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The Relationship Between Implicit and Explicit Memory in Negative and Positive Priming

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The Relationship Between Implicit and Explicit Memory in Negative and Positive Priming

A Dissertation submitted in partial satisfaction
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by

Elizabeth Ellen Melton

December 2011

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Acknowledgments

As George Burton Adams once said, “There is no such thing as a 'self-made' man. We are made up of thousands of others. Everyone who has ever done a kind deed for us, or spoken one word of encouragement to us, has entered into the make-up of our character and of our thoughts, as well as our success.”

Of these thousands, I must thank a special handful who have contributed to the completion of this work and my past and future successes.

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ABSTRACT OF THE DISSERTATION

The Relationship Between Implicit and Explicit Memory
in Negative and Positive Priming

by

Elizabeth Ellen Melton

Doctor of Philosophy, Graduate Program in Psychology
University of California, Riverside, December 2011
Dr. Michael A. Erickson, Co-Chairperson
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Two classes of theories of priming are ones that posit that negative priming follows from Logan's (1988) instance theory of automaticity, and ones that posit ideas of inhibition (Houghton & Tipper, 1994; Neill, 1977; Tipper & Cranston, 1985). One prediction of Logan's theory is that negative priming should be positively related to recognition. The present experiments aimed to investigate the relationship between implicit and explicit memory in negative and positive priming using a hybrid methodology following from work done by Turk-Browne, Yi, and Chun (2006) and Grison, Tipper, and Hewitt (2005). Turk-Browne et al. examined positive priming and BOLD responses to images as a function of later recognition and found greater positive priming for items later classified as old than for ones classified as new. Grison et al. examined priming using a task requiring participants to classify the gender of faces and animacy of objects. Negative priming was not consistently elicited in Ignore-Attend sequences of the current studies, and as such no conclusions can be drawn regarding the explanations of negative priming.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

Visual searches are made when searching for a friend in a crowd or when people scour the pages of a book for Waldo. These searches involve scanning through relevant and irrelevant visual information. During this scanning, items are either attended to or not attended to. This may likewise lead to responding to or not responding to an item. It would help speed the search process if these decisions could be made just once. If memory could somehow play a role in the search process by marking items to be attended versus items to be ignored, the search could focus on unscanned areas of the visual scene.

Evidence of a phenomenon known as *negative priming* has shown that this is exactly what happens in visual search. When people do not respond to an item on one trial, but are later required to respond to that same item, the responses tend to be slower and less accurate. This seems to be due to the fact that some mechanism serves to prevent the same item or location from being attended to after a decision has been made to ignore it. This is beneficial to visual search when a person chooses consciously or unconsciously to not attend to a particular stimulus. When this occurs, it makes the person less likely to return to the same stimulus or location. Once they have chosen to attend or not attend to an item, the overall search process is faster because the same "do not attend" decision does not need to be made repeatedly.

In an experimental investigation of this phenomenon, participants are presented with two or more stimuli and their job is to respond to one of them. The presentation of these initial stimuli is referred to as the *prime trial*. The stimulus that is responded to is the target and is defined by some attribute such as color, value, or shape. The distractor is the item that is not responded to on the prime trial. In a later trial, known as the *probe trial*, the participants are required to attend to the stimulus that they previously did not respond to. For example, the participants may be cued to report the letter with the dash beside it. Two letters are then presented such as D and F, D having the dash beside it. In this case, the participants report the letter D, the *target,* and they would not respond to the letter F, the *distractor*. In the subsequent probe trial, the critical letter F would be presented with another letter that does not have the dash beside it. In this probe trial, F is no longer the distractor; it is now the target. The item that was ignored on the prime trial and responded to on the probe trial is known as the *critical item*. On these kinds of probe trials, participants tend to be slower or less accurate in making their responses compared to control trials, a phenomenon known as *negative priming* (Tipper, 1985).

To understand the phenomenon of negative priming, attention to the distractor must be assessed. To what level is it processed? Is the distractor processed to a level that it can later be explicitly recognized? Is it recognized when presented as the target, or is its representation inhibited? If it is recognized, what is retrieved from memory? Priming, interference, working memory (inhibitory control), and recognition memory are all measures that can be used to assess processing of the distractor.

1.1 Theories of Priming

In this dissertation three explanations that have been proposed to account for the phenomenon of negative priming are discussed. These explanations include inhibitory theories, associative theories, and hybrid associative/inhibitory theories.

Inhibitory Theories of Negative Priming

One explanation is an inhibitory account, which has taken two different formulations. The first formulation holds that when a stimulus is not responded to on prime trials, the activation of the cognitive representation is suppressed below its baseline level (Neill, 1979). Therefore, at the start of the probe trial, it takes time for the activation of the cognitive representation of the critical item to reach a response threshold. In other words, there is residual inhibition of the internal representation. The length of time that it takes for this to occur is longer than that for the representation of a control item that has not previously been ignored. This yields responses that are either slower or less accurate on probe trials compared to control trials.

This can be seen in *Figure 1.1*. This figure charts the activation of a critical item during a priming sequence. The Y-axis represents time, from the start of the prime trial to the end of the probe trial. At this point the participant is ignoring the critical item, and thus the activation of the critical item is suppressed below the baseline level. At the end of the prime trial the participant makes a response and the RSI (Response to Stimulus Interval) begins. The RSI is the interval between the time at which the participant makes a response and the time at which the probe trial is presented. During this RSI, the activation of the critical item begins to approach baseline. At the start of the probe trial the participant must make a response, but because the activation level is starting below baseline, it will take longer for it to reach the threshold. For a control trial, on the other hand, the activation level begins at baseline and thus takes less time to reach threshold. The difference in the response times of the control and critical item is measured as negative priming.

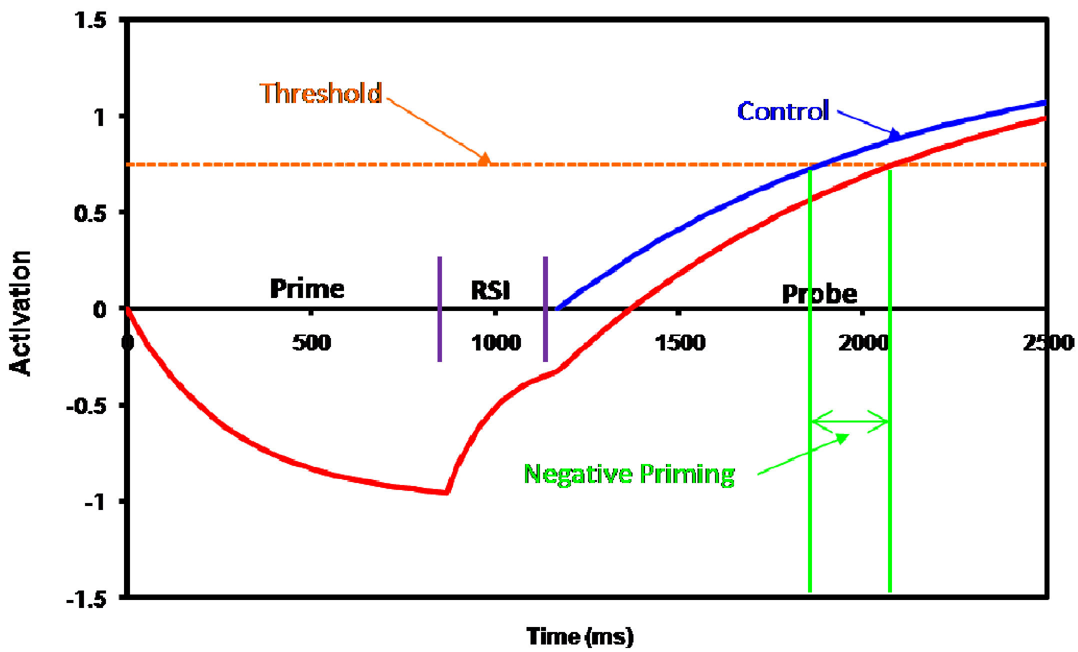

Figure 1.1. Activation level of the control and critical item across the time course of prime and probe trials.

The present conceptualization of the inhibitory account of negative priming was developed to explain the presence of positive priming in instances that lack response competition on the probe trial (Tipper & Cranston, 1985). This occurs when a traditional prime trial with a target and distractor is presented, followed by a probe trial that has only the prime-distractor (critical item) present. With only the critical item present, there is no response competition, and positive rather than negative priming is elicited. This conceptualization claims that the representation of the ignored information (critical item) remains active, and that what is blocked is the link between the activated cognitive representation and the response mechanism. According to Tipper and Cranston (1985), inhibition will continue for as long as a selection state is maintained (ie. in the presence of competing stimuli).

Houghton and Tipper (1994) specified a neural network model of inhibitory mechanisms in selective attention. This model argues for a dual mechanism of selection with both excitatory and inhibitory mechanisms that work independently and in parallel to activate the representation of the target and to inhibit the representation of the distractor. It proposes that internal representations of the target and distractor will be activated by the excitatory system when presented. The internal representation of the distractor is suppressed by the inhibitory system in order for successful selection of the target to take place. At this point, an internal template is developed to which perceptual inputs are compared. This template includes stimulus features that specify the target to be acted upon. This causes the activation level of the target to be more highly activated than the distractor. The excitatory influence on the internal representations of the target and distractor ceases when the external stimuli are removed. Though the excitatory influence ceases, the inhibitory mechanism continues to operate on the internal representation of the distractor that results in pushing its activation level below its resting level. If a distractor is subsequently presented as a target with another distractor, selection of this as a target will be impaired relative to a control stimulus, resulting in negative priming.

When examining processing of the distractor, one important factor to consider is if it is processed to a level that it can later be explicitly recognized. If inhibition operates in a successful manner and suppresses the activation of the critical item before the start of the probe trial, then in addition to this item producing negative priming, it would be expected that this item would not be retrieved or recognized later. If, on the other hand, inhibition does not serve to suppress the activation of the critical item, then negative priming would not be expected. A key prediction of the model that will be tested is whether or not the item's activation was suppressed. If the item's activation was not suppressed, it would be expected that this item would be retrieved or recognized later, as it received excitation as opposed to inhibition.

Associative Theory of Negative Priming

A second explanation of negative priming is an attentional association account (Erickson & Reder, 1998; Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992). This account proposes that associations are made between stimuli and their responses. These associations may be internal attentional responses that are not necessarily observable. They form episodes that are retrieved when the object reappears at a later time. If the retrieved episode is one of ignoring the stimulus when the participant is required to attend to it, then the response may be slower or less accurate.

This explanation is based on Logan's (1988) instance theory of automaticity. According to this account, when a target stimulus appears, it signals the retrieval of prior instances from memory that involve the same stimulus and contain information about the response that was executed. Therefore, if the retrieved instance matches the correct attentional response on the current trial, then processing should be facilitated. If it does not match, for example, if the retrieved instance is associated with a do- not- respond response when the item should now be attended, then processing should be slowed. When these mismatched instances that are associated with the stimuli are retrieved, this can cause negative priming, specifically long-term negative priming. This theory predicts that attending to or ignoring an item should facilitate further attention or inattention, respectively. If an item is seen as a distractor and then seen later as the target on a probe trial, the participant should be slower or less accurate compared to control trials because the stored instances have been associated with a do–not-respond response. Thus, negative priming occurs when inappropriate, rather than appropriate, response information is contained in the retrieved episode (Neill & Valdes, 1992). Episodic retrieval acts in a backward direction; the stimulus on the test display invokes the retrieval of a previous episode with that item (Kane et al., 1997).

According to this associative account, as distractor activation increases this causes the distractor to have a better chance of being encoded, however, a consequence of this is that interference also increases. This better distractor encoding leads more readily to a do-not-respond tag during retrieval, thus producing greater negative priming than for an episode without interference. As this theory draws on retrieval from memory, it would be expected that if negative priming is elicited on the probe trial, that the critical item would be retrieved or recognized later. This differs from the inhibitory account, as inhibition acts to suppress activation of the critical item such that it will be less likely to be retrieved or recognized later. Likewise, if negative priming is not elicited, then it can be expected that the critical item and its “ignore me” tag were not stored, and would thus not be retrieved or recognized.

Hybrid Associative/Inhibitory Theory of Negative Priming

The final explanation is a hybrid of the associative and inhibitory accounts, episodic retrieval of inhibitory processes, proposed by Grison, Tipper, and Hewitt (2005) and based upon Houghton and Tipper’s neural network model of inhibition (1994; Houghton et al., 1996). A full description of the theory will follow an explanation of the methodology and findings of Grison et al., as their findings led to the development of the theory.

Grison et al. investigated the existence of long-term negative priming, as its existence could indicate that task-irrelevant information (distractor) leaves a memory trace that impacts performance over time. DeSchepper and Treisman (1996; Treisman & DeSchepper, 1995) found evidence of long-term negative priming with random, closed, hand-drawn shapes as stimuli. DeSchepper and Treisman utilized a same-different judgment, as no prelearned naming responses were available. Participants were to decide on each trial whether the green shape in an overlapped pair exactly matched a white shape presented to the right of the pair. While making this decision, participants were to ignore the red shape in the overlapped pair. The unattended red shape in one pair became the attended green shape in the next pair on half of the trials. When pooling the data from seven experiments with a delay of 24 hours, 70% of participants had priming greater than zero. Some participants showed consistent facilitation rather than inhibition. Though DeSchepper and Treisman demonstrated the existence of long-term negative priming, Grison et al. aimed to further explore the processes that might elicit long-term negative priming and whether the effect extends to different stimuli.

Grison et al. explored the existence of long-term negative priming utilizing a three-item flanker task of color photographs of faces or objects. In their Experiment 1, displays presented either three faces or three objects, alternating photograph category every other trial. On each trial, the center photograph appeared 100 ms before the flankers. On prime trials, participants were to report whether the photographs on the left and right (flankers) were either male or female, or living or non-living. If the category of the flanker photographs did not match (ie. one male photograph and one female) a response was to be withheld. Trials with flankers that did not match were catch trials and served to ensure that both flankers were analyzed on prime trials. On probe displays, the stimuli were either all three stimuli repeated from the prime display (ignored-repetition plus) or three photographs that had not been previously seen (control). In the ignored-repetition plus condition, the photographs that were targets on the prime trial became distractors on the probe trial, and the photograph that was the distractor on the prime trial became the probe target. The photograph that was to be responded to on the probe trial differed from the photographs that were to be responded to on the prime trial. Participants were to respond on every probe display to the middle target and to ignore the flanking distractors.

Prime and probe trials were blocked, with participants first completing 56 prime displays over three minutes before receiving the related probe trials. Utilizing this methodology, Grison et al. sought to encourage deeper analysis of all stimuli to allow the correct categorical response (MacDonald et al., 1999; Yee, Santoro, Grey, & Woog, 2000). They further sought to provide more time for analysis of the distractor, increasing the opportunity to encode the photograph into memory (Milliken et al., 1998).

Results of Grison et al.'s Experiment 1 indicated that participants responded slower on the probe trial compared to the control trial to a target that was previously a distractor. Participants exhibited negative priming to items that had been distractors three minutes and 56 displays earlier. These results replicate DeSchepper and Treisman's (1996; Treisman & DeSchepper, 1995) findings of long-term negative priming. They furthermore provide evidence that memory processes must mediate long-term negative priming, as it is implausible that on-line processing of information could endure for such a long period and over continued processing of intervening trials.

Grison et al. modified their methodology to further explore the phenomenon of long-term negative priming and to determine if the presence of negative priming was due to episodic retrieval of information associated with the prime targets. The ignored-repetition plus condition was replaced for half of the participants with a traditional ignored-repetition condition with two new stimuli as probe distractors. This methodological change was implemented to examine what episodic information was retrieved on the probe trial. They reasoned that if the Experiment 1 results were due to episodic retrieval of information associated with the prime distractor when it was shown as a probe target, then this condition should yield long-term negative priming like the ignored-repetition plus condition. If, however, the long-term negative priming in Experiment 1 was due to episodic retrieval of information associated with the prime targets when they were shown as probe distractors, then this new condition should not result in negative priming because the probe distractors are new items.

Results of Grison et al.'s Experiment 2 provided additional support for the existence of long-term negative priming. Response times were slower on ignored repetition and attend-ignore trials compared to control trials. The fact that the negative priming effect was so robust in the ignored repetition condition suggests that retrieval of information that is associated with the prime-distractor may be what drives the long-term behavioral response. The results from Experiment 1 and Experiment 2 suggest that memory processes were engaged in the task, as on-line processing of prime information could not have lasted for the three minutes while processing of 56 intervening trials continued without affecting performance. They furthermore claim that these memory processes retrieved one specific instance of the irrelevant information from memory, specifically a prior inhibitory state (Tipper, 2001).

This retrieval from memory of a prior inhibitory state is at the heart of the theory proposed by Grison et al. Their theory requires that the Houghton and Tipper (1994) neural network model of inhibition be updated. Houghton and Tipper's model represents inhibition as neural activity rather than the absence of neural activity. Grison et al. suggest that the process of inhibition may be stored in memory and at later retrieval impact behavior. To implement this storage and subsequent retrieval into Houghton and

Tipper's model, Grison et al. suggest updating Houghton and Tipper's model to allow information associated with the prime targets and distractor to be encoded into a memory subnetwork. Then, even after inhibition decays, the inhibition that is associated with the distractor can still be a part of what is stored in episodic memory.

Levels of Selection on the Prime Trial

To explain the phenomenon of negative priming, it is necessary to determine the stage at which the distractor is processed on the prime trial. Early selection theories (e.g. Broadbent, 1958) propose that analysis for meaning or identification of an object is of limited capacity because only low-level physical features of objects are encoded in parallel, and thus objects are not recognized unless they receive focal attention. If a response is made on the prime trial in the absence of semantic processing of the distractors, then no negative priming would be expected on a subsequent probe trial (Yantis & Johnson, 1990; Paquet & Lortie, 1990).

