THESIS

THE ROLE OF EMOTION IN RECOGNITION WITH VERSUS WITHOUT CUED-RECALL

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY ANTHONY J. RYALS ENTITLED THE ROLE OF EMOTION IN RECOGNITION WITH VERSUS WITHOUT CUED RECALL BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

THE ROLE OF EMOTION IN RECOGNITION WITH VERSUS WITHOUT CUED-RECALL

In the present study, we sought to examine the effects of emotion on the processes that subserve recognition memory. Specifically, we explored how two primary dimensions of emotion (negative valence and high arousal) separately impact the two processes of recognition memory (recollection and familiarity). To separately examine recollection and familiarity, the recognition without cued-recall method was used to separate out judgments of recognition that are accompanied vs. unaccompanied by cued-recall. Data from three experiments suggest that both negative valence and high arousal increase both cued-recall performance itself and recognition accompanied by cued recall, without affecting the ability to recognize in the absence of cued-recall. Additionally, two emotional biases were found. The first bias, found in a within-subjects manipulation, involves an increase in recognition ratings for cues corresponding to unrecalled negative items relative to cues corresponding to unrecalled neutral items. The second bias was an increase in recognition ratings for cues corresponding to negative and arousing nonstudied items that were identified relative to cues corresponding to neutral nonstudied items that were identified.

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DEDICATION

I dedicate this thesis to my grandparents Daniel J. Dueppen and Joan M. Dueppen. Thank you for believing in me and supporting me throughout the years. I could not have done it without you.

TABLE OF CONTENTS

The Role of Emotion in Recognition with versus without Cued-recall

Chapter I

Introduction

Research investigating emotion in memory has resulted in an extensive body of literature spanning the last several decades. This research has increased understanding of emotion in eyewitness memory (Christianson & Loftus, 1987; Park, 2005), flashbulb memories (e.g. Brown & Kulik, 1977; Conway et al., 2004), and memory for traumatic events (Depue, Curran, & Banich, 2007; Marx, Marshall, & Castro, 2008). Despite this large body of research, little is known about how emotion may influence the ability to recognize something as familiar, as opposed to the ability to actually recollect (or recall) a prior experience. Although some findings suggest that the emotionality of a stimulus may enhance recall for an event (e.g. Heuer & Reisberg, 1990; Bradley, Greenwald, Petry, & Lang, 1992; Cahill & McGaugh, 1998), much less is known about how emotion impacts familiarity-based recognition of an event or situation. The current study explores how two specific dimensions of emotion, negative valence and high-arousal, affect the separate recollection and familiarity processes within recognition memory.

Chapter II

Dual Processes: Familiarity and Recollection

Recognition memory involves the ability to realize that something has occurred previously. According to dual process theories (see Yonelinas, 2002; Mandler, 2008 for reviews), recognition is comprised of two components; recollection and familiarity. Recollection-based recognition involves actually bringing to mind or recalling a prior experience, and is thought to involve a binding of contextual information to item information in order to create a coherent episode over time. An example of recollection-based recognition might be encountering a man at the grocery store and remembering his name and that he was at a work function two weeks ago. In comparison, familiarity-based recognition involves a feeling of having experienced something before devoid of contextual details; the person merely has the sense of prior experience. An example of familiarity-based recognition might be encountering a man at the grocery store and upon passing him, experiencing a striking feeling of having seen him before. This striking feeling occurs in the absence of an ability to recollect the man's name or the details about where or when he was seen before.

At least four experimental paradigms have traditionally been used in an attempt to tease recollection and familiarity apart in studies of recognition memory. One of the most frequently used methods is the Remember/Know (R/K) procedure (Tulving, 1985). In a typical R/K procedure, participants first study a series of items (e.g., words, pictures).

They then receive a test phase in which both studied and unstudied items are presented. For each item presented, participants must judge whether it is studied or unstudied. For "studied" responses, participants are asked to indicate whether they "remember" or simply "know" that the item was studied. Participants are instructed to provide a "remember" response when they can recall that an item was seen before within the context of the experiment. Participants are instructed to provide a "know" response when they merely feel they have experienced an item earlier in the experiment but they cannot recollect its prior occurrence. "Remember" responses are often interpreted as an index of recollection-based recognition, and "know" responses are often interpreted as an index of familiarity-based recognition.

