A DUAL PROCESS APPROACH TO EMOTIONAL MEMORY: EFFECTS OF EMOTION ON FAMILIARITY AND RETRIEVAL PROCESSES IN RECOGNITION

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IN RECOGNITION

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Research has indicated that emotion affects recognition memory by either increasing the hit rate and the false alarm rate (Windmann & Kutas; Windmann & Kruger, 1998), or by having selective effects on the hit rate (Maratos & Rugg, 2001). However, the recognition memory process that underlies these effects of emotion is not known. The purpose of this research was to determine the memory retrieval processes by which emotion influences recognition of items that are intrinsically emotional (Experiments 1 and 2) or that were associated with an emotional item during encoding (Experiment 3). Three response-signal associative recognition experiments are reported that demonstrate that emotion increases the proportion of "old" judgments for familiarity-based recognition judgments. In Experiment 1, emotional words were associated with a familiarity-based increase in the hit rate at short response lags. Experiment 2 demonstrated that this effect of emotion was driven by the arousal associated with the words, not their valence. And in Experiment 3, a familiarity-based effect of emotion was observed for neutral words that had been encoded in an emotional context. Taken together, these results suggest that emotion has a fast acting, low-level effect on recognition memory that is independent of the unique perceptual features of emotional items.

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Introduction.

"An impression may be so exciting emotionally as almost to leave a *scar* upon the cerebral tissues" (James, 1890, p. 670). Here James describes a link between emotion and memory that is a universal of human experience. Who thinks that they will forget their wedding day or the birth of their first child, or similarly, the death of a parent or close friend? Instead, it is thought that these emotionally charged events, and many of the details surrounding them, will be remembered with extraordinary accuracy for the remainder of one's life. Indeed, this intuition has been observed in some empirical studies of human memory.

Brown and Kulik (1977) coined the term "flashbulb memory" to describe the seemingly exceptional memory that is experienced for sudden, surprising events that have emotional significance. In their classic study, Brown and Kulik administered a questionnaire that contained several events (e.g., the assassinations of Martin Luther King Jr., Medgar Evers, and John F. Kennedy) that were hypothesized to differ in degree of novelty and consequentiality. They found that the higher the degree of novelty and consequentiality associated with an event, the more likely the event was to be classified as a flashbulb memory. However, the relationship between emotion and memory is much more complex than James describes and our experience with flashbulb memories suggests, as evidenced by later findings that suggest that flashbulb memories may not be as accurate as they seem (Neisser & Harsh, 1992; McCloskey, Wible, & Cohen, 1988).

Effects of Emotion on Memory

Empirically, emotion has been shown to enhance memory under some conditions and to have a detrimental effect under other conditions. For example, free recall for emotionally negative, and sometimes positive, pictures, words, and slide sequences may be increased compared with recall for non-emotional items (Christianson, 1992; Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Phelps, LaBar, & Spencer, 1997; Doerksen & Shimamura, 2001). Similarly, some researchers have found that recognition memory for emotional pictures and slide sequences is enhanced compared with recognition of non-emotional information (Heuer & Reisberg, 1990; Burke, Heuer, & Reisberg, 1992; Ochsner, 2000). However, there are also reports of reduced recall accuracy as a result of emotional encoding, especially in the domain of eyewitness memory (Loftus & Burns, 1982; Christianson & Loftus, 1987). Still other studies have found a negative effect of emotion on word recognition performance (Maratos, Allen, & Rugg, 2000), or that emotion changes response bias (Windmann & Kutas, 2001; Windmann, Sakhavat, & Kutas, 2002; Windmann & Kruger, 1998).

One contributing factor to these discrepant findings is that, in the memory literature, the term emotion describes several different types of manipulations. Emotion has been used to refer to an individual's mood state during encoding and retrieval (Bower, Monteiro, & Gilligan, 1978; Eich, Macaulay, & Ryan, 1994), or more generally whether an individual is performing a memory test under conditions of stress (e.g., Baddeley, 1972). Emotion has also been manipulated by presenting slide sequences that depict a stressful and potentially emotional event, such as a robbery or mugging, that have been engineered to resemble a real life situation that may be experienced by an eyewitness (Loftus & Burns, 1982; Christianson & Loftus, 1987). These types of manipulations tend to produce a memory decrement for both recall and recognition tests. However, when emotion is manipulated by presenting words or pictures for study and test that are intrinsically emotional, recall memory tends to be consistently enhanced (Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Phelps, LaBar, & Spencer, 1997; Doerksen & Shimamura, 2001), whereas recognition memory has been associated with three different patterns of responses in the literature (Ochsner, 2000; Maratos, Allen, & Rugg, 2000; Windmann & Kutas, 2001).

Effects of Emotion on Recognition

First, there is evidence that the likelihood of classifying an item as "old" on a recognition test is higher for emotional than non-emotional words regardless of whether or not the item had been studied previously (Windmann & Kutas, 2001; Leiphart, Rosenfeld, & Gabrieli, 1993; Doerksen & Shimamura, 2001; Pesta, Murphy, & Sanders, 2001). This is observed as an increase in the hit rate accompanied by an equal increment to the false alarm rate, and reflects a lowering of the response criterion for emotional words. In essence, emotional words are falsely recognized to a greater extent than non-emotional words.

Second, other evidence suggests that emotional words are not recognized as well as non-emotional words (Maratos, Allen, & Rugg, 2000; Danion, et al., 1995). Maratos et al. (2000) found reduced discrimination (as measured by d') for emotional words compared to neutral words on a recognition test because the false alarm rate to the emotional items was twice as high as the false alarm rate to non-emotional items. However, as noted by Windmann and Kutas (2001), reduced discrimination of emotional words may only be observed when semantic inter-relatedness is not controlled across both emotional and neutral items. Maratos et al. (2000) used a set of emotional stimuli (e.g., Siegle, Balanced Affective Word Project) that were not controlled for semantic relatedness, but were merely controlled for degree of negative valence. Thus, this result is likely driven by semantic similarity, and would probably be eliminated if semantic similarity were controlled for within the stimulus lists.

Finally, non-emotional information paired with an emotional context (e.g., a sentence or other emotional word) during encoding is associated with increased recognition performance compared with items that are encoded in a non-emotional context. For example, in their classic study, Kleinsmith and Kaplan (1963) paired digits with emotional and non-emotional words in a paired associate learning task. They found that the digits that had been paired with the emotional words were more likely to be retained on a delayed recall test. Kleinsmith and Kaplan's (1963) memory enhancement was for recall, however Maratos and Rugg (2001) found that presentation of neutral words in emotional sentence contexts led to increased recognition of these words compared with neutral words studied in neutral sentence contexts (see also LaBar & Phelps, 1998). Furthermore, Ochsner (2000) found that emotional pictures were associated with higher recognition memory performance than non-emotional pictures. However, the recognition memory evidence for enhanced discrimination is difficult to interpret because emotional encoding does not produce a emotional false alarm rate, therefore discrimination for both emotional and non-emotional words is derived from the non-emotional false alarm rate. In addition, the false alarm rate was extremely low in Ochsner's experiments, so the conclusion of increased discrimination is based entirely on the hit rates.

In the literature, recall of intrinsically emotional items is consistently enhanced, but emotion influences recognition in at least two main ways. First, emotion may make the response criterion on a recognition test more lenient, leading to increased "old" judgments for both studied and non-studied items. Second, emotion may enhance discrimination of studied from non-studied items on a recognition test. However, it is not known what causes these different response patterns.

Theoretical Explanations of Effects of Emotion on Memory

Theorists have attempted to account for disparate effects of emotion on memory by hypothesizing that encoding processes are influenced by emotion. For example, emotion has been hypothesized to produce a narrowing of attention (Easterbrook, 1959) that would enhance memory for emotional items but impair memory for more peripheral items (Christianson & Loftus, 1987). Effects of emotion on memory have also been hypothesized to follow the Yerkes-Dodson law, where moderate levels of emotion enhance encoding processes and subsequent memory performance, but more extreme levels of emotion impair performance (Yerkes & Dodson, 1908). Furthermore, others have claimed (e.g., Nadel & Jacobs, 1998; Metcalfe & Jacobs, 1998) that extreme emotional arousal disrupts functioning of the hippocampus, and as a result emotional memory is primarily modulated by the amygdala, which leads to non-contextualized sensory encoding of emotional information. However, none of these encoding accounts can explain the differences observed in recognition of emotional items. Importantly, few researchers have considered how emotion may influence memory *retrieval* processes.

The purpose of this research is to determine the memory retrieval processes by which emotion influences recognition of items that are intrinsically emotional (Experiments 1 and 2) or that were associated with an emotional item during encoding (Experiment 3). It will be argued that the pattern of recognition results may be understood by considering the underlying recognition process. Specifically, one factor that may contribute to the differential effects of emotion on recall and recognition of words concerns the processes that these two tasks engage during the retrieval phase of the memory test. Recall tests engage recollective processes that initiate a search of memory for the relevant information (Raaijmakers & Shiffrin, 1981). However, recognition tests only engage recollective processes under certain conditions of uncertainty and extreme item similarity (Atkinson & Juola, 1973, 1974; Hintzman & Curran, 1994; Rotello & Heit, 2000). The consistent presence of retrieval processes in recall, but not recognition, may account for the consistency in the effects of emotion on recall, and the inconsistency in the effects of emotion on recognition. Importantly, the different effects of emotion on recognition may be due to differential reliance on familiarity and recollection.

Because retrieval processes may not be available during recognition, recognition judgments can be based on familiarity, or gist-based responding, which is much more susceptible to response biases and similarity stemming from the emotional nature of the stimuli (Clark & Gronlund, 1996; Dosher, 1991). In particular, when emotion affects response bias or decreases discrimination, the recognition judgments may be primarily based on familiarity and the observed effects of emotion on response bias and decreased recognition performance may be due to a reliance on familiarity-based responding. In contrast, it is likely that retrieval-based responding contributes to the enhanced recognition performance of neutral items learned in an emotional context because retrieval processes have been shown to be necessary to gain access to associative information in memory (Clark, 1992). Thus, comparable effects of emotion on recognition and recall may only be observed when a retrieval process contributes to recognition. The next section will describe the processes involved in recognition memory of non-emotional items in more detail.

Dual-Process Theories of Recognition

Recognition memory performance is thought to rely on two distinct processes, familiarity and recollection (e.g., Atkinson & Juola, 1973, 1974; Mandler & Boeck, 1974; Mandler, 1980; see Yonelinas, 2002, for a review). This distinction is often experienced when we recognize a person as *familiar*, but we are unable to *recollect* who the person is or the details surrounding how we know them. In formal theories of memory (e.g., global matching models; SAM: Gillund & Shiffrin, 1984; MINERVA2: Hintzman, 1988; TODAM: Murdock, 1982; CHARM: Metcalfe, 1982; see Clark & Gronlund, 1996, for a review), the familiarity process is typically instantiated in terms of signal detection theory, where two overlapping distributions represent the memory strength of studied and non-studied items. Subjects place a criterion at some point along the strength dimension, and subsequently label items falling above that point as “old” and items falling below that point as “new”. In contrast, recollection refers to gaining access to the specific memory trace associated with an item on a recognition test, or to gaining access to contextual or source information.

One main line of evidence for the existence of two processes in recognition comes from experiments in which recognition judgments are speeded. In this paradigm, individuals are allotted a very limited amount of time to make recognition judgments under the assumption that these judgments will not be influenced by retrieval, which is slow, but will instead be based only on familiarity which is rapidly available. Several such experiments have demonstrated that rapidly available information provides global familiarity of test items and allows for discrimination of studied and non-studied items, whereas less rapidly available information provides veridical details about the items that are needed to determine when or where, or with which item, a word was previously studied (e.g., Hintzman & Caulton, 1997; Gronlund, Edwards, & Ohrt, 1997; Hintzman, Caulton, & Levitin, 1998).

Several studies have demonstrated that as processing time increases, the probability of accepting an item that is similar to a studied item initially increases, and then decreases as a function of processing time, producing a biphasic accuracy/response time function (e.g., Dosher, 1984; Gronlund & Ratcliff, 1989; Hintzman & Curran, 1994; McElree, Dolan, & Jacoby, 1999; Rotello & Heit, 2000). For example, Rotello and Heit (2000) provided evidence for this type of retrieval process in associative recognition, which they refer to as recall-to-reject. Their subjects studied lists of word pairs (e.g., lion-house, frog-store), and then at test were presented with intact pairs (e.g., lion-house), rearranged pairs (e.g., lion-store), and new pairs (e.g., grass-coat) with the instructions to respond “old” only to intact pairs. Rotello and Heit (2000) found that early in processing subjects tended to false alarm to rearranged pairs at a higher rate than to new pairs, but later in processing the false alarm rate to rearranged pairs was less than the false alarm rate to new pairs. This suggests that with increased processing time, subjects are able to recall the original study pairing and use this information to correctly reject the rearranged pairs. Other methods have also provided evidence for two processes in recognition, including analysis of receiver operating characteristics, event related potentials, and studies with amnesics.

Importantly for the present experiments, three different types of studies have demonstrated that it takes approximately 1000 msec in order for recollection to contribute to recognition judgments (Yonelinas, 2002). First, response time speed-accuracy tradeoff experiments (Dosher, 1984; Gronlund & Ratcliff, 1989; Hintzman & Curran, 1994; McElree, Dolan, & Jacoby, 1999; Rotello & Heit, 2000; Hintzman & Caulton, 1997; Gronlund, Edwards, & Ohrt, 1997; Hintzman, Caulton, & Levin, 1998) have demonstrated that recollection-based responses do not occur until after at least 750 msec of processing time. Second, studies using the process dissociation procedure indicate that recollection contributes to non-speeded recognition judgments, whereas familiarity contributes to both speeded and non-speeded judgments, and that recollection requires at least 900 msec (Toth, 1996; Yonelinas & Jacoby, 1996; Yonelinas & Jacoby, 1994). Finally, ERP studies show that the electrophysiological correlates of familiarity occur prior to those associated with recollection, and in the time range of approximately 800 msec (Curran, 2000; Duzel, Yonelinas, Mangun, Heinze, & Tulving, 1997; Klimesch, Doppelmayr, Yonelinas, Kroll, Lazzara, Rohm, & Gruber, 2001).

Although recognition involves both familiarity and recollective processes, the mechanism by which emotion influences recognition is not known. There are reasons to believe that emotion could influence familiarity, however there are also reasons to believe that emotion exclusively influences recollection. The next section will review efforts at separating familiarity and retrieval processes in the recognition of emotional information. As will become clear, it is not obvious from the existing literature what the contributions of familiarity and retrieval processes are to emotional recognition.

Evidence for Retrieval-Based Effects of Emotion

Empirical evidence for retrieval-based effects of emotion on recognition is contained in one paper in this small literature. Ochsner (2000) examined recognition of emotional pictures and estimated contributions of familiarity and recollection based on subjects' self reported experience of "remembering" (defined for subjects as recognition based upon recollection of contextual details from the previous experience) or "just knowing" that an item occurred on the previously studied list (e.g., Gardiner & Java, 1991; Rajaram, 1993). Emotional pictures resulted in higher recognition performance than non-emotional pictures, and this result was mainly observed for "remember" judgments, which he assumed index recollection.