Middle selection theories (ie. Treisman, 1960; 1964) operate in a similar manner to early selection theories, but allow some additional information in. An attentional filter is symbolic of the location of selection to attention. According to Broadbent (1957), the information that enters working memory is controlled by the filter and only enters from one channel at a time. Unattended information makes it past the attentional filter, but more weakly than attended information. If a response is made on the prime trial and unattended information makes it past the attentional filter, then negative priming would be possible on a subsequent probe trial.

Late selection theories (e.g. Deutsch & Deutsch, 1963), however, propose that recognizing well-learned stimuli is automatic and independent of attention, and that attentional selection is post-categorical. If, however, a response is made on the prime trial and distracting information is identified in parallel with target information, then negative priming would be expected on a subsequent probe trial.

Each of these selection theories will be discussed further in detail when predictions for the episodic and inhibitory theories are made based upon the level of selection of the distractor on the prime trial in Section 1.5 of this chapter.

1.2 Interference and Negative Priming

One way to explore the nature of processes responsible for negative priming and to assess the degree to which the distractor is processed is to manipulate the degree of interference. According to Eriksen and Eriksen (1974), *interference* is indicated in the prime display by longer reaction times in trials that contain targets and distractors that do not match relative to trials with targets and distractors that do match. The degree to which the distractor is processed on the prime trial ultimately affects how it is responded to as the probe target. Depending on the processes involved, the manipulation of the degree of interference should affect the degree of negative priming. The degree to which processing of the target and distractor is interfered with has been manipulated using such methods as pre-cueing (Fox, 1995; Richards, 1999), counting tasks (Driver & Tipper, 1989), masking (Tipper, 2001), onset times (Houghton et al., 1996), and stimulus location frequency (Reder, Weber, Shang, and Vanyukov, 2003).

Reder et al. (2003) manipulated distractor location using either a frequent-distractor location or a rare-distractor location to affect the degree to which the distractor influenced performance. Interference from the frequent-distractor location was reduced a great deal compared to the rare-distractor location, and negative priming was smaller when targets followed distractors in frequent-distractor locations. Thus, they demonstrated a positive relationship between negative priming and interference. This finding is consistent with their hypothesis that these stimulus locations are less likely to be chosen first for identification, and were therefore less likely to compete for attention. A competition occurs between the two stimuli once detected. If the distractor location is inspected first, then attention to that location is inhibited making inspection of the location less likely in the future. The reduction in interference from distractors positioned in the frequent-distractor location comes from the assumption that the system in fact detects a stimulus in two locations, but selects one to inspect first. It furthermore assumes that the system selects the stimulus that, based on past experience within the experiment, is less likely to be a distractor. Reder et al. argue that interference should be greatest in the rare-distractor location because this location tends to be inspected most frequently due to its having a target present most often. This would lead to increased interference, and thus increased negative priming.

Fox (1995) used pre-cueing to investigate whether negative priming is due to early or late selection. Fox examined these theories by testing to determine if negative priming is obtained when attention is focused on the location of the forthcoming target in a prime display. Fox utilized Eriksen and Eriksen's (1974) definition of interference to describe the degree to which the distractor is processed on the prime trial and how this ultimately affects how it is responded to on the probe trial. When the prime target is pre-cued sufficiently to eliminate interference, then the distractor is not processed enough to influence the response. If this is due to early selection and the absence of semantic processing of the distractors, then no negative priming should occur on a subsequent probe trial (Yantis & Johnson, 1990; Paquet & Lortie, 1990). If, on the other hand, distracting information is identified in parallel with target information, as occurs in late selection accounts, and the absence of interference effects is a result of successful inhibition, then on a subsequent probe display negative priming should be observed.

To examine the effects of pre-cueing on interference and negative priming, Fox completed three experiments using a version of the Eriksen flanker task, because it has been established that distracting letters produce interference (Eriksen & Eriksen, 1974; Eriksen, Coles, Morris, and O'Hara, 1985; Miller, 1991) and negative priming (Fox, 1994; Miller, 1991) in a later probe trial. Participants were presented with prime-probe pairs of letters. All pairs of letters were combinations of the letters A, B, C, or D and the target letter was indicated by a dash. Participants were to respond by reporting the letter with the dash beside it. On the prime trial, the target location was pre-cued for half of the blocks (with an asterisk at the to-be target location) and uncued, also referred to as both-cued, for half (with an asterisk at both the target and distractor location). Based upon this methodology, any benefit in performance in the cued condition can be attributed to attention being focused on the pre-cued target location.

Two types of trials were utilized in the design of the experiment. Response-compatible trials were those in which the target and distractor letters were the same (e.g. D D–), while response incompatible trials were those in which the target and distractor letters were different (e.g. –A B). The interference effect was assessed by comparing response-compatible trials with response-incompatible trials. Interference was indicated by longer reaction times in the response-incompatible trials. The control condition included probe trials following response-incompatible prime trials that contained target and distractor letters that were both different from the prime display (e.g. –A C followed by D B–). In the Ignore-Attend condition, the distractor in the prime display had the same shape as the target in the following probe display (e.g. –B A followed by C A–). Negative priming was determined by comparing control and ignored-repetition (IR) trials in the probe display. The only difference between the three experiments was that Experiment 3 altered the uncued condition to correct for possible forward masking in Experiments 1 and 2. Instead of both locations being cued for the uncued condition, the fixation asterisk was replaced by a centrally presented plus sign.

The results of Fox's Experiment 1 and Experiment 2 indicated that reliably pre-cueing the critical item (target) on the prime trial significantly reduced the magnitude of interference from response-incompatible distractors with the prime displays. Though interference was reduced, negative priming did not decrease in magnitude when the prime target was pre-cued, and in fact it significantly increased. One explanation that Fox provides for this unexpected finding is the possibility that the cueing manipulation may have inadvertently manipulated forward masking of the distractors in the both-cued condition instead of more efficient isolation of the items to be inhibited. In the both cued condition, the target and the distractor were both immediately preceded by an asterisk which may lead to forward masking. As masking of distractors can reduce the magnitude of negative priming (Neill et al., 1995), the increase in negative priming in the validly cued condition may have resulted from less masking of the distractor as the target was cued which eliminated the preceding asterisk in the distractor's position.

Experiment 3 altered the cueing manipulation in the both cued condition so that a plus sign replaced the centrally located fixation point and did not cue either the target or distractor location. The results of the experiment indicated that there was an absence of an interaction between pre-cuing and negative priming unlike in the other two experiments, which suggests that forward masking may have been an artifact previously. When this possibility was removed by altering the pre-cuing method, negative priming no longer increased in the cued condition relative to the uncued one. Reduced distractor interference did not result from less semantic processing of ignored objects, as shown by increases in selection efficiency. A decrease in distractor processing with pre-cued targets should have lead to a decrease in negative priming, but that was not found. The interference from incompatible distractors was virtually eliminated while the magnitude of negative priming from the same distractors did not show a corresponding decline when the prime target was pre-cued. The lack of interference effects in combination with stable negative priming leads to the conclusion that distractors were identified in the task even though an ample focusing of attention prevented the distractors from producing significant interference. This provides evidence for the late selection mechanism of selective attention, such that the distractors in the pre-cued condition were processed post-categorically as shown by the negative priming effect in the probe display.

On the other hand, the possibility that distractor processing was delayed rather than completely prevented is consistent with a modified early selection interpretation. It is possible that the distractor was processed semantically only after the target had been successfully selected. From the perspective of early selection, according to Driver and Tipper (1989), it may be argued that the contrast between priming and interference arises because the selective processes are implemented at different points in time, rather than them measuring different aspects of the processes. It is a possibility that noninterfering distractors are processed more slowly than interfering distractors. It may be expected that there would no interference effect if the distractors are only identified after response to the target has been completed. These distractors can still produce negative priming, however, as their delayed identification may be complete before the probe is presented. Rather than being completely filtered out as a traditional early selection view would predict, this modification claims that noninterfering distractors are now identified after a delay. This is in opposition to middle selection theories such that they claim that some additional information leaks past the attentional filter to be processed to a weaker degree, not that there is a delay in processing.

1.3 Working Memory Capacity and Negative Priming

Working memory capacity has been shown to be a valid predictor of attentional control capability that is critical in a range of cognitive contexts involving interference, long-term memory retrieval, language comprehension, and reasoning (Kane, Bleckley, Conway, & Engle, 2001). Kane and Engle's (2003) error interference findings suggest that working memory capabilities constrain attentional inhibition, or at least the constancy of its application. In the face of interference, the critical function of working memory capacity is information maintenance, so the attention-control capabilities involved in interference resistance can be used to understand the correlation between working memory capacity and complex cognition (Conway & Engle, 1994; Hasher & Zacks, 1988; Kane & Engle, 2000; Rosen & Engle; 1998).

Conway and Engle (1994) used a recognition task to examine the effects of working memory capacities on interference. Working memory capacity was measured using an operation-word span task. This task required participants to remember words while solving simple mathematical operations. For example, the participant would be presented with the following display: (8/4) + 2 = 4 BIRD. The goal of the participants was to say aloud "yes" or "no" if the answer to the operation was accurate, followed by reading aloud the word presented after the operation. Two to six of these trials appeared in a row followed by the presentation of a question mark that indicated to the participants that they were to recall, in order, all of the words that had been presented in the previous series of trials. The working memory span of the participants was calculated by summing the correctly recalled words for only those trials that were recalled in the correct order.

Twenty high- and 20 low-span participants learned various-sized sets of items and then were to perform a speeded recognition task of the items in those sets. High-span participants were classified as those with a span score of 20 or higher, while low-span participants were classified as those with a span score of 12 or lower. The task required participants to memorize four sets of letters that consisted of 2, 4, 6, and 8 letters. These letters were all consonants, excluding the letter “Y”. For example, for a 2-letter set-size, participants might need to memorize the two letters “Q” and “Z”. The items in the sets were either unique to their set or overlapped with another set. In other words, a letter could be present in two set-sizes.

In the speeded recognition test, participants were provided with a number on the top of the screen and a letter on the bottom of the screen. Participants were to indicate if the letter provided was a member of the set-size indicated by the number. For example, if a participant was presented with the number 8 and the letter “P”, if “P” was in the 8-letter set, then the participant would say “Yes” aloud. Letters that were members of two set-sizes would result in interference compared to letters that were members of one set-size, and lead to slower or less accurate responses. This would occur, for example, if the letter “P” was in the 8-letter set and the 2-letter set. As in Fox (1995) where interference was computed as the difference between response-compatible and response-incompatible trials, interference here could be computed by comparing response competition-free to response competition trials. If the items of different sets did not overlap, then the slope of the set-size effect in the regression equation was the same for participants who were measured to be either high or low in working memory capacity. If, however, each item was a member of two different sets, arising in response competition or interference at the time of retrieval, then the slope of the set-size effect was steeper for participants with low working memory than those with high working memory.

According to Conway and Engle (1994), inhibition is resource demanding. The participants with low working memory capacity did not have the attentional resources that were necessary to inhibit the connection between the cue and the irrelevant set on response competition trials. This led the low-span participants to perform a serial search of the tested set. This is similar to the explanation provided by Hasher and Zacks (1988) that there are reduced success rates in accessing the information that is needed from memory and it thus produces much noisier computations. For participants with high working memory capacity, however, their attentional resources were greater and were able to inhibit task irrelevant information. Individuals with greater working memory capacities thus would tend to show greater negative priming effects.

A study by Bleckley, Durso, Crutchfield, Engle, and Khanna (2003) explained the relationship between selective attention and working memory capacity similarly to Conway and Engle (1994). In Bleckley et al.'s study, participants were first screened for their working memory capacity using the operation-word-span task (OSPAN). In this task, participants verified series of simple mathematical operations while they were to remember a list of unrelated words. The participants were to read aloud each question, state whether it was correct or not, and speak the word aloud. At the end of a series of equation-word pairs, participants were to write down the words that they recalled from the set in serial order. After screening, 10 high-span and 10 low-span participants took part in the remainder of the experiment.

For the remainder of the experiment, participants were to identify a letter that flashed briefly at the center of fixation and to locate a letter presented on one of three concentric octagons, of which the final shape represented that of a spider web. Each display included a pair of letters, one at the center of the grid and one on one of the 24 possible locations on the octagons. Each trial could be validly cued, with the cue word indicating on which ring the displaced letter would occur, uncued, with no indication where the displaced letter would occur, or invalidly cued, with the cue word indicating where the displaced letter would not occur.

The results of the experiment indicated that high-span participants were more accurate than low-span participants at naming the center letter. In the validly cued condition, both high- and low-span participants performed equally well. In the invalidly cued condition, however, high-span, but not low-span, participants showed poorer location of the displaced letter when it was on a ring closer to fixation than the one cued. The performance of low-span participants inside the cued ring was superior and equivalent to performance on the validly cued trials.

According to Bleckley et al. (2003), the differences observed between the high- and low-working memory capacity participants resulted due to differences in the ability to inhibit the uncued rings. High-working memory capacity participants were able to suppress information in the uncued rings, while low-working memory capacity participants were less capable of doing this. This finding is similar to that of Conway and Engle (1994) and Hasher and Zacks (1988). Low-working memory capacity participants have a decline in their ability to inhibit irrelevant information, in this case uncued rings. High-working memory capacity participants have an increase in their ability to inhibit irrelevant information.

A series of studies by Conway, Tuholski, Shisler, and Engle (1999), further examine the relationship between working memory capacity and selective attention, most specifically negative priming. In one study, participants were screened for working memory capacity on the basis of performance on an operation-word span task similar to the one used by Conway and Engle (1994). The task required them to solve simple math problems while attempting to remember words. Low span participants were those who scored 10 or lower and those who scored 19 or higher were classified as high span. For those participants who reached 85% accuracy or higher, they participated in the remainder of the experiment.

During the actual experiment, participants were presented trials that consisted of a prime display followed by a probe display. A display would typically consist of a red letter and a green letter, and the participants' task was to name the red letter as quickly and accurately as possible. Trials occurred in groups of five, and after each trial a word was presented. After the fifth and final trial, participants were to determine if the fifth word matched any of the four previously presented words. Within the groups of five trials, memory load started at zero words for the first trial and was incremented to four words for the fifth trial.

According to Conway et al. (1999), high- and low-span participants showed different negative priming effects. Naming latency at load zero was faster than at all other levels of load. Reliable negative priming was not demonstrated at any level of load for low-span participants. High-span subjects, however, demonstrated reliable negative priming of 14 ms at load zero, but not at any other level of load. Conway et al. suggest that these data indicate that the negative priming effect results from provision of controlled attention and the individual differences present in working memory capacity correspond to the ability to proficiently handle irrelevant information.

Based upon the results of these experiments, working memory capacity appears to be a valid predictor of inhibitory control, and thus an appropriate measure to determine distractor processing. As individuals with a high working memory capacity were able to suppress information to a greater degree than those with low working memory capacity, it would be expected that these individuals would be more likely to inhibit the critical item on the prime trial, and thus be slower on the probe trial in a negative priming task.

1.4 Implicit and Explicit Memory

One question that drives memory research is the relationship between implicit and explicit memory. This relationship is important to consider when examining the likelihood of an implicitly encoded stimulus (critical item on the prime trial) being later recognized in an explicit memory task. Turk-Browne, Yi, and Chun (2006) analyzed fMRI blood oxygenation level dependent (BOLD) responses associated with repetition priming as a function of subsequent memory to explore the neural and behavioral relationship between implicit and explicit memory. Participants completed the long-term repetition priming portion of the experiment while in an fMRI scanner. Participants were presented with a green fixation cross for 200 ms followed by a scene for 200 ms. When presented with the image, participants were to indicate if the scene occurred indoors or outdoors. After the 200 ms presentation, participants were presented with a blank screen with a fixation dot that was filled-in after participants made their response. This outdoor/indoor task had two runs, each with 136 trials. The trials included 60 novel images, 60 repetitions of those images, 15 fixation trials, and one filler trial. The lag between the first and second exposure of scenes varied from 2 to 11 items, on average 19.5 sec apart.

Behavioral priming was measured by comparing the difference in reaction time between the first and second exposure of each scene. Neural attenuation was calculated at the peak of the hemodynamic response as the difference in activation between the first and second exposure of each scene. After completing the two runs of the priming task, participants were informed of the surprise recognition task. Before the recognition task, subjects completed a parahippocampal place area (PPA) localizer run. Participants were told that any image seen during the localizer run would not be part of the recognition task. The task presented alternating images of scenes or faces and required subjects to report if the presented image was an indoor or outdoor scene, or a male or female face. Upon completion of the localizer run, subjects were removed from the scanner and completed the recognition test in another room. The recognition test included 180 scenes, 120 old and 60 new. Trials were presented in the same fashion as during the priming task, this time with participants' responses indicating "new" if they did not recognize the scene or "low confidence studied" or "high confidence studied".

In the behavioral portion of the experiment, Turk-Browne et al. observed faster responses on the second exposure than on the first exposure. Greater priming was observed for items that were ultimately remembered than for those items that were forgotten. There was no significant effect of subsequent memory or response time on accuracy. When examining neural attenuation in the fMRI portion of the experiment, attenuation was assessed by comparing peak activity for the first exposure to the second exposure of each scene as a function of subsequent memory. Peak activation was greater for remembered scenes than for forgotten scenes, which replicates previous work done by Brewer, Zhao, Desmond, Glover, and Gabrieli (1998). In addition, there was more neural attenuation, as measured by the first exposure minus the second exposure, for remembered scenes. Turk-Browne et al.'s primary goal was to determine how processes at the first exposure impact subsequent priming and recognition. They found evidence of greater priming and attenuation for subsequently remembered scenes.

