# Taboo Words: The Effect of Emotion on Memory for Peripheral Information

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## Abstract

Three experiments examined memory for peripheral information that occurred in the same context as emotion-inducing information. In the first two experiments, participants studied either a sentence (Experiment 1) or a pair of words (Experiments 2a-c) containing a neutral peripheral word as well as a neutral, negative valence, or taboo word to induce an emotional response. At retrieval, participants were asked to recall the neutral peripheral word from a sentence fragment or emotion-inducing word cue. Experiment 3 presented word pairs at encoding and tested memory with associative recognition. In all three experiments, memory for peripheral words was enhanced when it was encoded in the presence of emotionally-arousing taboo words, but not when it was encoded in the presence of words that were only negative in valence. These data are consistent with priority-binding theory (MacKay, Shafto, Taylor, Marian, Abrams, & Dyer, 2004) and inconsistent with the attention-narrowing hypothesis (Easterbrook, 1959) as well as object-based binding theory (Mather, 2007).

# Taboo Words: The Effect of Emotion on Memory for Peripheral Information

Emotion is a central element of human life. While some aspects of emotion appear to be universal, others are culture-specific (Elfenbein & Ambady, 2002). Further, one's emotional state is influenced by both current circumstances and one's disposition (Wood, Maltby, Stewart, Linley, & Joseph, 2008). Given the importance of emotion to the human condition, it is not surprising that emotion plays a key role in our ability to remember events (Buchanan & Adolphs, 2002; Hamann, 2001). Indeed, one's emotional state during encoding can serve as a key retrieval cue for past events, even if those events were not the cause of the emotional state (Bartlett & Santrock, 1979), and events that induce emotional responses, whether arousing or valenced, are remembered better than events that do not induce emotional responses (Kensinger, 2004; Kensinger & Corkin, 2003).

Although there is substantial evidence that emotional events are remembered better than neutral events, applied and theoretical considerations suggest it is also important to understand how experiencing emotional events impacts memory for other events that occur in the same context. In applied domains, it is often important to understand how affective responses to circumstances such as witnessing a robbery or being in a car accident impact memory for aspects of those events that do not cause an affective response, such as what a perpetrator looked like or the events that preceded the car accident, because those events can be essential in a legal setting. In the theoretical domain, understanding how emotional responses influence memory for events that occurred in close temporal proximity or simultaneously with the emotion-inducing event can be used to test theories of why emotion enhances memory for emotional events. The research reported in this paper was designed with the latter purpose in mind.

In order to study the influence of emotional events on memory for other events, it is

necessary to operationally distinguish between what constitutes an emotional event, and what constitutes non-emotional events that occur in the same context. Prior research has generally divided events into central information and peripheral information. Central information is usually defined as the stimulus that produces an emotional response, while peripheral information is typically defined as the information that is not directly related to the emotion-inducing central stimulus (Kensinger, Garoff-Eaton & Schacter, 2007). Thus, the definition of a central event can include events related to the central stimulus, such as the visual details of a stimulus that evokes emotion (Kensinger, et al., 2007). For the purposes of the present research, we adopted the operational definitions used by Kensinger, Piguet, Krendl, and Corkin (2005): Central information is the portion of an event that produces an emotional reaction, while peripheral information comprises the elements of an event that are unrelated to the source of arousal. This operationalization of central and peripheral information is attractive because it can be objectively implemented, making it desirable for studying the effects of emotion-inducing stimuli on memory for peripheral events that occur in the same context.

Two primary theories have been used to explain the effects of emotion on memory for peripheral information: the *attention-narrowing hypothesis* (Easterbrook, 1959) and *priority-binding theory* (MacKay, Shafto, Taylor, Marian, Abrams, & Dyer, 2004). While both theories predict that emotional stimuli will be remembered better than neutral stimuli, they differ in their predictions regarding how experiencing emotional stimuli will affect memory for peripheral information. The attention-narrowing hypothesis (Easterbrook, 1959) suggests that a negative or threatening stimulus causes emotional arousal, which attracts attention to the arousing stimulus. Because attention is limited in capacity, the additional attention given to the arousing stimulus reduces the amount of attentional resources available to process other information present in the

same context. As a result, an arousing stimulus is remembered better than a non-arousing stimulus, while peripheral information is remembered *worse* in the presence of an arousing stimulus than a non-arousing stimulus. Thus, the attention-narrowing hypothesis generally predicts a trade-off between memory for central and peripheral information.

An alternative to the attention-narrowing hypothesis is priority-binding theory (Hadley & MacKay, 2006; MacKay & Ahmetzanov, 2005; MacKay, et al., 2004). This theory suggests that arousing stimuli evoke emotional reactions that give priority to the binding mechanisms that serve to strengthen the association between arousal-inducing stimuli and salient aspects of the context that are directly linked to the arousal-inducing stimuli. As a result, associations between emotional central information and peripheral information tend to be stronger than associations between neutral central information and peripheral information. Thus, if a memory task cues the retrieval of the association between central and peripheral information (Tulving & Thomson, 1973), memory for peripheral information will be better when it was encoded in the context of emotional information. Further, priority-binding theory suggests that there are limitations to binding in that priority only applies to neutral events or context present within a narrow time window around the arousal-inducing event. Thus, priority-binding theory can explain why memory is suppressed for neutral events that precede and follow an emotion-inducing stimulus within that narrow time window (Hadley & MacKay, 2006; MacKay, et al., 2004).

Existing research supports both hypotheses. Numerous studies have found a trade-off between memory for central arousing events and memory for peripheral events, supporting the attention-narrowing hypothesis. For example, studies have documented a weapon focus effect, in which participants focused on and remembered a weapon in a scene at the expense of memory for peripheral information such as the physical features of the perpetrator (Loftus, Loftus, &

Messo, 1987). Other studies presented a series of pictures depicting a story, with the manipulation of interest being whether or not one slide depicted an emotional event (e.g., a person in surgery) or a non-emotional event (e.g., a person working on a car; Burke, Heuer, & Reisberg, 1992; Christianson & Loftus, 1991). These studies found that emotion-inducing slides were remembered better than slides that did not induce emotions, but events from slides other than the emotion-inducing slide (i.e., peripheral information) were remembered worse in the emotional condition than the non-emotional condition. A third approach, using isolated emotional and neutral pictures, found that memory for peripheral information was impaired in emotional pictures compared to neutral pictures (Adolphs, Denburg, & Tranel, 2001; Kensinger, et al., 2005; Kensinger, et al., 2007). Thus, substantial evidence exists that when peripheral events occur in the context of emotional central events, memory for the peripheral events is harmed, consistent with the attention-narrowing hypothesis.

However, memory for peripheral information is sometimes enhanced when it occurs in the presence of an emotion-inducing central event, a result that favors priority-binding theory. While some studies that used pictorial stimuli showed enhanced memory for peripheral information experienced in the presence of an arousing central event (Heuer & Reisberg, 1990; Libkuman, Nichols-Whitehead, Griffith, & Thomas, 1999; Libkuman, Stabler, & Otani, 2004), most of the support for priority-binding theory comes from studies using verbal stimuli. In these experiments, negative valence words were presented and participants' memory for peripheral information such as the spatial location of the word, the ink color of the word, or a neutral word in the same sentence as the emotion-inducing word was measured. In general, such studies have found enhanced memory for peripheral information when the central word produced an emotional response (D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001;

Kensinger, Brierley, Medford, Growdon & Corkin, 2002; Kensinger & Corkin, 2003; MacKay & Ahmetzanov, 2005; MacKay, et al., 2004; Medford, Phillips, Brierly, Brammer, Bullmore, & David, 2005). These results generally support priority-binding theory because the source memory tasks used in these studies require the retrieval of associations between emotional central information and presentation characteristics of those emotional stimuli (Johnson, Hashtroudi, & Lindsay, 1993).

Most of the studies favoring priority-binding theory have tested memory for peripheral information that was a presentation feature of the word that induced an emotional response (D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001; Kensinger, et al. 2002; Kensinger & Corkin, 2003; MacKay & Ahmetzanov, 2005; MacKay, et al., 2004). It is possible to view enhanced memory for presentation features of emotional stimuli as simply due to general enhancement of memory for the emotion-inducing stimulus and not enhancement of memory for information peripheral to the emotion-inducing stimulus (Kensinger, et al., 2007). Indeed, a recent theory of emotion's effects on central and peripheral information suggests that the contradictory patterns reviewed above can be understood by distinguishing between objects that induce arousal and other objects in the same stimulus environment (Mather, 2007). This theory, which we refer to as *object-based binding theory*, argues that arousal enhances binding of the components of arousal-inducing items to one another (referred to as *within-object binding*), but that arousal-induced binding does not extend to other objects present in the same stimulus environment that do not create arousal (referred to as *between-object binding*). Thus, object-based binding theory explains arousal-enhanced memory for features of arousal-inducing stimuli (e.g., color, spatial location) as being due to within-object binding. Further, object-based binding theory suggests that arousing stimuli do not generally facilitate memory for non-arousing objects

that occur in the same context as arousing objects (e.g., Christianson & Loftus, 1991; Kensinger, et al., 2005) because remembering non-arousing objects can only be enhanced by between-object binding.

*The Present Studies*

In the first two experiments reported here, we tested these three theories by presenting emotion-inducing words and neutral peripheral words in the same encoding context and testing cued recall. We compared three types of central words, neutral (control) words, negative valence words, and highly-arousing taboo words (MacKay, et al., 2004). Taboo words are similar to highly arousing pictures in that they produce physiological arousal as measured by skin-conductance responses (SCRs; LaBar & Phelps, 1998) and attract attention involuntarily when they are encountered. Thus, taboo words cause greater Stroop interference than neutral words (MacKay, et al., 2004; Siegrist, 1995), increase the magnitude of the attentional blink relative to valenced or neutral words when they are the initial target in rapid serial visual presentation (RSVP; Anderson, 2005; Mathewson, Arnell, & Mansfield, 2008), and reduce the magnitude of the attentional blink relative to valenced or neutral words when they are the second target in RSVP (Mathewson, et al., 2008).