However, there are several problems with this interpretation. First, and most important, there is evidence (e.g., Christianson & Loftus, 1990) that emotion changes one's subjective experience, suggesting that self-reports may not be a valid means of making inferences about the underlying recognition processes. Furthermore, there is no clear evidence that a recollective process contributed to the recognition judgments in his task. For example, Gardiner, Ramponi, & Richardson-Klavehn (1999) provided suggestive evidence that "remember" judgments can be made on the basis of only purely familiarity-based responding. This means that subjects in Ochsner's experiments may have been making familiarity-based "remember" judgments because of the experienced vividness associated with emotional stimuli, but not because they were necessarily relying on a retrieval process. Therefore, it is unclear what the implications of Ochsner's findings are for other paradigms measuring retrieval-based responding in recognition. Finally, as will be discussed next, there is also evidence suggesting that effects of emotion can be familiarity-based.

Evidence for Familiarity-Based Effects of Emotion

The main source of evidence for familiarity-based effects of emotion on recognition comes from ERP studies. For example, Maratos et al. (2000) measured evoked response potentials (ERPs) while subjects recognized words with negative and neutral valence. They found that negatively valenced words elicited a higher false alarm rate than neutrally valenced words, with little difference in hit rates. In other words, they found reduced discrimination of emotional compared to non-emotional words. Interestingly, though, the ERPs associated with recognizing emotional and non-emotional words also differed. For the non-emotional words, three distinct ERPs were observed: 1) An early, bilateral frontal effect which has been associated with familiarity-based responding in recognition; 2) a slower, left parietal effect that has been associated with recollection in recognition; and 3) an extremely slow, right frontally-distributed effect that has been hypothesized to reflect post-retrieval monitoring (Rugg & Allan, 2000; Curran, 2000). However, for the emotional words, the left parietal effect was of much smaller magnitude, and the later onset frontal effect was not observed at all. Importantly, this means that retrieval processes were used to a lesser extent, if at all, for the emotional words, despite the presence of a clear behavioral effect of emotion. Furthermore, this suggests that familiarity-based responding dominated for the emotional words.

One thing that is still unclear, though, is how exactly these results map onto previous behavioral studies of the time course of recognition. This uncertainty stems from the fact that

Maratos et al.'s recognition task did not necessitate the use of a retrieval process. In particular, their behavioral data does not lead one to believe that recollection contributed because: 1) There is no distinct behavioral pattern of retrieval in the data (e.g., recall-to-reject), and 2) the task did not involve any difficult discrimination of the items that would require access to specific details. Furthermore, there is the problem with their stimuli that they did not control for semantic relatedness within the emotional words, which may have artificially elevated the false alarm rate to these emotional words.

Windmann and Kutas (2001) also measured the ERPs associated with recognition of emotional words. In contrast to Maratos et al. (2000), they found that negatively valenced emotional words were more likely to be classified as "old" on the recognition test than non-emotional words, regardless of actual study status. Thus, they observed a shift in response bias because they controlled for semantic relatedness of the emotional and non-emotional words. Interestingly, they observed that the ERPs for words called "old" were affected by emotional valence by 300 msec after the onset of the stimulus. These ERPs were mainly due to false alarms to unstudied items, which are responsible for the response bias associated with responding on the basis of familiarity. Thus, this study suggests that emotion may have effects on familiarity-based recognition. However, as in Maratos et al.'s experiments, there was no reason for the subjects to need to use a retrieval process, thus it is still unclear whether the presence of recollection would have influenced their results.

In short, although there is some evidence that suggests that emotion may affect recognition through a familiarity process, the issue of which memory process underlies effects of emotion on recognition has not been adequately examined in the literature. In this research, two related questions were addressed. First, does emotion influence familiarity and retrieval processes in recognition in the same manner? And second, is it possible to find emotional memory situations that differentially engage these two processes? The central hypothesis is that emotion may have effects on both familiarity and retrieval processes. On the basis of the existing literature, the prediction is that emotion may have familiarity-based effects. In particular, emotion may increase the hit rate and false alarm rate (e.g., Windmann & Kutas, 2000). This prediction is contrary to Ochsner's claim that recollection is necessary for emotion to have an effect on recognition. It is also predicted that when a recollective process becomes available, enhanced discrimination of emotional compared to non-emotional items may be observed. Discrimination of emotional information may be enhanced most when the emotional information itself needs to be retrieved from memory, as in the case of learned emotional associations.

Of secondary interest is the emotional property that might drive a familiarity-based effect of emotion on recognition. That is, are effects of emotion on familiarity and recollective processes due to the valence or the arousing properties of the words? In the literature, there have been claims that positive valence and negative valence affect recognition, and that increased arousal affects recognition, however only one set of experiments has addressed this question directly. Thus, it seems important to explore the issue further. The prediction is that arousal will drive familiarity-based effects, because arousal produces a fast-acting physiological response that may be available during even the fastest recognition judgments to provide a source of information.

The general goal of this research is to understand how emotion influences the processes involved in recognition memory. Related to this goal, are four specific aims of this research. First, Experiment 1 will determine if emotion influences familiarity-based recognition judgments. Second, Experiment 2 will determine if familiarity-based effects of emotion are due to the arousal associated with the words or their valence. Third, Experiment 3 will determine if the unique perceptual properties of emotional words contribute to familiarity-based effects of emotion on recognition. And fourth, Experiment 3 will determine the process by which emotion influences recognition when the emotional information itself is not present during the recognition test.

II.

Experiment 1

The primary goal of this experiment was to assess the effects of emotion on familiarity and recollective processes in recognition by using a response-deadline procedure to isolate familiarity-based recognition judgments. Specifically, effects of emotion that were based primarily on the familiarity of the recognition item were compared with effects that were based on both the familiarity of the item as well as recollection.

This experiment used an associative recognition paradigm modeled after Rotello & Heit (2000, Expt 2). Subjects studied pairs of words (e.g., cat-desk, plant-roof), and were tested on intact pairs (e.g., cat-desk), rearranged pairs (e.g., cat-roof), and new pairs (e.g., rug-frog). The main reason for using associative recognition is that it is well established in the literature that non-speeded associative recognition involves a specific type of retrieval process, recall-to-reject, whereas speeded associative recognition is based on only familiarity. In the literature, familiarity-based responding occurs prior to approximately 1000 ms, and recollective-based responding occurs after that amount of processing time (Yonelinas, 2002). This finding is well established in the recognition memory literature, and therefore because of the limited amount of emotional words available, two response lags will be used (one prior to and one after 1000 msec) that will reflect familiarity and recollective based processing. Rearranged pairs will be included in the design to ensure that subjects use a recall-to-reject retrieval process.

If, as recent ERP studies suggest (e.g., Windmann & Kutas, 2001), emotion increases overall familiarity of both studied and non-studied items, then emotion should increase the hit rate and false alarm rate by an equal increment or increase the false alarm rate to a greater extent than the hit rate (e.g., Maratos et al., 2001) at short response lags. However, if as Ochsner (2000) suggests, emotion exclusively effects retrieval processes, then emotion should have no effect at the short response lags, but will increase discrimination at the long response lags. If both of these are true, it is predicted that emotion will change response bias for familiarity-based recognition judgments, whereas emotion will increase the discrimination rate for recollective-based recognition judgments.

Participants

Fifty students from the University of Pittsburgh participated in partial fulfillment of a course requirement or for a payment of $7. Data from four participants were excluded from the analysis because of chance recognition performance at the longest response lag.

Design

The experimental design was a 2 x 2 x 3 factorial with three within-subjects factors: recognition test pair (intact, rearranged, new), response lag (300, 3000 ms), and valence of the words (negative, neutral, or positive). Half of the word pairs at each response lag had a neutral valence, one quarter of the word pairs at each response lag had a positive valence, and the remaining quarter of the word pairs had a negative valence.

Stimuli

Stimuli were selected from the ANEW pool of words (Bradley & Lang, 1999) for which normative valence and arousal scores were obtained via responses to the Self-Assessment Manikin (SAM: Lang, 1980). For the valence dimension, the scale ranges from a smiling happy figure (corresponding with the numeric value 9) to a frowning, unhappy figure (numeric value 1), and for the arousal dimension, the scale ranges from an excited, wide-eyed figure (corresponding with the numeric value 9) to a relaxed, sleepy figure (numeric value 1). Lang, Bradley, and Cuthbert (1998) demonstrated that the SAM self-reported arousal levels for words correlated with physiological measures of arousal, including changes in heart rate and skin conductance.

From the ANEW pool, 96 positive and non-arousing words (mean valence = 7.47; mean arousal = 4.66), 96 negative and arousing words (mean valence = 2.24; mean arousal = 6.63), and 192 neutral and non-arousing words (mean valence = 5.16; mean arousal = 4.15) were selected. An additional 384 words were selected from Kucera & Francis (1984). Norms collected via the Bradley and Lang (1999) procedure confirmed that these words were indeed neutral in valence (mean = 5.51) and low in arousal (mean = 4.83). See Appendix 1 for the stimuli and norms. Francis & Kucera (1982) word frequencies were equated for the groups in order to control for effects of item familiarity (see Table 1 for means and ranges). Finally, latent semantic analysis (Landauer, Foltz, & Laham, 1998) was used to control for semantic inter-relatedness within each valence category of words. Within each valence category, the semantic similarity of each word was compared to every other word and the resulting similarity scores were averaged. See Table 1 for the average semantic similarity scores for each valence category.

For each subject, these words were randomly arranged into pairs such that one member of the pair was positive, negative, or neutral (from Bradley & Lang, 1999), and the other member of the pair was always neutral (from Dougal norms, Appendix 1). Next, the word pairs were divided between study-test blocks, resulting in 48 pairs assigned to each block. In each block, 48 word pairs were presented for study, and 48 pairs were presented for the associative recognition test. The test list consisted of 16 intact pairs that had been studied, 16 rearranged pairs from the studied list, and 16 new pairs that had never been studied. The rearranged pairs were constructed by selecting one item from the remaining 32 studied pairs and randomly arranging these items into 16 pairs while preserving the match between valence and lag. Because of the limited number of emotional stimuli available, only two response deadlines were used (300, 3000 msec), and were selected on the basis of previous demonstrations of when retrieval processes become available (e.g., Rotello & Heit, 1999; Yonelinas, 2002). This resulted in eight test trials of each type (intact, rearranged, new) at each lag. One quarter of each type of these test trials were emotionally negative, one quarter were emotionally positive, and the remaining half were neutral. This resulted in two negative test trials of each type (intact, rearranged, new) at each lag (300, 3000 msec), two positive test trials of each type at each lag, and four neutral test trials of each type at each lag per block. The order of the presentation of word pairs for the study and test lists was completely randomized, as was the assignment of words to each block.

Procedure

Each subject participated in one, hour-long experimental session. At the beginning of the session, subjects completed a block of practice trials in which they practiced responding in the response signal procedure. During the practice block, subjects practiced responding to the words 'yes' and 'no' in order to learn the mapping between the response and the key press. For each practice trial, subjects saw a fixation point (->+<-) in the center of the screen for one second. Next, the fixation point was replaced by the word 'yes' or 'no' which appeared on the screen for a variable amount of time (300, 3000 msec) before being replaced by a mask (*****). The mask was presented simultaneously with a brief tone that signaled the subject to make the recognition response. Subjects pressed 'z' if the word 'yes' was presented, and '/' if the word 'no' was presented. They were instructed to respond as quickly as possible after the response tone even if they had to guess. Latency feedback was provided only when subjects responded within 50 msec of the response signal or after 350 msec of the response signal.

After the practice trials, subjects completed six blocks during the experimental session. Each experimental block consisted of presentation of 48 word pairs for study, followed by a response signal associative recognition test on 48 intact, rearranged, and new word pairs. The study word pairs were presented one at a time, in the center of the screen, at a rate of four seconds each. Immediately following presentation of the study list, subjects made speeded recognition decisions on the target pairs from the list, rearranged pairs from the list, and distractor pairs. Subjects were instructed to respond "old" only if the elements of the word pair had been studied together. "New" responses corresponded with rearranged pairs and distractor pairs. The speeded recognition trials were identical in procedure to the practice trials with the critical difference that the stimuli presented were target pairs and distractor pairs.

Results and Discussion

The following analyses were based on only those responses that occurred between 50 and 350 msec after the response signal. The other 18.5 % of responses were discarded because they were assumed to reflect anticipatory responses or additional uncontrolled processing of the stimulus.

The proportion of "old" judgments to intact, rearranged, and new word pairs is shown in Figure 1 as a function of response lag and valence. There are three important aspects of these data. First, as predicted, emotion did influence the proportion of "old" judgments to the word pairs ($F(2, 90) = 16.17$; $Mse = .01$; $p < .001$). Planned comparisons indicated that the proportion of "old" judgments was higher for words with a *negative* (mean = .37) than a neutral valence (mean = .33; $F(1, 45) = 26.20$; $Mse = .003$; $p < .001$). However, there was no difference in the proportion of "old" judgments for words with a positive valence (mean = .33) compared to the neutral pairs (mean = .33; $F(1, 45) = 1.69$; $Mse = .002$; $p = .20$). Because the negative words differed in arousal as well as valence, the observed effect of emotion may have been driven by either factor, and was further examined in Experiment 2.

Second, emotion interacted with the type of recognition pair ($F(4, 180) = 4.28$; $Mse = .01$; $p < .01$). The planned comparisons indicated that for the intact pairs, the proportion of “old” judgments was higher for negative pairs than neutral pairs ($F(2, 90) = 8.81$, $Mse = .02$, $p < .01$). Third, and most importantly, a familiarity-based effect of emotion was observed as indicated by the finding that the effect of emotion was not mediated by the response lag ($F < 1$). The magnitude of the effect of emotion was equivalent at the 300 and 3000 ms response lags (see Figure 1). This finding is generally inconsistent with Ochsner’s (2000) claim that effects of emotion on recognition are based on a recollective process.

Finally, as expected, the proportion of “old” judgments was higher for intact pairs (mean = .57), than rearranged pairs (mean = .26), than new pairs (mean = .11; $F(2, 90) = 152.81$, $Mse = .10$, $p < .01$). In addition, the proportion of “old” judgments was higher at the 3000 ms response lag (mean = .33) than the 300 ms response lag (mean = .29), indicating a shift in response bias that is consistent with the existing literature ($F(1, 45) = 5.54$, $Mse = .06$, $p < .05$). Furthermore, response lag mediated the proportion of “old’ judgments to the pairs. Whereas the proportion of “old” judgments to intact pairs increased from the 300 to 3000 ms response lag, the proportion of “old” judgments to rearranged pairs and new pairs decreased across lags ($F(2, 90) = 56.61$, $Mse = .02$, $p < .01$).