Turk-Browne et al. argue that their results suggest that implicit and explicit memory are subject to the same encoding factors and that they can rely on similar perceptual representations and processes. This conclusion is based on the differing findings between first and second exposure of scenes. At first exposure of a scene, two correlates of episodic (explicit) encoding were produced. The first was greater peak activation in medial temporal and frontal regions and the second was greater deactivation in anterior cingulate cortex and precuneus. At second exposure of a scene, the same items produced two correlates of implicit memory: behavioral priming and neural attenuation in medial temporal regions. In addition, the brain-behavior correlations between these two implicit measures were observed for remembered, but not for forgotten scenes. Their evidence suggests that while implicit and explicit memory can be dissociated, they may also be related in several ways.

Turk-Browne et al. propose a common-encoding independent-retrieval hypothesis. During the encoding of novel visual stimuli, the implicit and explicit memory systems may be dependent on common perceptual representations. Implicit and explicit memory may be modulated by factors that influence encoding, such as attention, by affecting the fidelity and durability of these representations. Though similar in this respect, implicit and explicit memory differ in terms of how these representations are retrieved. Explicit retrieval relies on elaboration, association, and conscious reflection, whereas implicit retrieval tends to be stimulus driven which results from perceptual representations by repeated stimuli in the environment being reactivated.

1.5 Present Study

The goals of the present study are threefold. The first is to determine if there are implicit effects of not responding to or attending to items. The effects of attending and not responding to items will be seen in the measures of positive and negative priming. The second goal is to assess if there is explicit memory of items that were previously not responded to or attended. The effects of attending and not attending to items on later recognition will be assessed using a recognition memory task. The third goal is to determine the relationship between implicit and explicit memory in priming. This will be assessed using conditional analyses of priming as a function of explicit memory.

The present studies utilize a hybrid methodology based upon Grison et al.'s negative priming task and Turk-Browne et al.'s (2006) priming and recognition memory experiments to examine questions regarding the relationship between implicit and explicit memory in negative and positive priming. By utilizing this methodology, it will address if the information that mediates negative priming is stored in implicit or explicit memory. At the core of addressing this question is the level at which the distractor is processed, which will be assessed by measuring interference and working memory capacity. As previously discussed in Section 1.2, manipulation of the degree of interference should affect the degree of negative priming due to increased processing of the distractor. Furthermore, working memory capacity is an indirect measure of the degree to which participants can inhibit irrelevant information.

Predictions

Of greatest interest in the present study is the degree to which previously not responded to and attended to items will be explicitly retrieved in a recognition memory task after completing what is considered to be an implicit task. At the time of the recognition memory task, participants will have been exposed to the critical item twice, once on the prime trial and once on the probe trial. Therefore, it is possible that when participants recognize a critical item in the recognition memory task that they are retrieving information either from the prime trial, the probe trial, or perhaps both. It is important to consider these possibilities when attempting to explain the processing of these items that ultimately lead to being recognized or not recognized on a recognition memory task. When considering the possibility of recognition of these items in terms of the theories utilized to explain the phenomenon of negative priming, these theories make very different predictions regarding the relationship between the degree of priming and recognition of the items. These predictions further differ depending on the selection mechanism that is thought to occur on the prime trial (ie. early, middle, or late).

Selection on the Prime Trial

Predictions based upon selection on the prime trial can be seen in table format in *Table 1.1a-d*. Processing of the distractor (critical item) on the prime trial may occur at either early, middle, or late selection, and as such would vary the strength of the processing of the distractor and ultimately the degree of priming observed on the probe trial. If an episodic retrieval account is used to explain the phenomenon of negative priming, storage and retrieval of a memory episode that includes the distractor and its response are at the heart of the theory. What would mediate success of storage of this episode, however, would be the stage of selection that operated. As can be seen in *Table 1.1a*, if selection occurs at any early level, then no priming is expected to be observed on the probe trial whether the distractor is recognized during the recognition memory task or not. Ultimately, if early selection is operating successfully, then participants should never remember the distractor because it was processed at such a low level.

If selection operates at the middle level, then it is assumed that some information regarding the distractor was processed, and as such some memory trace would be formed based on the predictions of the episodic retrieval account. The same is true if selection occurs at the late level, as late selection requires that the stimuli be processed to the semantic level. In both the middle and late selection cases, negative priming would be expected if the distractor is subsequently retrieved during the recognition memory task, but is not expected if there is not a subsequent memory of the item. The reasoning behind this is that the episodic retrieval account of negative priming requires that for negative priming to be elicited, an episode of the distractor and its previous response must be scored in memory and retrieved on the probe trial. The competition between remembering that one was supposed to ignore the item when presented with the required attend response slows the participant. If the distractor is not retrieved during the recognition memory task, then it is likely that it was not retrieved on the probe trial, and thus did not lead to negative priming.

The key element of an inhibitory account of negative priming suggests that suppression of the distractor carries over from the prime trial to the probe trial. If an inhibitory account is used to explain the phenomenon of negative priming, then suppression of the distractor that carries over from the prime trial to the probe trial is at the heart of the theory. If a previous distractor is presented as a target during the time that the representation of the critical item is rebounding from inhibition, selection of this item as a target will be impaired relative to a control stimulus. Based upon these assumptions, if an item is subsequently retrieved on the recognition memory task, despite being previously ignored as the target on a prime trial, it is likely that the representation of this item was not inhibited.

As can be seen in *Table 1.1b*, if selection occurs at an early level, then no priming is expected to be observed on the probe trial whether the distractor is retrieved during the recognition memory task or not. If selection operates at the middle or late level, then it is assumed that some information was not inhibited. Likewise, if this information is retrieved during the recognition memory task then the unsuppressed excitation will tend to result in positive priming on the probe trial. If, however, the item is not recognized in the recognition memory task, it is expected that there was greater suppression of the item on the probe to subsequently result in negative priming on Ignore-Attend sequences. These predictions are based upon selection against the distractor at either the middle or late levels. If selection takes place at the early level, then priming would not be expected as it is unlikely that the item was processed enough to even be suppressed.

As the episodic retrieval account draws on the retrieval of instances from memory to explain slowed responses in the negative priming phenomenon, it may also draw on the retrieval of instances from memory to explain faster responses on the probe trial of an item from an Attend-Attend (AA) sequence. An Attend-Attend sequence is one in which an item is attended to on the prime trial, and is subsequently to be attended to again on the probe trial. As can be seen in *Table 1.1c*, if an item is encoded with a "respond to me" tag on the prime display and this memory subsequently influences performance of this item on the probe trial, it follows that this item will be more likely to be remembered in the recognition memory task. Finding this result would replicate the results of Turk-Browne et al. (2006). If, however, the item is not remembered in the recognition memory task, it is expected that there was less facilitation provided by the item on the prime to subsequently effect the probe trial and thus less positive priming. Regardless of the level of selection that operates, if the item is not subsequently remembered during the recognition memory task, then it is unlikely that the item elicited positive priming.

When utilizing the inhibitory account of priming to explain facilitation on the probe trial, the level of selection of the target becomes very important. If early selection operates on the prime trial, then no priming is expected on the probe trial, regardless of whether or not the item is subsequently remembered. If middle or late selection operate, however, then positive priming would be expected if the items are subsequently remembered in the recognition memory task. If the items are not subsequently remembered, then priming would not be expected.

Selection on the Probe Trial

Predictions based upon selection on the probe trial can be seen in graphical form in Figure 2a and 2b. Processing of the critical item on the probe trial may only occur at the late selection level, as it is the to-be-responded to item. Therefore, no predictions are made regarding the early or middle selection theories. As the key to the episodic retrieval account of negative priming is storage and retrieval of a memory episode, then negative priming would be expected on Ignore-Attend sequences if the critical item is subsequently remembered on a recognition memory task, but would not be expected if the item is not remembered. If it is not remembered, then a memory trace was not retrieved on the probe trial. The same would hold true for Attend-Attend sequences, with positive priming being elicited if the critical item is subsequently remembered, and no priming being elicited if the item is not remembered.

Table 1.1a

Predictions for Ignore-Attend Prime Trials Based on the Episodic Retrieval Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	-	0	-	0

Table 1.1b

Predictions for Ignore-Attend Prime Trials Based on the Inhibitory Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	+	-	+	-

Table 1.1c

Predictions for Attend-Attend Prime Trials Based on the Episodic Retrieval Account

Early		Middle		Late	
R	NR	R	NR	R	NR
+	0	+	0	+	0

Table 1.1d

Predictions for Attend-Attend Prime Trials Based on the Inhibitory Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	++	+	+	0

Note. R = Recognized, NR = Not Recognized
- = Negative Priming, 0 = No Significant Priming,
+ = Positive Priming, ++ = Most positive priming

Predictions of Priming for the Episodic and Inhibitory Accounts of Negative Priming
Based on High Threshold Responses for Probe Trials

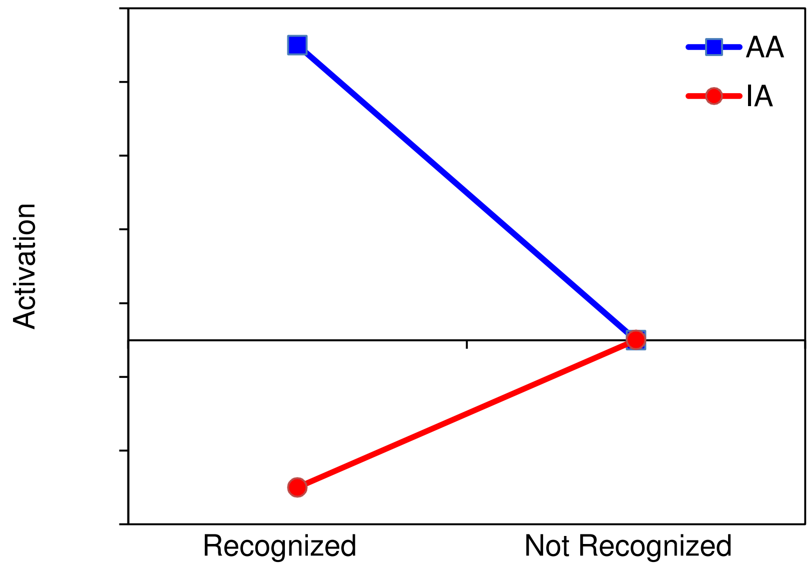

Figure 2.1a. Predictions of priming conditional on subsequent recognition for the episodic account of negative priming.

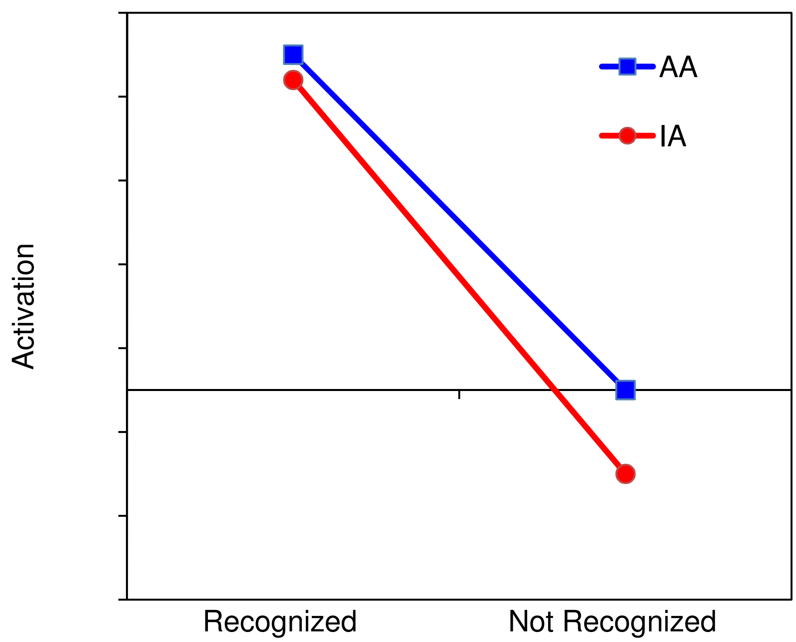

Figure 2.1b. Predictions of priming conditional on subsequent recognition for the inhibitory account of negative priming.

As the key to the inhibitory account of negative priming is suppression of activation of the critical item that carries from the prime trial to the probe trial, if the critical item is remembered at the recognition memory task, then it is expected that this will elicit positive rather than negative priming in Ignore-Attend sequences. If the item is subsequently remembered, then it would not appear that the item was suppressed on the prime trial, and as such the suppression did not carry over to the probe trial. If the item is not subsequently remembered then it would appear that the critical item was suppressed and hence negative priming would be expected. The same pattern of results would be expected for Attend-Attend sequences, with the exception that if the item is not subsequently remembered no priming would be expected.

Interference

Interference is predicted for all trials that contain incompatible flankers. No interference should be elicited on trials that contain compatible flankers. Likewise, it is predicted that participants will respond slower on trials with incompatible flankers than those with compatible flankers. The presence of interference in an Ignore-Attend sequence indicates that the distractor was processed to some degree, despite the do-not-respond decision.

Chapter 2

Experiment 1

2.1 Method

Participants

Four-hundred and thirteen individuals enrolled in introductory undergraduate psychology courses at the University of California, Riverside served as participants in partial fulfillment of a course requirement.

Design

Participants completed three tasks that included a priming task, a working memory capacity task, and a recognition memory task.

Priming Task: Sequence type (Ignore-Attend, Attend-Attend, control, fill, or catch), flanker (compatible or incompatible), stimulus type (face or object), and critical category (male/female or living/nonliving) were varied factorially within subjects. Examples of all types of the priming task can be seen in Figures 2.1 and 2.2. Ignore-attend (Ignore-Attend) sequences are those in which a participant is not to respond to an item on the prime trial and then must respond to it on the probe trial. In Attend-Attend

(AA) sequences, participants are to respond to an item on the prime trial and then subsequently respond to the same item on the probe trial.

Control sequences are composed of images that have never been seen before, and are thus compared to Ignore-Attend and Attend-Attend probe trials as a measure of priming. Fill trials also included images that had never been seen before, but were utilized to ensure proper spacing of trials and an equal number of attend to the central image and attend to the left and right images responses. Catch trials include flankers that are mismatched on category (ie. one male face and one female face). Flankers are the images that appear to the left and right of the centralized image. As will be discussed, participants must withhold a response when presented mismatched flankers to ensure that they are accurately completing the task. Compatible flankers are those in which the flankers belong to the same category as the center item (ie. male central image and male left and right images), while incompatible flankers are those in which the flankers belong to the opposite category (ie. male central image and female left and right images). Samples of both types of flankers can be seen in Figure 2.1 and Figure 2.2.

Materials

For the priming task, a set of 320 trials was generated for each participant. These trials included two sets of stimuli, faces and objects, drawn from the Florida Department of Corrections and other sources (Nene, Nayar, & Murase, 1996; Sheikh, Sabir, & Bovik, 2006; Nilsback & Zisserman, 2006). Of the 320 trials, there were 20 practice trials, 96 Ignore-Attend (IA) sequences, 96 Attend-Attend (AA) sequences, 20 catch trials, and 88 fill trials. The 192 experimental trials included a prime display, a probe display, and a control display for each Ignore-Attend and Attend-Attend sequence.

Target and distractor stimuli were faces or objects 182 pixels in height and 179 pixels wide and were viewed from a distance of about 45 cm. The prime and probe displays were always presented with three images side by side.

The working memory capacity task that participants completed was Engle's (2005) automated symmetry span task. The automated symmetry span task measured working memory span by having participants keep track of the locations of filled cells as they were displayed sequentially in a grid with a secondary task of judging whether or not displays composed of filled cells in a grid possessed symmetry about the vertical axis.

The recognition memory task included 256 trials, of which 128 included faces or objects that were seen during the priming task (old), and 128 faces or objects that the participant had never seen (new). Of the 128 old items, 96 of those items were critical items from probe and control trials in Ignore-Attend and Attend-Attend sequences, and 32 were flankers from fill trials.

Procedure

All instructions to the participants were presented on the computer screen. All participants completed a negative priming task, a working memory capacity task, and an explicit recognition memory task.

Priming Task The instructions for the priming portion of the experiment indicated that three images would appear on the screen, and that the participant's task was to press the 4 or 6 key on the numeric keypad. The images would either be three faces or three objects, varying by gender (male/female) and animacy (living/non-living). A center fixation appeared at the start of each trial indicated whether participants made their selection based upon the category of the images on the left and right (*flankers*) of the screen, or upon the category of the image in the center of the screen based upon a center fixation that indicated the task. A plus sign (+) fixation indicator required participants to report the category of the image in the center of the screen, while a double headed arrow (<->) fixation indicator required participants to report the category of the images on the left and right of the screen.

On catch trials, participants were to withhold a response if the images on the left and right were not members of the same category (i.e., one male face and one female face). A sample catch trial would occur as follows. A prime trial begins with a central fixation of a plus sign or a double headed arrow. The three presented images include a female face as the central image, a male face as the left flanker, and a female face as the right flanker. Regardless of which image the central fixation indicates should be responded to, the participant should withhold a response, as the left and right images are not of the same category (ie. both faces are not male or female).

As an example of a typical prime trial, example, if a plus sign appeared in the center of the screen followed by three images with a male face in the center, the participant would respond by pressing the 4 key to indicate that the center image was a male face. It was emphasized that participants should keep their eyes focused on the location of the fixation indicator in the center of the screen, even when the fixation indicator was no longer present.

All three tasks were run using E-Prime software on IBM PC compatible computers. Stimuli were displayed on a 17-inch display set to a resolution of 600 x 800. Participants' response times in the priming task were measured using the 4 and 6 keys on the numeric keypad.