In Experiment 1, we presented participants with central words that were taboo, negatively valenced, or did not induce emotion (neutral words) in a sentence (Medford, et al., 2005). In order to assess memory for peripheral words, we chose a neutral word from each sentence and tested participants' memory for both the central emotion-inducing word and the peripheral neutral word using a sentence-based cued recall task. In Experiment 2, neutral, negative valence and taboo words (central words) were randomly paired with neutral words (peripheral words) to create a series of paired associates. At test, participants were provided with the central word in

each pair and were asked to recall the peripheral word that was paired with it during encoding. Thus, the first experiment sought to examine whether the presence of an emotion-inducing word in a sentence enhanced memory for other words in the sentence, while Experiment 2 examined whether encoding emotion-inducing words enhanced the strength of an association between central words and unrelated peripheral words. In Experiment 3, the influence of emotional content on associative recognition of word pairs was examined. Thus, the final experiment also assessed the strength of the association between central words and unrelated words, but did so with a recognition memory task instead of a cued recall task.

The three primary theories of emotional arousal's effects on memory for central and peripheral information predict different results for these three experiments. The attention-narrowing hypothesis (Easterbrook, 1959) predicts a trade-off between memory for central and peripheral words, such that the more emotionally arousing central words are, the worse memory for peripheral words should be. In contrast, priority binding theory (MacKay, et al., 2004) predicts that memory for peripheral words should increase as emotion-inducing words become more arousing because arousal helps bind stimuli to elements of their encoding context, such as the peripheral words presented in the same sentence (Experiment 1) or paired associate (Experiments 2 & 3). Thus, to the extent that those associations are accessed at retrieval in order to complete cued recall (Experiments 1 & 2) or associative recognition (Experiment 3), enhanced memory should result when emotional words are encountered during encoding. Finally, object-based binding theory (Mather, 2007) expects binding to occur, but only within the object that produces emotional arousal. Thus, the presence of an emotion-inducing item in Experiment 1 should enhance memory for other words in the same sentence because the inclusion of an emotion-inducing item affects both the meaning and the arousal characteristics of the entire

sentence, allowing the sentence to act as a single object. However, the theory would not predict enhanced memory for word pairs containing an emotionally-arousing word in either Experiment 2 or 3, because each word in a paired associate has its own arousal characteristics and semantics, leading each word to function as a separate object. Thus, because paired associates were formed by arbitrarily pairing an emotion-inducing central word with an unrelated neutral peripheral word, enhanced paired associate learning requires between-object binding, which object-based binding theory argues is not enhanced by emotional reactions.

## Experiment 1

In Experiment 1, central and peripheral words were presented to participants in the context of sentences (Medford, et al., 2005). Participants read sentences containing a central emotion-inducing word, and a neutral peripheral word. Prior work has demonstrated enhanced recognition memory for peripheral words from a sentence when another word in the sentence was negatively valenced compared to neutral (Medford, et al., 2005). In order to examine the effects of highly arousing stimuli on memory for peripheral words, Experiment 1 presented participants with highly arousing (taboo) central words in addition to negative and neutral central words. At test, participants were presented with studied sentences that had the central and peripheral words deleted, and were asked to fill in the missing words. Thus, Experiment 1 tested cued recall, rather than recognition (Medford, et al., 2005), of central and peripheral information. Finally, Experiment 1 examined the generality of the results of two prior studies that tested the recall of neutral information that was encoded as part of emotional sentences (Kensinger, et al., 2002; Phelps, LaBar, & Spencer, 1997). Both of these prior studies found that when participants were asked to generate a sentence that included a neutral word, free recall of the neutral words was enhanced when the generated sentence contained negative emotional connotations. Thus,

Experiment 1 examined whether self generation of an emotional sentence was necessary for enhancing recall of neutral words, or if the emotional response produced by a sentence that was read was sufficient to enhance recall of neutral peripheral words.

## Method

### *Participants*

Participants were 48 Middlebury College students who participated in order to fulfill a research appreciation requirement, were compensated with $10 payment, or volunteered to participate in this study without compensation. In this study and all others reported in this paper, only native English speakers were asked to participate because autonomic reactions to taboo words are different for native and non-native speakers (Harris, Aycicegi, & Gleason, 2003).

### *Materials and Design*

Stimuli used in Experiment 1 came from a variety of sources. The manner in which stimuli were selected and the design of the study were modeled after the procedures of Medford et al. (2005). Thirty negative valence words, 30 neutral words, and 30 taboo words were chosen as central stimuli. Negative valence words were selected from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999), and were high in arousal ($M$ = 6.88, $SD$ = 2.27) and low in valence ($M$ = 2.74, $SD$ = 1.82). Neutral words were judged by us to be neutral in valence and arousal because many stimuli that are neutral in valence and arousal do not appear in the ANEW.[1] Taboo words were chosen from Jay (1992) and Kensinger and Corkin (2003).[2] Negative valence, neutral, and taboo central stimuli were matched for frequency of occurrence using estimates based on an internet search engine (Blair, Urland, & Ma, 2002).

The 30 negative valence central words were used to construct 30 sentences, each containing one of the negative valence central words. Parallel versions of the 30 negative valence

sentences were constructed using neutral and taboo central words, yielding 30 sentence triplets. The sentences within a triplet were identical with the exception of the taboo, negative valence, or neutral central word inserted in each sentence (see Table 1 for examples and Appendix A for a list of all central and peripheral words). Finally, in each sentence, one word was designated as the peripheral word. It was ensured that peripheral words were linguistically classified as content words (e.g, nouns, verbs, or adjectives), and were chosen based on their apparent neutrality in terms of valence and arousal. The same peripheral word was used for all three sentences in a triplet, which ensured that the only factor that influenced the ability to recall peripheral words across the different types of sentences was the emotional reaction induced by the presence of a neutral, negative valence, or taboo central word in the sentence.

Sentences were divided into three sets for counterbalancing purposes. Each set contained 10 neutral sentences, 10 negative valence sentences, and 10 taboo sentences, and only one sentence was chosen from each triplet to serve in each of the three sets of stimuli. A stimulus counterbalancing scheme ensured that each of the sentences within a triplet was shown equally often across participants.

To ensure that each type of sentence differed in measures of arousal and valence, 31 volunteers who were not participants in the three experiments reported here were asked to rate each target word for arousal and valence. Raters were asked to judge how arousing each word was on a scale of 1 to 7 where 1 = “no reaction” and 7 = “strongest reaction imaginable” (Medford, et al., 2005). Similarly, participants were asked to judge the valence of the words on a scale of 1 to 7 where 1 = “negative,” 4 = “neutral,” and 7 = “positive” (Medford, et al., 2005). Table 2 presents the mean arousal and valence ratings for neutral, negative, and taboo words (see Appendix A for the arousal and valence characteristics of individual words). Taboo words were

rated as significantly more arousing than both negative words, $t(30) = 3.98$, and neutral words, $t(30) = 16.09$. Negative words were also rated as significantly more arousing than neutral words, $t(30) = 12.49$. In terms of valence, negative words were rated as significantly more negative than both taboo words, $t(30) = 7.02$, and neutral words, $t(30) = 19.37$. Taboo words were also rated as significantly more negative than neutral words, $t(30) = 8.33$. Nineteen additional volunteers were asked to rate each sentence for arousal and valence, using the same scales. Table 3 presents the mean arousal and valence ratings for neutral, negative, and taboo sentences. Similar to taboo words, taboo sentences were rated as significantly more arousing than negative sentences, $t(18) = 7.55$, and neutral sentences, $t(18) = 12.62$. Negative sentences were also rated as significantly more arousing than neutral sentences, $t(18) = 10.40$. Regarding valence, negative sentences were rated as significantly more negative than neutral sentences, $t(18) = 14.53$, and taboo sentences were rated as significantly more negative than neutral sentences, $t(18) = 6.66$, but there was no significant difference in valence ratings for taboo and negative sentences ($t(18) = 1.14$, $p > .20$).

*Procedure*

Prior to the presentation of the stimuli, participants were informed that they would encounter a series of sentences that would contain words that are sometimes considered offensive. Participants were told to read each sentence silently because they would be asked questions about the sentences at the end of the experiment. Participants were not told that there would be a memory test; instead, they were told that the experimenter was interested in studying the cognitive processes involved in sentence comprehension. Presentation of the sentences then began on the computer screen. Each sentence was presented using a masked reading technique (Just, Carpenter, & Woolley, 1982), in which sentences appeared one word at a time. Participants pressed the space bar to control the rate at which the words appeared on the computer screen, and

were asked to read through the sentences as normally as possible. Following the reading of the final word in each sentence, the lines indicating the words in the next sentence appeared on the computer screen and the participant was allowed to begin reading that sentence by pressing the space bar. Participants were told to proceed through the sentences at their own rate.

After presentation of the study sentences was completed, participants completed math problems during a five minute retention interval. Following this filler task, participants were asked to perform a cued-recall memory task, in which they were presented with incomplete sentences one at a time. Each incomplete sentence was missing two words: the central word, which was either a neutral, negative valence, or taboo word, and the peripheral word, which was always a neutral word. Participants filled in each blank as best they could by typing their responses into two response boxes on the computer screen, and were asked to guess if they could not remember a word. The order of presentation of sentences in the study list and during the cued recall test was determined randomly for each participant.

## Results and Discussion

Two dependent variables were analyzed: the reading times for central and peripheral words during encoding, and the number of central and peripheral words correctly recalled in each emotion condition (depicted in Figure 1). Both dependent measures were analyzed separately for central and peripheral words using one-way repeated measures ANOVAs. All results were deemed significant at an alpha level of .05.