In order to evaluate the influence of emotion independent of bias and to determine if emotion had differential effects on familiarity and recollection, the logistic discrimination measure d_L was computed[1] (Snodgrass & Corwin, 1988). The discrimination rate (d_L) for intact pairs was computed by comparing the probability of “old” responses to these items to the probability of “old” responses to new pairs. Figure 2 shows the discrimination rate of intact (d_L-

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[1] $D_L = \ln[HR(1 - FAR) / FAR(1 - HR)]$, where HR is the hit rate and FAR is the false alarm rate. It is approximately equal to 1.67 times d’.

old) pairs as a function of processing time and emotion. Overall, as expected, discrimination increased from the 300 (mean = 2.36) to the 3000 (mean = 3.46) ms response lag ($F(1, 45) = 71.93$, $Mse = 1.17$, $p < .01$). In addition, discrimination was affected by emotion, although in an unexpected manner; discrimination was higher for the neutral (mean = 3.06) and negative (mean = 3.02) pairs than for the positive pairs (mean = 2.65; $F(2, 90) = 5.59$, $Mse = .82$, $p < .01$). This finding does not support the hypothesis that emotion may *enhance* discrimination for recollection-based recognition judgments. In the literature, there is only one other report of emotion reducing recognition performance, and it was obtained for negative emotion in experiments where the semantic intra-relatedness was greater for the emotional than neutral words. However, semantic relatedness was equivalent for each group of words in this experiment, making this a rather unexpected result. Given that a decrease in discrimination for positive word pairs was both unpredicted and not observed in the subsequent experiments it seems likely to represent a Type 1 error.

III.

Experiment 2

In Experiment 1, emotion increased the proportion of "old" judgments to intact pairs at the 300 and 3000 ms response lags, demonstrating that a recollective process is not necessary in order to observe effects of emotion on recognition. This finding is counter to Ochsner's (2000) claim that effects of emotion in recognition are based on recollective processing. Interestingly, though, the effects of emotion on the proportion of "old" judgments were observed for the negative, but not the positive word pairs.

There is one primary difference in these word pools aside from the relative valence levels; the negative words were high in arousal, whereas the positive words were low in arousal and were matched to the neutral words on arousal level. Thus, the goal of Experiment 2 was to examine the role of arousal in producing the observed effects of emotion in Experiment 1. In order to do this, a group of positive words that were matched in arousal to the negative words was added to the design.

If the effects of emotion observed in Experiment 1 were due to differences in the arousal levels of the words, then the proportion of "old" judgments should be higher for the negative and positive words that are high in arousal, than the positive and neutral words that are low in arousal. If however, the effects of emotion observed in Experiment 1 are due to an interaction between arousal and negative valence, then the proportion of "old" judgments should be higher for the negative words than the positive high arousal words, the positive low arousal words, and the neutral words.

Participants

Sixty students from the University of Pittsburgh participated in partial fulfillment of a course requirement or for a payment of $7. Data from five participants were excluded from the analysis because of chance recognition performance at the longest response lag or failure to follow instructions.

Design

The experimental design was a 2 x 2 x 3 factorial with three within-subjects factors: recognition test pair (intact, rearranged, new), response lag (300, 3000 ms), and valence and arousal level of the words (neutral low, negative high, positive low, and positive high). One quarter of the word pairs at each response lag had a neutral valence, one quarter of the word pairs at each response lag had a positive valence and were low in arousal, one quarter of the word pairs at each response lag had a positive valence and were high in arousal, and the remaining quarter of the word pairs had a negative valence and were high in arousal.

Stimuli

Stimuli were identical to those used in Experiment 1 except for the addition of positive and highly arousing words and the removal of 96 neutral words used in Experiment 1. From the ANEW pool, 96 positive and arousing words (mean valence = 7.79; mean arousal = 6.48) were selected. Francis & Kucera (1982) word frequencies for these words were equated to the other groups in order to control for effects of item familiarity (see Table 1 for means and ranges). Latent semantic analysis (Landauer, Foltz, & Laham, 1998) was used to match the semantic inter-relatedness of these words to the other valence categories of words. These positive and arousing words replaced 96 neutral words that were used in Experiment 1 in order to equate the number of stimuli between Experiments 1 and 2. Discarding these 96 neutral words did not change the average stimulus properties of the neutral words.

For each subject, the words were randomly arranged into pairs such that one member of the pair was positive and non-arousing, positive and arousing, negative, or neutral (from Bradley & Lang, 1999), and the other member of the pair was always neutral (from Dougal norms, Appendix 1). Next, the word pairs were divided between study-test blocks, resulting in 48 pairs assigned to each block. In each block, 48 word pairs were presented for study, and 48 pairs were presented for the associative recognition test. The test list consisted of 16 intact pairs that had been studied, 16 rearranged pairs from the studied list, and 16 new pairs that had never been studied. The rearranged pairs were constructed by selecting one item from the remaining 32 studied pairs and randomly arranging these items into 16 pairs while preserving the match between valence and lag. As in Experiment 1, two response deadlines were used (300, 3000 msec). This resulted in eight test trials of each type (intact, rearranged, new) at each lag. One quarter of each type of these test trials were negative, one quarter were positive and low in arousal, one quarter were positive and high in arousal, and the remaining quarter were neutral. This resulted in two negative test trials of each type (intact, rearranged, new) at each lag (300, 3000 msec), two positive and non-arousing test trials of each type at each lag, two positive and arousing test trials of each type at each lag, and two neutral test trials of each type at each lag per block. The order of the presentation of word pairs for the study and test lists was completely randomized, as was the assignment of words to each block.

Procedure

The procedure was identical to Experiment 1.

Results and Discussion

As in Experiment 1, the following analyses were based on only those responses that occurred between 50 and 350 ms after the response signal. The other 22 % of responses were discarded because they were assumed to reflect anticipatory responses or additional uncontrolled processing of the stimulus.

The proportion of "old" judgments to intact, rearranged, and new word pairs is shown in Figure 3 as a function of response lag and valence. First, consider the effect of emotion on the proportion of "old" judgments to the word pairs. If the effects of emotion in Experiment 1 were caused by arousal, then an effect of emotion should be observed for the negative and positive arousing words, but not for the non-arousing positive words. As expected, emotion did influence the proportion of "old" judgments ($F(3, 177) = 4.68$; $Mse = .02$; $p < .01$). Planned comparisons indicated that the proportion of "old" judgments was higher for negative (mean = .57) than neutral pairs (mean = .54; $F(1, 59) = 7.67$; $Mse = .01$, $p < .01$). Interestingly, the planned comparisons further indicated that the proportion of "old" judgments was also higher for positive *arousing* pairs (mean = .56) than for neutral pairs (mean = .54; $F(1, 59) = 4.78$, $Mse = .02$, $p < .05$). However, there no was difference between the positive non-arousing pairs (mean = .53) and the neutral pairs ($F < 1$). Thus, the effect of emotion observed in Experiment 1 was due to the arousal of the items, and was not influenced by the valence.

In addition, emotion interacted with the type of recognition pair ($F(6, 354) = 2.51$; $Mse = .01$; $p < .05$). Whereas emotion influenced the proportion of "old" judgments to intact and rearranged pairs, it did not influence the proportion of "old" judgments to new pairs. Importantly, as in Experiment 1, the effect of emotion was not mediated by the response lag ($F < 1$). Thus, these results replicate the familiarity-based effects of emotion observed in Experiment 1. In addition, they extend the results of Experiment 1 by demonstrating that the effects of emotion are caused by the arousing property of the emotional stimuli, not by an interaction between arousal and negative valence.

As expected, the proportion of "old" judgments was higher for intact pairs (mean = .55), than rearranged pairs (mean = .24), than new pairs (mean = .07; $F(2, 118) = 295.85$, $Mse = .02$, $p < .01$). In addition, the proportion of "old" judgments was higher at the 3000 ms response lag (mean = .32) than the 300 ms response lag (mean = .25), indicating an overall shift in response bias ($F(1, 59) = 28.66$, $Mse = .06$, $p < .01$). Furthermore, the response lag mediated the proportion of "old' judgments to the pairs. Whereas the proportion of "old" judgments to intact pairs increased from the 300 to 3000 ms response lag, the proportion of "old" judgments to rearranged pairs and new pairs decreased across lags ($F(2, 118) = 110.59$, $Mse = .03$, $p < .01$). These findings replicate the results of Experiment 1.

In order to determine if emotion had differential effects on familiarity and recollective-based recognition performance, discrimination scores were calculated as in Experiment 1. Figure 4 shows the discrimination rate to intact (d_L-old) pairs as a function of processing time and emotion. Overall, discrimination increased from the 300 (mean = 3.00) to the 3000 (mean = 4.75) ms response lag ($F(1, 59) = 77.79$, $Mse = 4.72$, $p < .01$). However, discrimination was not affected by emotion in this experiment ($F < 1$). Thus, the decreased discrimination of positive items observed in Experiment 1 was not replicated. However, as in Experiment 1, this result is contrary to the hypothesis that emotional words may be associated with enhanced discrimination when recollection was available. This result was surprising and will be addressed further in the general discussion.

IV.

Experiment 3

To summarize the findings so far, Experiment 1 demonstrated that emotion influences familiarity-based recognition judgments. Experiment 2 replicated and extended this result by demonstrating that the effect of emotion is due to the arousal elicited by the emotional words, and is not due to valence. A comparable effect of emotion was observed for high arousal negative and positive words, but not for positive low arousal words. However, in these experiments, the items were all intrinsically emotional, and the presentation of an emotional item on the recognition test may have altered normal recognition processing. Thus, Experiment 3 was designed to examine this potential problem in interpreting the results of the previous experiments.

Experiment 3 addressed two main issues: First, are recognition judgments comparable for items that are intrinsically emotional compared with those that were associated with an emotional item during encoding? This question is important because the nature of the items in the previous experiments may have fundamentally changed the speed of the recognition process. Several researchers have found that emotional stimuli have unique perceptual characteristics that may allow them to be recognized more quickly than non-emotional stimuli (Anderson & Phelps, 2001; Bargh, Chaiken, Govender, & Pratto, 1992; Kitayama, 1990). For example, Anderson and Phelps (2001) found that emotional words, in contrast to non-emotional words, are not susceptible to the "attentional blink". Furthermore, Kitayama (1990) found that emotional words are sometimes identified as words more quickly than non-emotional words.

These findings suggest that non-memorial processes may have influenced the recognition judgments in Experiments 1 and 2. Presentation of non-emotional words on the recognition test that had been encoded with or without an emotional context would alleviate this potential problem in interpretation of Experiments 1 and 2. Thus, Experiment 3 will replicate the previous experiments with the critical difference that the stimuli themselves on the recognition test will not be outwardly emotionally arousing.

The second question is: is it possible to find an emotional memory situation that depends on recollection in recognition? By establishing an association between the neutral word pairs and emotional words during encoding, retrieval of associative information may be necessary in order to gain access to the emotional context and thereby produce an effect of emotion. Because the associations between the word pairs and emotional context are only recently learned, and will not be learned to a high level of accuracy, this emotional context may only become activated once the specific association has been retrieved from memory (e.g., Clark, 1992). If this is the case, the prediction is that an effect of emotion will be observed at the 3000 ms response lag, but not at the 300 ms response lag.

However, if the emotional information is available in a sparse low-level form during recognition, it may affect familiarity-based responses. LeDoux (1995) has claimed that organisms have evolved so that emotional information is available quickly and readily so as to increase an organism's chance of survival. If the emotional information were indeed available very rapidly, it may influence recognition judgments to the neutral word pairs in the absence of retrieval of the specific emotional context presented at encoding. In this case, the prediction is that emotion would increase the hit rate and false alarm rate to familiarity-based responses.

Participants

Forty students from the University of Pittsburgh participated in partial fulfillment of a course requirement.

Design

The experimental design was a 2 x 2 x 3 quasi factorial with three within-subjects factors: emotionality of the context word during encoding (negative, positive, neutral), response lag (300, 3000 msec), and word pair (intact, rearranged, new). Half of the intact and rearranged word pairs at each response lag were studied with an emotional context word, and the other half of the intact and rearranged word pairs at each response lag were studied with a non-emotional context word. New pairs on the recognition test will not have an emotional association.

Stimuli

Stimuli were identical to those in Experiment 1.

Procedure

Each subject participated in one, hour-long experimental session. At the beginning of the session, subjects completed a block of practice trials in which they practiced responding in the response signal procedure. This practice block was identical to the practice blocks in Experiments 1 and 2.

After the practice trials, subjects completed eight experimental blocks. Each experimental block was identical to those in Experiments 1 and 2 with two critical differences. First, the word pairs presented for study and test were all intrinsically non-emotional. And second, during the encoding phase of the block, an emotional context word (either negative or positive) was presented in red font directly above half of the word pairs, and a non-emotional context word was presented in red font directly above the other half of the word pairs. Subjects were instructed to form an association between the context word and its corresponding word pair.

Results and Discussion

As in Experiments 1 and 2, the following analyses were based on only those responses that occurred between 50 and 350 ms after the response signal. The other 15 % of responses were discarded because they were assumed to reflect anticipatory responses or additional uncontrolled processing of the stimulus.

The proportion of “old” judgments to intact and rearranged word pairs is shown in Figure 5 as a function of response lag and valence (the new word pairs were never presented with an emotional context). Again, the proportion of “old” judgments was higher for intact pairs (mean = .48), than rearranged pairs (mean = .33), than new pairs (mean = .09; $F(2, 78) = 212.98$, $Mse = .04$, $p < .01$). In addition, the proportion of “old” judgments was higher at the 3000 ms response lag (mean = .36) than the 300 ms response lag (mean = .24), indicating a shift in response bias ($F(1, 39) = 45.61$, $Mse = .06$, $p < .01$). Furthermore, the response lag mediated the proportion of “old’ judgments to the pairs. Whereas the proportion of “old” judgments to intact and rearranged pairs increased from the 300 to 3000 ms response lag, the proportion of “old” judgments to new pairs did not change across lags ($F(2, 78) = 43.85$, $Mse = .02$, $p < .01$). This result was unexpected and will be considered further in the general discussion.

Next, to examine effects of emotion in this experiment, a separate ANOVA was performed on only the intact and rearranged pairs. Overall, the proportion of “old” judgments was influenced by emotion ($F(2, 78) = 3.64$, $Mse = .02$, $p < .05$). Planned comparisons showed that the proportion of “old” judgments was higher for word pairs with a negative (mean = .43) than neutral valence (mean = .39; $F(1, 39) = 6.49$; $Mse = .05$; $p < .05$). However, the proportion of “old” judgments did not differ between the positive (mean = .40) and neutral word pairs (mean = .39; $F < 1$). Furthermore, there was a trend for emotion to interact with the type of word pair and the response lag ($F(2, 78) = 3.02$, $Mse = .01$, $p < .06$). Importantly, as in Experiments 1 and 2, the effect of emotion was observed at both the 300 and 3000 ms response lags (emotion x lag: $F < 1$). This result is important because it demonstrates that the familiarity based effects of emotion observed in Experiments 1 and 2 were not caused by faster processing or different stimulus characteristics of the emotional items. In addition, it is notable that the effect of emotion was observed early in processing because recollection was not yet available. Therefore, the emotional information was available in the absence of recollection, suggesting that emotion is having a low level effect on recognition even when the emotional information is not present at the time of recognition.

In order to evaluate the influence of emotion independent of bias, the discrimination rate (pseudo-d_L) for intact pairs was computed by comparing the probability of "old" responses to these items to the probability of "old" responses to rearranged pairs. This comparison was made because the new pairs were not associated with any emotion. Figure 6 shows the discrimination rate of intact (pseudo-d_L) pairs as a function of processing time and emotion. Discrimination was higher at the 3000 ms lag (mean = 1.14) than at the 300 msec lag (mean = .56; $F(1, 39) = 12.98$, Mse = 1.55, $p < .01$). However, as in Experiment 2, the effect of emotion on discrimination was not statistically significant ($F < 1.23$).