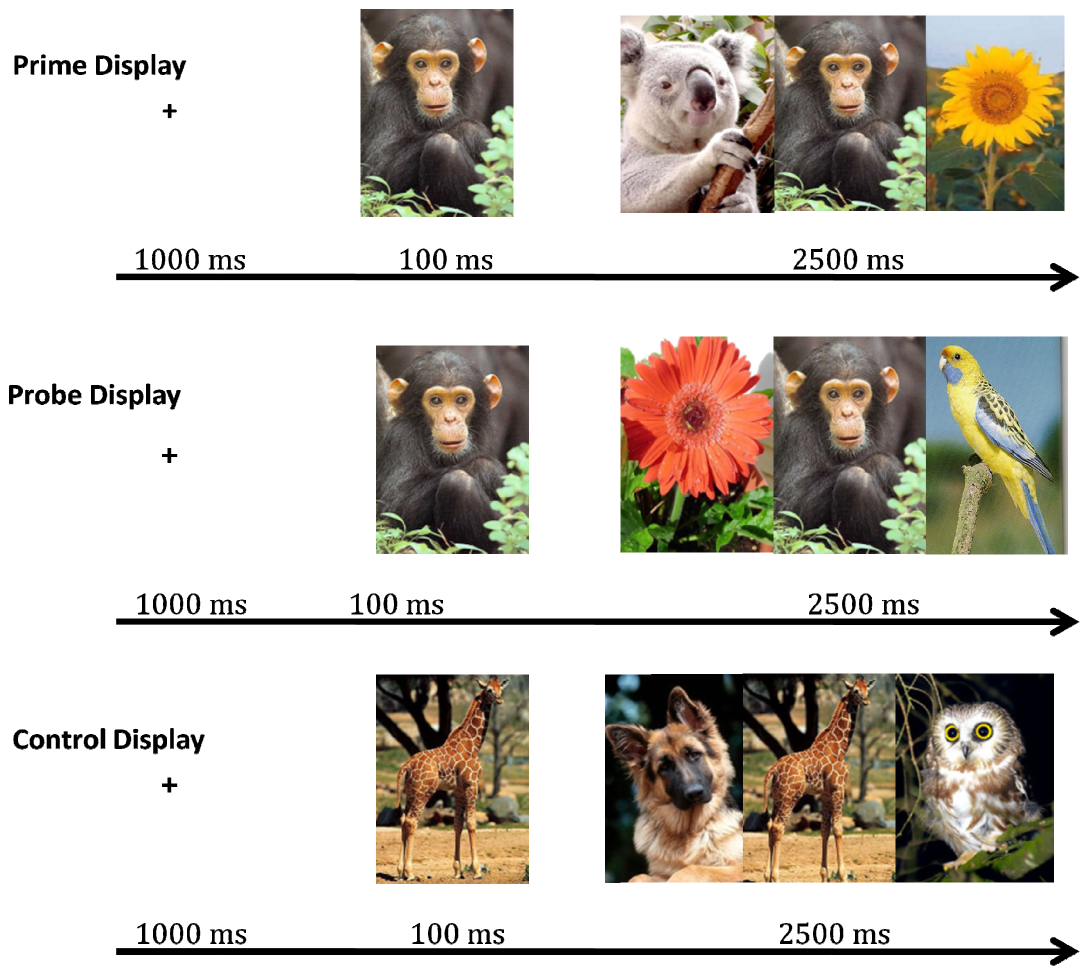

Figure 2.1. Sample Attend-Attend compatible flanker trial sequence.

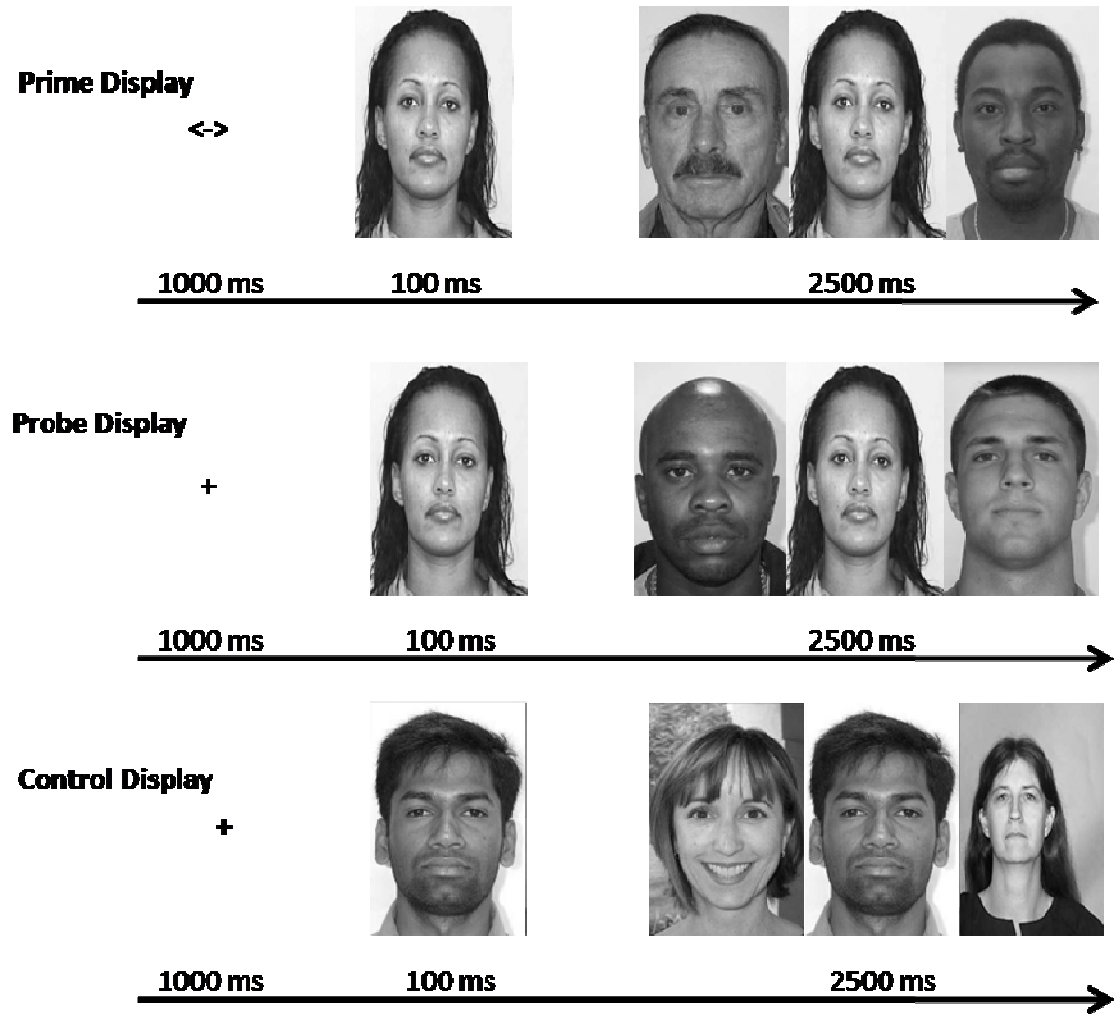

Figure 2.2. Sample Ignore-Attend incompatible flanker trial sequence.

Each trial proceeded as follows. On the prime trial a fixation indicator (<-> or +) was presented at the center of the screen for 1000 ms and then disappeared. Upon removal of the fixation indicator, either a face or object appeared in the previous location of the fixation indicator for 100 ms. This central image remained constant, while new left and right flankers appeared for 2500 ms. (See Figure 2.1 for a sample Attend-Attend sequence and Figure 2.2 for a sample Ignore-Attend sequence.). This was followed by a blank screen in which participants were to make their response. If participants did not respond within 2500 ms, they were reminded that their responses must be made both quickly and accurately. If an incorrect response was given, a message appeared reminding participants of the goals of the task. As an example of a typical prime trial, if a plus sign appeared in the center of the screen followed by three images with a male face in the center, the participant would respond by pressing the 4 key to indicate that the center image was a male face. It was emphasized that participants should keep their eyes focused on the location of the fixation indicator in the center of the screen, even when the fixation indicator was no longer present.

After responding, the probe trial began with the presentation of a fixation indicator (+) that remained on the screen for 1000 ms. As on the prime trial, either a face or object appeared in the previous location of the fixation indicator for 100 ms. This image was replaced with three faces or objects in horizontal orientation in the center of the screen, the center image remaining constant, for 2500 ms. This was followed by a blank screen in which participants were to make their response. If a response was not made within 2500 seconds of the images appearing, a message appeared reminding the participants that they need to respond more quickly and how to accurately complete the task. Participants were provided with feedback if an incorrect response was given that reminded them of the requirements of the task. Priming is computed by comparing response times on the probe trial to those on control trials. Control trials contain three images that have not been previously seen or responded to.

Working Memory Capacity Task In addition to the negative priming task, participants completed Engle's (2005) automated symmetry span task. All responses for this task were made using the mouse. The automated symmetry span task was adapted from the symmetry span task described by Kane et al. (2004). This task consisted of two main parts: a practice session and the actual working memory capacity assessment. The practice session was itself composed of three parts.

In the practice session, participants were first exposed to the sequence task. In this practice task, they were presented with a sequence of black 4×4 grids on a white background. These sequences were comprised of three to seven grids. In each grid, a different cell was colored red. Each grid was presented for 650 ms with 500 ms intervals between grids. After each presentation of a sequence, participants were required to recall the locations of the colored cells in order. They gave their responses using the computer mouse by clicking cells in a grid in the order they had seen those cells filled and these responses were untimed. In this task, they saw two series of set size 2 and of set size 3, where *set size* indicates the number of grids in the sequence.

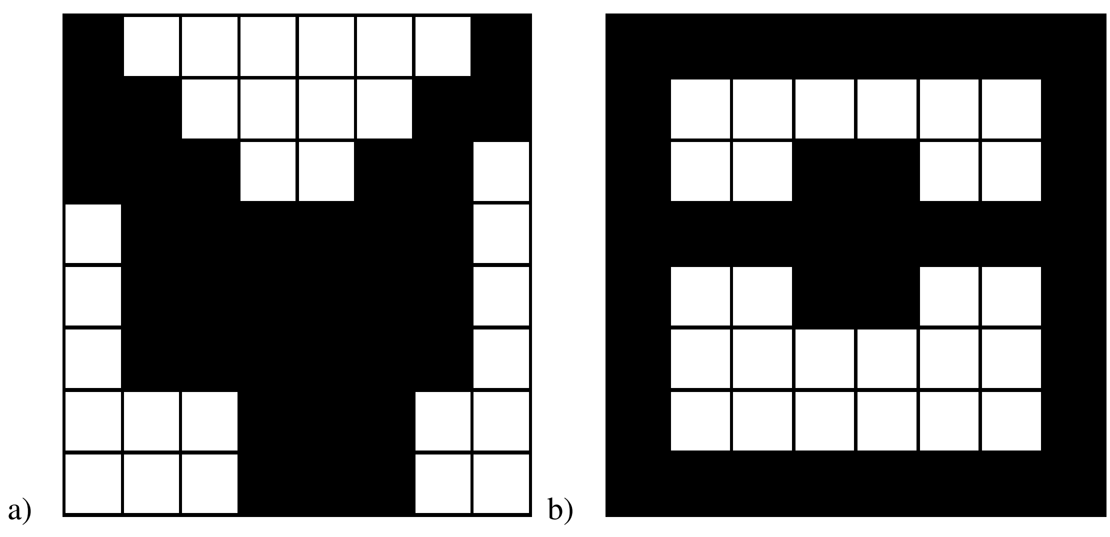

Figure 2.3. Samples of the left-right symmetry task. A) Indicates example that lacks symmetry. B) Indicates example that has left-right symmetry.

Next, they were given the practice symmetry task. In each trial in this task, they were presented with a black 8×8 grid in which some of the cells were colored black. The grid was presented on a white background. The participants were required to determine whether the colored cells showed left-right symmetry (See Figure 2.3a and Figure 2.3b). Once a decision was made, they clicked the mouse button to proceed to a response display. They gave their response by clicking a "yes" or a "no" box with the mouse. This was followed by accuracy feedback. They saw 15 symmetry trials in the symmetry task. The practice symmetry task served to familiarize participants with the task itself and to measure how long each participant took to evaluate symmetry. Participants' mean response time plus 2.5 *SD* was used as a deadline for the symmetry portion of the working memory capacity assessment. Adjusting the deadline according to individual participants' practice response times was used to help account for individual differences in the assessment so that faster participants could not use extra time to compensate for interference from the secondary task.

The final practice task combined the sequence and the symmetry tasks by interleaving the memory sequences and the symmetry judgments. Each item in each sequence was preceded by a symmetry judgment trial. This final practice task was the same as the working memory capacity assessment that followed. In these tasks, accuracy on the symmetry portion was emphasized, and participants were told that they needed to obtain 85% correct. An accuracy of 85% is required by Engle (2005) to successfully complete the working memory capacity tasks. Participants were also informed that they would need to respond as quickly on the symmetry task as they had during practice or the trial would count as an error. Participants completed three final practice sequences of set size 2. This was followed by a brief set of instructions reminding them of the importance of maintaining symmetry accuracy of at least 85%, and then by the working memory capacity assessment itself which consisted of three sequences of each of the set sizes 2, 3, 4, and 5, which yielded 12 sets total.

Explicit Recognition Memory Task The instructions for the explicit recognition memory portion of the experiment indicated that one image would appear on the screen, and that the participant's task was to press the 1, 5, or 9 keys on the numeric keypad to indicate whether or not that image had been seen in the negative priming task and how confident they were. Participants could indicate that the item was new, meaning that it was not present in the earlier task by pressing the 1 key. They could indicate that the item was old, it was present in the earlier task, by pressing the 5 or 9 key. Five indicated low confidence, and nine indicated high confidence. Participants had up to 5 s to make their response (See Figure 2.4). Upon receipt of response, a message appeared on the screen indicating that their response was recorded. No feedback was given regarding accuracy. If participants did not respond within 5000 ms, participants were reminded to respond both quickly and accurately.

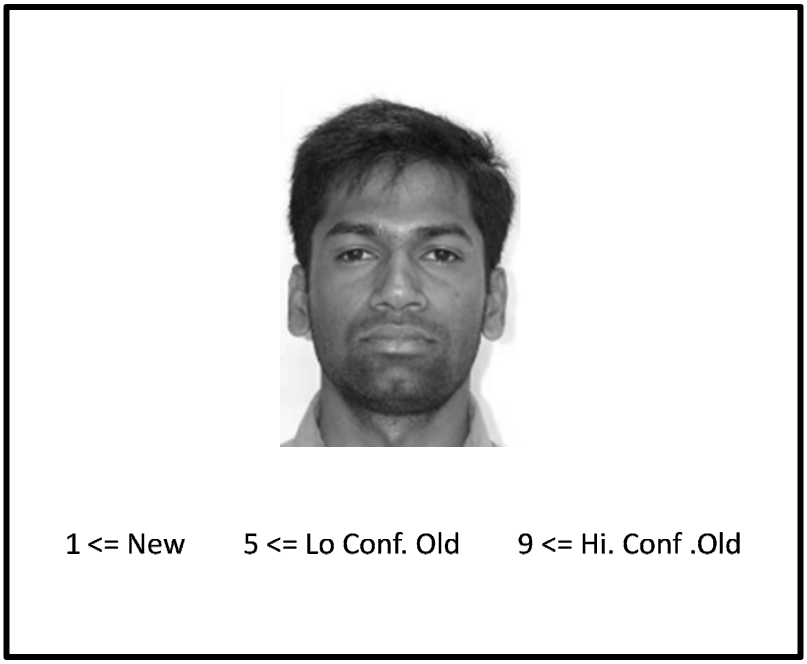

Figure 2.4. Sample trial from the recognition memory task.

2.2 Results

The effect of interference on prime trials was examined by measuring the reaction time difference between compatible (flankers that are of the same category as the central item) and incompatible (flankers that are of the opposite category as the central item) trials and the effect of priming on probe trials was examined by comparing reaction times on probe trials to control trials. Only prime sequences in which the prime, probe, and control trials were all accurate were included in the analyses. Overall, subjects had 88% accuracy on Attend-Attend sequences and 89% accuracy on Ignore-Attend sequences. In addition, median reaction times for cue type and stimulus type by subject were computed and trials were dropped that were plus or minus two standard deviations from the mean. Recognition memory was computed using d', with participants averaging a d' of .75.

Table 2.1

Mean Response Times on Attend-Attend (AA) and Ignore-Attend (IA)Prime Trials as a Function of Flanker Compatibility (with Standard Deviations in Parentheses)

Flanker	AA	IA
Compatible	908 (263.48)	1066 (265.28)
Incompatible	899 (270.37)	1116 (270.71)

Interference in the Prime Displays

According to Eriksen and Eriksen (1974), interference is indicated in the prime display by longer reaction times on trials that contain targets and distractors that are members of the same category relative to trials with targets and distractors that are members of different categories. A four-way within-subjects sequence type (Attend-Attend or Ignore-Attend) by flanker (compatible or incompatible) by stimulus type (faces or objects) by critical category (male or female/living or nonliving) repeated measures ANOVA was performed. There was a significant sequence type by flanker interaction, $F(1, 247) = 13.58$, $MSE = 43187$, $p < .001$. As can be seen in Table 2.1, response times were slower on incompatible trials in Ignore-Attend sequences, while response times were not significantly different for compatible and incompatible trials in Attend-Attend sequences. Interference is indicated by the difference in reaction time on trials with incompatible flankers compared to trials with compatible flankers. As this interaction was significant, all further interference analyses will be performed separately for Ignore-Attend and Attend-Attend sequences.

Interference in the prime displays was examined by performing a series of three-way within-subjects critical category (male vs. female or living vs. nonliving) by stimulus type (faces or objects) by flanker (compatible or incompatible) repeated measures ANOVAs on reaction times separately for Ignore-Attend and Attend-Attend sequences.