### *Reading Times*

Analyses of mean and median reading times led to the same conclusions. For simplicity, we present only analyses of median reading times. There was a significant difference among the emotion conditions for central words, $F(2,94) = 8.25$, $MSE = 6529.37$, but not for peripheral

words, $F(2,94) = 1.03$, $MSE = 3872.16$. Taboo central words were read more slowly ($M = 593$ msec) than negative central words ($M = 543$ msec; $t(47) = 3.36$) and neutral central words ($M = 529$ msec; $t(47) = 3.53$), which did not differ in reading times ($t(47) = 0.82$).

*Recall*

Analyses of the number of central and peripheral words recalled indicated that there was a significant difference among the conditions for central words, $F(2,94) = 92.52$, $MSE = 1.75$, as well as peripheral words, $F(2,94) = 15.71$, $MSE = 2.38$. Bonferroni-adjusted $t$-tests ($\alpha = .008$) were performed to explore the effects of emotion on each word type. For central words, all three pair-wise comparisons were significant (smallest $t(47) = 2.75$), indicating that central word recall was lowest for neutral words ($M = 2.38$), intermediate for negative words ($M = 3.04$), and highest for taboo words ($M = 5.81$). While the same qualitative pattern occurred for peripheral word recall, only the comparisons between the taboo condition ($M = 5.19$) and the negative condition ($M = 3.85$; $t(47) = 4.30$), as well as between the taboo condition and the neutral condition ($M = 3.54$; $t(47) = 4.84$), were significant ($t(47) = 1.13$, $p > .20$ for the comparison between peripheral word recall in neutral and negative sentences).

The results of Experiment 1 showed enhanced memory for neutral peripheral words that occurred in the same sentence as emotional words, which replicates several prior results (Kensinger, et al., 2002; Medford, et al., 2005; Phelps, et al., 1997). Thus, the results of Experiment 1 contradict the attention-narrowing hypothesis because the high levels of emotional arousal caused by taboo words in a sentence did not impair memory for other words in that sentence. Instead, peripheral words were remembered better when sentences contained an arousing taboo word, supporting priority-binding theory (MacKay, et al., 2004) as well as object-based binding theory (Mather, 2007).

One possible limitation to interpreting the results of this experiment is that reading times for central words differed across stimulus types, such that taboo words took longer to read than negative valence or neutral words. These reading time differences may partially explain why taboo words were recalled more often than negative valence and neutral words. More problematic, however, is that recalling the central word in each sentence may have facilitated recall of the peripheral word independent of enhanced binding of the peripheral word to the sentence in which it occurred. Specifically, recalling the central word in a sentence may have made the sentence a better retrieval cue for recalling the peripheral word in that sentence. Thus, it may have been easier to recall a word from a sentence when it was missing a single word than when it was missing two words. Because participants recalled central words that were taboo more often than they recalled negative and neutral central words, they were likely to have had better retrieval cues for peripheral words in sentences that contained taboo words. Consequently, even if the peripheral words were not bound to the sentences better in the taboo condition, recall could have been enhanced simply due to improved recall of central taboo words. In Experiment 2, we created paired associates using one central word and one neutral peripheral word to address this concern as well as to further test the three candidate theories of emotion and memory.

## Experiment 2a, 2b, and 2c

In Experiment 2, participants studied word pairs, created by randomly pairing central words with peripheral words. The memory test was a cued recall task, where participants were presented with the first word in each pair (the taboo, negative valence, or neutral central word) and were asked to recall the second word in each pair (the peripheral word). Thus, this memory task assessed the strength of the association between emotion-inducing words and neutral peripheral words, independent of memory for the emotion-inducing words.

Three versions of Experiment 2 were conducted. In Experiment 2a, the same central and peripheral words from Experiment 1 were used. In both Experiment 1 and Experiment 2a, the selection of stimuli was limited by sentence constraints: Words that fit together in the context of a sentence had to be used, and as a result, the stimuli were not rigorously controlled for arousal and valence. For example, both taboo and negative valence words were more arousing and negative in valence than neutral words (albeit not to the same extent). Therefore, for Experiments 2b and 2c, new stimuli were chosen that better controlled the arousal and valence characteristics of central words. Specifically, neutral words were neutral in arousal and valence, negative words were neutral in arousal and negative in valence, and taboo words were high in arousal and negative in valence. Thus, by comparing recall of peripheral words paired with negative central words to recall of peripheral words paired with neutral central words, it was possible to assess the influence of emotional *valence* on the strength of the association between central and peripheral information. Similarly, by comparing recall of peripheral words paired with taboo central words to recall of peripheral words paired with negative central words, it was possible to assess the influence of emotional *arousal* on the strength of the association between central and peripheral information.

Experiment 2 again tested priority-binding theory, object-based binding theory and the attention narrowing hypothesis. The attention-narrowing hypothesis suggests that memory for paired associates should decline as emotional content increases, because emotional responses to central words attract attentional resources to central words, producing a decrement in encoding resources available to encode other aspects of the scene in which the emotional stimulus is found. In contrast, priority-binding theory suggests that emotional responses generated by central words should enhance associations between those words and elements of their context. In

Experiment 2, peripheral words that were paired with emotion-inducing central words are a feature of central items' context, such that enhanced binding of emotion-inducing words to their stimulus context should increase memory for peripheral words when recall is cued with central emotional items. In comparison, object-based binding theory suggests that learning paired associates requires between-object binding, which it argues is not enhanced by the presence of an emotional central item. Between-object binding is required for enhanced paired associate learning because central and peripheral words have distinct semantic and arousal properties. Thus, arousing stimuli, such as taboo words, tend to be consolidated in memory as distinct objects from other objects in their environment. (Mather, 2007). Specifically, arousal-inducing stimuli attract focused attention, which improves binding of those objects in to a coherent whole, as well as to their presentation features (e.g., font color). However, the focused attention that enhances binding within arousal-inducing objects does not extend to other objects in their stimulus context, and may impair binding for those items. For example, when people were asked to generate associates to stimulus words, their memory for the generated associates was poorer when the stimulus terms produced emotional reactions (e.g., Jones, O'Gorman, & Byrne, 1987; but see Parkin, Lewinsohn, & Folkard, 1982). Object-based binding theory explains this result by suggesting that while emotional reactions enhance binding of the emotion-inducing item to its component features, those emotional reactions do not aid, and may hinder, binding of the emotion-inducing item to other objects present in the same encoding context, such as the generated associates (Mather, 2007).

Although words generated from an arousing stimulus term are more poorly remembered than words generated from non-arousing stimulus terms (Jones, et al., 1987), when paired associates are read, arousal has been shown to enhance paired associate recall (e.g., Kleinsmith

& Kaplan, 1963; 1964; Kleinsmith, Kaplan, & Trate, 1963), such that numbers paired with high-arousal words were recalled better than numbers paired with low-arousal words. As detailed above, this result would tend to favor priority-binding theory over object-based binding theory and the attention narrowing hypothesis. However, whether a word was high-arousal or low-arousal was determined individually for each participant using galvanic skin responses, which may confound arousal with primacy (Schürer-Necker, 1990). Experiments 2 a-c remedied this problem by using normed stimuli to determine high arousal, negative valence, and neutral words. Additionally, neutral words were randomly assigned to emotion conditions in Experiment 2, while associations between neutral and arousing stimuli (Kleinsmith & Kaplan, 1963; 1964; Kleinsmith et al., 1963), as well as self-generated associates and emotional words (Jones, et al., 1987) were necessarily correlational in prior work. Experiments 2a, b, and c, therefore, are the first studies to examine the influence of emotional central words on the strength of associations between arbitrarily-related central and peripheral words.

## Method

### *Participants*

Participants were a total of 73 Middlebury College students (24 in Experiment 2a, 25 in Experiment 2b, and 24 in Experiment 2c) who participated in order to fulfill a research appreciation requirement or were compensated with $10 payment.

### *Materials and Design*

The stimuli for Experiment 2a were the same 30 neutral words, 30 negative words, and 30 taboo words that were used as central stimuli in Experiment 1 and the same 30 neutral words that had been designated as peripheral words in Experiment 1. However, Experiment 2a did not present participants with sentences; only the to-be-recalled words from Experiment 1 were used

as stimuli. The central stimuli for Experiments 2b and 2c were 10 neutral words, 10 negative words, and 10 taboo words (see Appendix B). Both the neutral and negative words for Experiments 2b and 2c were chosen from the ANEW (Bradley & Lang, 1999). On a scale of 1 to 9, in which 1 was *not at all arousing* and 9 was *highly arousing*, both the neutral words ($M$ = 4.50, $SD$ = 0.21) and the negative words ($M$ = 4.54, $SD$ = 0.42) were neutral in arousal. On a scale of 1 to 9, in which 1 was negative and 9 was positive, the negative words were strongly negative in valence ($M$ = 2.04, $SD$ = 0.36), while the neutral words were neutral in valence ($M$ = 5.04, $SD$ = 0.71). Because taboo words do not tend to appear in the ANEW, no direct comparisons among the taboo, negative, and neutral words' valence and arousal properties were possible. However, the taboo words were chosen specifically because they tend to be more arousing than negative words (Kensinger & Corkin, 2003), and were presumed to be negative in valence (see norming for Experiment 1 as well as Kensinger & Corkin, 2003). The 10 taboo words were selected from MacKay and colleagues (2004) and Jay (1992), and were considered by us to be the most arousing and offensive of the taboo words used in previous research. The three groups of central words were matched for average frequency using an Internet search engine (Blair, et al., 2002). Experiments 2b and 2c also used 30 neutral peripheral words taken from Kensinger and Corkin (2003).