Thus, Experiment 3 demonstrated that the familiarity-based effects of emotion are not caused by unique processing of the properties of the emotional words. The effects of emotion observed in Experiment 3 for neutral words that had been encoded in an emotional context are comparable to those observed in Experiment 1 and 2 when the emotional words themselves appeared on the recognition test. Interestingly, Experiment 3 also demonstrated that encoding neutral words in an emotional context produces a familiarity-based effect of emotion.

V.

General Discussion

In summary, four main results emerged from this research. First, familiarity-based effects of emotion were observed consistently across experiments. In Experiment 1, the proportion of "old" judgments was higher for negative than positive or neutral intact pairs at both the 300 and 3000 ms response lags. A comparable effect of emotion was observed for intact pairs at both response lags in Experiments 2 and 3. Second, the observed effects of emotion were due to the arousal associated with the words, not their valence. This was demonstrated in Experiment 2, where the proportion of "old" judgments to intact pairs was higher for negative and positive words that were high in arousal, than for positive and neutral words that were low in arousal. Third, the observed effects of emotion were not caused by unique perceptual properties of emotional words. As demonstrated in Experiment 3, the proportion of "old" judgments was higher for neutral pairs encoded in a negative context than a positive or neutral context. And fourth, a familiarity-based effect of emotion was observed even when the emotional information was not present during recognition. In Experiment 3, the proportion of "old" judgments was higher for neutral pairs encoded in a negative context than a positive or neutral context at both the 300 and 3000 ms response lags. Next, each of these findings will be considered in more depth.

Familiarity Produces Effects of Emotion

In three experiments, emotion had a clear effect on recognition when the recognition judgment was assumed to rely on only a familiarity process. These findings contrast with those of Ochsner (2000) who estimated familiarity and recollection in recognition on the basis of subjective reports of "remembering" and "knowing" (Rajaram, 1993; Tulving, 1985). In three experiments in which separate analyses were performed for arousal and valence, Ochsner found only one effect of emotion on estimates of familiarity. In his Experiment 2, the medium arousal pictures were associated with increased estimates in familiarity compared to the high and low arousal pictures.

There are several ways of accounting for the disparity between the results of the present experiments and Ochsner's findings. First, and perhaps most interesting, the subjective experience of "remembering" and "knowing" may not correspond with the processes of recollection and familiarity for emotional stimuli. In particular, emotional stimuli may elicit the subjective experience of recollection even when the recognition judgment is made on the basis of familiarity. If this were the case, it would have important implications for discussions of the mechanisms by which emotion influences recognition memory. Much effort has been focused on establishing that the remember/know procedure does in fact measure the underlying processes of recollection and familiarity (see Yonelinas, 2002, for a review). Indeed, this approach is advantageous in that it is much less time and cost intensive than response deadline procedures. However, the present research may have identified one important boundary condition for the use for this procedure, and more specifically, that it may not be a viable methodology for studying emotional recognition.

Second, an alternative explanation for the difference between Ochsner's data and the present results is that emotion may change the time course of recognition of emotional words. The response lags in the present experiments were chosen on the basis of when retrieval contributes to recognition of non-emotional words. But, if the time course of recognition were faster for emotional than non-emotional words, then it could be that recollection was contributing at the 300 ms response. This would mean that the short response lags were actually based on recollection and that the observed effects of emotion were retrieval-based, like Ochsner's. However, the results of Experiment 3 would still present a problem for this interpretation. It would seem that the emotional information would need to be present on the recognition test in order for there to be a change in the time course of recognition. In addition, in Experiment 3 there was suggestive evidence that retrieval did not contribute to the recognition judgments because the proportion of "old" judgments to rearranged pairs *increased* between the 300 and 3000 ms response lags. Furthermore, of all of the experiments that have used the response signal paradigm, none have reported contribution of recollection until at least 750 msec of processing time. Thus, it is highly unlikely that retrieval contributed at the early response lag. However, in order to completely rule out this possibility, a full-time course study would need to be done, in which various responses lags between 300 and 3000 ms could capture the biphasic response time and accuracy changes observed in the literature (e.g., Rotello & Heit, 2000; Dosher, 1984; Hintzman & Curran, 1994).

Third, another factor that may have contributed to the discrepancy between the present experiments and Ochsner's experiments is the nature of the emotional stimuli. Ochsner used emotional pictures, which are likely much richer sources of information than emotional words. This may have fundamentally changed the processing of the stimuli. For example, Dewhurst and Conway (1994) demonstrated that the distinctiveness with which stimuli are encoded is maximized when the number of stimulus attributes is increased, which then increases recollection of the stimuli. Although this finding does not directly help to reconcile the present findings with Ochsner's, it suggests that if pictures have more attributes than words, and are therefore encoded differently, then the associated retrieval processes may differ as well. Future research is needed to resolve this issue.

Familiarity-based Effects of Emotion are Caused by Arousal

The results of Experiment 2 demonstrated that the effects of emotion observed in the present experiments are caused by arousal, not the valence dimension of emotion. In the existing emotional recognition literature, Ochsner (2000) provides the only independent manipulation of arousal and valence, and he finds that changes in both valence and arousal produce effects on "remember" recognition judgments. In addition, the one hint at a familiarity-based effect in his experiments was caused by differences in the arousal level of the pictures. However, no effects of valence were observed in the present experiments, therefore other differences in Ochsner's stimuli may be responsible for this difference.

It should be noted, that the stimuli in the present experiments were carefully selected not only on the basis of normative values of valence and arousal, but word frequency and intra-word group semantic similarity were also controlled. Therefore, any differences between the effects of emotion observed in the present experiments and other experiments in the literature (none of which simultaneously controlled all of these variables) may be due to these factors. Although Ochsner used pictures rather than words, other important stimulus attributes may exist that make the contribution of valence more important for pictures than words. In particular, many of the pictures in the stimulus set that he used (IAPS: Lang, Greenwald, Bradley, & Hamm, 1993), especially the negative and positive groups of pictures, are semantically similar, which may have contributed to his valence effects.

Finally, future work should demonstrate directly that the subjective reports of arousal associated with Bradley and Lang's (1999) words do reflect physiological arousal. Lang et al. (1998) showed that the arousal ratings to the words correlate with several physiological measures of arousal including changes in heart rate and skin conductance, however further research may examine this more directly by measuring physiological response during encoding and retrieval of the words.

Familiarity-based Effects are not Caused by Emotional Stimulus Properties

Some researchers have demonstrated that word identification is affected by the emotionality of the word. For example, Kitayama (1990) found that emotional words were identified more quickly than non-emotional words. Therefore, one concern in interpreting the results of Experiments 1 and 2 was that the effects of emotion were caused by differential stimulus processing and not memory processing. However, in Experiment 3, when the items on the recognition test were not intrinsically emotional, the same effects of emotion were observed. Thus, the results of Experiments 1 and 2 do not seem to be caused by an increase in the time course of identification of emotional words. This also has implications for the conclusion that the effects of emotion observed in the present experiments are not in fact familiarity-based, but are based on recollection because of an increase in the time course of recognition of emotional words. This seems unlikely based on the results of Experiment 3, unless emotional encoding somehow increases the identification on non-emotional words.

Familiarity-based Effect of Emotional Encoding

The most interesting, and perhaps controversial, result in these experiments is the finding that encoding neutral words in an emotional context produced a familiarity-based effect of emotion. This result was surprising because it was assumed that a recollective process was necessary in order to access to the emotional context. However, there is a body of research that suggests that emotion has very fast-acting, low-level associative effects (e.g., LeDoux, 1995). In this view, the emotional context itself may not have to be retrieved from memory because during recognition some affective information is available in the absence of recollection of the specific item information. When one of the emotional items is encountered on the recognition test, the associated feeling of arousal enhances the feeling of familiarity that drives the speeded recognition judgments, thereby producing an effect of emotion. However, there is an alternative explanation for this result that cannot be ruled out on the basis of this research. Specifically, the contribution of a retrieval process may have been reduced by the subjective experience of "recollection" associated with emotional stimuli. It is possible that the emotional stimuli seemed as if they were being retrieved, and therefore subjects may have been less likely to actually use a recollective process on the recognition test. Indeed, suggestive evidence for this interpretation is provided in Experiment 3 in that the proportion of "old" judgments to rearranged words increased from the 300 to 3000 ms response lags.

Bias and Discrimination Effects of Emotion on Recognition

Two predictions were made regarding the nature of the effects of emotion on familiarity- and recollection-based recognition judgments. It was predicted that familiarity-based effects of emotion would be observed as increased hit and false alarm rates for emotional compared to non-emotional words. There have been reports of changes in response bias as a function of emotion in the literature for what may be familiarity-based recognition judgments (e.g., Windmann & Kutas, 2001). There was no evidence for this in the present experiments. Rather, the both Experiments 1 and 2, the proportion of "old" judgments to negative intact pairs was higher than that to positive or neutral intact pairs at the 300 msec response lags. Thus, emotion consistently increased the proportion of "old" judgments to intact pairs, and no emotion-induced change in response bias was observed.

It was also predicted that emotion would increase the discrimination rate of intact pairs for recognition judgments based on both familiarity and recollection. Although the hit rate and false alarm rate data are suggestive of this pattern in Experiments 1 and 2, these effects were not observed in the standardized discrimination measure dL. The reason for the failure to detect these changes is unclear, although it should be noted that the only other claims of enhanced emotional discrimination of words in the literature were based on studies in which only one, non-emotional, false alarm rate was used to compute both emotional and non-emotional discrimination. Thus, all that would be needed to observe increased emotional discrimination in these studies would be an increase in the hit rate for emotional words, which was observed in all three experiments. Ochsner (2000) observed enhanced discrimination of emotional pictures, however picture recognition tends to be much better than word recognition in general, and this might have contributed to his findings. Thus, these results suggest that emotion may not enhance discrimination of emotional words in recognition.

How does Emotion Influence Familiarity-based Recognition?

These experiments demonstrate that emotion influences familiarity-based recognition judgments by increasing the proportion of "old" judgments to intact word pairs. There are two related properties of emotional information that may produce the observed effects of emotion on recognition. First, familiarity was originally conceptualized as depending on the ease, or fluency, with which an item can be processed (Gardiner & Java, 1993). There is behavioral evidence suggesting that without prior study, emotional stimuli are processed more fluently than non-emotional stimuli. For example, emotional words are identified more quickly than non-emotional words (Kitayama, 1990), and emotional pictures are identified more quickly than non-emotional pictures (Christianson, Loftus, Hoffman, & Loftus, 1991).

Second, there is physiological evidence suggesting that emotional stimuli are processed and may influence behavior very rapidly and automatically (e.g., LeDoux, 1992, 1995). LeDoux demonstrates that the amygdala is critically involved in fear conditioning, and that fear conditioning can occur via input from the thalamus to the amygdala without input from the neocortex. LeDoux (1992, p. 277) claims that this thalamus to amygdala pathway could “generate emotional responses and memories on the basis of features and fragments rather than full-blown perceptions of objects”. Although this result has not been extended to verbal stimuli, it may have implications for the way that emotional information influences behavior. Taken together with the behavioral evidence, emotion may have powerful and low-level effects on cognitive processing which likely contribute to the effects of emotion on familiarity-based recognition.

These properties of emotional stimuli may influence recognition judgments by making the items seem more familiar, or perceptually fluent. This added feeling of familiarity likely increases the proportion of “old” judgments to items that have an emotional association. This also means that “old” judgments would be increased for both studied and non-studied items. If emotion also increases the vividness and feelings of having recollected an item, then the emotion elicited by the items on the recognition test may cause a false sense of recollection. This type of effect has been observed in other studies of recognition memory for which it is hypothesized that an emotional reaction is confused with a feeling of remembering (e.g., Schooler & Dougal, submitted). Specifically, we have demonstrated that an experience of discovering the solution to an anagram, which presumably elicits positive emotion and arousal, causes an increase in the proportion of “old” judgments to the anagram solution on a recognition test, even if the anagram’s solution had not been presented on the study list.

One way to determine if emotion changes the subjective experience of “remembering” and “knowing” by increasing familiarity-based “remember” judgments would be to conduct a response-deadline experiment in which subjects make remember/know recognition judgments rather than old/new recognition judgments. If emotion causes of false experience of “remembering”, the prediction is that “remember” judgments that are based on only a familiarity process would be made at a higher frequency than familiarity-based “remember” judgments to non-emotional items. This would demonstrate an important illusion on the subjective experience of remembering, and would be an interesting area for further investigation. Although more research will be needed in order to fully understand the mechanisms by which emotion influences speeded recognition judgments, one conclusion seems absolutely clear. Emotion has a remarkably fast acting effect on the cognitive processing involved in recognition memory.

	Neutral (B & L)	Neutral (Dougal)	Negative	Positive	Positive, arousing
Median word frequency	14.5	16	15	15	16
Range of word frequencies	1-126	1-146	1-127	1-114	1-143
Mean valence	5.16	5.51	2.24	7.47	7.79
Mean arousal	4.15	4.83	6.63	4.66	6.48
Mean LSA similarity	.10	.11	.15	.13	.13

Table 1: Summarized stimulus properties for Experiments 1, 2, and 3.

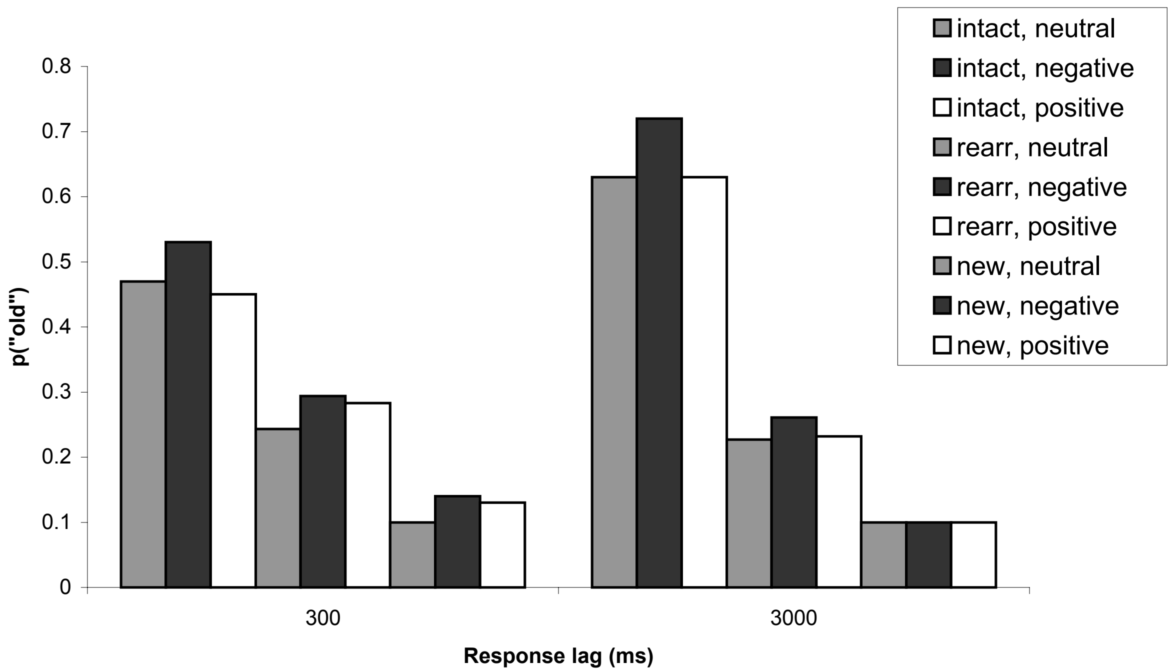

Figure 1: The proportion of "old" judgments to intact, rearranged, and new pairs as a function of emotion and response lag for Experiment 1.