Interference in Ignore-Attend Sequences: There was a significant effect of flanker type, as indicated by slower reaction times on incompatible trials (M = 1116 ms, SD = 278 ms) than on compatible trials (M = 1065 ms, SD = 283 ms), $F(1,297) = 47.79$, $MSE = 31101$, $p < .0001$, which indicated overall interference on incompatible trials. The presence of interference in an Ignore-Attend sequence indicates that the distractor was processed to some degree, despite the do-not-respond decision. There was a significant main effect of stimulus type, $F(1, 297) = 218$, $MSE = 60119$, $p < .0001$. Response times were faster for trials containing faces (M = 1015 ms, SD = 242 ms) than for those containing objects (M = 1166 ms, SD = 293 ms). Mean response times on Ignore-Attend trials as a function of stimulus type and flanker compatibility can be seen in Table 2.2. Interference was moderated by stimulus type, $F(1, 297) = 20.11$, $MSE = 28781$, $p < .0001$. Significant interference was seen for all categories except living objects. Furthermore, interference was greater for face stimuli than object stimuli, as can be seen in Figure 2.5. As discussed previously, interference was computed by comparing responses times on compatible versus incompatible prime trials.

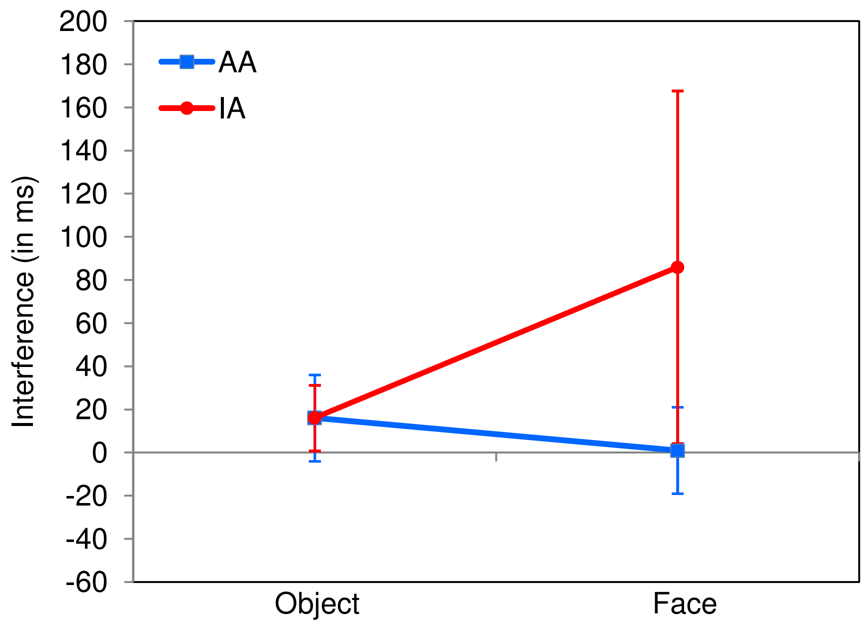

Figure 2.5. Interference by stimulus type in the Ignore-Attend and Attend-Attend conditions. Error bars reflect 95% confidence intervals.

Interference in Attend-Attend Sequences: There was a trend towards an effect of flanker type in Attend-Attend sequences, $F(1, 302) = 2.39$, $MSE = 29461$, $p = .12$ (see Figure 2.5). Reaction times were faster for face stimuli (M = 845 ms, SD = 245) than for object stimuli (M = 960 ms, SD = 289), $F(1, 302) = 166.56$, $MSE = 47113$, p < .0001, which indicated an effect of stimulus type. Mean response times on Attend-Attend prime trials as a function of stimulus type and flanker compatibility can be seen in Table 2.3. Though there was not an effect of interference, there was a two-way interaction of stimulus type and critical category on interference, $F(1, 302) = 4.86$, $MSE = 32396$, p = .03. Interference, as defined as slower response times on incompatible compared to compatible trials, for Attend-Attend trials is only seen for the female critical category.

Table 2.2

Mean Response Times on Ignore-Attend Prime Trials as a Function of Stimulus Type and Flanker Compatibility (with Standard Deviations in Parentheses)

	Face		Object	
Flanker	Male	Female	Living	Non-living
Compatible	988 (231.65)	958 (233.39)	1168 (294.77)	1150 (301.28)
Incompatible	1053 (252.07)	1064 (247.02)	1159 (287.84)	1190 (295.93)

Table 2.3

Mean Response Times on Attend-Attend Prime Trials as a Function of Stimulus Type and Flanker Compatibility (with Standard Deviations in Parentheses)

	Face		Object	
Flanker	Male	Female	Living	Non-living
Compatible	868 (246.34)	825 (231.07)	986 (283.54)	951 (292.95)
Incompatible	841 (258.44)	849 (243.32)	945 (292.12)	931 (287.62)

As the effect of interference was not the same in the Attend-Attend and Ignore-Attend conditions, a four-way sequence type by flanker by stimulus type by sequence category ANOVA was performed to examine the differences. There was an interaction of sequence type and flanker, $F(1, 247) = 42.85$, $MSE = 27742$, $p < .0001$, that indicated that the effect of interference varied by sequence type. The fact that interference was not equivalent on both trial types despite a control to ensure that participants responded to the central and outside items equally indicates that perhaps Attend-Attend trials were easier and thus uninfluenced by the flankers.

Priming on Probe Displays

The median probe display reaction time data were analyzed in a repeated measures ANOVA using the design: trial type (probe or control) by sequence type (Ignore-Attend or Attend-Attend) by flanker (compatible or incompatible) by stimulus type (face or object). The main effect of sequence type was significant, $F(1, 398) = 44.80$, $MSE = 39038$, $p < .0001$. Response times were different on Ignore-Attend and Attend-Attend trials. Furthermore, there was a significant main effect of trial type, $F(1, 398) = 39.57$, $MSE = 25438$, $p < .0001$, which indicated priming. These effects were moderated by a two-way interaction of stimulus type and sequence type on priming, $F(1, 398) = 5.88$, $MSE = 27723$, $p = .02$. Priming varied by sequence and stimulus type, with the largest amount of positive priming in the Attend-Attend object condition and the least amount of priming (neither significantly positive or negative) in the Ignore-Attend object condition, as can be seen in Figure 2.6.

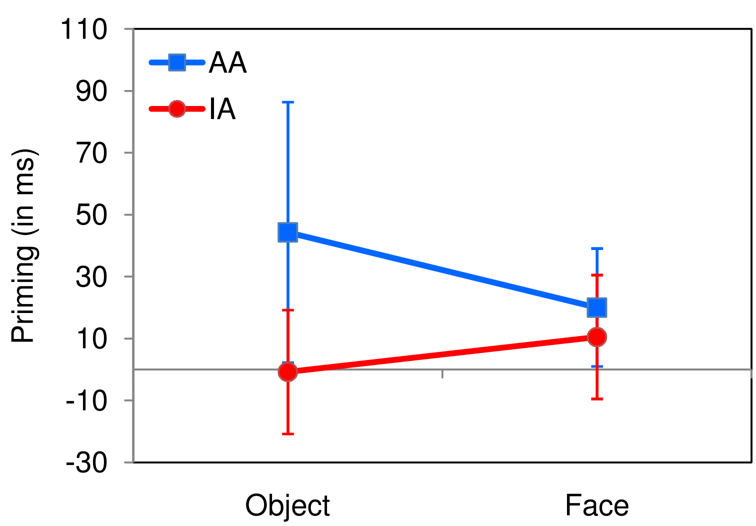

Figure 2.6. Priming by stimulus type for Ignore-Attend and Attend-Attend sequences. Error bars reflect 95% confidence intervals.

As discussed previously, priming was computed by subtracting the reaction time on the probe trial from the reaction time on the control trial. Priming overall was greater in the Attend-Attend than the Ignore-Attend sequence type.

All further analyses were conducted using separate repeated measures ANOVAs by sequence type (Ignore-Attend or Attend-Attend) on reaction time data. The design used was: trial type (probe or control) by flanker (compatible or incompatible) by stimulus type (face or object).

Priming in Attend-Attend Sequences Probe trials were faster (M = 841 ms, SD = 261 ms) than control trials (M = 872 ms, SD = 256 ms), $F(1, 405) = 53.32$, MSE = 27108, $p < .0001$, which indicated positive priming. Mean response times on Attend-Attend trials as a function of sequence type, stimulus type, and flanker compatibility can be seen in Table 2.4. Furthermore, trials with face stimuli were faster (M = 801 ms, SD = 229 ms) than trials with object stimuli (M = 912 ms SD = 275 ms), $F(1, 405) = 140.76$, MSE = 51046, $p < .0001$, which indicated an effect of stimulus type. The effect of trial type interacted with stimulus type, $F(1,405) = 13.85$, MSE = 2530, $p < .0001$. Probe trials with face stimuli were faster (M = 791 ms, SD = 228 ms) than control trials with face stimuli (M = 811 ms, SD = 229 ms), which indicated 20 ms of positive priming. Probe trials with object stimuli were faster (M = 892 ms, SD = 282 ms) than control trials with object stimuli (M = 934 ms, SD = 282 ms), which indicated 42 ms of positive priming. There was a trend towards an effect of flanker, $F(1, 405) = 3.32$, MSE = 30487, $p = .07$, which could indicate an effect of interference.

Table 2.4

Mean Response Times on Attend-Attend Trials as a Function of Sequence Type, Stimulus Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		Probe	
Flanker	Face	Object	Face	Object
Compatible	828 (231.35)	961 (292.45)	810 (238.66)	884 (285.28)
Incompatible	829 (259.91)	925 (275.21)	806 (261.03)	876 (292.40)

Table 2.5

Mean Response Times on Ignore-Attend Trials as a Function of Sequence Type, Stimulus Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		Probe	
Flanker	Face	Object	Face	Object
Compatible	827 (227.37)	950 (277.03)	828 (228.11)	928 (260.88)
Incompatible	863 (258.90)	968 (297.13)	848 (250.78)	971 (298.39)

Priming in Ignore-Attend Sequences There was not an overall effect of priming, $F(1, 401) = 2.04$, $MSE = 27261$, $p = 0.15$. Mean response times on Ignore-Attend trials as a function of sequence type, stimulus type, and flanker compatibility can be seen in Table 2.5. Trials with compatible flankers were faster (M = 874 ms, SD = 249) than trials with incompatible flankers (M = 889 ms, SD = 260 ms), $F(1,401) = 16.61$, $MSE = 40269$, $p < .0001$. Furthermore, trials with face stimuli were faster (M = 824 ms, SD = 227 ms), than those with object stimuli (M = 937 ms, SD = 266 ms), $F(1, 401) = 216.57$, $MSE = 49406$, $p < .0001$, which indicated an effect of stimulus type.

Priming Conditional on Recognition

Priming was examined on the basis of recognition in the subsequent recognition memory task based upon whether participants called an item new or old as a function of sequence type. Analysis of old items utilized only those items that participants responded "high confidence" based upon Turk-Browne et al. (2006). Response times were analyzed with a repeated measures ANOVA using the design: sequence type (Ignore-Attend or Attend-Attend) by trial type (probe or control) by flanker (compatible or incompatible) by stimulus type (face or object) by high old response (true - confident old response or false - new response). High old response indicates whether or not subjects were highly confident when they called an item old. True represents a high confident old response, while false represents a new response. There was not a significant effect of high old response, $F(1, 40) = 0.26$, $MSE = 38092$, $p = 0.62$. Probe trials were faster (M = 776 ms, SD = 248 ms) than control trials (M = 796 ms, SD = 246 ms), $F(1, 40) = 5.56$, $MSE = 2136$, $p = .02$, which indicated positive priming. Priming was further modulated by sequence type, $F(1, 40) = 4.15$, $MSE = 18492$, $p = .04$ and flanker, $F(1, 40) = 4.54$, $MSE = 17388$, $p = .04$.

Priming Conditional on Recognition in Attend-Attend Sequences: Reaction times on probe trials were faster (M = 809 ms, SD = 267 ms) than control trials (M = 839 ms, SD = 263 ms), $F(1, 87) = 10.33$, $MSE = 31488$, $p < .001$, which indicated positive priming of 30 ms. Mean response times on Attend-Attend trials as a function of recognition ,trial type, and flanker compatibility can be seen in Table 2.6. The effect of high old response was not significant, $F(1, 87) = 1.17$, $MSE = 36922$, $p = .28$. The main effect of stimulus type was also significant, $F(1,87) = 41.45$, $MSE = 6478$, $p < .0001$. Mean response times on Attend-Attend trials as a function of recognition, trial type, and stimulus type can be seen in Table 2.8. Priming conditional on high threshold responses with lower and upper confidence limits can be seen in Figure 2.7.

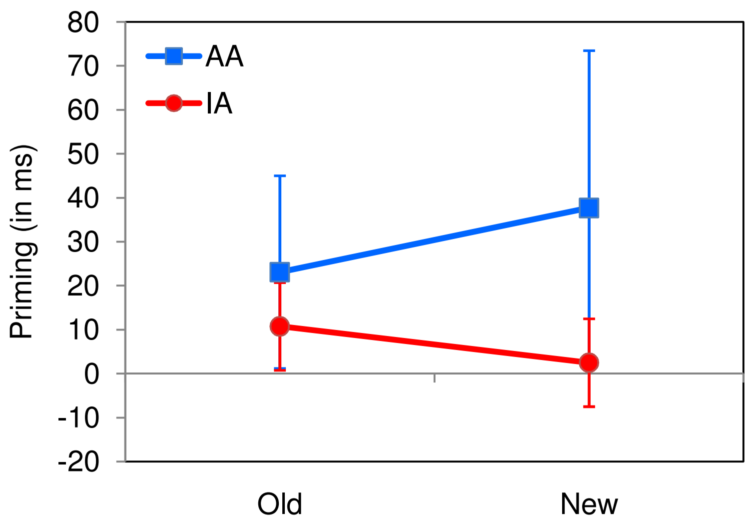

Figure 2.7. Priming for Ignore-Attend and Attend-Attend sequences conditional on recognition memory. Error bars reflect 95% confidence intervals.

Table 2.6

Mean Response Times on Attend-Attend Trials as a Function of Recognition, Trial Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		Probe	
Flanker	Not Recognized	Recognized	Not Recognized	Recognized
Compatible	874 (235.61)	845 (234.78)	844 (257.91)	822 (235.96)
Incompatible	877 (257.55)	825 (235.32)	835 (240.28)	794 (233.26)

Table 2.7

Mean Response Times on Ignore-Attend Trials as a Function of Recognition, Trial Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		Probe	
Flanker	Not Recognized	Recognized	Not Recognized	Recognized
Compatible	888 (270.63)	837 (220.60)	880 (259.16)	826 (218.93)
Incompatible	874 (250.22)	859 (236.50)	880 (241.46)	849 (246.63)

Table 2.8

Mean Response Times on Attend-Attend Trials as a Function of Recognition, Trial Type, and Stimulus Type (with Standard Deviations in Parentheses)

	Control		Probe	
Stimulus	Recognized	Not Recognized	Recognized	Not Recognized
Face	783 (232.38)	786 (216.11)	780 (219.03)	759 (205.21)
Object	877 (239.93)	921 (275.79)	847 (252.68)	884 (283.69)

Table 2.9

Mean Response Times on Ignore-Attend Trials as a Function of Recognition, Trial Type, and Stimulus Type (with Standard Deviations in Parentheses)

	Control		Probe	
Stimulus	Recognized	Not Recognized	Recognized	Not Recognized
Face	813 (238.66)	802 (205.58)	806 (238.59)	787 (203.93)
Object	911 (256.66)	903 (255.36)	900 (248.31)	899 (271.59)

Priming Conditional on Recognition in Ignore-Attend Sequences: Reaction times on probe trials (M = 819 ms, SD = 252 ms) were not significantly different from control trials (M = 826 ms, SD = 247 ms), $F(1, 104) = 0.72$, $MSE = 25540$, $p = .39$, which indicated no overall priming. Mean response times on Ignore-Attend trials as a function of recognition, trial type, and flanker compatibility can be seen in Table 2.7. The effect of high confidence old response was not significant, $F(1, 104) = 0.10$, $MSE = 33973$, $p = 0.75$. There was a main effect of stimulus type, $F(1,104) = 48.18$, $MSE = 80949$, $p < .0001$. Mean response times on Ignore-Attend trials as a function of recognition, trial type, and stimulus type can be seen in Table 2.9. Unlike in Attend-Attend sequences, incompatible trials were slower (M = 835 ms, SD = 257 ms) than compatible trials (M = 812 ms, SD = 240 ms), $F(1,104) = 7.18$, $MSE = 32181$, $p < .01$, which indicated interference on the probe trial. Overall, recognition memory did not significantly affect the degree of priming, as priming was not significantly different from zero when the items were remembered or not. Priming conditional on high threshold responses can be seen in Figure 2.7.

Though there is no overall priming when collapsing across stimulus type, positive priming is observed in the Ignore-Attend condition for face stimuli when participants subsequently remember the stimuli. When looking at priming conditional on recognition by stimulus type, as can be seen in Figures 2.8a and 2.8b, positive priming in the Ignore-Attend condition seems to be driven by face stimuli that were later remembered (20.96 ms). In the three other conditions, priming was not significantly different from zero.

Priming Conditional on High Confidence Responses by Sequence and Stimulus Type

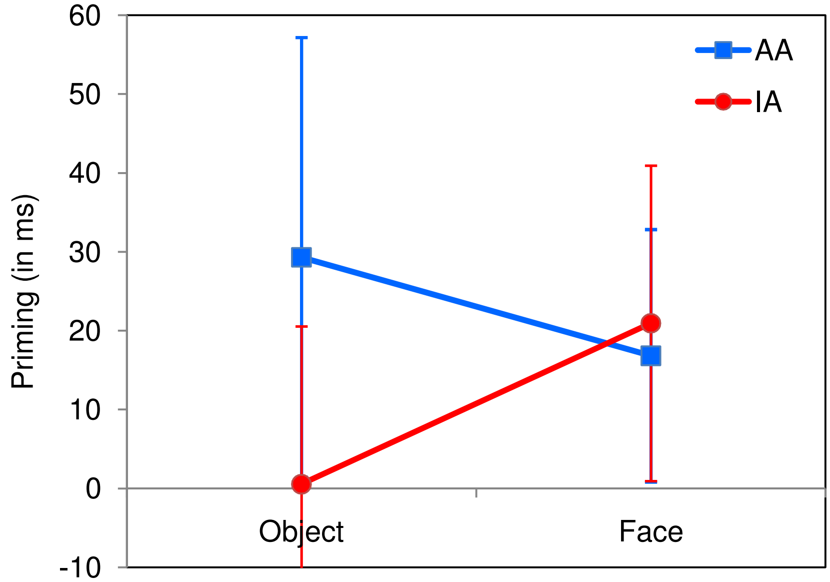

Figure 2.8a. Priming conditional on high confidence recognized responses by stimulus type. Error bars reflect 95% confidence intervals.