In all three versions of Experiment 2, each of the 10 neutral words, 10 negative valence words, and 10 taboo words that served as central stimuli was paired with one of the 30 peripheral words. Pairing of central and peripheral words was randomly determined for each participant, and word pairs were constructed such that the central word was always shown as the left-hand member of each pair, and the peripheral word was always shown as the right-hand member of each pair. Because there were 30 central words in each emotion category in Experiment 2a

(rather than 10 central words in each emotion category for Experiments 2b and 2c), a stimulus counterbalancing scheme was used to ensure that the taboo, negative, and neutral central words were presented equally often across participants.

*Procedure*

The procedure for Experiments 2a and 2b was identical. Prior to the presentation of the study list, participants were informed that they would encounter a list of 30 pairs of words, including taboo words sometimes considered offensive. Participants were told that they should read each word pair silently and try to remember the words as they were paired, because there would be a memory test following the presentation of the word pairs. Intentional memory instructions were used to ensure that participants attended to the words as pairs rather than individual entities, thus avoiding floor effects in paired-associate recall performance. As will be shown in the results section, this procedural difference did not alter the effect of the emotional content of the central words on memory for the peripheral words that was found in Experiment 1. Presentation of the stimuli then began on the computer screen. Word pairs were presented in a different random order for each participant at the rate of 3000ms per pair.

After presentation of the study list was completed, participants were asked to work on a series of simple math problems for five minutes. Following this filler task, participants were asked to perform a cued-recall task, in which they were presented with the left-hand word of each studied word pair (the emotion-inducing central word) one at a time. Participants were then asked to respond with the right-hand word of the word pair (the neutral peripheral word) by typing it in to a response box, and to guess if they could not remember a word. Test items were presented in a different random order for each participant.

In Experiment 2c, stimuli were arbitrarily divided into two study and test lists in an

attempt to minimize floor effects. Both study lists were comprised of 15 word pairs, each with equivalent numbers of neutral, negatively-valenced, and taboo central words. Study presentation and test of the first list proceeded as in Experiments 2a and 2b. Immediately following the test for the first study list, presentation of the second study list and its corresponding test began.

## Results and Discussion

Figure 2 presents the number of peripheral words correctly recalled in Experiments 2a (top panel), 2b (middle panel), and 2c (bottom panel) when participants were presented with the taboo, negative, or neutral central words from each word pair as a recall cue. The conclusion reached from the statistical analysis was the same for all three sub-experiments; thus, we present analyses of the sub-experiments together. A repeated-measures ANOVA indicated that there was a difference in recall among the three conditions (smallest $F(2,44) = 11.04$, $MSE = 1.63$, in Experiment 2a). Bonferroni-adjusted *t*-tests ($\alpha = .017$) indicated that recall of peripheral words in the taboo condition was greater than recall of peripheral words in the negative condition (smallest $t(24) = 3.73$ in Experiment 2b) and the neutral condition (smallest $t(23) = 4.05$ in Experiment 2a). However, there was no significant difference between recall in the negative and neutral conditions in any of the three sub-experiments.

The results of Experiments 2a-c replicated and extended the results of Experiment 1: Peripheral words studied with taboo words were recalled better than peripheral words that were studied with negative valence or neutral words. Similarly, there was not a reliable difference in recall of peripheral words that were studied with negative and neutral central words, even when measures were taken in Experiment 2c to eliminate floor effects. Building on Experiment 1, the results of Experiments 2a-c showed that enhanced memory for peripheral words associated with taboo central words occurred when the association between central and peripheral words was

arbitrarily determined, and when the characteristics of the central words were rigorously controlled for arousal and valence.

The results of Experiment 2 reinforce the evidence found in Experiment 1 that the attention-narrowing hypothesis (Easterbrook, 1959) cannot explain the effects of emotion-inducing words on memory for peripheral words. Instead, the results of Experiment 2 suggest that the high arousal properties of taboo words trigger binding mechanisms, which in turn enhance memory for peripheral words by strengthening the association between the representations of peripheral words and taboo words. Thus, the results of Experiment 2 suggest that the enhanced recall of neutral peripheral words that were studied with taboo words was due to *between-object binding* (MacKay, et al., 2004) rather than *within-object binding* (Mather, 2007). Experiment 3 explored the generality of the results from Experiment 2 with another task that should assess between-object binding, associative recognition.

## Experiment 3

Experiment 3 tested the generality of the results of Experiments 1 and 2 with an associative recognition task, which has different retrieval demands than cued recall, but is also sensitive to the strength of associations between word pairs (Hockley & Cristi, 1996a; 1996b). As in Experiments 2a-c, participants viewed a list of paired associates and were asked to remember them as best they could. At test, words were presented in their studied (intact) pairs or in rearranged pairs, composed of words that were both studied, but were not studied together. In addition to examining the generality of the results of Experiments 1 and 2, this study again tested the binding hypothesis (MacKay et al., 2004), object-based binding theory (Mather, 2007) and the attention-narrowing hypothesis (Easterbrook, 1959). Testing memory with an associative recognition test should directly assess the strength of the association between central and

peripheral words without also involving search for and production of a target memory, as was the case with the cued recall tasks used in Experiments 2a-c. Thus, each theory makes the same predictions for associative recognition as it made for cued recall of paired associates. Those predictions were detailed in the introduction to Experiment 2, so we do not reiterate them here.

## Method

### *Participants*

Participants were 54 Middlebury College students who participated in order to fulfill a research participation requirement or were compensated with $10 payment.

### *Materials and Design*

The stimuli for Experiment 3 were identical to the stimuli used in Experiments 2b and 2c, with the addition of 2 neutral, 2 negative, and 2 taboo central words, as well as 6 neutral peripheral words. Thus, there was a total of 12 neutral, 12 negative, and 12 taboo central words, and 36 peripheral words (see Appendix C). The relative arousal and valence characteristics of central words were not altered as a result of the additional words. For each participant, study phase paired associates were formed by randomly assigning each of the 36 central words to one of the 36 peripheral words. In the test phase of the experiment, half of the paired associates in each emotional condition were the same word pairs presented at study (*intact* pairs), while the other half of the paired associates were randomly rearranged, such that each central word was paired with a different peripheral word than it was studied with (*rearranged* pairs). Thus, all test pairs were composed of a central and peripheral word that had been studied, but half of the pairs were composed of central and peripheral words that had not been studied together. Rearrangements occurred within each emotion condition: For example, a taboo central word was re-paired with a peripheral word that had been originally studied with a different taboo central

word. Constructing rearranged word pairs in this manner allowed us to measure false alarm rates for word pairs within each of the emotion conditions.

*Procedure*

Experiment 3's study instructions, study list presentation, and the filler task between study and test lists were the same as Experiments 2b, with the exception of the study list length, which was 36 word pairs. Following the filler task, participants were asked to perform an associative recognition task, in which they were presented with 18 intact pairs of words and 18 rearranged pairs. Participants were asked to distinguish between intact and rearranged pairs by pressing the O key for an old, intact pair and the N key for a new, rearranged pair. Test word pairs were presented in a different random order for each participant.

## Results and Discussion

Figure 3 depicts the percentage of test pairs that participants judged to be intact. Intact judgments for intact pairs indicate correct responses (hits), while intact judgments for rearranged pairs indicate incorrect responses (false alarms). A repeated-measures ANOVA for hits indicated a difference among the three conditions, $F(2,106) = 16.25$, $MSE = .03$. Bonferonni-adjusted *t*-tests showed higher hits for word pairs containing a taboo item compared to word pairs containing a neutral item ($t(53) = 4.99$) or negative item ($t(53) = 4.40$). There was not a reliable difference in hits between pairs containing a neutral item and pairs containing a negative item ($t(53) = 0.82$, $p > .40$). A repeated-measures ANOVA for false alarms indicated a near significant difference in incorrect responses among the three conditions, $F(2,106) = 2.72$, $MSE = .03$, $p > .10$. This trend reflects a tendency for false alarms to be lower for neutral pairs than taboo or negative valence word pairs.

Because there was a tendency for participants to incorrectly label rearranged test pairs

intact more often if it contained a negative word or a taboo word, we also assessed participants' ability to differentiate between intact and rearranged pairs with two measures of discriminability: A High Threshold correction ([Hits-False Alarms]/[1-False Alarms]) and *d'* (Snodgrass & Corwin, 1988). Both analyses led to the same conclusions, so we present the high threshold analysis for simplicity. A repeated-measures ANOVA indicated a significant difference among the three conditions, $F(2,106) = 11.62$, $MSE = .07$. Bonferonni-adjusted *t*-tests ($\alpha = .017$) showed greater discriminability for pairs containing taboo items ($M = .85$) than for pairs containing neutral items ($M = .63$, $t(53) = 4.23$) or negative items ($M = .63$, $t(53) = 3.87$), and that negative and neutral pairs did not differ in discriminability ($t(53) = .02$).

The results of Experiment 3 again support priority-binding theory over object-based binding theory and the attention narrowing hypothesis. Further, replicating Experiments 1 and 2, these results suggest that arousal, but not valence, triggers binding mechanisms, because word pairs containing negative words that did not induce arousal failed to show a discriminability advantage over word pairs with neutral central words.

## General Discussion

Two main regularities were observed in the experiments presented here. First, associations between central and peripheral words were enhanced when the central word created arousal, but not when it was negatively valenced. Second, the enhancement of associations between central and peripheral words occurred both when arousing and peripheral words occurred in the same sentence (Experiment 1; Kensinger, et al., 2002; Medford, et al., 2005; Phelps, et al., 1997) and when arousing and peripheral words were arbitrarily paired (Experiments 2a-c and 3). These regularities generally replicate results found in studies using *written* stimuli, where it has been found that the presence of an emotion-inducing stimulus

enhanced memory for peripheral information (e.g., D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001; Kensinger & Corkin, 2003; MacKay & Ahmetzanov, 2005; MacKay, et al., 2004; Medford, et al., 2005), and are inconsistent with much of the literature using *pictorial* stimuli, where encountering an emotion-inducing stimulus generally impaired memory for peripheral stimuli (e.g., Adolphs, et al., 2001; Burke, et al., 1992; Christianson & Loftus, 1991; Kensinger, et al., 2005, 2007; Loftus, et al., 1987).