Some support for dual process theory has come from functional dissociations found using the R/K procedure. A functional dissociation occurs when one experimental manipulation affects two measures of memory differently. One such dissociation involves the level-of-processing effect, whereby deeper semantic processing facilitates recall relative to shallow perceptual processing (Craik & Lockhart, 1972). Using the R/K procedure, Rajaram (1993) manipulated levels of processing by having participants produce words associated with study items at a deep (semantic) or a shallow (rhyming) level. Rajaram found that "remember" responses increased for deep relative to shallow encoding. In contrast, "know" responses increased for shallow relative to deep encoding. In a subsequent finding, Rajaram presented participants with either pictures or words at study. "Remember" responses increased for pictures whereas "know" responses increased for words. Rajaram also found that perceptual priming (rapidly flashing a masked study item) prior to test presentation increased "know" but not "remember" responses (but see

Higham & Vokey, 2004).

In another study, Gardiner and Parkin (1990) found that dividing attention through performing an additional task at study reduced “remember” but not “know” responses. The fact that many manipulations have been shown to affect “remember” and “know” judgments differently has often been viewed as evidence for the existence of two separate processes, recollection and familiarity, in recognition memory (see Yonelinas, 2002, for a review). This is in contrast to single-process strength based models (e.g. Wixted & Stretch, 2004).

Methods other than the R/K paradigm exist for separating familiarity from recollection. Examples include the process dissociation procedure (Jacoby, 1991), the signal-lag procedure (Hintzman & Curran, 1994) and the use of receiver operated characteristics or ROCs (Yonelinas, 1994), though each method has its own set of controversial issues (see Yonelinas, 2002; but see Wixted & Stretch, 2004).

Other evidence for dual process theory comes from neurological dissociations. For example, hippocampal damage has long been shown to disrupt memory by producing anterograde amnesia. Anterograde amnesics can no longer bind context to experience, thus they cannot form explicit memories for new episodes (Scoville & Milner, 1957; Milner, 2005). Research has shown that when damage is limited to the hippocampus but spares the perirhinal cortex, recollection is impaired but familiarity-based discrimination may be preserved (Aggleton et al., 2005). Furthermore, benzodiazepines disrupt recollection, resulting in a very similar yet temporary form of anterograde amnesia that appears to leave familiarity spared (e.g. Reder et al., 2006). This specific pattern of disruption likely also involves impairment of contextual binding via the hippocampus.

Conversely, damage to perirhinal cortex in the absence of hippocampal damage has been shown to impair familiarity while leaving recollection intact (Bowles et al., 2007). Specifically, after surgical lesioning of the perirhinal cortex, a patient showed disruption of familiarity-based but not recollection-based performance. These differences manifested across four experiments using several different paradigms to separate the two processes; the R/K procedure, ROCs, and a signal-lag procedure.

Some additional neurological support for dual process theory has come from electrophysiological (event-related potential and magnetoencephalography) studies, which suggest that differences in temporal processing may separate recollection from familiarity. Correlates of familiarity-based recognition appear rapidly (as early as 150-200 ms), whereas correlates of recollection appear at later latencies (500-700 ms or later) after stimulus presentation (e.g. Rugg & Curran, 2007; Gonsalves et al., 2005).

Neuroimaging has provided further support for dual-process theory. Whereas electrophysiology is a useful tool for measuring time-based differences in recognition memory, functional imaging (fMRI) is a useful tool for measuring neural source differences in recognition memory processes. Though somewhat controversial, some fMRI research has supported the idea that familiarity may primarily involve the perirhinal cortex whereas recollection may involve the hippocampus itself (e.g. Diana, Yonelinas, Raganath, 2007). Functional imaging and electrophysiological data combined have provided neural evidence for the two different processes of recollection and familiarity in recognition.

Taken together, functional dissociations found using behavioral tasks such as the R/K paradigm, neurological dissociations found with various types of neurological impairment, electrophysiological differences, and finally, fMRI differences all converge on the idea that at least two different processes contribute to recognition memory: familiarity and recollection. Given the growing empirical support for these two processes in recognition memory, an important consideration is the fact that different dimensions of emotion may affect these two processes of recognition differently.