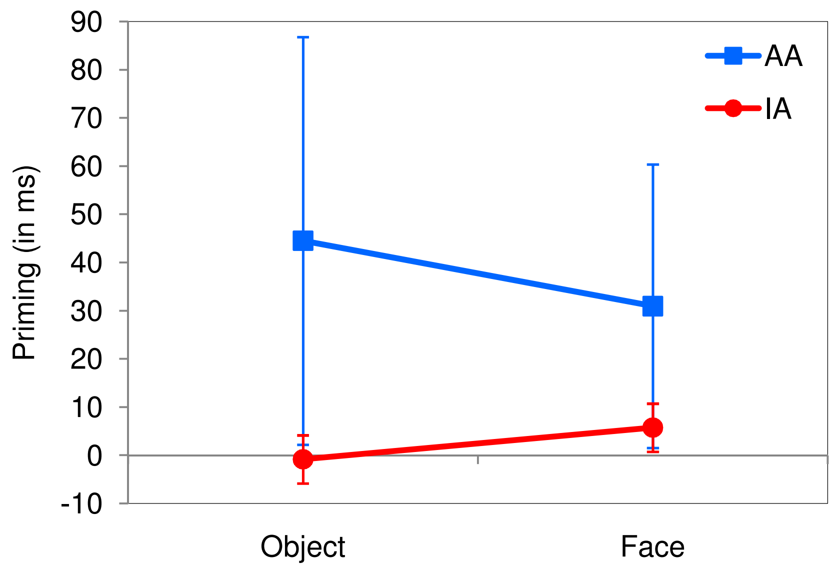

Figure 2.8b. Priming conditional on new responses by stimulus type. Error bars reflect 95% confidence intervals.

Priming Conditional on Recognition By d'

To further examine these results, a three way trial type (probe or control) by flanker (compatible or incompatible) by high old response (true or false) ANOVA was performed separately for each sequence type and d' divided on a median split (high or low).

Attend-Attend Sequences – d' low There was a significant main effect of high old response, $F(1, 139) = 8.89$, $MSE = 23110$, $p < .01$, which indicated an overall effect of recognition. Response times were faster for items that were not subsequently recognized during the recognition memory task (M = 807 ms, SD = 231 ms) than for items that were subsequently recognized during the recognition task (M = 834 ms, SD = 240 ms). There was further an effect of trial type, $F(1, 139) = 22.01$, $MSE = 15567$, $p < .0001$, which indicated positive priming. Response times were faster on probe trials (M = 802 ms, SD = 238 ms) than on control trials (M = 837 ms, SD = 234 ms). Recognition was modulated by flanker, $F(1,139) = 3.93$, $MSE = 19266$, $p = .04$, which could be driving the differences in positive and negative priming seen in the overall recognition analyses. Effects of priming conditional on recognition by d' and flanker compatibility can be seen in Figure 2.9a.

Attend-Attend Sequences – d' high There was a significant main effect of high old response, $F(1, 152) = 14.73$, $MSE = 41286$, $p < .0001$, which indicated an overall effect of recognition. Response times were faster for items that were not subsequently recognized during the recognition memory task (M = 835 ms, SD = 238 ms) than for items that were subsequently recognized during the recognition task (M = 879 ms, SD =

254 ms). There was further an effect of trial type, $F(1, 152) = 11.63$, $MSE = 21367$, $p < .0001$, which indicated overall positive priming. Response times were faster on probe trials ($M = 843$ ms, $SD = 246$ ms) than on control trials ($M = 871$ ms, $SD = 248$ ms). Effects of priming conditional on recognition by d' and flanker compatibility can be seen in Figure 2.9b.

Ignore-Attend Sequences – d' low There was a significant main effect of high old response, $F(1, 138) = 4.14$, $MSE = 27268$, $p = .04$, which indicated an overall effect of recognition. Response times were faster for items that were not subsequently recognized during the recognition memory task ($M = 829$ ms, $SD = 225$ ms) than for items that were subsequently recognized during the recognition task ($M = 849$ ms, $SD = 246$ ms). There was not an effect of trial type, $F(1, 138) = 0.98$, $MSE = 15951$, $p = .32$, which indicated no overall effect of priming. Response times were not significantly different between probe trials ($M = 835$ ms, $SD = 234$ ms) than on control trials ($M = 843$ ms, $SD = 239$ ms). Though there was not an overall effect of priming, there was an interaction of priming and flanker, $F(1,138) = 4.15$, $MSE = 22256$, $p = .04$, which could further be driving the differences in positive and negative priming seen in the overall recognition analyses.

Ignore-Attend Sequences – d' high There was a significant main effect of high old response, $F(1, 139) = 22.89$, $MSE = 37176$, $p < .0001$, which indicated an overall effect of recognition. Response times were faster for items that were not subsequently recognized during the recognition memory task ($M = 857$ ms, $SD = 236$ ms) than for items that were subsequently recognized during the recognition task ($M = 913$ ms, $SD =$

261 ms). There was not an effect of trial type, $F(1, 139) = 0.11$, $MSE = 22313$, $p = .73$, which indicated no overall effect of priming. Response times were not significantly different between probe trials (M = 883 ms, SD = 249 ms) than on control trials (M = 886 ms, SD = 251 ms). Though there was not an overall effect of priming, there was an interaction of priming and flanker, $F(1,139) = 3.76$, $MSE = 22505$, $p = .05$, which could further be driving the differences in positive and negative priming seen in the overall recognition analyses. As can be seen in Figure 2.10a and 2.10b, compatibility and recognition interact in such a way to produce completely opposite results depending upon a participant's d'. Those with high d' produce positive priming for compatible flankers and negative or no priming for incompatible flankers, while those with low d' produce positive priming for incompatible flankers and negative or no priming for compatible flankers.

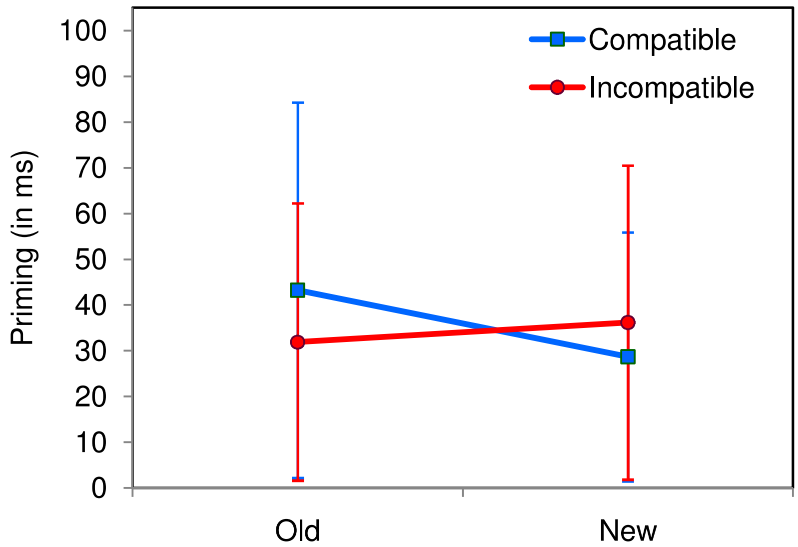

Figure 2.9a. Priming conditional on recognition for Attend-Attend sequences and low d'. Error bars reflect 95% confidence intervals.

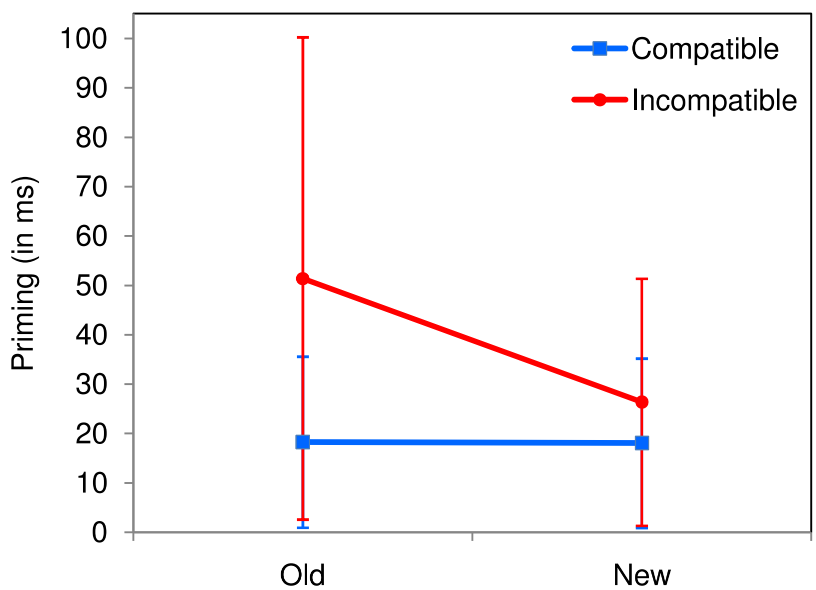

Figure 2.9b. Priming conditional on recognition for Attend-Attend sequences and high d'. Error bars reflect 95% confidence intervals.

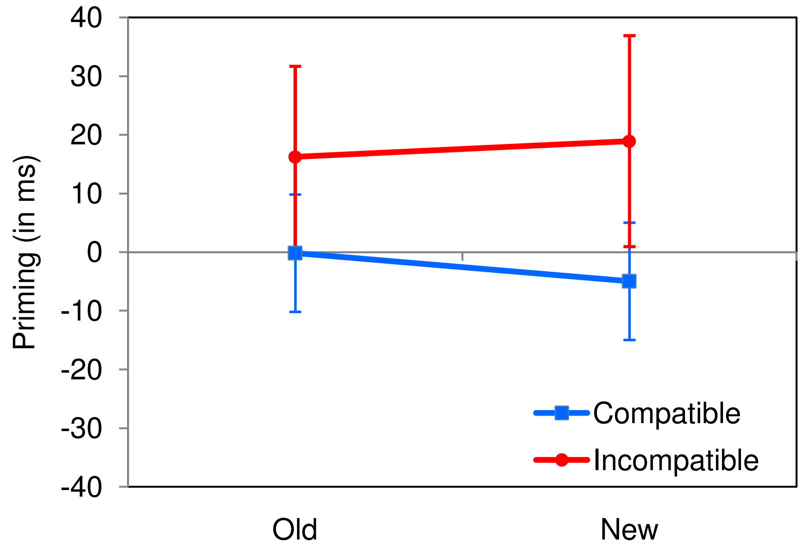

Figure 2.10a. Priming conditional on recognition for Ignore-Attend sequences and low d'. Error bars reflect 95% confidence intervals.

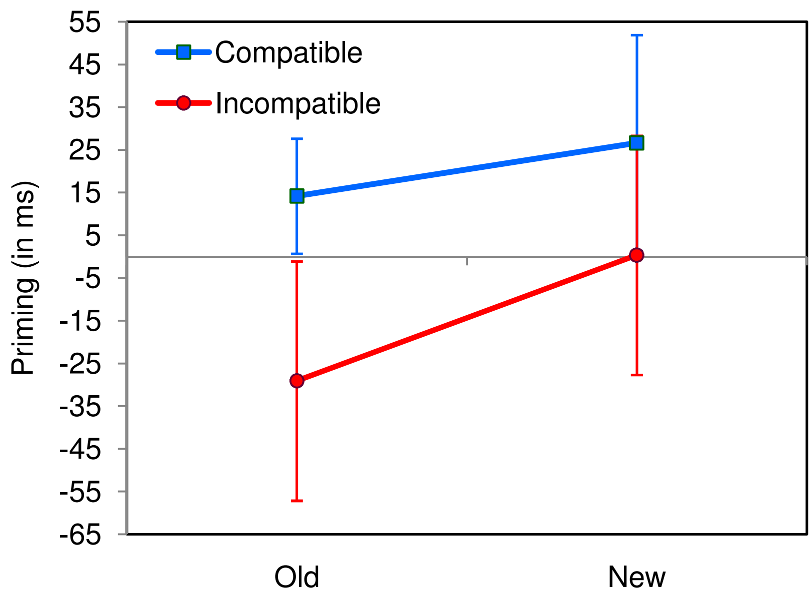

Figure 2.10b. Priming conditional on recognition for Ignore-Attend sequences and high d'. Error bars reflect 95% confidence intervals.

Working Memory Capacity

The mean symmetry span score was 27.13 (SD = 7.77). The correlation between priming in Ignore-Attend sequences and working memory capacity was not significant, $r(225) = 0.01$, $p = 0.833$. Likewise, the correlation between priming in Attend-Attend sequences and working memory capacity was not significant, $r(225) = 0.06$, $p = 0.39$. 13

2.3 Discussion

The goal of Experiment 1 was to examine whether or not there is explicit memory of items that lead to negative and positive priming. When priming analyses were not conditional upon recognition, overall positive priming was seen in the Attend-Attend condition and no significant overall priming was seen in the Ignore-Attend condition. Though it was expected that incompatible flankers would lead to slower response times than compatible flankers in both the Ignore-Attend and Attend-Attend condition, interference was only present in the Ignore-Attend condition. The Attend-Attend and Ignore-Attend conditions differed with regard to the task that the participant completed from prime to probe trial. For Attend-Attend sequences, participants were to report the gender of the face or the animacy of the object for the center item on the prime trial, and then perform the same task of reporting the center image on the probe trial. For Ignore-Attend sequences, participants were to report the gender of the face or the animacy of the object for the images to the left and right of the center image on the prime trial, followed by classifying the center item on the probe trial.

As the task generated more trials that required responses to the center item than the outside items, filler trials requiring responses to be made to the outer items were added so that participants responded an equal number of times to both locations. Filler trials were dispersed randomly throughout the experiment, with the requirement that they not interfere with necessary placement of prime, probe, and control trials. The fact that interference was not equivalent on both trial types despite this control indicates that perhaps Attend-Attend trials were easier and thus uninfluenced by the flankers.

According to Conway et al. (1999), individual differences in working memory capacity correspond to the ability to proficiently handle irrelevant information. Therefore, working memory capacity can be seen as a measure of inhibitory capacity, such that the greater one's working memory capacity, the more information that can be inhibited. As such, if the presence of negative priming in the present experiment was the result of inhibitory processes, then a correlation between negative priming and working memory capacity should have been observed. A correlation was not observed, however, which fails to provide support for Engle's hypothesis, as priming did not vary with working memory capacity. Furthermore, the amount of negative priming did not change as a function of interference, which is also not consistent with the inhibitory account of negative priming.

Theory Prediction Verification

Selection at the Prime Trial

When examining the predictions for selection on the prime trial for Ignore-Attend sequences, the inhibitory account predicts positive priming for remembered items when selection occurs at the middle and late levels (See Table 2.9b). This prediction matches the results of positive priming in the negative priming condition when only face stimuli are considered. Though this finding matches the prediction for the inhibitory account of priming, this is only true in this specific subset of stimuli which is not enough to provide confirmatory evidence of the inhibitory account of priming. None of the predictions regarding non-remembered items were matched for either theory of priming. See Table 2.9a-2.9d for a verification of predictions against the data for selection on the prime trial.

When examining the predictions for selection on the prime trial for Attend-Attend sequences, the inhibitory account further predicts positive priming for non-remembered items with middle selection (See Table 2.9d). Positive priming is also predicted for remembered items at all levels of selection by both theories, except for selection at the early level based upon the inhibitory account. The Attend-Attend-new condition resulted in 37.9 ms of positive priming, and the Attend-Attend-old condition resulted in 23.09 ms of positive priming. These results match the predictions of the inhibitory account of priming for non-remembered items when middle selection occurs, and both theories at all levels of selection for the episodic retrieval account, and the late selection level for the inhibitory account. (See Table 2.9c and Table 2.9d). These results do not provide enough confirmatory support to explain the presence of positive priming with either the inhibitory or episodic retrieval accounts of priming.

Table 2.9a.

Predictions for Ignore-Attend Prime Trials Based on the Episodic Retrieval Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	-	0	-	0

Table 2.9b

Predictions for Ignore-Attend Prime Trials Based on the Inhibitory Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	+	-	+	-

Table 2.9c

Predictions for Attend-Attend Prime Trials Based on the Episodic Retrieval Account

Early		Middle		Late	
R	NR	R	NR	R	NR
+	0	+	0	+	0

Table 2.9d

Predictions for Attend-Attend Prime Trials Based on the Inhibitory Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	0	++	+	+	0

Note. R = Recognized, NR = Not Recognized
- = Negative Priming, 0 = No Significant Priming,
+ = Positive Priming, ++ = Most Positive Priming,
Black = Prediction Not Met, Red = Prediction Met

Selection at the Probe Trial

The point of divergence between the episodic and inhibitory theories for probe trial selection is based on whether a remembered item from the Ignore-Attend condition produced positive or negative priming. The episodic theory predicts negative priming for remembered items, whereas the inhibitory account predicts positive priming for remembered items (See Figure 2.1a and Figure 2.1b in Chapter 1). The present results indicate no significant priming in this condition, and as such do not provide support for the episodic or inhibitory accounts of priming or distinguish between them. When considering an average of 20.96 ms of priming in the old condition for Ignore-Attend sequences, there is a trend towards explaining the results with an inhibitory account, but lack of statistical significance hinders this theory from explaining the data.