These results expand our knowledge of the effects of emotion on memory for written stimuli in three ways. First, the present research investigated both recognition and recall, while most prior studies using written materials have only investigated recognition (e.g., D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001; Kensinger & Corkin, 2003; MacKay et al., 2004; Medford, et al., 2005; Sharot & Phelps, 2004). This difference in memory retrieval demands did not prove critical to arousal's enhancement of memory for peripheral words—the results reported here found that recall of peripheral words was enhanced when they occurred in the presence of arousing central words, provided the memory retrieval task cued the association between the central and peripheral words. Second, this research compared memory for peripheral words that occurred in the presence of extremely arousing words, negatively valenced words that were not arousing, and neutral words in order to separate the effects that arousal and valence had on memory for peripheral words. Most prior studies have not rigidly defined emotional stimuli such that they are able to separate the influence of arousal and valence on memory for central and peripheral information (see Kensinger & Corkin, 2003; and Libkuman, et al., 2004 for exceptions). Distinguishing between the arousal and valence properties of central words proved critical to understanding emotion's influence on memory for peripheral words, because only central words that produced arousal enhanced memory of peripheral words. Prior research

corroborates the finding that valence and arousal have different effects on memory (e.g., Kensinger & Corkin, 2003; Libkuman, et al., 2004), consistent with Kensinger's (2004) claim that arousal and valence generally affect memory via distinct mechanisms. Kensinger (2004) suggested that the amygdala is responsible for arousal's effects on memory (Phelps, 2004), while non-amygdalar networks influence the role that valence plays. Thus, it may be the case that amygdala activation induces binding mechanisms, while activation of non-amygdalar networks enhances memory for central stimuli via some mechanism other than contextual binding. Third, the present research examined conditions where central and peripheral words were arbitrarily paired with one another, while most prior studies have examined situations where emotional stimuli were related to peripheral information by being part of the same story line (Burke, et al., 1992), sentence (Kensinger, et al., 2002; Medford, et al., 2005; Phelps, et al., 1997), or scene (Adolphs, et al., 2001; Libkuman, et al., 2004; Kensinger, et al., 2007). Despite arbitrarily pairing central and peripheral words, enhanced memory for the association between central and peripheral words resulted when central words were arousing, suggesting that arousal-induced enhancement of memory occurrs in the absence of a meaningful connection between the central and peripheral stimuli.

With regard to the three main theories that explain the effect of emotion-inducing stimuli on memory for peripheral information, the present research supports priority binding theory over object-based binding theory and the attention-narrowing hypothesis. Although object-based binding theory can explain many aspects of how emotion influences memory for the context of central and peripheral information (Mather, 2007; Mather & Nesmith, 2008), it does not appear to provide a comprehensive account of the binding mechanisms that are enhanced by emotional arousal, such as the between-object binding that was observed in Experiments 2 and 3. One

reason object-based binding theory may have been designed to prohibit between-object binding is that most prior research has not used memory tasks that are likely to be sensitive to between-object binding. Specifically, most prior research has examined situations where memory for associations between emotional central items and their sources was tested (Doerksen & Shimamura, 2001; D'Argembeau & Van der Linden, 2004; Kensinger & Corkin, 2003; MacKay & Ahmetzanov, 2005; MacKay, et al., 2004), situations where memory for central and peripheral stimuli was tested in isolation (Kensinger, et al., 2005, 2007; Medford, et al., 2005), or situations where memory for the association between central items and their sources, as well as peripheral items and their sources, was tested (Mather & Nesmith, 2008). These prior studies did not employ memory tasks that are likely to be sensitive to between-object binding because memory for the association between arousing central objects and non-arousing peripheral objects was not tested. Thus, an important question for future research will be to determine when and why between-object binding occurs following emotional arousal, as well as when and why within-object, but not between-object, binding occurs.

The attention-narrowing hypothesis (Easterbrook, 1959) cannot account for the results of the present research, because it generally proposes a trade-off between memory for central and peripheral information. However, as noted by Reisberg and Hertel (2004), understanding how emotion affects memory for central and peripheral information in part rests on how central and peripheral information are operationally defined. Thus, if the stimuli we classified as peripheral information can be classified as central information, it is possible that the attention-narrowing hypothesis can account for the present data by using a different operational definition of central and peripheral information. For example, it has been suggested that the attention-narrowing hypothesis can explain instances where memory for information semantically linked to an

emotionally arousing central stimulus is enhanced (e.g., Libkuman, et al., 1999). Even if this operational definition was used, the attention-narrowing hypothesis could only account for the results of the first experiment, where central and peripheral information were semantically linked by being in the same sentence. Thus, the attention-narrowing hypothesis would still be unable to account for the results of Experiments 2a-c and 3 which showed that memory for the association between central and peripheral stimuli that were *arbitrarily* paired was nevertheless enhanced when central stimuli were arousing.

A second operational definition of central information comes from Burke et al. (1992), who explored a variety of operational definitions for central and peripheral information in an effort to find what types of memory were enhanced by emotion-inducing stimuli and what types of memory were hindered. Most relevant to the current studies are Burke et al's results for events that occurred simultaneously in time with emotional information: The presence of an emotion-inducing stimulus enhanced memory for information that was spatially or conceptually linked to the emotion-inducing item, whether that information was detailed visual information or "gist" information. Further, memory for information that was not linked to central information (i.e., background information that could be changed without altering the story depicted in a series of slides) was harmed by emotional central information. The operational definitions of central and peripheral information used in the present studies align with those found by Burke et al. (1992) to produce memorial trade-offs between central and peripheral information. Specifically, peripheral information in Experiments 2a-c and 3 was arbitrarily related to the source of emotion, and could have been changed (and indeed was changed across participants) without altering the interpretation of the central stimuli. Yet, in contrast to the results of Burke and colleagues (1992), we found enhanced, not decreased, memory for central-peripheral information

associations in the present studies. Thus, it seems that it is difficult to generate an operational definition of central and peripheral information that would make the results of the present studies explicable by the attention-narrowing hypothesis.

One final concern with the present results may be that in Experiments 2 and 3, intentional learning instructions were utilized, while most prior research on memory for emotional information has used incidental learning. Thus, if participants focused their encoding resources on unitizing word pairs as part of their encoding, it is possible the attention-narrowing hypothesis and object-based binding theory could explain the results of Experiments 2 and 3 by claiming the paired associates participants studied were parts of a single arousing stimulus (attention narrowing) or object (object-based binding). However, remembering paired associates involves the encoding of both item and associative information, such that factors which encourage focus on item information are detrimental to encoding associative information (Hockley & Cristi, 1996a). In the case of the present experiments, reading times from Experiment 1 suggests that taboo words attracted more attention than negative valence or netural words. Further, prior research examining Stroop interference (MacKay, et al., 2005; MacKay & Ahmetzanov, 2005; Siegrist, 1995) and the attentional blink (Anderson, 2005; Mathewson, et al., 2008) suggest that taboo words attract attention involuntarily. Thus, any intent to encode associative information should have been disrupted by the presence of a taboo word as one of the terms, resulting in reduced cued recall and associative recognition performance, and not the enhanced cued recall and associative recognition observed in Experiments 2 and 3.

In summary, the present research makes three main contributions to understanding the effects of emotion-inducing stimuli on memory for peripheral information. First, memory for the association between central and peripheral stimuli was enhanced when the central stimuli created

high arousal, but not when central stimuli were only negative in valence. Second, emotional enhancement of memory for the association between central and peripheral information occurred in recall as well as recognition (e.g., D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001; Kensinger & Corkin, 2003; McKay, et al., 2004; Sharot & Phelps, 2004). Third, emotional enhancement of memory for the association between central and peripheral information occurred even when there was an arbitrary association between the two stimuli, which required between-object binding. Taken together, these regularities favor the interpretation that experiencing arousing written stimuli triggers binding mechanisms, which in turn enhance associations between the arousing stimulus and elements of its stimulus context, both within the object and between objects (MacKay, et al., 2004).

# References

Adolphs, R., Denburg, N.L., & Tranel, D. (2001). The amygdala's role in long-term declarative memory for gist and detail. *Behavioral Neuroscience, 115*(5), 983-992. doi: 10.1037/0735-7044.115.5.983

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*, 258-281. doi: 10.1037/0096-3445.134.2.258

Bartlett, J.C., & Santrock, J.W. (1979). Affect-dependent episodic memory in young children. *Child Development*, *50*, 513-518. doi: 10.2307/1129430

Blair, I.V., Urland, G.R., & Ma, J.E. (2002). Using internet search engines to estimate word frequency. *Behavior Research Methods, Instruments, and Computers, 34*(2), 286-290.

Bradley, M.M., & Lang, P.J. (1999). Affective norms for English words (ANEW). *The NIMH Center for the Study of Emotion and Attention*, University of Florida, Gainesville, FL.

Buchanan, T.W. & Adolphs, R. (2002). The role of the human amygdala in emotional modulation of long-term declarative memory. In S.C. Moore and M. Oaksford (Eds.), *Emotional Cognitive: From Brain to Behaviour*. Amsterdam: John Benjamins Publishing Company.

Burke, A., Heuer, F., & Reisberg, D. (1992). Remembering emotional events. *Memory & Cognition*, *20*(3), 277-290.