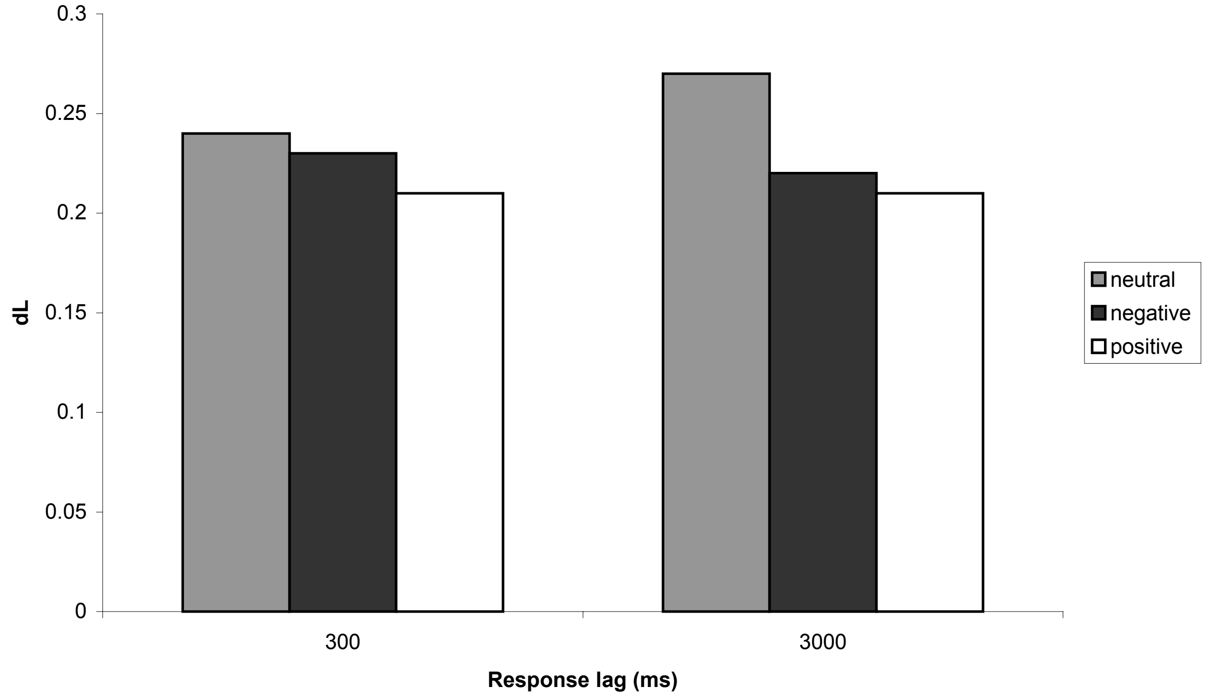

Figure 2: Discrimination as a function of emotion and response lag for Experiment 1.

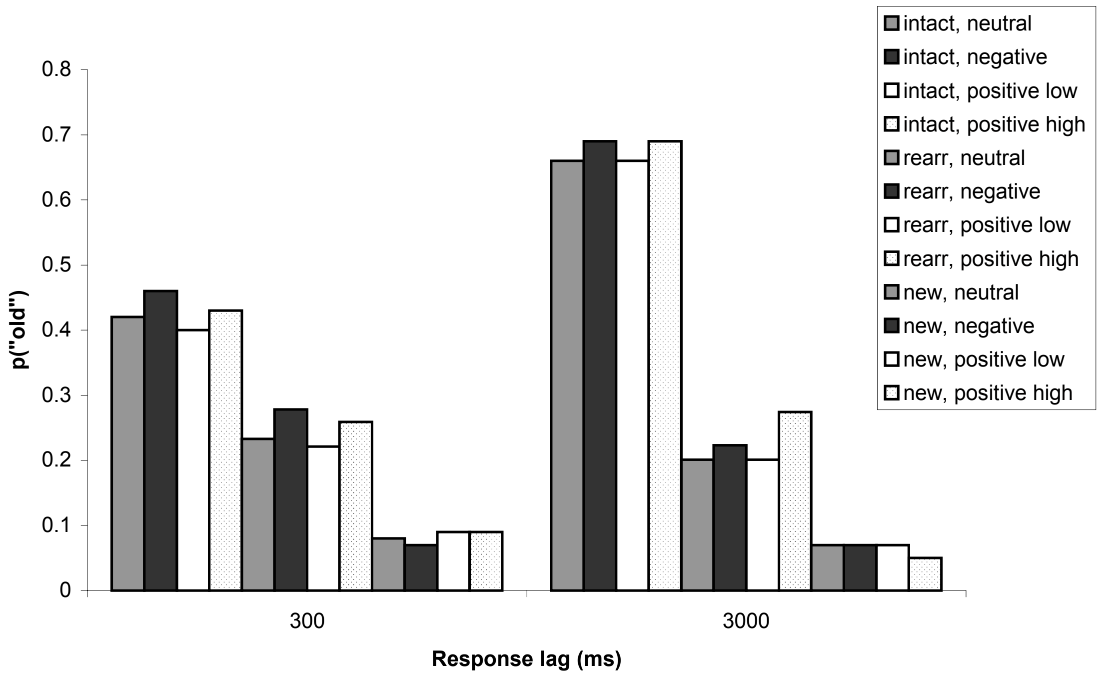

Figure 3: The proportion of "old" judgments to intact, rearranged, and new pairs as a function of emotion and response lag for Experiment 2.

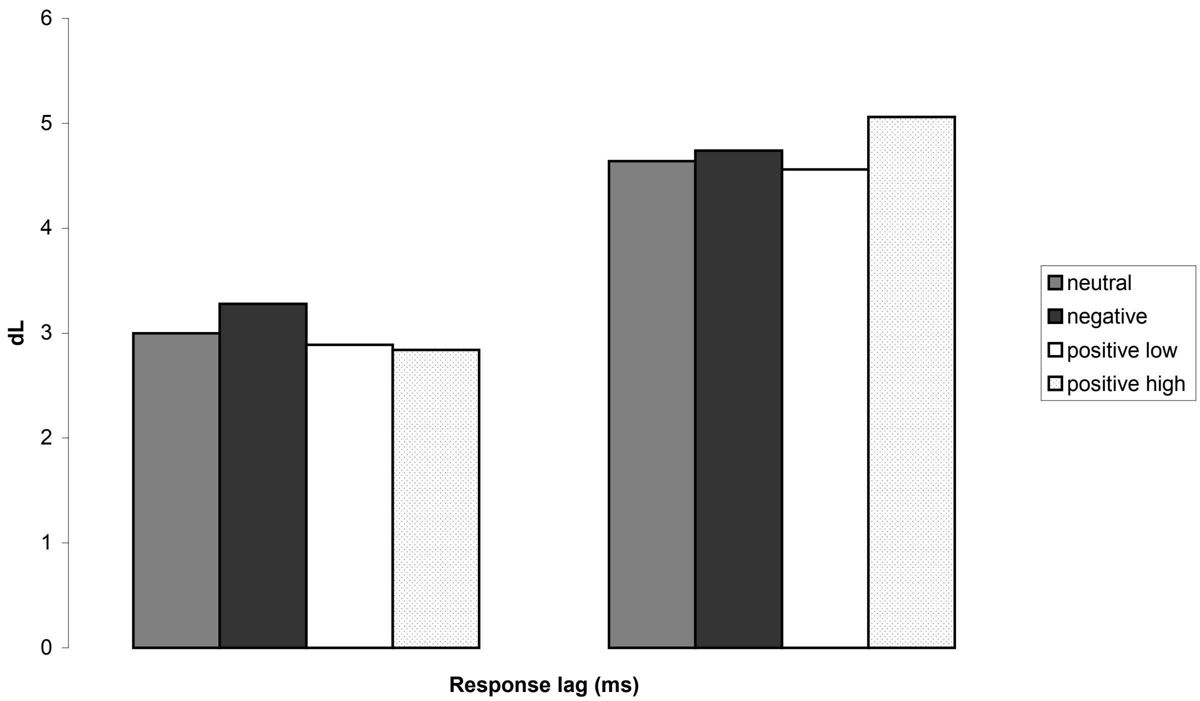

Figure 4: Discrimination as a function of emotion and response lag for Experiment 2.

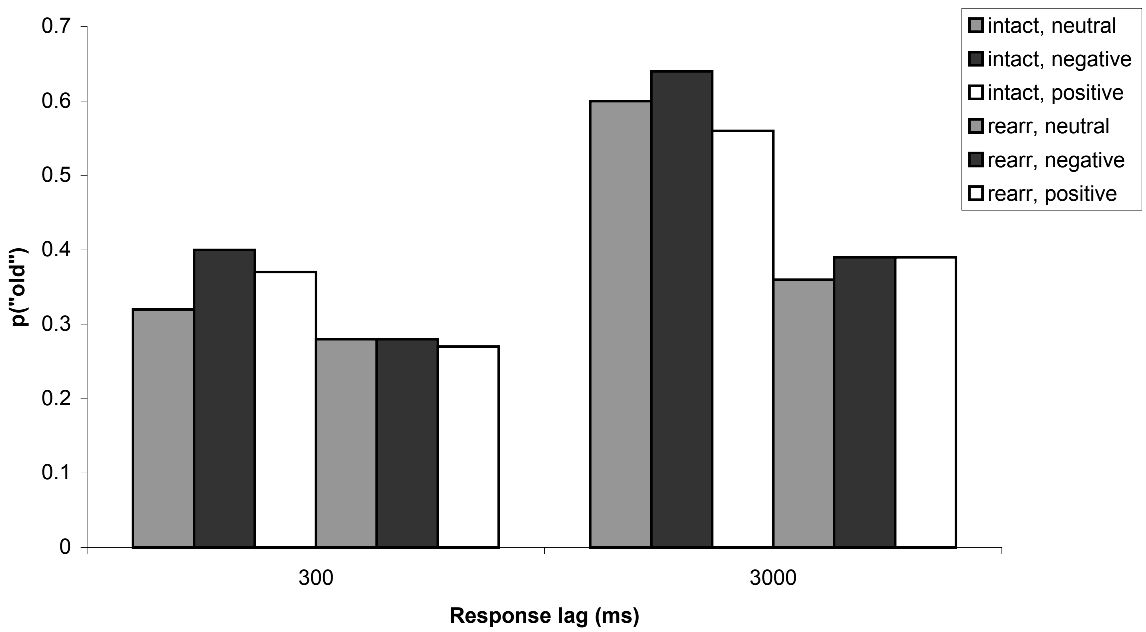

Figure 5: The proportion of "old" judgments for intact and rearranged pairs as a function of emotion and response lag for Experiment 3.

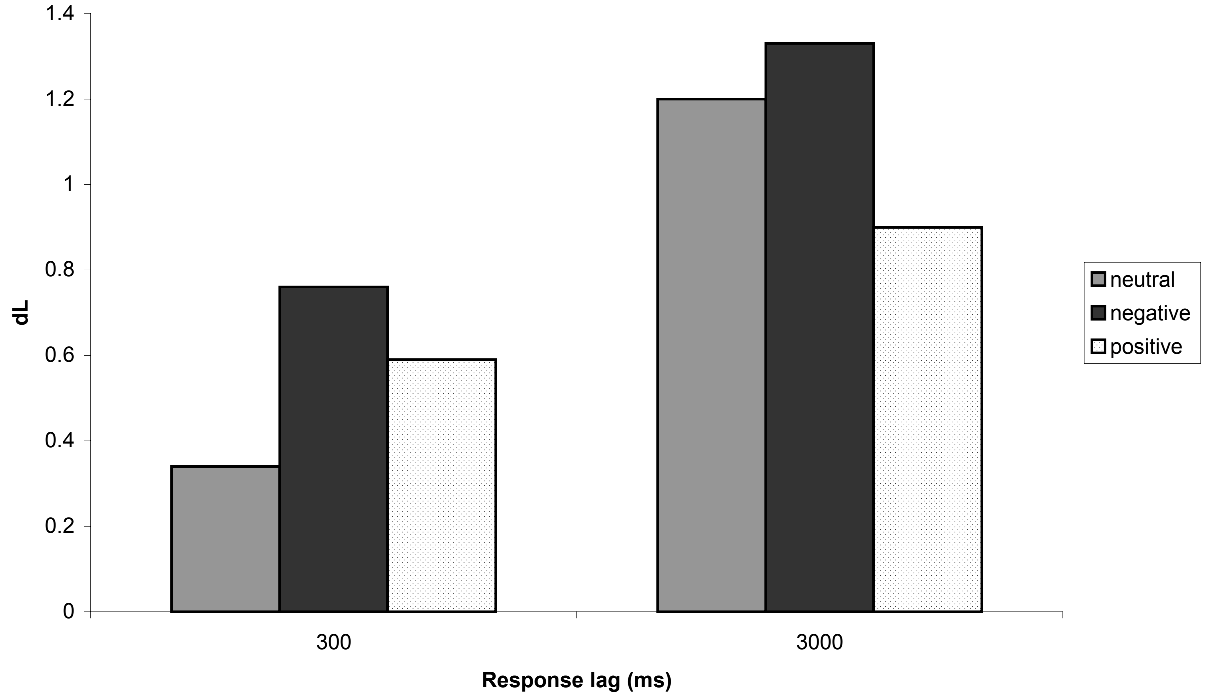

Figure 6: Discrimination as a function of emotion and response lag for Experiment 3.

APPENDIX A

Norming Study

The goal of this experiment was to replicate and extend the normative ratings of valence and arousal obtained by Bradley and Lang (ANEW: 1999) for words. From their word pool, 192 neutral and non-arousing, 96 negative and arousing, 96 positive and non-arousing, and 96 positive and arousing words were selected. In addition, 384 words that were hypothesized to be neutral and non-arousing were selected from Francis and Kucera (1982).

Participants

One hundred and seventy three students from the University of Pittsburgh participated in partial fulfillment of a course requirement.

Design

The experimental design was a 5 x 6 factorial with one within-subjects factor; hypothesized word type (neutral from B & L; neutral from F & K; positive low arousal; positive high arousal; and negative high arousal), and one between subjects factor; test form (1-6). There were 192 neutral words taken from Bradley and Lang (1999), 384 neutral words taken from Francis and Kucera (1982), 96 positive low arousal words, 96 positive high arousal words, and 96 negative high arousal words, all from Bradley and Lang (1999). Each rating booklet contained one sixth of each type of word. This resulted in 32 neutral words taken from Bradley and Lang (1999), 64 neutral words taken from Francis and Kucera (1982), 16 positive low arousal words, 16 positive high arousal words, and 16 negative high arousal words per rating booklet. Words were randomly selected for each booklet. The order of the words was randomized in each booklet, and two random orders were created for each booklet to control for order effects.