When addressing priming conditional on recognition by d', priming affected subsequent recognition in both sequence types when recognition is divided into high and low d'. Significant positive priming was demonstrated in the Attend-Attend sequence regardless of high or low d', while significant priming was not observed in the Ignore-Attend sequence regardless of d'.

Interestingly, in support of Turk-Browne et al.'s (2000) results, participants were more likely to recognize an item later if it had not only been seen twice, but responded to twice, as can be seen in the Attend-Attend-old condition. As priming was not significantly different from zero when the items were recognized or not, the conclusion can be drawn that participants do not seem to have explicit memory of items that were previously not responded to. Though results indicated that participants did not seem to have explicit memory of items that were not previously responded to, the goal of the study was to examine whether or not there is explicit memory of items that produced negative priming. As significant negative priming was not obtained in Ignore-Attend sequences, design changes were made in Experiment 2.

Chapter 3

Experiment 2

As in Experiment 1, the goal of Experiment 2 is to examine whether or not there is explicit memory of items that lead to negative priming. To this effect, the methodology from Experiment 1 must be altered, as significant negative priming was not observed in Ignore-Attend sequences. As the point of greatest interest in teasing apart the episodic and inhibitory accounts of negative priming is the Ignore-Attend-old condition, Attend-Attend sequences were eliminated. Object stimuli were also eliminated.

In addition to altering the negative priming task, the recognition memory portion of the experiment was changed to utilize a two-alternative forced-choice (2AFC) task with confidence ratings instead of a yes-no task with confidence ratings paradigm. According to Wickens (2002), one advantage of the forced-choice procedure over the yes/no task is that it eliminates the need to consider the bias for or against reporting a signal (p. 93). As each trial essentially contains both a yes and no response, this type of bias is eliminated. Furthermore, trials in a 2AFC task do not differ among themselves as much as in a yes/no task, in which some trials are noise and some are signal. In a 2AFC task, each is trial is composed of the same two events, simply rearranged. According to Tulving (1983), a 2AFC task of recognition memory is a direct measure of explicit, specifically episodic, memory, as the task can be described in terms of the subject's earlier personal experience. The personal experience addressed here concerns the two images the participant encountered in the priming task of the experiment. The present 2AFC also requires participants to rate their confidence in their responses. The cueing manipulation was modified to utilize a red or green circle to indicate whether the center image or outside images were to be classified.

3.1 Method

Participants

One-hundred and thirty-eight individuals enrolled in introductory undergraduate psychology courses at the University of California, Riverside served as participants in partial fulfillment of a course requirement.

Design

Participants completed the same three tasks as completed previously, with the exception of the Attend-Attend sequence type and the object response category.

Materials

For the priming task, a set of 314 trials was generated for each participant. These trials included one set of stimuli, faces, drawn from the Florida Department of Corrections, and other sources (Sheikh, Sabir, & Bovik, 2006; Nilsback & Zisserman, 2006). Of the 314 trials, there were 10 practice trials, 68 prime trials, 68 prime-control trials, 68 probe trials, 68 probe-control trials, 16 catch trials, and 16 fill trials.

The recognition memory task was a two alternative forced-choice task (2AFC) that included 136 trials. Each display included one face that was present during the priming task, and one new face. Of the 136 old items, 68 of those items were critical items from prime and probe trials in Ignore-Attend sequences, and 68 were from control trials. The old items were counterbalanced to appear on the right 50 percent of the time and on the left 50 percent of the time.

Procedure

All instructions to the participants were presented on the computer screen. All participants completed a negative priming task and an explicit recognition memory task.

Negative Priming Task The instructions for the negative priming portion of the experiment were the same as for Experiment 1, with the exception that only images of faces were presented. Whether the gender of the center face or the peripheral faces was to be reported was indicated by a red or green circle that appeared on the center face. A sample of the stimuli and time course of the trials can be seen in *Figure 3.1*. A red circle required participants to report the category of the face in the center of the screen, while a green circle required participants to report the category of the faces on the left and right of the screen. Participants were to withhold a response if the images on the left and right were not members of the same category (ie. one male face and one female face). As an example of a typical prime trial, if a red circle appeared on the center face followed by three images with a male face in the center, the participant would respond by pressing the 4 key to indicate that the center image was a male face. It was emphasized that participants should keep their eyes focused on the location of the fixation indicator in the center of the screen, even when the fixation indicator was no longer present.

Both tasks were run using E-Prime software on IBM PC compatible computers.

Stimuli were displayed on a 17-inch display set to a resolution of 600 x 800. Participants' response times in the priming task were measured using the 4 and 6 keys on the numeric keypad.

Target and distractor stimuli were faces 182 pixels in height and 179 pixels wide and were viewed from a distance of about 45 cm. The prime and probe displays were always presented with three images side by side.

Each trial proceeded as follows. On the prime trial, the central image appeared with a red or green circle in the middle of the image. After 300 ms, this image was replaced with three faces in a row in the center of the screen, the center image remaining constant, for 900 ms. This was followed by a blank screen in which participants were to make their response. If participants did not respond within 2500 ms, they were reminded that their responses must be made both quickly and accurately. If an incorrect response was given, a message appeared reminding participants of the goals of the task.

After responding, the probe began with the presentation of a central image and a red or green circle fixation indicator. As on the prime trial, this image was replaced with three faces in a row in the center of the screen, the center image remaining constant, for 2500 ms. This was followed by a blank screen in which participants were to make their response. If a response was not made within 2500 seconds of the images appearing, a message appeared reminding the participants that they need to respond more quickly and how to accurately complete the task. Participants were provided with feedback if an incorrect response was given that reminded them of the requirements of the task. Unlike in Experiment 1, prime, probe, and control placement was not random. Participants saw in succession a prime-Ignore-Attend trial and a probe-Ignore-Attend trial followed by a prime-control trial and a probe-control trial. This design allowed for the use of matched trials in computing negative priming.

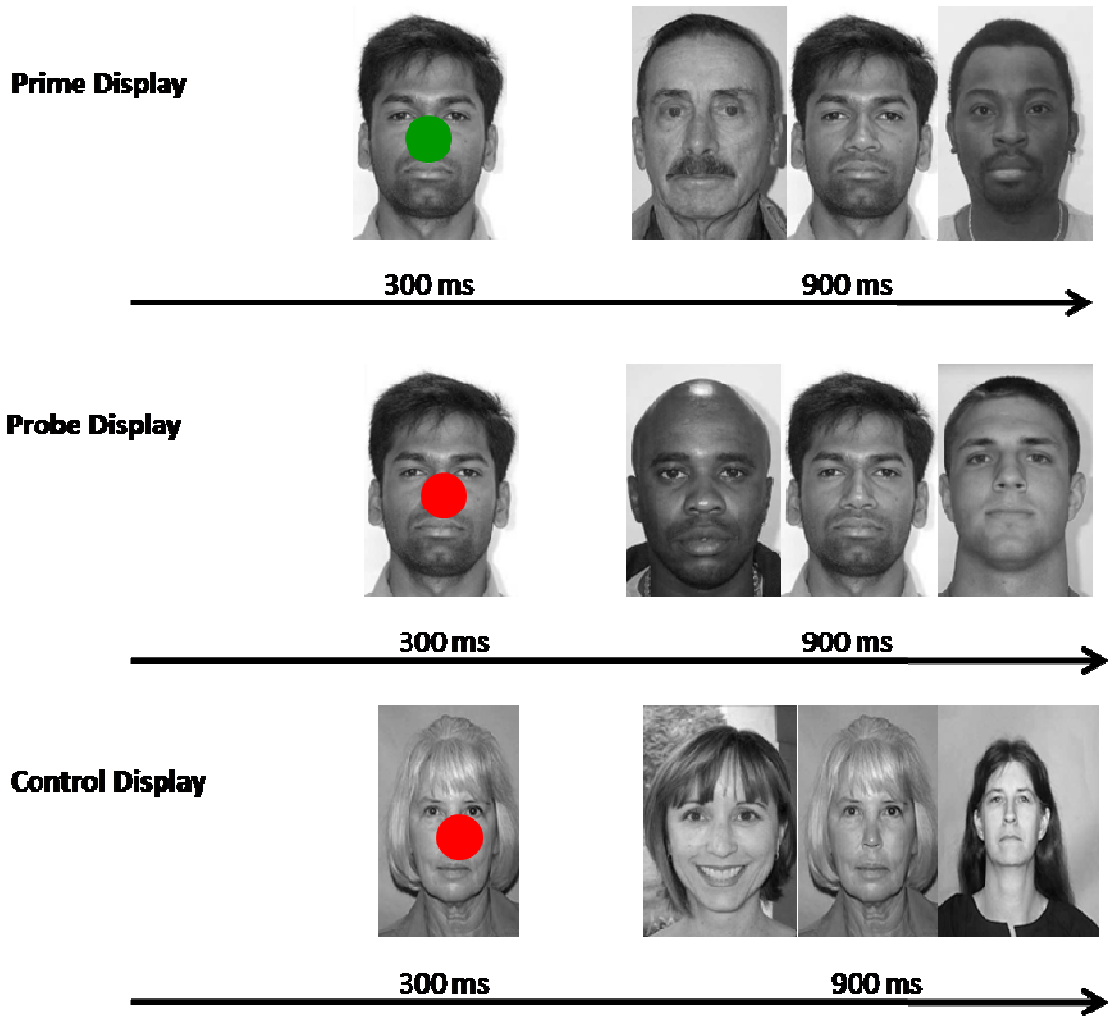

Figure 3.1. Sample Ignore-Attend compatible flanker trial sequence.

Working Memory Capacity Task The procedure was the same as in Experiment 1.

Explicit Recognition Memory Task The instructions for the explicit recognition memory portion of the experiment indicated that two images would appear on the screen, and that the participant's task was to indicate which of the two faces was more familiar and how confident they were in that judgment. They were to press the S, D, F, J, K, or L keys to indicate which image had been in the negative priming task and how confident they were. Keys S, D, and F indicated that the left face was more familiar, while J, K, and L indicated that the right face was more familiar. High confidence was indicated by the S and L keys, moderate confidence was indicated by the D and K keys, and the F and J keys indicated low confidence. Participants had up to 10 s to make their response. Upon receipt of response, a message appeared on the screen which indicated that their response was recorded. No feedback was given regarding accuracy. If participants did not respond within 10 s, participants were reminded to respond both quickly and accurately.

3.2 Results

The effect of interference on prime trials was examined by measuring the reaction time difference between compatible and incompatible trials and the effect of priming on probe trials was examined by comparing reaction times on probe trials to control trials. Only accurate sequences were included in the analyses. Overall, participants had 57% accuracy on Ignore-Attend sequences. In addition, mean reaction times for cue type and stimulus type by subject were computed and trials were dropped that were plus or minus two standard deviations from the mean. Recognition memory was indicated using d'. Overall, participants' median d' for high confidence responses was .98. These d' were converted to yes/no d' calculations for comparison with Experiment 1.

Priming Task

Only prime sequences in which the matched trials were all accurate were included in the analyses. In addition, mean reaction times for cue type and stimulus type by subject were computed and trials were dropped that were plus or minus two standard deviations from the mean.

Interference in the Prime Displays

Interference in the prime displays was examined by performing a three-way within-subjects critical category (male or female) by flanker (compatible or incompatible) by sequence type (Ignore-Attend or control) repeated measures ANOVAs on correct reaction times.

Reaction times were slower on incompatible trials (M = 1134 ms, SD = 178 ms) than on compatible trials (M = 1029 ms, SD = 153 ms), $F(1,134) = 164.44$, $MSE = 18079$, $p < .0001$, which indicated overall interference on incompatible trials. Mean response times on Ignore-Attend trials as a function of critical category and flanker compatibility can be seen in Table 3.1. This effect was mediated by critical category as seen in the interaction between flanker and critical category, $F(1, 134) = 9.86$, $MSE = 13601$, $p < .001$. The effect of interference was greater for the female critical category (147 ms) than for the male category (64 ms). The effect of critical category on interference can be seen in Figure 3.2.

Table 3.1

Mean Response Times on Ignore-Attend Trials as a Function of Critical Category and Flanker Compatibility (with Standard Deviations in Parentheses)

Flanker	Male	Female
Compatible	1050 (161.84)	995 (137.45)
Incompatible	1110 (161.67)	1158 (192.27)

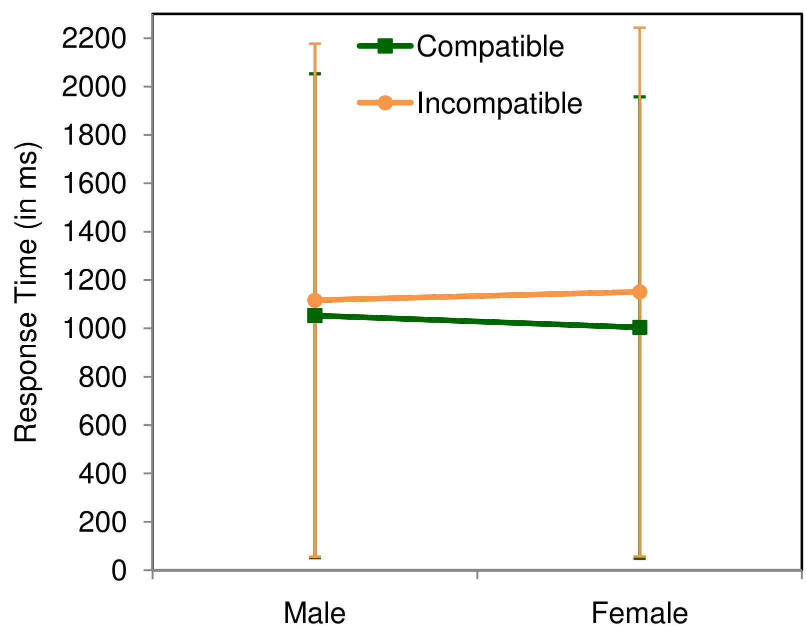

Figure 3.2a. The effect of critical category on interference combined across sequence type. Error bars reflect 95% confidence intervals.

Table 3.2

Mean Response Times on Ignore-Attend Trials as a Function of Trial Type, Stimulus Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		Probe	
Gender	Compatible	Incompatible	Compatible	Incompatible
Male	919 (168.11)	948 (223.81)	914 (158.97)	910 (163.19)
Female	973 (201.09)	966 (229.43)	938 (163.84)	963 (197.07)

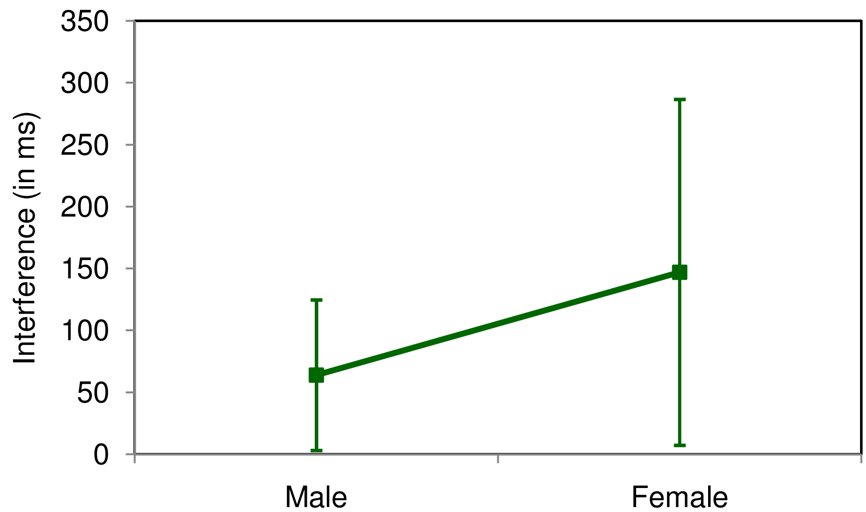

Figure 3.2b. Interference by critical category combined across flanker type. Error bars reflect 95% confidence intervals.

Priming on Probe Displays

The median probe display reaction time data were analyzed in a three-way within-subjects sequence type (control or Ignore-Attend) by flanker (compatible or incompatible) by critical category (male or female) repeated measures ANOVA. Ignore-Attend trials were faster (M = 934 ms, SD = 171 ms) than control trials (M = 955 ms, SD = 203 ms), $F(1,123) = 6.58$, $MSE = 15021$, p = .01, which indicated overall positive priming. Mean response times on Ignore-Attend trials as a function of trial type, stimulus type, and flanker compatibility can be seen in Table 3.2. Priming was modulated by flanker and critical category as indicated by the two-way flanker and critical category interaction on priming, $F(1, 123) = 5.45$, $MSE = 12258$, p = .02. This effect can be seen in Figure 3.3.

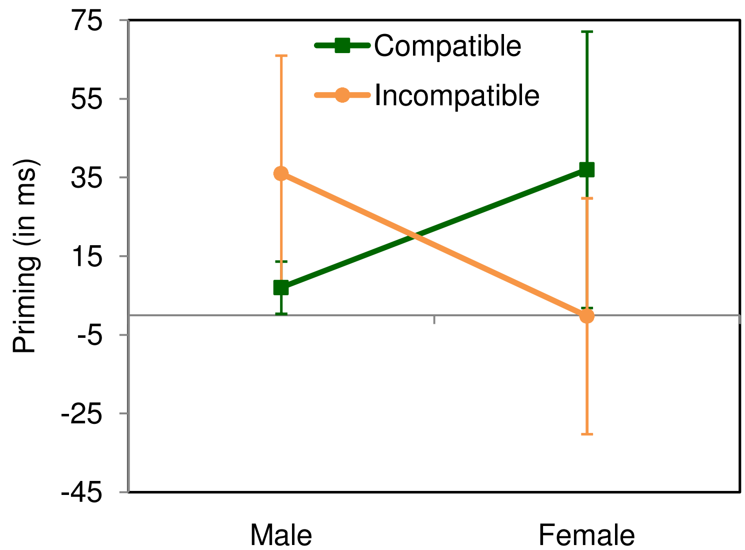

Figure 3.3. Priming by flanker compatibility and critical category in ms. Error bars reflect 95% confidence intervals.