Christianson, S-A. & Loftus, E.F. (1991). Remembering emotional events: The fate of detailed information. *Cognition and Emotion, 5*(2), 81-108. doi: 10.1080/02699939108411027

D'Argembeau, A. & Van der Linden, M. (2004). Influence of affective meaning on memory for contextual information. *Emotion*, *4*(2), 173-188. doi: 10.1037/1528-3542.4.2.173

Doerksen, S. & Shimamura, A.P. (2001). Source memory enhancement for emotional words. *Emotion*, *1*(1), 5-11. doi: 10.1037/1528-3542.1.1.5

Easterbrook, J.A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66*(3), 183-201. doi: 10.1037/h0047707

Elfenbein, H.A., & Ambady, N. (2002). On the universality of cultural specificity of emotion recognition: A meta-analysis. *Psychological Bulletin*, *128*, 203-235. doi: 10.1037/0033-2909.128.2.203

Hadley, C.B., & MacKay, D.G. (2006). Does emotion help or hinder immediate memory? Arousal versus priority-binding mechanisms. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *32*, 79-88. doi: 10.1037/0278-7393.32.1.79

Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Neuroscience, 5*(9), 394-400. doi: 10.1016/S1364-6613(00)01707-1

Harris, C.L., Aycicegi, A., & Gleason, J.B. (2003). Taboo words and reprimands elicit greater autonomic reactivity in a first language than in a second language. *Applied Psycholinguistics, 24,* 561-579. doi: 10.1017/S0142716403000286

Heuer, F. & Reisberg, D. (1990). Vivid memories of emotional events: The accuracy of remembered minutiae. *Memory & Cognition, 18*(5), 496-506.

Hockley, W.E., & Cristi, C. (1996a). Tests of encoding tradeoffs between item and associative information. *Memory & Cognition*, *24*, 202-216.

Hockley, W.E., & Cristi, C. (1996b). Tests of the separate retrieval of item and associative information using a frequency-judgment task. *Memory & Cognition*, *24*, 796-811.

Jay, T. (1992). *Cursing in America: A Psycholinguistic Study of Dirty Language in the Courts, in the Movies, in the Schoolyards and on the Streets*. Amsterdam: John Benjamins

Publishing Company.

Johnson, M.K., Hashtroudi, S., & Lindsay, D.S. (1993). Source monitoring. *Psychological Bulletin*, *114*, 3-28. doi: 10.1037/0033-2909.114.1.3

Jones, E.B., O'Gorman, J.G., & Byrne, B. (1987). Forgetting of word associates as a function of recall interval. *British Journal of Psychology*, *78*, 79-89.

Just, M.A, Carpenter, P.A, & Woolley, J.D. (1982). Paradigms and processes in reading comprehension. *Journal of Experimental Psychology: General, 111*(2), 228-238. doi: 10.1037/0096-3445.111.2.228

Kensinger, E.A. (2004). Remembering emotional experiences: The contribution of valence and arousal. *Reviews in the Neurosciences, 15*(4), 241-253.

Kensinger, E.A., Brierly, B., Medford, N., Growdon, J.H., & Corkin, S. (2002). Effects of normal aging and Alzheimer's Disease on emotional memory. *Emotion, 2*(2), 118-134. doi: 10.1037/1528-3542.2.2.118

Kensinger, E.A. & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory and Cognition*, *31*(8), 1169-1180.

Kensinger E.A., Garoff-Eaton R.J., and Schacter D.L. (2007). Effects of emotion on memory specificity: Memory trade-offs elicited by negative visually arousing stimuli. *Journal of Memory and Language, 56*, 575-591. doi: 10.1016/j.jml.2006.05.004

Kensinger, E.A., Piguet, O., Krendl, A.C. & Corkin, S. (2005). Memory for contextual details: Effects of emotion and aging. *Psychology and Aging, 20*(2), 241-250. doi: 10.1037/0882-7974.20.2.241

Kleinsmith, L.J. & Kaplan, S. (1963). Paired-associate learning as a function of arousal and

interpolated interval. *Journal of Experimental Psychology, 65,* 190-193. doi: 10.1037/h0040288

Kleinsmith, L.J., & Kaplan, S. (1964). Interaction of arousal and recall interval in nonsense syllable paired-associate learning. *Journal of Experimental Psychology*, *67*, 124-126. doi: 10.1037/h0045203

Kleinsmith, L.J., Kaplan, S., & Trate, R.D. (1963). The relationship of arousal to short- and long-term verbal recall. *Canadian Journal of Psychology*, *17*, 393-397. doi: 10.1037/h0083278

LaBar, K.S., & Phelps, E.A. (1998). Arousal-mediated memory consolidation: Role of the medial temporal lobe in humans. *Psychological Science*, *9*, 490-493. doi: 10.1111/1467-9280.00090

Libkuman, T.M., Nichols-Whitehead, P., Griffith, J., & Thomas, R. (1999). Source of arousal and memory for detail. *Memory and Cognition, 27*(1), 166-190.

Libkuman, T.M., Stabler, C.L., & Otani, H. (2004). Arousal, valence, and memory for detail. *Memory, 12*(2), 237-247. doi: 10.1080/09658210244000630

Loftus, E.F., Loftus, G.R. & Messo, J. (1987). Some facts about "weapon focus." *Law and Human Behavior*, *11*(1), 55-62. doi: 10.1007/BF01044839

MacKay, D.G. & Ahmetzanov, M.V. (2005). Emotion, memory, and attention in the taboo Stroop paradigm. *Psychological Science, 16*(1), 25-32. doi: 10.1111/j.0956-7976.2005.00776.x

MacKay, D.G., Shafto, M., Taylor, J.K., Marian, D.E., Abrams, L., & Dyer, J.R. (2004). Relations between emotion, memory, and attention: Evidence from taboo Stroop, lexical decision, and immediate memory tasks. *Memory & Cognition, 32*(3), 474-488.

Mather, M. (2007). Emotional arousal and memory binding. *Perspectives on Psychological*

*Science, 2*(1), 33-52. doi: 10.1111/j.1745-6916.2007.00028.x

Mather, M. & Nesmith, K. (2008). Arousal-enhanced location memory for pictures. *Journal of Memory and Language, 58*, 449-464. doi: 10.1016/j.jml.2007.01.004

Mathewson, K.J., Arnell, K.M., & Mansfield, C.A. (2008). Capturing and holding attention: The impact of emotional words in rapid serial visual presentation. *Memory & Cognition*, *36*, 182-200.

Medford, N., Phillips, M.L., Brierley, B., Brammer, M., Bullmore, E.T., & David, A.S. (2005). Emotional memory: Separating content and context. *Psychiatry Research: Neuroimaging*, *138*, 247-258. doi: 10.1016/j.pscychresns.2004.10.004

Parkin, A.J., Lewinsohn, J., & Folkard, S. (1982). The influence of emotion on immediate and delayed retention: Levinger & Clark reconsidered. *British Journal of Psychology*, *73*, 389-393.

Phelps, E.A. (2004). Human emotion and memory: Interactions of the amygdala and hippocampal complex. *Current Opinion in Nuerobiology*, *14*, 198-202. doi: 10.1016/j.conb.2004.03.015

Phelps, E.A., LaBar, K.S. & Spencer, D.D. (1997). Memory for emotional words following unilateral temporal lobectomy. *Brain and Cognition*, *35*, 85-109. doi: 10.1006/brcg.1997.0929

Reisberg, D. & Hertel, P. (Eds.). (2004). *Memory and Emotion.* New York: Oxford University Press.

Schürer-Necker, E. (1990). Arousal and paired-associate learning: Evidence refuting the action decrement theory of Walker and Tarte (1963). *Pavlovian Journal of Biological Science*, *25*, 195-200.

Sharot, T. & Phelps, E.A. (2004). How arousal modulates memory: Disentangling the effects of attention and retention. *Cognitive, Affective, & Behavioral Neuroscience*, *4*(3), 294-306.

Siegrist, M. (1995). Effects of taboo words on color-naming performance on a Stroop test. *Perceptual and Motor Skills, 81,* 1119-1122.

Snodgrass, J.G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*, *117*, 34-50. doi: 10.1037/0096-3445.117.1.34

Tulving, E., & Thomson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*, 352-373. doi: 10.1037/h0020071

Wood, A.M., Maltby, J., Stewart, N., Linley, P.A., & Joseph, S. (2008). A social-cognitive model of trait and state levels of gratitude, *Emotion*, *8*, 281-290. doi: 10.1037/1528-3542.8.2.281

