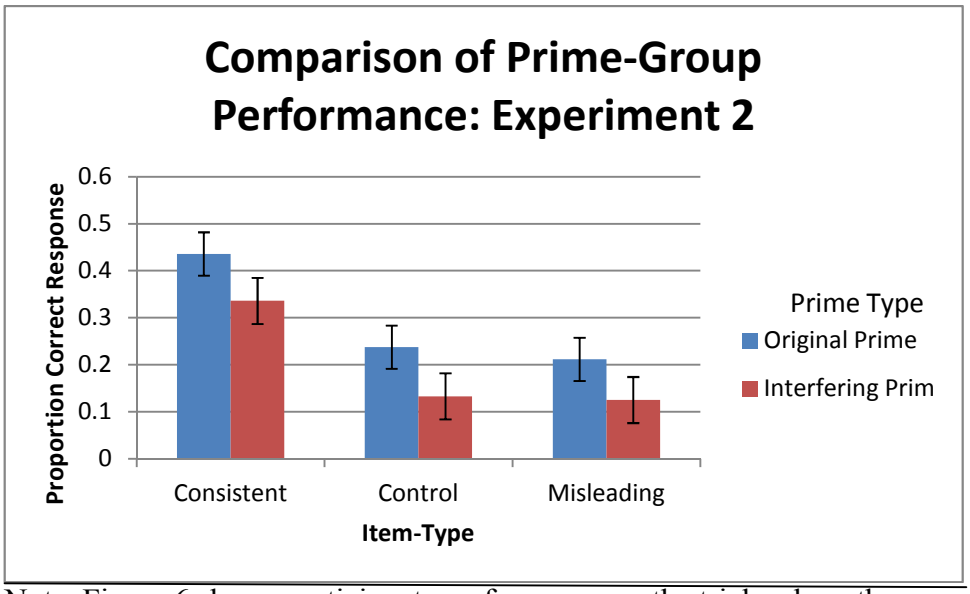
**Figures 4 and 5**




Note. Figure 4 refers to the original prime-group's overall recall accuracy in the forced-cued recall test. Notice the main effect of the true original prime across item types, ($F(2,76) = 5.833$, $MSE = .204$, $p = .005$). Figure 5 represents participants' overall recall accuracy in the forced-cued recall task in experiment 1. Notice that the effect of priming towards originally learned information is consistent across experiments.

**Figure 6**




Note. Figure 6 shows participants performance on the trials where they received either an original-prime or interfering-prime. This between subjects measurement was meant to ensure that the original prime was, in fact, helping more than the interfering one. Although differences are not statistically significant, they are trending towards significance.

**Table 3**

| Cue | Target 1 | Target 2 | Original-Prime | Interfering-Prime | Neutral-Prime | Original-Prime → Target 1 FAS | Original-Prime → Target 2 FAS |
|---|---|---|---|---|---|---|---|
| illegal | subtract | caring | add | loving | bagel | 0.68 | 0.49 |
| temple | couch | girl | sofa | boy | helpful | 0.5 | 0.7 |
| muffin | rage | elephant | anger | tusk | boring | 0.55 | 0.66 |
| marble | seller | leg | buyer | arm | mountain | 0.57 | 0.67 |
| lighter | nun | rain | convent | umbrella | brick | 0.74 | 0.7 |

Note. Unless listed, associative strengths between words are 0.