Stimuli

Stimuli were words hypothesized to differ in valence and arousal taken from Bradley and Lang (1999) and Francis and Kucera (1982).

Procedure

The procedure was identical to Bradley and Lang (1999) except for the exclusion of ratings of dominance for the words. Subjects received a booklet containing the words to be rated, a packet of rating sheets, and instructions for using the SAM rating scale (see below). Subjects rated valence and arousal for each word with the Self-Assessment Manikin (SAM) devised by Lang (1980). For the valence dimension, the scale ranges from a smiling happy figure (corresponding with the numeric value 9) to a frowning, unhappy figure (numeric value 1), and for the arousal dimension, the scale ranges from an excited, wide-eyed figure (corresponding with the numeric value 9) to a relaxed, sleepy figure (numeric value 1).

Instructions

The study being conducted today is investigating emotion, and concerns how people respond to different types of words. You will notice that you have a packet of words and a packet of rating scales (SAM scales). You will use the scales to rate how you felt while reading each word. The SAM scales show two different kinds of feelings: Happy vs. unhappy (the smiling vs. frowning figure), and excited vs. calm (the excited vs. calm looking figure). You will use both scales for each word that you read.

Please notice that each of the two feelings is displayed along a different scale. The left panel shows the happy-unhappy scale, which ranges from a smile to a frown. At one extreme of the scale, you are happy, pleased, satisfied, contented, and hopeful. When you feel completely happy, you should indicate this by bubbling in the figure at the left. The other end of the scale is for when you feel completely unhappy, annoyed, unsatisfied, melancholic, despaired, or bored. You can indicate feeling completely unhappy by bubbling in the figure at the right. The figures also allow you to describe intermediate feelings of pleasure or displeasure, by bubbling in any of the other pictures. If you feel completely neutral, neither happy nor sad, bubble in the figure in the middle. If your feeling of pleasure or displeasure falls between two of the pictures, then bubble in the space between the figures. This permits you to make more finely graded ratings of how you feel in reaction to each word. There are a total of nine possible points along each rating scale that you can bubble in to indicate the extent to which you felt unhappy or happy.

The excited vs. calm scale is the second type of feeling displayed here, and it is the second scale in each row (on the right). At one extreme of this scale you are stimulated, excited, frenzied, jittery, wide-awake, or aroused. When you feel completely aroused, bubble in the figure at the left of the scale. Now look at the other end of the excited-calm scale, which represents the completely opposite feeling. Here you would feel completely relaxed, calm, sluggish, dull, sleepy, or unaroused. Indicate feeling calm by bubbling in the figure at the right of the scale. As with the happy-unhappy scale, you can represent intermediate levels of excitedness or calmness by bubbling in any of the other figures. If you are not excited nor at all calm, bubble in the figure in the middle of the row. Again, if you wish to make a more finely tuned rating of how excited or calm you feel, bubble in the space between the pictures.

When you have made both ratings for each word, you will have filled in two bubbles per row.

Please work at a rapid pace and don’t spend too much time thinking about each word. Rather, make your ratings based on your first and immediate reaction as you read each word. When you are finished, please sit quietly and wait until the rest of the group is finished. Please ask the experimenter if you have any questions.

Results

Hypothesized word type: Negative high arousal

Word	Valence (mean)	Valence (stdev)	Arousal (mean)	Arousal (stdev)
herpes	1.54	1.57	6.25	2.74
humiliate	1.68	1.31	5.68	3.15
cunt	4.82	2.74	5.21	2.63
terrorist	1.21	0.79	6.54	3.12
death	1.25	0.84	5.21	3.53
stress	1.54	1.67	6.32	3.37
pain	1.57	1.20	6.50	3.43
slut	2.46	2.05	6.14	2.79
fear	2.25	2.03	6.11	2.99
guillotine	2.43	2.18	5.39	2.87
faggot	3.07	2.32	5.57	2.57
asshole	3.07	2.57	5.68	2.75
terror	1.54	1.69	6.39	3.27
bitch	2.68	2.29	5.86	2.94
suffer	1.50	0.96	6.64	3.06
panic	2.21	1.85	6.82	3.01
accident	1.78	1.34	6.31	1.99
incest	2.19	1.20	6.58	2.43
warfare	2.17	1.56	5.74	1.77
lie	2.10	1.56	5.87	2.11
mad	1.68	1.13	6.68	1.98
evil	2.14	2.09	6.35	2.72
bomb	1.81	1.07	7.19	2.08
anger	2.07	1.33	7.36	2.12
destroy	2.53	1.69	6.67	1.69
violent	2.48	1.44	6.81	2.01
afraid	2.37	1.67	6.57	1.94
danger	2.41	1.80	6.76	2.22
hate	1.62	1.14	6.22	2.41
terrible	1.87	1.02	6.19	2.26
tragedy	1.55	1.16	5.82	2.79
rejected	3.89	1.08	6.09	2.61
troubled	1.97	1.45	5.41	2.18
killer	1.69	1.11	6.52	2.49
hatred	1.31	0.71	6.17	2.55
disaster	1.76	1.27	6.48	2.15
guilty	1.86	1.03	5.66	2.00
cancer	1.52	1.09	5.76	2.87
devil	2.07	1.39	5.79	2.34
quarrel	3.07	1.51	6.07	2.17
tumor	1.86	1.33	5.62	2.60
victim	2.28	1.41	5.48	2.50
slave	2.31	1.95	5.55	2.41
punishment	2.17	1.71	5.28	2.46

suicide	1.31	0.71	5.93	2.70
scared	2.59	1.86	6.21	2.66
crash	1.97	1.52	6.21	2.64
divorce	2.45	1.74	5.45	2.38
wicked	2.63	2.20	7.13	1.61
slaughter	1.15	0.44	6.88	1.90
abuse	1.10	0.31	7.70	1.49
demon	2.18	1.87	6.42	1.87
murderer	1.08	0.27	7.57	2.01
nightmare	1.97	0.82	6.98	1.44
burn	2.20	1.55	7.35	1.69
horror	1.65	0.88	6.87	1.52
assault	1.36	0.61	6.43	3.23
rage	1.25	0.42	8.30	1.00
bloody	2.09	1.59	7.36	1.84
sin	2.60	2.35	6.10	3.17
poison	1.33	1.15	5.86	2.17
thief	2.50	1.30	5.67	2.08
agony	1.25	0.89	7.13	2.51
hostile	2.35	1.13	6.63	2.75
rude	2.39	1.14	6.56	1.08
ulcer	1.32	0.70	5.53	3.01
toxic	1.68	0.99	6.04	2.62
torture	1.32	0.70	6.57	3.14
vomit	1.83	1.57	6.60	2.46
jealousy	2.00	1.36	6.63	1.99
brutal	1.95	1.10	5.96	2.75
rape	1.20	0.61	7.11	3.22
betray	1.43	0.68	6.01	3.41
terrified	1.62	0.85	6.63	3.00
riot	2.05	1.31	6.17	2.27
ambulance	2.96	1.36	6.34	2.43
distressed	1.93	1.10	5.58	2.08
whore	2.32	1.87	6.23	1.83
surgery	2.85	1.90	6.00	2.64
despise	2.17	1.18	6.24	2.61
vandal	2.86	2.23	5.79	2.42
enraged	2.18	2.04	7.11	2.36
hostage	2.68	2.61	6.89	2.45
plague	2.50	2.39	5.82	2.67
disloyal	1.89	1.14	6.07	2.23
intruder	2.07	1.50	7.25	2.15
leprosy	1.82	1.45	5.75	2.27
tornado	2.96	2.44	7.43	1.64
crucify	2.89	2.37	6.89	1.80
roach	2.89	1.93	6.21	1.69
annoy	2.68	2.15	6.50	1.75
slap	2.21	1.89	7.41	1.58
mutilate	2.04	1.77	6.00	2.26
pervert	2.41	1.95	6.77	2.58

trauma	2.30	1.97	6.56	2.04
drown	1.44	0.93	6.52	2.46
AVERAGE	**2.07**	**1.45**	**6.34**	**2.39**

Hypothesized word type: Neutral (from Bradley & Lang, 1999)

Word	Valence (mean)	Valence (stdev)	Arousal (mean)	Arousal (stdev)
coarse	3.93	1.41	4.54	1.99
arm	5.39	1.20	4.50	1.37
cat	6.75	2.50	5.54	2.22
circle	5.18	0.82	4.18	1.87
bus	4.64	2.02	4.61	2.31
absurd	4.18	2.31	5.18	2.68
blase	4.64	1.25	4.57	1.89
bench	5.18	1.31	4.71	1.94
alien	4.29	2.37	6.18	2.60
bandage	3.68	1.59	4.39	2.22
clumsy	3.68	1.72	4.61	2.45
basket	5.07	0.81	4.14	1.82
cabinet	4.93	1.27	4.22	1.80
butter	6.07	1.49	4.78	1.63
activate	6.39	1.59	5.75	2.41
cellar	3.93	1.76	4.39	2.22
chin	5.11	1.23	3.68	1.85
boxer	5.86	1.24	5.04	2.15
branch	5.18	0.48	4.07	1.74
clock	5.39	1.20	4.86	2.43
appliance	5.29	1.08	4.00	1.91
ankle	5.25	1.55	3.79	1.79
bereavement	4.32	1.76	4.61	1.87
bathroom	6.18	1.49	4.39	2.15
aloof	4.78	1.63	4.50	1.99
alley	3.50	1.53	5.36	2.63
beast	3.11	1.95	5.68	2.70
cane	4.79	1.37	4.21	1.91
avenue	5.67	1.27	4.19	1.75
cannon	4.11	1.53	5.33	2.13
banner	5.56	1.15	4.26	2.05
bowl	5.68	1.28	3.36	1.93
custom	5.32	1.50	4.86	1.93
golfer	5.66	1.59	4.14	2.27
egg	5.23	1.57	4.33	1.69
fabric	5.37	0.89	4.57	1.54
curtains	4.69	1.24	4.47	2.02
habit	5.17	1.42	4.66	1.48
context	5.28	0.27	4.19	1.61
cork	5.45	1.47	5.08	1.91
contents	5.52	1.01	4.88	2.13
fork	5.14	1.28	4.01	2.16
corner	4.84	1.50	4.84	1.61
engine	4.76	1.09	4.83	1.58
foot	4.63	1.75	4.13	2.17
elevator	4.58	1.91	5.16	2.27
concentrate	5.49	1.34	4.75	1.85

coast	6.34	1.73	5.98	2.37
cow	5.39	1.59	4.27	1.59
frog	5.56	1.23	4.62	1.91
fur	5.38	1.93	4.76	2.29
finger	5.39	1.16	4.82	2.36
elbow	5.06	1.00	3.94	1.77
glass	5.27	0.87	4.57	1.83
detail	4.04	1.45	4.88	1.59
dentist	4.59	2.11	4.99	2.28
desk	4.94	1.09	3.89	1.64
errand	4.91	1.46	4.29	1.66
cord	5.30	1.09	4.02	2.01
farm	5.32	1.54	4.46	2.16
corridor	4.43	1.03	4.45	1.81
dirt	4.08	1.81	3.85	1.86
excuse	4.72	1.31	5.24	1.46
column	5.69	0.93	3.78	1.83
kick	4.59	2.11	6.28	1.67
hide	3.24	1.92	4.93	2.19
iron	5.07	0.96	4.62	1.90
icebox	5.10	1.26	4.00	1.81
jug	5.34	1.29	3.83	1.77
hat	6.03	1.64	4.14	1.90
invest	6.07	1.31	5.03	1.94
ketchup	6.14	1.83	4.54	1.75
jelly	6.14	1.92	4.14	1.81
kerosene	3.86	1.66	5.07	2.05
kerchief	5.25	1.29	4.36	1.73
inhabitant	5.03	0.57	4.17	1.85
insect	4.24	1.62	5.24	1.98
kettle	5.14	1.01	4.36	1.64
lamp	5.11	1.07	4.04	1.62
jacket	5.90	1.37	3.79	1.80
item	5.24	0.83	4.10	1.42
hay	5.10	1.68	3.69	1.98
knot	4.62	1.47	4.79	1.70
hawk	5.36	1.13	4.50	1.64
horse	6.00	1.51	4.90	1.97
hotel	6.83	1.73	5.72	2.43
humble	5.97	1.55	3.52	1.66
hammer	5.03	1.38	4.48	1.81
journal	5.55	1.12	4.17	1.67
indifferent	4.68	0.90	3.86	1.74
headlight	4.97	1.38	4.52	1.92
highway	5.36	1.66	4.57	1.99
hairpin	5.45	1.15	4.00	2.15
ink	5.07	0.46	4.31	1.75
lamb	6.10	1.52	3.86	1.68
key	5.66	1.11	4.00	1.41
pencil	5.10	0.79	4.57	0.95

machine	5.18	0.68	4.22	2.43
lantern	5.77	1.07	3.23	1.46
metal	5.43	1.14	3.79	0.71
odd	4.50	1.47	5.50	1.12
mushroom	4.99	2.17	4.18	2.34
neurotic	3.57	1.64	7.32	1.42
owl	6.48	0.85	4.35	1.65
patent	5.97	1.55	4.50	1.84
lawn	4.60	1.75	4.33	1.38
mystic	6.45	1.43	5.00	1.28
modest	5.77	0.92	3.13	2.11
nonchalant	5.98	1.79	2.70	1.81
patient	5.12	1.61	4.27	1.64
news	6.16	1.15	4.67	2.45
locker	5.77	1.07	3.78	1.88
pamphlet	5.05	0.63	4.79	2.18
nonsense	4.50	1.53	4.86	1.07
muddy	5.13	2.46	5.52	1.99
paint	6.27	1.52	5.32	2.45
obey	4.00	1.11	4.59	1.02
limber	6.14	1.09	5.49	1.45
manner	5.73	1.26	5.31	1.65
passage	5.89	1.48	4.17	1.37
nursery	7.05	1.70	3.79	2.44
museum	7.12	1.84	4.14	2.51
medicine	5.73	2.96	4.18	2.78
mischief	5.48	2.42	6.29	1.57
milk	6.81	2.40	3.76	2.29
lump	3.50	2.00	5.52	2.27
mantel	5.43	1.53	3.64	2.31
lighthouse	6.10	2.17	3.33	3.01
skeptical	3.68	1.48	4.87	2.10
sphere	5.32	0.66	4.13	1.94
shy	4.09	1.47	2.70	1.57
shadow	4.21	1.05	4.96	1.92
scissors	4.48	1.41	4.78	1.58
rattle	5.42	1.58	5.75	2.20
reverent	5.65	1.36	4.17	1.99
reserved	5.25	1.52	3.17	2.03
rain	4.67	2.17	3.62	1.96
radiator	5.15	0.78	5.02	1.91
salad	6.65	1.57	5.80	1.66
revolver	3.13	2.10	6.75	2.38
ship	5.58	1.53	5.57	2.42
salute	5.58	1.52	4.88	1.83
rough	4.50	1.77	5.59	1.49
pig	5.96	2.01	5.57	1.95
serious	4.63	0.88	4.33	2.12
rock	5.22	0.73	4.14	1.97
spray	4.82	0.92	4.30	2.04

poster	5.75	1.58	4.78	2.15
privacy	6.40	1.19	4.22	1.79
solemn	4.83	1.59	3.22	2.23
quart	5.38	1.03	4.40	2.29
sentiment	6.13	1.37	4.68	1.64
poetry	6.45	1.99	3.98	3.05
prairie	6.09	1.34	3.54	2.15
razor	4.55	0.99	5.46	1.20
runner	6.45	1.69	6.07	2.28
plant	5.76	1.74	4.90	1.88
phase	5.17	1.25	4.83	1.77
sheltered	4.90	1.69	3.69	1.77
seat	5.45	1.45	4.48	1.64
tease	4.67	2.54	5.56	1.95
stagnant	3.85	1.60	3.15	1.56
windmill	5.89	1.57	4.43	1.97
unit	5.18	1.45	3.68	1.93
watch	5.21	1.81	4.57	2.03
tower	4.93	1.99	5.00	2.28
statue	5.79	1.64	4.61	1.77
tank	4.54	2.22	5.50	2.08
yellow	6.50	1.94	5.14	2.21
stomach	4.89	1.74	4.43	2.15
violin	6.61	2.06	5.46	2.13
window	5.57	1.85	4.21	2.27
storm	4.32	2.98	6.64	2.23
writer	5.50	2.39	4.46	2.59
tool	4.96	1.63	4.07	2.04
trumpet	5.68	2.09	5.07	2.36
tamper	3.54	1.60	4.96	1.79
trunk	4.57	1.40	3.96	2.08
village	5.00	1.88	4.71	2.23
stiff	3.82	1.96	3.64	2.15
swamp	3.19	1.83	4.19	1.98
vanity	4.43	2.54	4.46	2.10
wine	6.61	2.04	5.71	2.84
wagon	5.44	1.82	4.33	1.96
teacher	5.68	2.24	5.14	1.76
stove	5.11	1.92	4.46	1.91
whistle	6.50	1.80	5.74	2.30
thermometer	4.59	2.00	4.56	1.87
stool	4.67	1.55	3.89	1.80
vest	4.93	1.72	4.07	2.09
umbrella	5.15	1.98	4.31	2.02
truck	5.56	1.78	5.22	1.87
AVERAGE	**5.19**	**1.51**	**4.57**	**1.94**