# Appendix A

*Arousal and Valence Ratings of Neutral, Negative Valence, and Taboo Central Words Used in Experiments 1 and 2a*

| | Valence | | Arousal | |
|---|---|---|---|---|
| *Neutral* | *M* | *SD* | *M* | *SD* |
| athlete | 5.39 | 1.28 | 2.48 | 1.67 |
| bandage | 3.97 | 1.38 | 1.90 | 1.49 |
| bowl | 3.97 | 0.41 | 1.52 | 1.06 |
| cathedral | 4.81 | 1.11 | 2.29 | 1.74 |
| cliffs | 3.81 | 1.01 | 2.32 | 1.70 |
| coward | 2.39 | 1.17 | 3.19 | 1.58 |
| dance | 5.00 | 1.18 | 2.84 | 2.07 |
| daughter | 4.87 | 1.48 | 2.58 | 2.17 |
| derelict | 3.45 | 0.85 | 2.32 | 1.68 |
| detective | 4.16 | 0.45 | 1.65 | 1.14 |
| dock | 4.06 | 0.25 | 1.29 | 0.97 |
| fatigue | 3.16 | 1.07 | 2.32 | 1.54 |
| girl | 4.94 | 1.15 | 2.42 | 1.75 |
| golfer | 4.13 | 0.62 | 1.65 | 1.25 |
| habit | 4.06 | 0.51 | 1.58 | 1.29 |
| indifference | 3.29 | 1.04 | 1.81 | 1.38 |
| lazy | 2.81 | 1.17 | 2.48 | 1.71 |

| | | | | |
|---|---|---|---|---|
| letter | 4.26 | 0.82 | 1.32 | 0.70 |
| polite | 5.58 | 1.26 | 1.97 | 1.43 |
| publicity | 3.90 | 0.60 | 1.94 | 1.29 |
| relatives | 5.45 | 1.26 | 3.77 | 2.29 |
| relax | 5.87 | 1.15 | 2.81 | 2.06 |
| seaweed | 4.03 | 1.14 | 1.90 | 1.49 |
| sleepy | 3.84 | 1.19 | 2.35 | 1.56 |
| soup | 4.42 | 1.18 | 1.45 | 1.15 |
| stomach | 3.97 | 0.80 | 1.55 | 1.15 |
| subdued | 3.84 | 0.78 | 1.61 | 0.95 |
| teenager | 3.97 | 0.66 | 2.00 | 1.26 |
| tomboy | 3.71 | 1.19 | 2.48 | 1.82 |
| watched | 3.26 | 1.00 | 2.48 | 1.36 |

| | Valence | | Arousal | |
|---|---|---|---|---|
| *Negative* | *M* | *SD* | *M* | *SD* |
| accident | 2.48 | 0.96 | 3.35 | 1.52 |
| anger | 2.58 | 0.99 | 3.16 | 1.49 |
| assassin | 2.16 | 1.00 | 3.90 | 1.85 |
| assault | 1.71 | 0.94 | 4.35 | 1.66 |
| bomb | 1.87 | 1.15 | 4.77 | 1.87 |

| | | | | |
|---|---|---|---|---|
| burn | 2.81 | 0.98 | 3.48 | 1.75 |
| chaos | 3.00 | 1.00 | 3.55 | 1.52 |
| evil | 1.97 | 1.28 | 3.97 | 1.54 |
| fear | 2.35 | 0.98 | 3.71 | 1.55 |
| fight | 2.71 | 1.16 | 3.71 | 1.57 |
| fire | 3.16 | 1.32 | 3.13 | 1.65 |
| gun | 2.00 | 1.18 | 4.45 | 1.86 |
| hatred | 1.81 | 0.87 | 4.55 | 2.11 |
| hostage | 1.81 | 1.01 | 4.81 | 1.78 |
| intruder | 2.39 | 0.92 | 3.77 | 1.87 |
| killer | 1.55 | 0.96 | 4.90 | 1.40 |
| murderer | 1.52 | 0.77 | 5.00 | 1.67 |
| nervous | 2.97 | 1.02 | 2.97 | 1.60 |
| obsession | 3.00 | 1.00 | 3.52 | 1.75 |
| outrage | 2.74 | 1.21 | 3.52 | 1.50 |
| panic | 2.52 | 1.06 | 4.19 | 1.60 |
| pervert | 1.87 | 1.20 | 4.87 | 1.54 |
| rape | 1.03 | 0.18 | 6.39 | 0.99 |
| rejected | 2.00 | 0.89 | 4.19 | 1.76 |
| scream | 3.06 | 0.81 | 3.26 | 1.53 |
| shark | 3.32 | 1.33 | 2.84 | 1.92 |
| slave | 1.48 | 0.72 | 4.90 | 1.74 |
| snake | 3.35 | 1.14 | 2.58 | 1.46 |

| | | | | |
|---|---|---|---|---|
| terrorist | 1.52 | 1.15 | 5.48 | 1.69 |
| thief | 2.32 | 1.30 | 3.55 | 1.65 |

| | Valence | | Arousal | |
|---|---|---|---|---|
| *Taboo* | *M* | *SD* | *M* | *SD* |
| ass | 3.35 | 1.33 | 4.06 | 1.61 |
| asshole | 2.26 | 0.96 | 4.32 | 1.58 |
| bastard | 2.06 | 0.89 | 4.16 | 1.51 |
| bitch | 1.90 | 0.83 | 4.90 | 1.45 |
| blowjob | 4.00 | 1.91 | 5.65 | 1.05 |
| breasts | 4.77 | 1.23 | 3.87 | 1.61 |
| clitoris | 3.97 | 1.45 | 4.90 | 1.68 |
| cock | 2.90 | 1.19 | 5.03 | 1.54 |
| cocktease | 2.06 | 1.24 | 5.29 | 1.37 |
| cum | 3.00 | 1.34 | 5.29 | 1.49 |
| dick | 3.03 | 1.22 | 4.42 | 1.82 |
| dildo | 3.26 | 1.21 | 4.97 | 1.47 |
| erection | 4.00 | 1.18 | 4.97 | 1.30 |
| faggot | 1.48 | 0.96 | 5.84 | 1.44 |
| fuck | 2.61 | 1.31 | 5.06 | 1.41 |
| hooker | 2.35 | 1.23 | 4.65 | 1.45 |
| lesbian | 4.03 | 1.11 | 3.94 | 1.69 |

| | | | | |
|---|---|---|---|---|
| masturbate | 3.39 | 1.45 | 5.06 | 1.39 |
| nipple | 4.42 | 1.34 | 4.16 | 1.59 |
| orgasm | 5.84 | 1.29 | 5.55 | 1.26 |
| porn | 3.35 | 1.56 | 4.48 | 1.59 |
| prick | 2.06 | 0.81 | 4.29 | 1.49 |
| pussy | 2.42 | 1.43 | 5.55 | 1.23 |
| sex | 5.16 | 1.19 | 4.58 | 1.61 |
| shit | 2.52 | 0.96 | 3.68 | 1.68 |
| slut | 1.68 | 1.14 | 5.06 | 1.61 |
| stripper | 2.77 | 1.33 | 4.29 | 1.68 |
| tits | 3.55 | 1.67 | 4.97 | 1.28 |
| vagina | 4.00 | 1.06 | 4.45 | 1.82 |
| whore | 1.65 | 0.71 | 5.26 | 1.32 |

# Appendix B

*Neutral, Negative Valence, and Taboo Central Words Used in Experiments 2b and 2c*

| Neutral Words | Negative Valence Words | Taboo Words |
|---|---|---|
| alley | ache | chink |
| frog | corpse | cum |
| garment | defeat | cunt |
| obey | deformed | dyke |
| rattle | gloom | faggot |
| rigid | grief | fuck |
| scissors | lonely | nigger |
| stove | scum | orgasm |
| trunk | stench | pussy |
| whistle | unhappy | whore |

# Appendix C

*Neutral, Negative Valence, and Taboo Central Words Used in Experiment 3*

| Neutral Words | Negative Valence Words | Taboo Words |
|---|---|---|
| razor | misery | bitch |
| cliff | hurt | cock |
| rigid | gloom | nigger |
| frog | stench | cunt |
| alley | grief | pussy |
| obey | unhappy | chink |
| scissors | corpse | faggot |
| trunk | lonely | dyke |
| rattle | defeat | fuck |
| stove | scum | whore |
| garment | deformed | orgasm |
| whistle | ache | cum |

## Author Note

Rebecca Guillet and Jason Arndt, Department of Psychology, Middlebury College, Middlebury, VT, USA. The first experiment reported in this paper was submitted to the Department of Psychology at Middlebury College in partial fulfillment of the requirements for graduation with honors in Psychology by Rebecca Guillet. Portions of this research were supported by grant 1R15 MH077665 from the National Institutes of Health.

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# Footnotes

[1] A subsequent norming study, described below, indicated that neutral stimuli were less negative and less arousing than the other stimuli.

[2] We thank Elizabeth Kensinger for providing the stimulus materials from Kensinger and Corkin (2003).

Table 1.

*Examples of Neutral, Negative Valence, and Taboo Sentences in Experiment 1*

| Neutral Sentence | Negative Sentence | Taboo Sentence |
|---|---|---|
| She played the part of the tomboy in the production. | She played the part of the hostage in the production. | She played the part of the whore in the production. |
| The package contained a bowl. | The package contained a bomb. | The package contained a dildo. |
| My uncle is a golfer. | My uncle is a pervert. | My uncle is a faggot. |

*Note.* Each group of three sentences differed by one word (the central, emotion-inducing word). In the cued recall test, participants were presented with incomplete sentences in which the underlined words were missing, and were asked to recall the missing words.