Chapter III

Two Dimensions of Emotion: Valence and Arousal

Emotion plays a large role in our everyday experiences. The study of emotion involves accounting for the fact that the quality of stimuli can differ on two primary emotional dimensions: valence and arousal (Lang, Bradley, & Cuthbert, 1990). Valence is the degree to which a stimulus is positive or negative in nature, and arousal is the degree to which a stimulus is exciting or calming. For example, a highly arousing negative event might involve having to swerve to avoid a high-speed collision on a crowded freeway. In comparison a low-arousing negative event might be learning that a distant acquaintance is ill. On the other end of the emotional spectrum, winning the lottery jackpot would be an example of a highly arousing positive event, whereas watching the sun set while sitting on the front porch would be low in arousal yet still positive. One of the challenges of emotion research is separating valence from arousal. Although it is theoretically possible for an event to vary on one dimension and not the other, valence and arousal often vary simultaneously (see Dolan, 2002 for a review).

In order to understand the role of emotion in memory, it is important to consider how valence and arousal differ. Cognitive neuroscience data suggest that valence and arousal may involve two separate pathways of distributed network activity in the brain (LaBar & Cabeza, 2006). While valence has been shown to involve cognitive appraisal through prefrontal activity coupled with the hippocampus and surrounding cortices, arousal has been shown to activate a pathway involving the amygdalae coupled with the hippocampus and extrahippocampal cortices (Kensinger & Corkin, 2004; Phelps, 2004). Prefrontal cortices are involved in higher cognitive or executive processes (Fernandez-Duque, Baird, & Posner, 2000) whereas the amygdalae are deep limbic structures responsible for regulation of autonomic arousal (Critchley, Corfield, Chandler, Mathias, & Dolan, 2000). Despite an understanding of how emotion can occur on two dimensions, little is known about how these two dimensions affect recognition memory, particularly the separate processes of familiarity and recollection.

Chapter IV

Valence and Arousal in Recollection vs. Familiarity

Relatively few studies have explored the effects of valence and arousal in recognition memory. Some evidence suggests that these emotional dimensions may impact familiarity and recollection differently. Sharot, Verfeille, & Yonelinas (2007) used the R/K procedure to compare aversive (negatively valenced, highly arousing) and neutral images in amnesics and healthy controls. Their results indicated that emotion increased "remember" responses but not "know" responses in controls. Recognition confidence ratings (1= sure not studied; 6 = sure studied) mirrored this pattern, with the highest confidence ratings (6) corresponding to the increase in "remember" judgments. In amnesic participants, for whom recollection is impaired, aversive images elicited an enhancement in "know" responses. This finding suggests that when recollection is unavailable (as in amnesia), emotion may facilitate familiarity-based recognition. Although Sharot, Verfeille, & Yonelinas (2007) did not separate valence and arousal in their aversive stimuli, the dissociation found in amnesics versus controls offers evidence that emotion in general may affect familiarity and recollection differently.

Several studies suggest that emotion in general may affect recollection but not familiarity. Using the R/K procedure, Ochsner (2000) found that both negatively valenced and highly arousing images elicited a higher number of "remember" responses than neutral items, but this pattern was not found for "know" responses. After mathematically transforming R/K data to reflect recollection and familiarity estimates (see Yonelinas et al., 1998), a similar pattern emerged, such that both negatively valenced and highly arousing items enhanced recollection but not familiarity.

Results from the aging literature also suggest that emotion may enhance recollection. In older adults, healthy aging leads to impaired recollection over time despite familiarity-based recognition remaining intact (Old & Naveh-Benjamin, 2008). That is, despite being able to feel that something has been experienced before, older adults may experience difficulties remembering contextual details about these experiences. Kensinger, Garoff-Eaton, & Schacter (2007) demonstrated that older adults are able to show enhanced recollection of negatively valenced items as compared to neutral items. This may reflect the fact that emotional processing is relatively preserved in healthy aging (Kensinger, 2008; 2009). Several other studies support this notion of preserved emotional processing and suggest that age-related deficits in recollection may be counteracted by emotionality (e.g. Davidson & Glisky, 2002; Kensinger, Krendl & Corkin 2006b).

Much of the evidence thus far has indicated that valence (particularly negative valence) can impact recollection. Less is known about how emotion is involved in familiarity-based recognition, but there is some evidence suggesting that high stimulus arousal may impact familiarity. Kensinger & Corkin (2004) describe activation of two different network pathways in relation to valence and arousal during encoding. The authors posit that while valence demands deliberate and controlled processing through prefrontal cortex activation, processing of arousal occurs automatically through autonomic activation involving the amygdala. Kensinger and Corkin (2004) found that this interaction between hippocampus and amygdala at encoding correlated highly with similar network activation at retrieval and provided a benefit in memory for arousing versus neutral items. Within recognition, several studies in particular suggest that rapid autonomic arousal may be associated with familiarity.