Hypothesized word type: Neutral (from Francis & Kucera, 1982)

Word	Valence (mean)	Valence (stdev)	Arousal (mean)	Arousal (stdev)
introduce	6.21	1.23	5.50	2.24
contact	6.44	1.28	5.44	2.21
cell	4.64	1.70	4.61	1.89
instrument	6.43	1.14	5.25	2.20
feature	6.14	1.51	5.43	2.18
cattle	5.39	1.87	4.36	1.87
railroad	5.39	0.79	5.04	1.79
speaker	5.04	1.93	4.79	2.27
angle	5.11	1.57	4.64	2.04
soil	3.86	1.58	4.30	1.98
vehicle	7.14	1.56	6.86	2.03
concept	5.68	1.54	4.82	2.02
wind	5.50	1.73	4.07	1.88
practice	5.54	2.38	5.64	2.66
economy	4.75	1.65	4.32	2.18
headquarters	5.21	1.32	4.79	1.79
estimate	5.00	0.88	4.07	1.71
session	4.68	1.59	4.50	2.43
chair	5.68	1.52	4.43	2.10
dust	2.93	1.54	3.61	2.17
sing	7.50	1.73	6.43	2.33
radio	7.61	1.97	6.50	2.47
valley	5.82	1.93	5.21	2.18
bar	6.43	2.03	6.07	2.68
management	5.29	1.51	5.21	2.06
majority	5.07	1.18	5.29	1.90
garden	6.68	2.13	5.07	2.57
bottle	5.89	1.71	5.04	2.57
league	5.71	1.24	4.86	2.09
instance	5.04	1.04	4.29	2.12
occasion	6.86	1.41	6.21	1.91
perform	6.64	2.02	6.82	2.23
automobile	6.86	1.88	6.64	1.52
dollar	7.61	1.50	6.43	2.43
green	6.00	1.44	4.79	2.57
signal	5.36	0.95	4.32	2.40
camp	6.00	1.96	5.46	1.97
facility	5.29	1.01	3.93	2.12
answer	6.25	1.58	4.79	2.33
owner	6.04	1.53	4.89	2.53
magazine	6.74	1.51	4.89	2.47
dress	6.79	2.08	5.82	2.55
inform	6.18	1.49	4.33	2.09
library	4.82	1.89	3.36	2.39
preserve	5.54	1.26	3.96	1.93
background	5.25	1.17	4.36	2.11
notice	5.25	1.80	5.04	2.38

bird	6.32	1.89	4.57	2.47
musical	6.82	2.36	5.54	2.46
soft	7.52	1.48	4.19	3.15
square	5.07	0.60	3.82	1.83
vision	6.61	1.37	4.37	2.22
candidate	5.39	0.83	4.29	1.98
brain	6.14	1.33	4.39	2.44
foam	5.89	1.55	4.54	2.47
derive	4.96	1.60	4.00	1.92
objective	5.29	1.51	4.21	2.27
contract	4.79	1.45	4.64	1.85
capacity	5.43	1.14	3.82	2.11
author	5.07	1.12	3.75	1.90
firm	5.11	1.59	4.46	1.97
guard	5.50	1.40	4.11	2.50
coffee	5.54	2.69	5.71	2.97
stone	5.00	1.47	3.75	2.34
pond	6.23	1.10	4.34	2.26
oxygen	5.32	1.19	5.15	1.71
code	5.40	1.32	4.78	1.41
corn	5.06	1.00	4.96	1.55
concrete	4.08	1.34	3.96	1.91
row	6.15	0.73	4.16	2.02
grass	5.58	1.16	5.07	1.92
abstract	5.12	1.12	4.10	1.96
melt	5.49	1.51	4.13	1.66
shoes	5.33	1.75	5.58	2.00
calculate	4.54	1.91	4.89	2.03
wire	5.44	1.36	4.86	1.81
grade	5.26	1.96	5.89	2.09
cotton	5.31	1.39	4.36	1.55
beard	4.93	2.23	4.86	2.15
basement	5.49	2.09	5.41	2.13
edition	5.19	1.04	4.11	1.96
charter	6.06	1.57	4.39	2.36
exhibit	6.27	1.52	4.95	2.19
enterprise	6.95	1.58	5.74	1.67
earn	5.95	1.20	6.32	2.18
minute	5.57	1.36	4.81	2.05
convention	6.04	1.16	4.55	2.03
bread	6.93	1.06	4.11	1.76
restaurant	5.86	1.26	5.99	2.10
fence	5.43	1.31	4.32	1.84
advise	5.96	1.67	5.11	1.77
ticket	6.34	2.17	6.01	2.32
qualify	5.94	1.54	6.09	1.96
comparison	5.16	0.93	4.23	1.65
explanation	6.16	1.42	5.77	1.69
sugar	5.89	1.80	5.96	2.12
legislation	5.77	1.29	4.01	1.73

gallery	5.69	1.42	5.38	2.23
compute	5.50	1.56	4.42	1.43
shade	6.64	1.58	5.04	1.62
appreciate	6.31	0.98	6.02	1.94
origin	5.73	1.49	4.74	1.87
persuade	5.36	1.64	5.30	1.82
velocity	5.16	1.40	5.16	2.33
pupil	5.08	0.89	4.27	1.64
display	4.81	1.14	4.36	1.92
core	4.74	0.59	3.72	1.80
transfer	5.32	1.53	4.84	1.87
sketch	5.73	1.51	4.62	1.85
solve	5.42	2.05	5.59	1.74
saline	4.99	1.09	4.14	1.84
colony	4.98	1.27	4.33	2.12
institute	5.16	1.50	5.01	1.66
barrel	5.09	1.02	4.24	1.79
distinction	5.08	0.86	4.41	1.68
commit	5.15	1.84	5.75	1.56
interview	5.05	1.25	5.89	2.04
string	6.27	0.97	4.06	1.85
lunch	6.28	1.25	5.50	1.92
profession	6.35	1.63	5.75	2.16
meat	5.33	1.95	4.96	2.19
tendency	5.79	1.28	4.04	1.72
sand	5.21	1.67	5.60	2.27
factory	5.79	1.21	3.94	1.99
piano	5.82	1.50	5.80	1.93
furniture	5.34	1.26	4.43	1.79
assemble	5.67	1.29	5.02	1.88
skin	6.82	1.43	4.70	1.60
bass	5.54	1.75	4.25	2.27
proprietor	5.00	1.19	4.11	1.79
foil	4.62	1.70	4.83	1.87
negotiate	5.45	2.08	5.10	1.74
refrigerator	5.24	1.18	4.17	2.04
clothing	7.41	1.76	5.97	2.20
profile	5.21	1.08	4.07	1.58
formulate	4.93	1.53	4.28	2.03
expert	7.36	1.64	5.52	1.99
banker	4.86	1.64	4.24	1.57
associate	5.14	1.25	4.34	1.70
carve	5.17	1.31	4.97	1.72
aunt	7.10	1.40	4.93	2.22
vacuum	4.55	1.59	3.59	1.62
saddle	5.52	2.01	4.52	2.08
magnitude	5.31	1.39	4.97	1.97
solar	5.93	1.33	5.10	1.99
logic	5.69	1.65	4.55	1.57
rent	3.38	1.97	4.86	1.98

saloon	6.18	1.49	5.54	1.95
hypothesis	4.48	1.72	4.07	1.81
arrow	4.45	1.45	4.79	1.86
symbolize	5.29	0.81	4.39	1.42
elephant	6.55	1.21	5.14	1.33
cabin	6.59	1.64	5.24	2.23
plead	3.10	1.70	5.03	2.13
circuit	4.93	0.96	4.00	1.89
coin	6.41	1.50	4.55	2.06
restore	6.24	1.21	4.79	1.40
illuminate	6.62	1.78	5.00	1.83
portrait	5.72	1.41	4.38	1.95
costume	6.59	1.27	5.86	1.77
scan	4.97	0.73	3.72	1.77
generate	5.55	1.02	4.31	1.58
sauce	6.00	1.31	4.64	1.79
pipe	5.07	1.93	4.52	2.25
lever	4.79	1.08	3.90	1.63
autumn	6.69	1.69	5.10	2.18
vessel	5.17	0.66	4.24	1.66
monk	4.97	1.30	2.48	1.64
potato	6.28	1.46	4.62	1.72
ambassador	5.24	1.24	4.17	1.85
diffusion	4.83	1.20	3.90	1.82
canvas	6.14	1.22	4.31	2.00
vegetable	6.00	1.79	4.31	1.54
fade	4.24	1.81	4.03	1.64
clarify	5.62	0.94	4.48	1.79
flag	6.34	1.65	4.83	2.05
café	5.70	1.71	4.19	1.52
link	5.10	0.49	4.03	1.74
episode	5.07	1.28	4.76	1.68
mathematics	4.07	2.00	4.31	2.22
hint	6.10	1.29	5.17	1.93
substitute	5.14	1.53	4.83	1.44
contemplate	4.93	1.10	4.62	1.54
revise	4.41	0.98	4.24	1.75
steam	4.83	1.56	5.17	2.32
permission	5.48	2.03	5.59	1.52
candy	8.00	1.25	5.83	2.30
graduate	8.00	1.67	7.00	2.20
criterion	4.52	1.33	4.28	1.91
replacement	3.86	1.60	4.86	1.88
doll	6.04	1.71	4.29	1.88
reverse	4.62	1.05	4.66	1.76
piston	5.13	1.31	6.67	1.98
thumb	5.82	1.50	2.77	1.21
limb	4.97	0.43	3.20	1.42
lime	7.38	1.61	4.27	2.34
bargain	5.98	1.29	7.64	1.63

hound	5.30	1.72	6.32	2.46
inn	6.03	1.59	4.05	2.51
instructor	4.78	2.16	5.39	2.10
recital	5.95	1.54	7.10	2.09
eagle	6.12	1.24	4.38	2.04
beverage	7.72	1.36	5.52	3.64
concord	5.42	1.12	4.18	1.87
refine	6.43	2.30	4.65	1.22
settler	4.85	1.46	4.63	2.17
apple	7.38	1.36	4.70	2.38
pension	6.23	1.55	4.05	2.34
cigar	5.41	2.88	4.60	1.67
fox	5.48	1.34	6.07	2.68
gymnastics	6.67	2.61	5.66	3.50
molecule	4.63	1.36	4.26	1.76
cheer	8.17	1.27	7.53	1.75
ensemble	6.50	0.94	4.57	2.97
applaud	7.65	1.90	6.97	2.42
microscope	4.17	1.48	3.72	0.63
idiom	5.10	0.56	4.25	1.31
clap	7.30	1.80	6.67	2.15
mouse	4.13	1.47	5.95	1.72
lease	5.83	1.39	4.85	1.00
align	5.65	1.11	3.67	2.18
chant	6.85	2.13	5.55	3.58
plank	4.12	1.48	5.17	2.40
nephew	7.20	1.25	6.04	2.05
avocado	5.62	1.86	3.93	2.19
semester	5.15	1.08	5.57	1.46
array	4.87	1.62	4.38	1.66
reminder	5.95	1.66	4.14	1.79
rod	5.22	0.83	4.18	1.64
prompt	6.05	1.61	4.83	1.91
poll	5.49	1.98	3.90	2.19
residue	3.60	2.39	4.41	1.76
glaze	6.22	1.53	4.90	2.58
pepper	5.85	1.44	5.23	2.02
evidence	6.04	1.24	5.71	1.88
moisture	5.88	1.36	4.60	0.98
vapor	5.80	1.62	4.13	1.32
toast	6.73	0.91	5.05	3.35
harness	4.21	2.01	4.96	1.51
tablespoon	5.54	1.21	4.16	1.60
oven	5.96	1.22	4.84	2.39
decorate	6.73	0.90	6.02	1.98
outline	5.50	1.57	4.29	1.47
compact	5.61	1.70	4.64	2.47
forge	4.23	1.80	5.50	1.69
garment	5.21	1.53	4.45	1.69
edit	4.10	1.12	5.44	1.71

attendant	5.55	1.02	3.71	1.25
slipper	6.30	1.58	4.37	2.51
endorse	5.31	2.13	3.86	2.33
rattle	4.71	1.91	4.33	2.18
reflex	5.31	1.77	3.98	2.31
bow	5.48	1.77	3.88	2.21
wheat	5.26	1.57	3.45	1.81
boulder	4.71	1.25	5.00	1.58
hierarchy	4.00	1.76	4.02	2.22
abbey	5.13	0.46	4.68	0.77
amplifier	6.10	1.29	6.43	1.81
lecturer	3.95	1.41	3.98	2.03
sandal	5.90	1.79	5.43	2.34
delegate	4.73	1.23	5.04	2.28
keg	7.14	2.07	6.81	2.34
dweller	4.23	1.58	4.56	2.03
carrot	5.76	2.00	4.60	2.18
aisle	5.24	0.60	3.59	2.09
animate	6.68	1.67	6.57	1.62
leaflet	4.80	0.91	3.75	1.68
orient	5.36	1.01	5.14	1.10
lemonade	7.50	1.59	5.58	2.32
butcher	3.38	1.79	4.68	2.67
mast	4.88	0.39	4.60	0.94
bronze	5.55	1.32	4.98	1.35
flask	6.33	1.76	5.70	1.65
feudal	2.98	1.50	6.00	1.81
update	5.32	0.90	5.47	2.51
peach	7.15	1.65	5.65	2.08
thicket	4.65	0.99	5.30	1.14
binder	4.72	1.25	4.00	1.85
multiplication	4.80	1.00	4.55	1.49
omelet	6.77	1.57	5.28	1.48
tabulate	4.73	1.13	4.28	1.72
centennial	6.47	1.86	5.70	2.64
axle	4.62	0.99	4.80	1.08
falcon	5.58	1.34	5.17	2.20
buffet	7.05	1.41	6.00	1.68
yacht	7.23	2.00	5.97	2.57
nectar	5.93	1.19	4.49	1.11
vacate	3.47	1.79	5.18	2.61
abdomen	5.12	0.62	4.87	1.65
mammal	6.32	1.77	5.28	1.97
intellect	7.09	1.01	6.36	2.01
gravity	5.65	1.70	5.17	1.82
dip	5.03	1.66	5.00	1.95
mule	4.68	0.67	3.75	1.78
alligator	4.30	1.42	6.22	1.36
esteem	6.75	1.05	5.23	1.89
patrol	5.12	1.17	5.48	1.71