Priming Conditional on Recognition

Priming was examined on the basis of recognition in the subsequent recognition memory task based upon whether participants called an item new or old as a function of sequence type. Analysis of old items utilized only those items that participants responded "high confidence" based upon Turk-Browne et al. (2006). Though the "new" and "old" nomenclature is not often utilized in conjunction with 2AFC, it is utilized here to allow for comparison with Experiment 1. Old responses are classified as those in which the participant accurately indicated which of the two images was seen during the negative priming task. New responses are classified as those in which the participant incorrectly identifies an item as one that was present in the negative priming task when it was not. When a participant classifies an item as new with high confidence, the participant is indicating that they thought that the actual "old" item had never been seen before and was thus "new". Response times were analyzed with a repeated measures ANOVA using the design: sequence type (Ignore-Attend or control) by flanker (compatible or incompatible) by critical category (male or female) by high old response (true - confident old response or false – new response). High old response indicates whether or not subjects were highly confident when they called an item old. True represents a high confident old response, while false represents a new response.

Table 3.3

Mean Response Times on Ignore-Attend Trials as a Function of Recognition, Trial Type, and Flanker Compatibility (with Standard Deviations in Parentheses)

	Control		ProI	
Flanker	Not Recognized	Recognized	Not Recognized	Recognized
Compatible	859 (147.25)	998 (155.15)	918 (234.62)	908 (109.14)
Incompatible	960 (277.82)	880 (266.29)	949 (266.72)	903 (146.66)

There was a significant effect of high old response, $F(1, 9) = 11.57$, $MSE = 6450$, $p < .01$, indicating that priming affected subsequent recognition. The effect of high confidence old responses can be seen in Figure 3.4a and the effect of high confidence new responses can be seen in Figure 3.4b. A table of mean response times on Ignore-Attend trials as a function of recognition, trial type, and flanker compatibility can be seen in Table 3.3. There was not a main effect of sequence type, $F(1, 9) = 0.30$, $MSE = 19563$, $p = .59$, which indicated no overall effect of priming. Though there was not a significant overall effect of priming, priming interacted with high old response, critical category, and flanker, $F(1, 9) = 5.30$, $MSE = 16276$, $p = .04$. Compatibility and critical category interacted to produce an opposite pattern of results for old and new responses. When participants called an item old, negative priming was elicited for the compatible-female and incompatible-male trial types, while positive priming was elicited for the incompatible-female and compatible-male trial types. In contrast to this, when participants called an item new, negative priming was elicited for the compatible-male and incompatible-female trial types, while positive priming was elicited for the compatible-female and incompatible-male trial types. These results are discussed in further detail in the General Discussion.

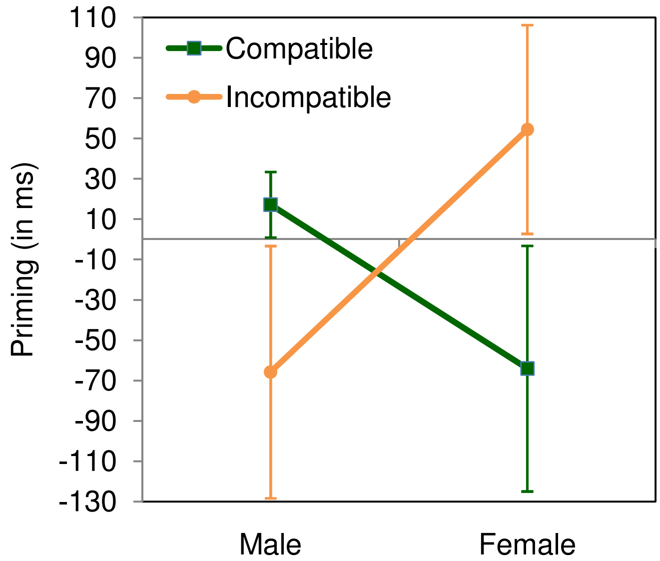

Figure 3.4a. Priming conditional on high confidence old responses by flanker and category in ms. Error bars reflect 95% confidence intervals.

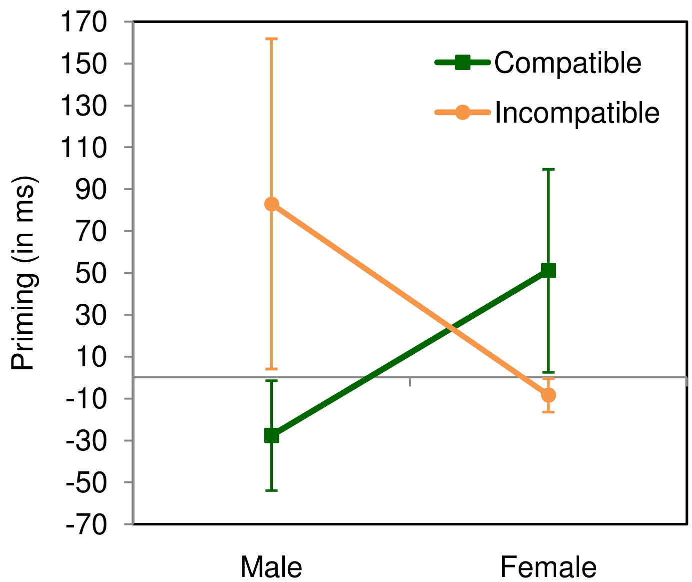

Figure 3.4b. Priming conditional on new responses by flanker and category in ms. Error bars reflect 95% confidence intervals.

Working Memory Capacity

The mean symmetry span score was 31.5 (SD = 7.93). The correlation between priming in Ignore-Attend sequences and working memory capacity was not significant, $r(135) = 0.05$, $p = 0.52$.

3.3 Discussion

As in Experiment 1, the goal of Experiment 2 was to examine whether or not there is explicit memory of items that lead to negative priming. Unlike Experiment 1 where no significant priming was observed for Ignore-Attend sequences, there was overall positive priming for Ignore-Attend sequences when recognition is not considered. . Negative priming was observed in specific critical category and flanker conditions, however, as will be discussed in the General Discussion. Though there was not a main effect of flanker, priming was modulated by interference and critical category. As discussed, this facilitation may be due to processing of the distractor as an invalid flanker. As predicted, the presence of interference in this condition indicates that the distractor was processed to some degree, despite the do-not-respond decision.

When analyzing priming conditional on recognition, there is an overall effect of recognition, but no overall effect of sequence type. Flanker and critical category seem to be driving the priming effects. As previously discussed, when participants called an item old, negative priming was elicited for the compatible-female and incompatible-male trial types, while positive priming was elicited for the incompatible-female and compatible-male trial types. In contrast to this, when participants called an item new, negative priming was elicited for the compatible-male and incompatible-female trial types, while positive priming was elicited for the compatible-female and incompatible-male trial types. These contrasting effects seem to be leading to no overall priming in the conditional analyses. These results are discussed in further detail in the General Discussion and can be seen in Figure 3.4a and 3.4b.

Theory Prediction Verification

Selection at the Prime Trial

The current data indicated no significant overall priming for Ignore-Attend sequences when recognition is considered. When examining the predictions for selection on the prime trial for Ignore-Attend sequences, both the inhibitory and episodic accounts predict no overall priming for remembered items when selection occurs at the early level (See Table 3.4a and 3.4b). As both theories predict the same result for early selection, this result does not provide confirmatory evidence for either theory. When examining the predictions for selection on the prime trial for non-remembered items, no priming is predicted when selection occurs at any level for the episodic retrieval account and at the early level for the inhibitory account. No priming was observed for non-remembered items which matches these predictions, but does not provide sufficient support for either theory of priming.

A comparison of the results and predictions for Experiment 1 and Experiment 2 Ignore-Attend prime trials based on the episodic retrieval and inhibitory accounts of priming can be seen in Table 3.5a and Table 3.5b.

Table 3.4a

Predictions for Ignore-Attend Prime Trials Based on the Episodic Retrieval Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	**0**	-	**0**	-	**0**

Table 3.4b

Predictions for Ignore-Attend Prime Trials Based on the Inhibitory Account

Early		Middle		Late	
R	NR	R	NR	R	NR
0	**0**	+	-	+	-

Table 3.5a

Predictions for Ignore-Attend Prime Trials Based on the Episodic Retrieval Account

	Early		Middle		Late	
	R	NR	R	NR	R	NR
Experiment 1	0	0	-	0	-	0
Experiment 2	**0**	**0**	-	**0**	-	**0**

Table 3.5b

Predictions for Ignore-Attend Prime Trials Based on the Inhibitory Account

	Early		Middle		Late	
	R	NR	R	NR	R	NR
Experiment 1	0	0	+	-	+	-
Experiment 2	**0**	**0**	+	-	+	-

Note. R = Recognized, NR = Not Recognized
- = Negative Priming, 0 = No Significant Priming,
+ = Positive Priming, ++ = Most Positive Priming,
Black = Prediction Not Met, **Red** = Prediction Met

Selection at the Probe Trial

Whether or not a recognized item from the Ignore-Attend condition produced negative or positive priming is the distinction between the episodic and inhibitory theories when considering selection on the probe trial. The episodic theory predicts negative priming for remembered items, while the inhibitory account predicts positive priming for remembered items. The present results indicated no overall significant priming for remembered items. Based upon the overall priming results, combined across critical category and flanker, the results do not provide support for either theory.

The priming results were, however, moderated by critical category and flanker. As previously discussed, negative priming was elicited for compatible-female and incompatible-male trial types that participants remembered. In contrast to this, positive priming was elicited for incompatible-female and compatible-male trial types that participants remembered. The presence of both positive and negative priming provides conflicting evidence for the episodic and inhibitory theories.

As in Experiment 1, a correlation between negative priming and working memory was not observed which fails to provide support for Engle's hypothesis, as negative priming persisted in certain conditions.

Chapter 4

4.1 General Discussion

This dissertation has addressed the nature of processing items in an implicit task, and the degree to which that implicit processing leads to explicit memory. The implicit effect of not responding to or attending to items was assessed through measures of positive and negative priming. The level of processing of these not responded to items was further explored to assess if there is explicit memory of these items through the use of a recognition memory task. Ultimately, the relationship between implicit and explicit memory was assessed using conditional analyses of priming as a function of explicit memory. Two factors were explored in two experiments to test implicit processing and explicit recognition. These factors were priming (trial type of control vs. probe) and interference (flanker compatibility vs. incompatibility).

Interference and Processing

The results of both experiments indicate overall interference on the prime trial. An interference effect was observed when reaction times were slower on incompatible flanker trials than on compatible flanker trials. This difference in reaction time for incompatible flankers suggests that the increased processing time is due to the incompatible flankers interfering with the processing of the to-be-responded to item (target). In Ignore-Attend trials, if the incompatible flankers are processed, this indicates that the distractor (not responded to item) may be processed to some degree.

When interference is coupled with negative priming, it suggests that the distractor was processed to the degree of either inhibiting the internal representation of the item or pairing the distractor with a “do not respond” tag that ultimately slows processing of the prime-distractor (probe-target) on the probe trial. Negative priming was only observed in certain flanker compatibility and critical category conditions in Experiment 2. As Fox (1995) and Reder et al. (2003) have proposed, the pairing of negative priming and interference suggests that the distractor was processed on the prime trial and that this processing affected later responding to this item on the probe trial as demonstrated by increased reaction times compared to control trials.

Turk-Browne et al.’s goal was to determine how processes at the first exposure impact subsequent priming and recognition. Experiment 1 included conditions varying the number of times that the item was presented versus the number of times that it was responded to. The greatest probability of correct recognition occurred in the seen twice–responded to twice condition (Attend-Attend). There was no difference in probability between the seen once–responded to once condition and the seen twice–responded to once condition. These results suggest it is not the number of times that an item is seen that affects future recognition, but rather it is the number of times that an item is responded to.

Priming Conditional on Recognition

Results of Experiment 1 indicated that recognition memory did not significantly affect the degree of priming, as priming was not significantly different from zero when the items were recognized or not. Unlike Experiment 1, the results of Experiment 2 indicated an overall effect of recognition. Most importantly, neither experiment consistently elicited negative priming in Ignore-Attend sequences. A conclusion thus cannot be drawn regarding the degree to which previously not responded to items will be explicitly recalled in a recognition memory task. This fact will be discussed further in the Limitations section.

The priming conditional on recognition results of Experiment 2 produced an unusual pattern of results. When participants called items old, negative priming was elicited for compatible-female and incompatible-male trials, while positive priming was elicited for incompatible-female and compatible-male trials. The exact opposite pattern of results was elicited when participants called items new. One interesting pattern within the data when participants called items old was that negative priming was elicited when both flankers were female and positive priming was elicited when both flankers were male. The opposite was true when participants called items new. This was an unexpected finding that is not explained by current literature. Future research will need to be done to understand how the gender of face stimuli affects processing of to be ignored and to be attended to faces.

Working Memory Capacity Engle's working memory capacity task was utilized as a measure of inhibitory control and provision of controlled attention. A negative correlation was predicted, as those individuals with lower working memory capacities have a decreased ability to inhibit irrelevant information (Bleckley et al., 2003; Conway & Engle, 1994; Conway et al., 1999; Kane et al. 2001; Kane & Engle, 2003; Zacks, 1988). The decreased ability to inhibit irrelevant information increases the likelihood of processing the distractor which may lead to negative priming. A correlation between working memory capacity and negative priming was not observed in Experiments 1 or 2. The fact that this correlation was not observed provides evidence against the inhibitory account of negative priming, as inhibitory control drives the basis of the theory.

Theoretical Findings

Both experiments aimed to examine whether or not there is explicit memory of items that lead to negative priming. One way to address this question is to develop predictions regarding the type of priming that will be elicited if a stimulus is ultimately remembered or not on a subsequent recognition memory task. To thoroughly address the question, predictions were made for selection of the critical item on the prime or probe trial, as well as the level of processing at selection (ie. early, middle, or late). As previously discussed, these predictions were made for all levels of selection for both the episodic and inhibitory accounts of priming.

Table 4.1 provides a breakdown of the theoretical findings for both experiments based upon the predictions of selection occurring at either the prime or probe trial. Though there is a trend towards explaining the priming conditional on recognition data with the inhibitory account of priming, there is no confirmatory evidence for either theory to explain the data. Detailed discussions of the theoretical findings for both experiments can be found in the discussion section of each experiment under the section Theory Prediction Verification.

Table 4.1

Theory Results by Experiment

	Experiment 1	Experiment 2
Prime Trial Selection	Trend towards inhibitory/ No confirmatory evidence	Trend towards both/ No confirmatory evidence
Probe Trial Selection	Trend towards inhibitory/ No confirmatory evidence	No confirmatory evidence

At the level of priming conditional on recognition by d', the results of Experiment 1 replicate Turk-Browne et al.'s (2006) findings of greater priming for subsequently remembered images. This finding, coupled with less priming for not remembered items, further trends towards matching the predictions of the inhibitory account of negative priming (Tipper, 2001), but results do not provide sufficient evidence to support the episodic or inhibitory accounts of priming. Though Experiment 2's data matched some predictions made by the episodic and inhibitory theories for selection at the prime trial, there was not enough confirmatory evidence for either theory. . The predictions made for selection at the probe trial did not match the data for either theory. Experiment 2 does not provide evidence for explicit memory of not responded to items, nor does it provide sufficient theoretical evidence to explain priming conditional on recognition memory.

Limitations

The present experiments each yielded one major problem in attempting to address the question of whether or not participants have explicit memory for previously not responded to items. Neither of the experiments produced a reliable negative priming effect. In order to be able to discuss the relationship between explicit memory and negative priming (implicit memory), the phenomenon must first reliably be produced. To determine the aspect of the methodology that failed to elicit negative priming, Grison, Tipper, and Hewitt (2005)'s study can be compared to Experiment 1 and Experiment 2. A comparison of the methodology can be seen in Table 4.2.

One critical methodological difference was the blocking of prime and probe trials in Grison et al.'s study. In addition to all prime trials occurring at once, the same items repeated in the same order as probe trials (targets and distractors reversed). Though significant negative priming has been elicited utilizing the methodology from Experiment 1 and Experiment 2 (Fox, 1995; Erickson & Reder, 1998), perhaps the design used by Grison et al. is necessary with such complex stimuli as faces and intricate objects.

A future direction for this study would be to utilize a task that more reliably elicits the negative priming phenomenon, so that the desired relationship can be accurately examined. One possibility would be to start by replicating Grison et al.'s exact methodology without the recognition task used in the present studies to determine if negative priming could be elicited with their task and the stimuli utilized in Experiment 1 and Experiment 2.

Table 4.2

Comparison of Experimental Methodology

	Grison, Tipper, Hewitt (2005)	Experiment 1	Experiment 2
Stimuli	Faces and Objects (Art Explosion CD-ROMs, 1995)	Faces and Objects (Florida Department of Corrections, Nene, Nayar, & Murase, 1996; Sheikh, Sabir, & Bovik, 2006; Nilsback & Zisserman, 2006)	Faces (Florida Department of Corrections, Sheikh, Sabir, & Bovik, 2006; Nilsback & Zisserman, 2006)
Trial Sequence	all prime trials 30 second delay all probe trials (in same order)	prime trial followed by probe trial	prime trial followed by probe trial
Display	3 horizontally displayed images	3 horizontally displayed images	3 horizontally displayed images
Trials	224 total trials 96 prime 96 probe 32 catch	320 total trials 96 AA 96 IA 20 practice 20 catch 88 fill	314 total trials 68 prime 68 prime-control 68 probe 68 probe-control 10 practice 16 catch 16 fill
Fixation Cross	No	1000ms exposure	1000ms exposure
Central Item	100ms exposure	100ms exposure	100ms exposure
Prime and Probe Presentation Time	2500ms exposure to all 3 images	2500ms exposure to all 3 images	2500ms exposure to all 3 images
Recognition Task	No	Yes	Yes

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