Using the R/K procedure, Kensinger & Corkin (2003) found that aversive words elicited an increase in "remember" responses in comparison to neutral items. Upon computing recollection and familiarity estimates, the increase in "remember" responses translated to an increase in recollection for emotional versus neutral items. In their second experiment, Kensinger & Corkin (2003) compared negatively valenced words (e.g. *sorrow*) to highly arousing yet neutrally valenced taboo words (e.g. *shit)*. Taboo words elicited higher "remember" responses, and negative words led to only marginal differences in "remember" responses compared to neutral words. "Know" responses did not differ for either condition. Recollection estimates mirrored the increase in "remember" responses. Unexpectedly, taboo words also elicited higher computed familiarity estimates as well. This finding suggests that when separated, negative valence and arousal may both enhance recollection but only arousal may affect familiarity.

Goldinger and Hansen (2005) also reported evidence suggesting that arousal may be related to familiarity. After having participants learn words, pictures, or faces, the experimenters had individuals perform a simple old /new recognition test and provide a 1-7 confidence rating. At test, Goldinger and Hansen (2005) coupled the old/new visual stimuli with a subliminal (60 Hz.) auditory tone through speakers attached to the participant chair. The imperceptible arousal of this "buzz" presented with each test item resulted in both an increased hit and false alarm rate. In other words, the "buzz" led to a bias to respond "old" to the recognition test items. The authors argued that this bias arose from participants interpreting the arousal of the “buzz” as stimulus familiarity.

Although Goldinger and Hansen (2005) demonstrated that participants may attribute sensory arousal to the familiarity of the test stimulus, the level of autonomic arousal itself was not measured directly in their study. Physiological measures of autonomic arousal such as skin conductance responses (SCRs) provide a means of directly measuring autonomic arousal. Several additional studies provide support for the notion that autonomic arousal and familiarity are linked.

Tranel and Damasio (1985) used SCR to investigate the hypothesis that autonomic arousal is involved in familiarity and is preserved in prosopagnosia. In prosopagnosia (also termed face blindness), bilateral brain damage to the occipito-temporal fusiform gyrus impairs explicit recognition of faces. Tranel and Damasio found that prosopagnosics could still discriminate between familiar and unfamiliar faces through galvanic skin responses even when they could not verbally identify the faces. These authors attributed this ability to differential levels of autonomic arousal in familiarity-based recognition when facial identification was absent.

In a similar experiment, Newcombe & Fox (1994) used SCR to gauge physiological responses in facial recognition in schoolchildren. Newcombe and Fox capitalized on what is know as “childhood amnesia”, whereby children are rarely able to explicitly remember anything prior to about 5 or 6 years of age. The researchers showed a group of 10-year-old participants two sets of photographs. The first set of photographs included preschool classmates known when the participants were under five years old, and the second set included control pictures. Prior to SCR measurement, the children were asked to indicate whether a photograph was someone that they had seen before, and they then provided a 1-5 “liking” rating for each participant. Regardless of overt recognition, photos of past classmates elicited significantly shorter SCR latencies than control photos. Newcombe and Fox postulated that physiological discrimination can occur for familiar versus unfamiliar faces in the absence of explicit recognition.

In another recent study, Morris, Cleary, and Still (2008) showed further support for the idea that autonomic arousal and familiarity are related. Using a variation of the recognition without identification paradigm (e.g. Cleary & Greene, 2005), participants studied lists of items and then viewed foreword and backward masked test items at one of two durations (30 and 50 ms). Half of the test items were old, and half were new. Participants attempted to identify the test item and then rated the likelihood that the test item was studied using a 0 (sure not studied) to 10 (sure studied) scale. Behaviorally, participants were able to discriminate studied from unstudied items as evidenced by higher recognition ratings for unidentified studied items than for unidentified unstudied items. This discrimination is the standard recognition without identification effect. Using SCR, Morris, Cleary & Still (2008) found that longer response latencies were associated with viewing studied versus nonstudied items at test. Importantly, these longer galvanic latencies also corresponded to an increase in recognition ratings. The authors argued that autonomic arousal leads to the “feeling” of familiarity, which in turn leads to an increase of attentional resource allocation for arousing items.