caravan	5.43	1.01	4.15	1.95
retailer	5.63	1.44	5.03	2.16
disclosure	4.10	1.50	5.00	1.36
attribute	6.33	1.27	5.13	1.87
procession	4.72	1.62	4.17	2.04
extract	4.62	1.25	4.79	0.86
inaugurate	5.23	1.22	5.07	1.40
pedal	5.42	0.69	4.60	2.07
franchise	5.55	1.15	5.08	1.74
moss	4.93	0.95	3.29	1.93
tripod	5.32	1.04	3.91	1.89
rendezvous	5.72	1.67	6.31	2.38
articulate	5.62	1.62	5.24	1.63
arithmetic	4.28	2.20	4.14	2.02
bacteria	3.00	1.63	5.55	2.53
nutmeg	5.66	1.36	4.48	2.37
vocation	5.21	1.37	4.31	2.18
aggregate	4.52	1.17	4.31	1.85
premise	5.31	0.86	4.14	1.65
initiate	5.93	1.50	5.62	2.25
metropolis	5.83	1.33	5.41	2.16
clam	5.55	2.03	4.07	2.33
varnish	4.83	1.47	3.90	1.84
skillet	5.04	1.88	3.82	2.65
pudding	6.18	2.15	5.14	2.07
fiord	4.44	1.54	4.41	1.82
heredity	5.71	1.45	4.29	1.65
caterpillar	5.68	2.36	5.14	2.27
quadruple	5.00	1.65	4.46	2.25
enunciate	4.82	1.63	4.32	1.83
spinach	4.89	2.58	4.33	2.27
hangar	5.00	1.59	4.30	1.84
invoice	4.61	2.06	4.39	2.04
trellis	5.52	1.94	5.44	2.15
emporium	5.50	2.14	4.75	2.37
induct	6.04	1.86	5.68	2.28
preview	5.64	2.52	5.86	2.22
labyrinth	4.78	2.16	5.59	2.19
whale	5.79	1.75	5.39	2.23
paraphrase	4.82	1.62	3.71	1.86
acrobat	6.43	1.39	6.21	1.99
verbalize	5.57	1.91	4.39	2.15
harp	6.36	2.21	4.50	2.78
eraser	4.82	1.81	3.39	2.04
strawberry	7.50	2.00	6.21	2.51
baron	4.57	2.08	3.82	2.06
bungalow	5.93	1.56	4.39	2.20
unravel	4.39	1.89	4.39	2.17
reptile	5.04	2.08	5.50	2.27
mosquito	2.96	1.59	5.18	2.33

asphalt	4.79	2.01	4.00	2.40
camouflage	5.07	2.07	5.29	2.16
adage	4.93	1.81	4.37	1.69
tailor	4.32	1.74	3.82	2.20
pouch	5.57	1.80	3.96	2.50
romanticize	7.11	2.54	6.96	2.52
gingham	4.74	1.97	3.96	2.10
cuisine	6.75	2.13	6.18	1.83
parrot	5.75	2.11	5.21	2.33
gist	5.29	1.86	4.57	2.23
whittle	5.07	1.85	3.30	2.27
traction	4.79	2.13	4.54	2.47
slush	4.56	2.06	4.48	2.26
cobblestone	5.11	2.13	4.07	2.13
protract	4.50	1.28	4.07	1.92
fig	4.89	2.06	3.56	1.95
admiral	5.58	2.06	5.31	2.43
digest	4.93	1.79	4.00	2.07
interact	6.04	1.83	5.86	1.90
macaroni	6.36	2.08	5.07	2.40
accordion	5.43	1.59	4.00	2.05
allegory	5.25	2.04	4.93	1.76
lobster	5.36	2.64	5.32	2.58
bagpipe	5.33	3.04	4.46	3.00
juggler	6.00	1.84	5.57	2.06
honeycomb	5.93	2.09	5.00	2.17
vaccination	3.78	2.04	5.85	2.18
geese	5.00	1.64	4.92	1.83
incremental	4.70	1.26	4.35	1.74
eject	4.59	2.01	5.07	1.96
modulate	4.77	1.42	4.04	1.80
tweezers	4.48	1.88	4.56	1.74
valet	6.41	1.78	5.63	2.08
sewn	5.00	1.66	4.44	2.12
armadillo	4.93	1.57	4.52	1.70
beaver	4.93	1.72	4.59	1.97
goblet	5.62	1.79	4.81	2.00
AVERAGE	**5.52**	**1.52**	**4.83**	**2.00**

Hypothesized word type: Positive high arousal

Word	Valence (mean)	Valence (stdev)	Arousal (mean)	Arousal (stdev)
brave	7.81	1.49	6.56	2.68
champ	8.32	1.31	7.57	2.28
champion	8.37	1.24	7.37	2.40
admired	8.32	1.47	7.32	1.85
circus	8.04	1.17	7.18	1.66
applause	7.82	1.36	7.57	1.91
cheer	7.57	2.18	7.75	1.99
adventure	7.89	1.73	8.07	1.39
couple	7.74	1.89	7.22	2.33
cash	8.29	1.61	7.57	1.89
affection	8.29	1.67	6.86	2.35
birthday	8.21	1.52	8.07	1.72
confident	8.07	1.46	6.32	2.92
aroused	7.75	1.27	7.54	1.86
comedy	8.26	1.32	6.96	2.47
christmas	8.57	1.55	8.54	1.00
sunlight	8.12	1.12	6.84	1.81
win	8.21	1.33	7.80	1.78
treasure	7.38	1.20	7.08	1.84
talent	8.01	1.52	6.76	1.90
thrill	7.98	1.41	7.84	2.07
wedding	8.13	1.55	7.48	1.78
triumph	7.92	1.22	7.03	2.26
terrific	8.38	1.08	7.48	1.73
triumphant	7.83	1.27	7.24	1.98
wealthy	7.84	1.65	6.29	2.29
victory	8.08	0.94	7.60	1.66
success	7.65	1.06	7.44	1.72
valentine	6.84	2.50	6.28	1.94
surprised	7.62	1.62	7.39	1.73
thoughtful	7.51	1.19	6.42	1.97
travel	7.57	1.48	6.83	2.39
romantic	8.14	1.38	7.57	1.53
promotion	8.34	1.14	7.45	1.88
pleasure	8.17	1.31	6.38	2.43
snowflake	7.97	1.38	5.97	2.49
pretty	7.83	1.58	5.83	2.36
riches	7.50	1.73	6.21	2.53
star	7.66	1.32	5.55	2.35
silly	8.07	1.28	6.69	2.07
sexy	7.79	1.52	7.24	1.88
sex	8.21	1.37	8.00	1.56
prestige	7.03	1.40	5.17	2.21
rescue	7.07	1.41	6.45	2.15
profit	7.10	1.32	6.10	1.93
savior	7.45	1.50	5.62	2.37
puppy	8.14	1.19	6.24	2.32

rollercoaster	8.29	1.15	7.86	1.88
leader	5.82	1.85	6.73	2.17
laughter	8.87	0.57	6.80	3.06
passion	7.23	1.24	7.62	2.13
merry	8.50	0.78	6.38	3.00
outdoors	7.13	2.38	5.05	1.77
lucky	7.93	1.58	5.83	2.52
lust	6.97	1.45	7.72	1.79
perfection	6.85	2.99	5.60	2.81
outstanding	8.84	0.45	6.66	3.20
kiss	8.71	0.80	7.54	2.09
millionaire	7.65	2.29	7.08	2.81
memories	7.89	1.85	6.36	2.98
loved	8.65	0.78	5.90	2.77
miracle	7.81	0.97	5.81	2.75
magical	6.76	2.44	6.07	1.82
orgasm	8.55	1.37	8.33	2.25
joyful	8.68	0.62	6.83	2.31
imagine	7.73	1.40	5.61	2.15
hopeful	8.03	1.36	7.34	1.62
handsome	8.01	1.08	7.32	2.17
graduate	8.27	1.26	8.02	1.09
heart	8.02	1.26	6.93	2.54
glory	8.23	0.97	7.15	2.30
happy	8.78	0.49	7.32	1.82
gift	8.40	1.11	7.78	1.88
intercourse	8.55	1.72	7.48	1.65
intimate	6.62	1.45	6.28	2.44
joke	6.45	1.08	6.07	1.40
inspired	7.86	1.81	6.59	1.53
holiday	5.62	1.72	5.24	1.39
joy	5.76	1.04	4.90	2.20
incentive	7.31	1.47	7.54	1.87
excitement	8.29	1.06	7.32	2.13
fame	7.43	1.62	6.89	2.10
dazzle	7.86	1.31	6.89	2.20
erotic	7.25	2.37	7.64	1.75
elated	7.56	1.91	6.67	2.62
engaged	7.75	1.68	7.07	2.63
fascinate	7.79	1.46	7.14	1.74
festive	8.11	1.30	7.54	1.43
exercise	7.64	1.49	7.07	2.00
flirt	7.54	1.54	7.32	2.34
desire	7.07	1.89	7.11	1.99
fireworks	7.96	1.27	7.21	2.36
diamond	7.79	1.19	7.32	1.89
ecstasy	7.22	2.59	7.42	2.10
fun	8.52	1.14	8.52	1.05
dollar	8.04	1.29	6.73	2.05
AVERAGE	**7.81**	**1.43**	**6.94**	**2.08**

Hypothesized word type: Positive low arousal

Word	Valence (mean)	Valence (stdev)	Arousal (mean)	Arousal (stdev)
delight	8.79	0.57	5.18	2.50
elegant	8.71	0.60	5.93	2.32
earthy	6.00	1.66	4.50	1.84
cuddle	8.57	1.10	5.71	2.89
dinner	8.46	1.04	4.36	2.33
caress	8.14	1.58	5.96	2.85
dignified	7.75	1.40	5.71	2.34
familial	7.15	1.92	5.74	2.46
capable	7.63	1.64	5.00	2.53
devoted	8.04	1.50	6.07	2.79
carefree	7.61	2.11	6.11	2.66
enjoyment	8.43	1.17	5.50	2.20
colorful	8.07	1.44	5.43	2.63
easygoing	7.57	1.20	3.96	3.00
cozy	8.18	1.09	4.43	3.18
comfort	8.04	1.50	4.68	3.29
grin	7.30	1.37	5.63	1.71
impressed	7.47	1.26	5.33	1.66
friendly	8.11	1.09	4.90	1.96
fantasy	7.34	1.40	5.53	1.74
learn	7.06	1.58	5.93	1.90
grateful	7.84	1.22	4.38	1.73
kindness	7.74	1.29	6.33	2.13
greet	6.68	1.30	6.01	2.05
justice	7.11	1.86	5.28	2.19
hug	7.87	1.03	4.12	2.06
jewel	7.04	1.37	6.22	2.17
gentle	7.53	1.37	5.48	2.54
honest	7.65	1.45	5.94	2.44
humor	7.21	0.94	5.18	1.82
household	6.73	1.87	5.63	2.15
heal	6.44	1.32	5.67	1.83
rainbow	7.97	1.27	5.28	2.19
pillow	7.41	1.38	3.79	2.28
politeness	7.66	1.32	4.55	2.05
palace	7.93	1.39	5.24	1.98
luxury	7.69	1.51	6.00	2.55
masterful	6.31	1.71	4.86	1.90
peaceful	8.03	1.05	3.62	2.90
luscious	7.24	1.50	5.62	1.99
paradise	8.17	1.31	6.31	2.70
ocean	8.03	1.35	5.00	2.89
loyal	7.17	1.26	4.72	2.10
musical	6.97	1.50	5.31	2.47
protected	7.69	1.23	4.52	2.44
refreshment	7.17	1.47	5.14	1.87
relaxed	7.55	1.40	2.21	1.66

melody	7.21	1.29	4.83	2.38
soothe	7.30	0.68	1.70	1.01
reward	8.56	0.74	5.35	2.28
secure	8.35	1.02	3.92	2.96
satisfied	7.93	1.04	4.20	2.87
snuggle	8.75	0.50	2.83	1.71
sailboat	6.32	1.71	4.25	1.98
respectful	6.55	1.06	4.70	2.62
sunrise	7.85	0.33	5.05	3.73
sunset	7.87	0.35	3.72	2.40
safe	8.38	1.00	3.69	2.25
spouse	7.55	2.01	5.88	2.04
sky	8.00	1.41	4.55	2.19
sapphire	6.76	1.30	4.60	1.75
soft	7.07	1.03	2.67	2.02
sleep	8.79	0.81	1.76	2.91
scholar	6.79	2.13	4.29	2.18
wise	7.86	1.36	5.97	2.42
sweetheart	4.28	1.19	4.14	2.45
wish	3.00	0.98	5.55	2.03
vanilla	5.66	1.33	4.48	1.51
waterfall	5.21	1.17	4.31	2.90
twilight	5.17	1.70	4.83	2.80
untroubled	4.52	1.37	4.31	3.31
toy	2.17	1.22	4.24	2.27
wit	4.90	1.34	3.69	1.86
candy	5.31	1.23	4.14	1.83
cocoa	5.93	1.54	5.62	1.70
useful	5.83	0.88	5.41	1.82
cookie	7.03	1.23	6.25	2.14
trophy	5.45	1.59	4.48	1.94
warmth	5.55	1.55	4.07	2.60
aroma	4.83	1.48	3.90	1.96
acceptance	7.61	1.82	5.70	2.46
bless	7.44	2.02	5.81	2.25
butterfly	7.07	2.30	5.57	2.54
beauty	7.93	1.68	5.93	2.37
alive	8.57	0.72	5.11	2.38
bird	5.71	1.95	5.32	1.83
angel	7.57	1.98	5.43	2.54
cake	7.57	2.04	5.68	2.16
bunny	7.14	2.07	5.57	2.25
bright	7.39	1.87	5.25	2.40
bouquet	7.18	1.92	5.50	2.40
adorable	7.86	1.40	4.61	2.25
bath	7.75	1.36	5.36	2.70
brother	6.82	2.20	5.63	2.17
agreement	6.33	2.16	5.30	1.73
blossom	7.41	1.58	5.15	2.46
AVERAGE	**7.16**	**1.38**	**4.94**	**2.29**

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