Table 2

*Mean Arousal and Valence Ratings for Taboo, Negative Valence, and Neutral Words and Sentences in Experiment 1*

| | Arousal | | Valence | |
|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* |
| Taboo Words | 4.76 | 1.95 | 3.13 | 0.65 |
| Taboo Sentences | 4.08 | 1.10 | 3.02 | 0.65 |
| Negative Words | 4.03 | 1.15 | 2.30 | 0.48 |
| Negative Sentences | 2.98 | 0.83 | 2.86 | 0.37 |
| Neutral Words | 2.14 | 0.75 | 4.14 | 0.26 |
| Neutral Sentences | 1.70 | 0.40 | 4.00 | 0.20 |

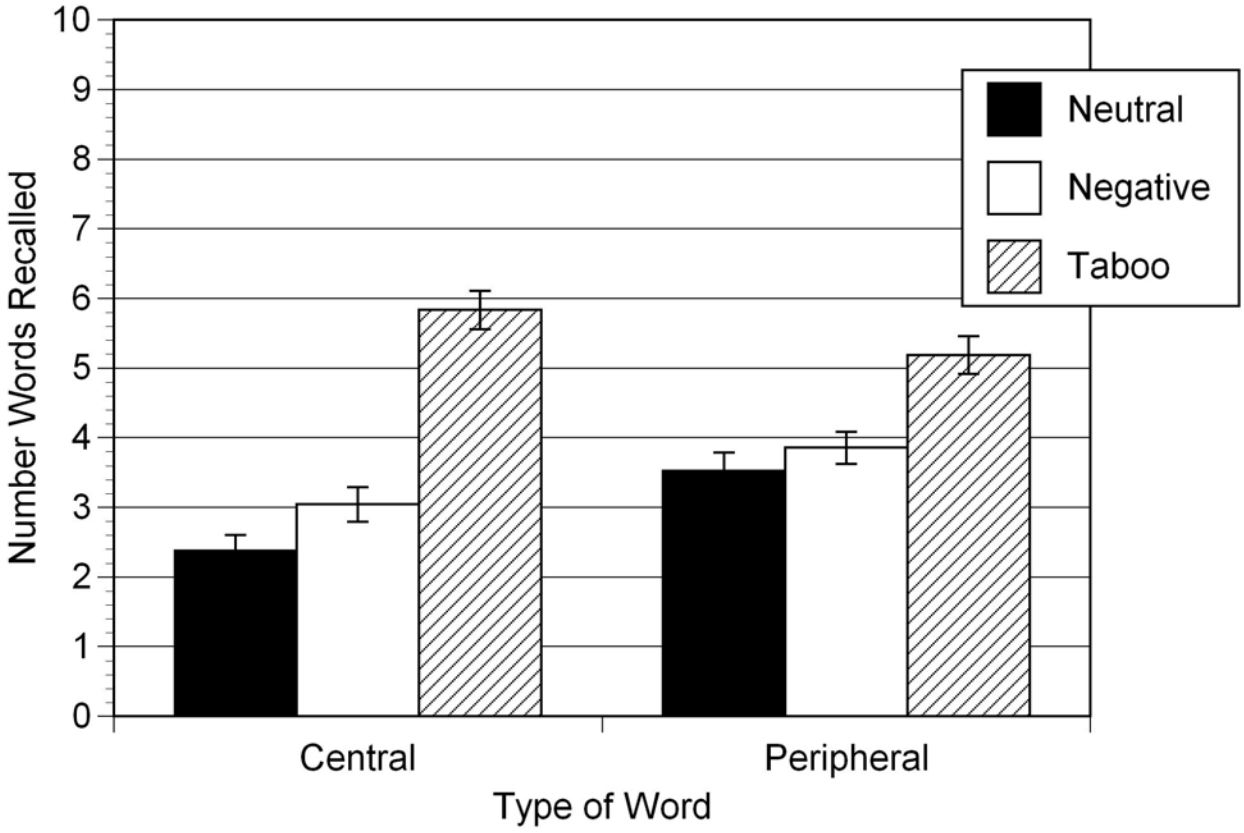
*Note.* Arousal was rated on a scale of 1 to 7 where 1 = "no reaction" and 7 = "strongest reaction imaginable." Valence was rated on a scale of 1 to 7 where 1 = "negative," 4 = "neutral," and 7 = "positive."

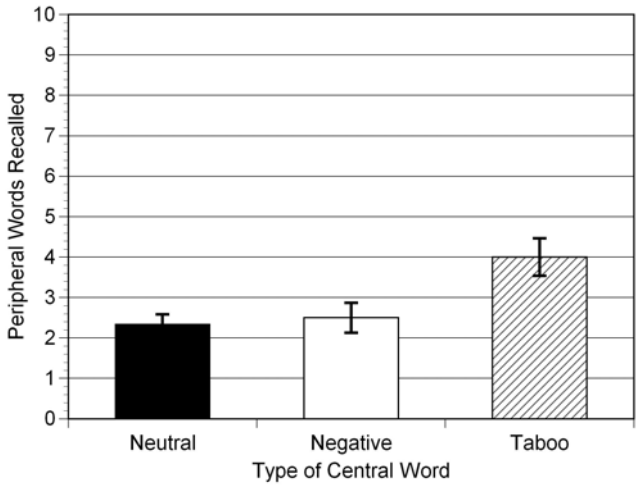
# Figure Captions

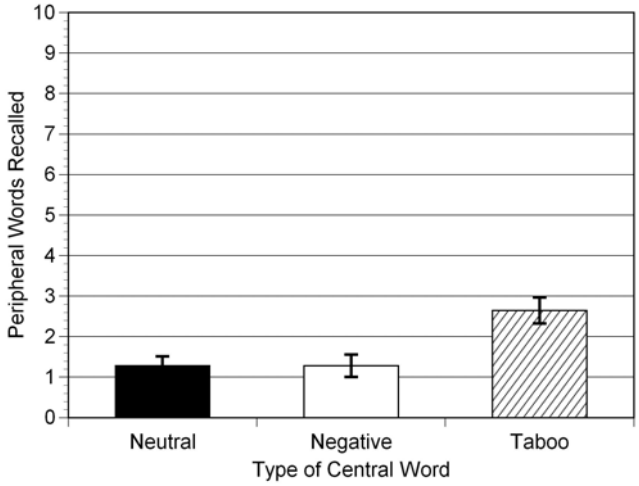
*Figure 1.* Recall of central and peripheral words in Experiment 1. Error bars represent the standard error of the mean.

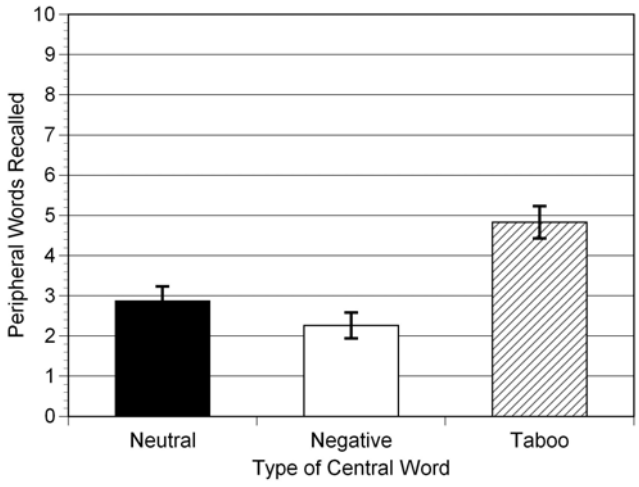
*Figure 2.* Recall of peripheral words in Experiments 2a (top panel), 2b (middle panel), and 2c (bottom panel). Error bars represent the standard error of the mean.

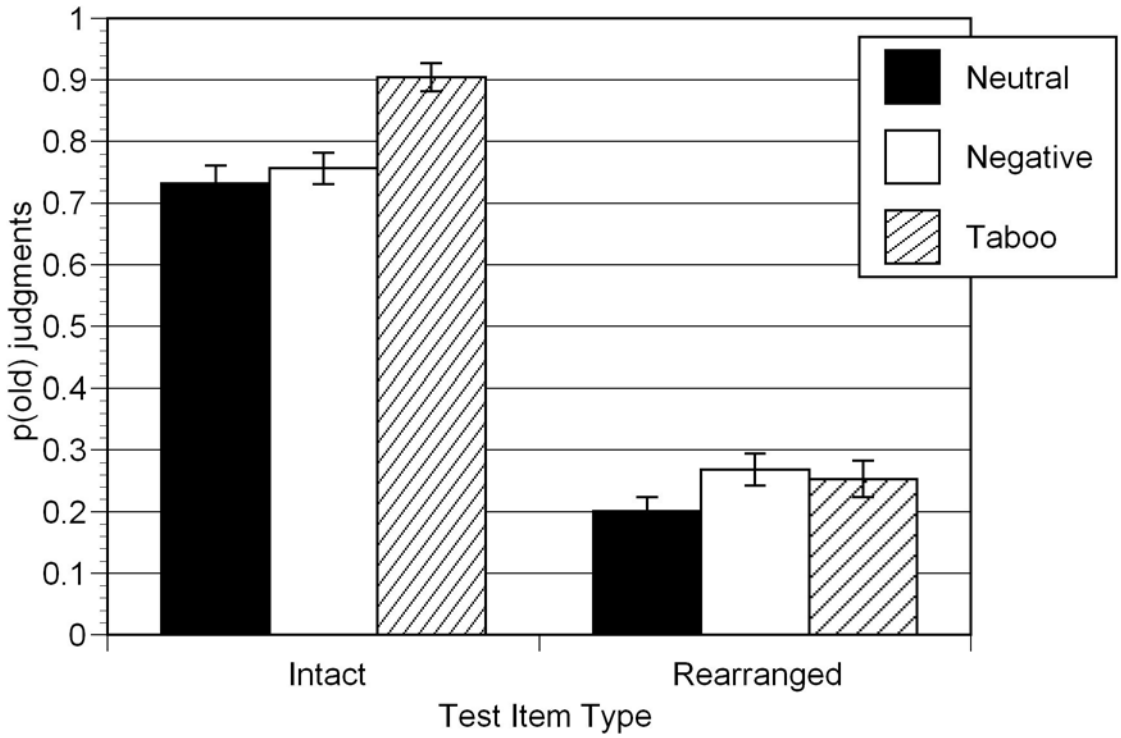
*Figure 3*. Hits and false alarms for central and peripheral items in Experiment 3 for taboo, negative valence and neutral word pairs. Error bars represent the standard error of the mean.


10
9
8
7
6
5
4
3
2
1
0
Number Words Recalled
Neutral
Negative
Taboo
Central
Peripheral
Type of Word


Peripheral Words Recalled
0
1
2
3
4
5
6
7
8
9
10
Neutral
Negative
Taboo
Type of Central Word


Peripheral Words Recalled
0
1
2
3
4
5
6
7
8
9
10
Neutral
Negative
Taboo
Type of Central Word


Peripheral Words Recalled
0
1
2
3
4
5
6
7
8
9
10
Neutral
Negative
Taboo
Type of Central Word


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
p(old) judgments
Neutral
Negative
Taboo
Intact
Rearranged
Test Item Type