Despite a number of studies that point toward a potential link between familiarity and arousal, surprisingly little research has been done to associate the two with high arousal stimuli. Previous research has shown a direct relationship between stimulus arousal and physiological arousal which is commonly indexed through SCRs

(Greenwald, Cook & Lang, 1989; Bradley, Greenwald, Petry, & Lang, 1992). Given this, it is reasonable to assume that if physiological arousal is related to familiarity, then stimulus arousal too, should be related to familiarity.

Despite evidence that hints at the possibility that valence impacts recollection and arousal impacts familiarity, several inconsistencies appear in the literature. For example, Ochsner (2000) found that both high arousal and negative valence benefited recollection but not familiarity. Kensinger and Corkin (2003) found the same benefit for recollection, but in contrast to Ochsner, they found that high arousal enhanced familiarity.

In another inconsistency, Dougal & Rotello (2007) fit R/K data to four different mathematical models. Despite the fact that R/K data indicated an increased proportion of correct "remember" responses for negative old items, Dougal & Rotello (2007) argued that these data merely represent a shift in response bias for negative versus neutral items rather than a benefit for emotion in recollection.

There are two primary methodological reasons for these inconsistencies in the literature. The first reason involves a series of debates regarding the R/K procedure. The degree to which the states of awareness involved in "remembering" or "knowing" map on to recollection and familiarity is not agreed upon (Yonelinas, 1998; 2002, Wixted, 2007a; Parks & Yonelinas, 2007; Wixted, 2007b). Another aspect of the R/K procedure that is not agreed upon involves the optimal way to calculate R/K responses. For instance, R/K responses can be calculated based on the assumption of mutual exclusivity or the assumption of process independence (e.g. Jacoby, Yonelinas, & Jennings 1997; Yonelinas et al., 1998). Depending on which assumption is accepted in analyses, experimental results may differ. A final consideration is that the R/K procedure is quite sensitive to differences in the nature and terminology of directions given to participants during experimentation (McCabe & Geraci, 2009).

The second reason for inconsistencies in the emotion recognition literature involves the fact that levels of stimulus valence and arousal are often allowed to co-vary. This can occur in one of two ways. The first way is through use of "aversive" stimuli that are both negatively valenced and highly arousing (e.g. a graphic photo of a car crash, or the word *terrified*). Aversive stimuli are often used in neuroimaging studies to elicit the largest emotional response possible. For example, Dolcos, LaBar, & Cabeza (2004) used pictorial stimuli that were all highly arousing while varying in valence. The experimenters compared these stimuli to neutral stimuli in order to create general inferences about neural correlates of emotionality in memory.

A second way the valence can co-vary with arousal is through lack of control. For example, Dewhurst & Parry (2000) used word stimuli that varied in positivity or negativity in the R/K paradigm. The authors found that emotional words increased "remember" responses but not "know" responses which they interpreted as an effect of emotion in recollection but not familiarity. Dewhurst & Parry's claim is confounded by the fact that stimulus arousal levels were not accounted for. This could have led to a systematic influence of arousal in their results that remained unaccounted for.

In order to understand the nature of how two dimensions of emotion impact recollection, it is necessary to control for each dimension. The present study seeks to investigate negative valence and high-arousal to determine how they impact recollection and familiarity using a relatively new task known as the recognition without cued-recall (RWCR) paradigm

Chapter V

The Recognition without Cued-recall (RWCR) Paradigm

The recognition without cued-recall paradigm (Cleary, 2004) is unique, in that it indexes recollection through cued-recall, and it also indexes familiarity through recognition ratings given in the absence of cued-recall. The recognition without cued-recall effect, or RWCR, is the finding that even when participants are unable to recall a studied item when cued at test, they can reliably discriminate between cues that resemble studied items and cues that do not. The RWCR paradigm is a variation of the recognition without identification (RWI) paradigm (Peynircioğlu, 1990; Cleary & Greene, 2000; Kostic & Cleary, 2009). Whereas RWI focuses primarily on preventing identification of test items through perceptual degradation of the test stimuli, RWCR uses similarity between study items and test cues to elicit cued-recall. This study-test similarity can vary on a number of different dimensions.

In the first RWCR experiments, Cleary (2004) showed that specific item features (orthography, phonology, and semantic relatedness) can elicit RWCR. Orthographic (or graphemic) similarity can be thought of as the degree to which one word looks like another in terms of its letters. Phonological similarity is the degree to which one word sounds like another phonetically. Semantic relatedness is the degree to which stimulus meanings overlap from study to test.

In Cleary's (2004) first experiment, participants studied a list of 60 words chosen from stimuli used by Blaxton (1989). One-hundred-twenty test words were chosen from

Blaxton's graphemic similarity list, half of which (60) corresponded to the study words for each participant, and half of which (60) were new. For example, a participant might have studied a list containing the words *dolphin* and *hemlock*. At test, twice as many graphemically (orthographically) similar counterparts were presented, half of which resembled studied items (e.g. *endorphin* and *hammock)* and half of which were new. These study-test sessions were divided up into four blocks, such that participants received 15 study words and 30 test cues (15 resembling studied words, 15 new) per block. For each test cue, participants were first asked to use the cue to recall a word from study that resembled that test cue. Then, regardless of whether or not a participant could recall a similar word from study, he or she was asked to rate the likelihood that the test cue resembled a studied item by providing a recognition rating using a scale of 0 (sure no) to 10 (sure yes). After rating items, participants were given a second chance at recall to account for any answers that came to mind after the first try.

Cleary (2004) found that the RWCR effect persisted across several subsequent manipulations. One manipulation involved a visual/auditory modality switch from study to test. In the next manipulation, test cues phonologically rhymed with studied items (e.g. *eighty* at study, *lady* at test). Finally, in a semantic relatedness condition, test cues possessed similar meaning to studied items (e.g. *castle* at study, *palace* at test). The RWCR effect was found across all of these manipulations, though the magnitude of the effect was largest for the orthographic condition.

Chapter VI_

The Present Study

Using the RWCR paradigm as the method of separating recollection and familiarity in recognition, in the present study, we examine several hypotheses regarding how emotion impacts recognition. Based on prior research described above, we explore the main hypothesis that negative stimulus valence primarily impacts recollection and that high stimulus arousal impacts familiarity. We also examine the degree to which high-arousal impacts recollection in addition to familiarity.

In the present study, we use the RWCR paradigm as a means of separating recollection and familiarity for a number of reasons. First, the effects of emotion on familiarity and recollection have never been examined using this method. Thus, this task presents a novel means of seeking converging evidence regarding the role of emotion in familiarity and recollection.

Second, the RWCR method presents a quantifiable means of separating instances of recognition accompanied by recollection from instances that are not. That is, participants either successfully recall an item or they do not, and they give recognition ratings in both instances.

Third, the RWCR paradigm provides a simple framework for manipulating item characteristics such as valence and arousal in emotion. Study stimuli can be varied on the emotional dimensions of interest, and test cues can be created to resemble the study stimuli both orthographically and phonologically, as in Cleary (2004, Experiment 1). Thus, at test, cues will either resemble a studied item or will not, and this will allow us to examine the effects emotional dimensions on recognition by varying these dimensions in stimuli at encoding.

We first present data from Experiment 1, a within-subjects design examining how negatively valenced items impact recognition while controlling for arousal using a variant of the RWCR paradigm. Next, we present data from Experiment 2, a between-subjects design using negative versus neutral study items. Finally, Experiment 3 compares the impact of negatively valenced, highly arousing, and neutral study items on recollection and familiarity using a between-subjects design in the same RWCR paradigm

Chapter VII

Experiment 1

Experiment 1 used a variation of the RWCR paradigm (Cleary, 2004) to examine the effects of negative valence on cued-recall performance, as well as on recognition that occurs in the absence of cued-recall. This latter type of recognition is presumably familiarity-based. We first hypothesized that even in the absence of cued-recall, participants would be able to reliably discriminate between non-word test cues that orthographically and phonologically resembled study items from those that did (the RWCR effect). The second hypothesis was that when controlling for level of arousal, test cues resembling negatively valenced study words would increase cued-recall as compared to test cues resembling neutral study words. The third hypothesis was that when controlling for arousal, negative valence would not affect the magnitude of the RWCR effect compared to neutral valence (familiarity based discrimination would not be impacted).

Method

Participants. Forty-eight Colorado State University undergraduate students participated in partial fulfillment of a course requirement.

Materials. Study items for Experiment 1 were a subset of 56 negatively valenced (e.g. *terrible*) and neutral words (e.g. *passage*) selected from a pool compiled from the ANEW database (Bradley & Lang, 1999). The full list of negatively valenced study words and test cues are presented in Appendix A. The full list of neutral study words and test cues are presented in Appendix B. Mean valence ratings differed significantly between negative and neutral words [t (238) =31.41, $p < .001$, Cohen's $d = 4.07$] whereas mean arousal ratings did not differ (p =.21). Additionally, word frequency and length of these study items were controlled for, such that none of these items differed significantly between pools. These mean study stimulus characteristics for Experiment 1, including ratings of valence, arousal, and word frequency from the ANEW, can be found in Table 7.1. Test cues were created to orthographically and phonologically resemble both negative and neutral items in line with previous research (Blaxton, 1989; Cleary 2004). For example, the nonword *terligle* corresponded to the studied negative item *terrible*, and *pasroge* to the neutral item *passage.* Nonword test cues were equated on length, number of letters altered from study to test, and number of syllables. In creating test cues, first and last letters of study word counterparts were preserved.

Study and test stimuli were separated into four study-test blocks. Each study session contained seven negatively valenced words and seven neutral words. Each test session contained twice as many (14) nonword counterparts for both negative and neutral dimensions. Of these nonword counterparts, half (7) orthographically resembled studied items and half (7) were new. Study-test presentation and block were fully counterbalanced across eight experimental versions.

Procedure. All stimuli were presented visually using E-Prime software (PST Inc.) on Dell PCs in our laboratory. After signing consent forms detailing the nature of the experiment, participants read instructions on the computer screen prior to beginning. Each study item was presented in the upper left corner of the computer screen for two seconds. After completing the first study list of 14 items, participants were presented with nonword test cues and asked "do you recall a word from the study list that resembles this item?" Participants were asked to attempt to recall a word from study that resembled the nonword cue, and they were then prompted to type the studied word in a response box. After attempting recall, participants were asked to provide a rating indicating how likely it was that the current nonword cue resembled a word from the previously studied list. These ratings, used to indicate how familiar a test cues seemed, were made using a 0-10 (0 = definitely not studied, 10 = definitely studied) scale. After the familiarity rating, participants were given a second chance to recall a similar item from study, and they were encouraged to guess during this stage. This second chance was to eliminate any recall that came to mind after the first chance expired. This process was repeated for each of the 28 nonword test cues across four blocks. Data were coded by hand and spellchecked to assure that any misspellings were binned in the correct identification category.

Results and Discussion

The following experiment used an alpha criterion set at $p < .05$ and effect sizes are reported. The first important step in understanding these data involves determining how many study items were recollected through cued-recall at test and whether or not this differed as a function of emotion. A paired-samples *t*-test was used to assess the proportion of targets recalled for negative compared to neutral items. These proportions can be found in Table 7.2. Negative test cues elicited a significantly higher probability of cued-recall than neutral test cues [t (47) =2.03, Cohen's d = .296]. This finding indicates that test cues resembling negative study words enhance cued-recall compared to cues resembling neutral study words, which is in line with prior research showing a benefit in memory for negative valence (Kensinger & Corkin, 2003; Ochsner, 2000).

As with all studies of RWCR, the primary data of interest were ratings given to cues that did not elicit cued-recall. These data are presented in Table 7.3. A 2 X 2 Valence (positive vs. negative) X Study Status (similar cue vs. dissimilar cue) repeated measures ANOVA was performed on ratings given in the absence of cued-recall. This analysis revealed a marginally significant main effect of Study Status [F (1, 47) = 3.58, MSE= 1.38, p = .06, $p\eta^2$ =.07]. In the absence of cued-recall, ratings given to cues resembling studied items were marginally higher than ratings given to cues that did not resemble studied items. This suggests a pattern in the direction of the typical RWCR effect. A significant main effect was found for valence [F (1, 47) = 4.08, MSE= 0.44, $p\eta^2$ =.08]. In the absence of cued-recall, mean familiarity ratings were significantly higher for both old and new test cues resembling negatively valenced words than cues that resembled neutral words. The interaction between study status and valence did not reach significance (F<1), thus the magnitude of the RWCR effect was not affected by negative valence. Finally, an independent samples *t*-test that explored ratings given to cues corresponding to unstudied yet identified targets did not differ significantly as a function of emotion.

This first experiment revealed an RWCR effect similar to that found in Cleary (2004), which suggests orthographic and phonological similarity from study to test can elicit familiarity-based discrimination even in the absence of cued-recall. Given that the significance of this effect was marginal (p = .06), increasing power will likely lead to statistical significance. A main effect of valence indicates the presence of a recognition bias for cues corresponding to unrecalled targets resembling negatively valenced items compared to cues corresponding to unrecalled targets resembling neutral items. This suggests that orthographic and phonological similarity to negatively valenced items may be sufficient to influence (and increase) recognition ratings for both cues of studied and cues of unstudied words. A lack of an interaction between valence and study status indicates that negative valence does not influence familiarity-based recognition. Instead, a significant increase in the proportion of targets recalled for cues resembling negative versus neutral items suggests that negative valence influences recollection-based recognition. This finding of a benefit for recollection is in accordance with previous studies (e.g. Sharot, Verfaillie, and Yonelinas, 2002; Kensinger & Corkin 2003).

Table 7.1
Stimulus ratings by emotion and dimension for Experiment 1.

	Negative Valence		Neutral	
Dimension	*M*	*SD*	*M*	*SD*
Valence	2.21*	*1.46*	5.48	*1.86*
Arousal	5.47	*2.59*	5.30	*2.27*
Word Frequency	24.5	*13.6*	28.4	*33.4*
Word Length	6.46	*1.59*	6.23	*1.61*
Cue Length	6.46	*1.51*	6.34	*1.61*
Syllables	2.03	*0.76*	1.96	*0.77*
Letters Altered From Study to Test	1.73	*0.58*	1.85	*1.05*

* mean difference between negative and neutral words at p <.001.
All other differences p < .12 or above.

Table 7.2
Mean proportion of targets recalled per emotional condition for Experiments 1 and 2.

Experiment	Condition	*M*	*SD*
Expt. 1	Negative Valence	0.37*	*.07*
	Neutral	0.35	*.06*
Expt. 2.	Negative Valence	0.69	*.11*
	Neutral	0.64	*.14*

* Differences significantly different than neutral cues at *p* <.05 or below

Table 7.3
Mean familiarity ratings by recall status, study status, and emotion for Expts. 1 and 2

		Recalled				Unrecalled			
		Studied		Unstudied		Studied		Unstudied	
Experiment	Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Expt. 1	Negative	8.78	*0.77*	5.12	*1.98*	2.91	*1.64*	2.58	*1.64*
	Neutral	8.84	*0.81*	4.56	*2.02*	2.71	*1.52*	2.39	*1.51*
Expt. 2	Negative	7.96	*1.50*	5.48	*1.68*	2.38	*0.86*	2.01	*0.86*
	Neutral	7.07	*1.58*	3.91	*2.00*	2.04	*1.58*	1.52	*1.26*

Note: Recalled Unstudied items refer to identified cues corresponding to nonstudied words that were attributed to the experimental context.

Chapter VIII

Experiment 2

The results of Experiment 1 replicated the general pattern indicative of the RWCR effect using orthographic and phonological similarity from study to test. However, this effect only reached marginal significance. In the original RWCR paradigm, Cleary (2004) used twice as many stimuli in a between-subjects design (15 study items and 30 test cues across four blocks for a total of 120 stimuli). Therefore, increasing the number of stimuli will likely give rise to a larger RWCR effect. Experiment 2 utilized a between-subjects design to explore this possibility. The hypotheses from this experiment are identical to the first experiment. First, ratings given to test cues resembling studied items will be significantly higher than ratings given to cues that do not. Second, an increase in the proportion of targets recalled will be higher for negative than neutral items. Finally, we hypothesized that the magnitude of the RWCR effect will not differ as a function of negative valence.

Method

Participants. Twenty four Colorado State University undergraduate students participated in partial fulfillment of a course requirement.

Materials. Study items for Experiment 2 were a subset of 120 negatively valenced (e.g. *injury*) and neutral words (e.g. *context*) selected from a pool using the ANEW database (Bradley & Lang, 1999). The full list of negatively valenced study words and test cues are presented in Appendix C. The full list of neutral study words and test cues are presented in Appendix D. Mean valence ratings according to the ANEW differed significantly between negative and neutral words [t (238) =21.20, p <.001, Cohen's $d = 2.74$] whereas mean arousal ratings did not differ significantly (p =.21). Study items were also equated on word frequency and word length. These mean study stimulus characteristics for Experiment 2, including ratings of valence, arousal, and word frequency can be found in Table 8.1. Test cues were created to orthographically and phonologically resemble both negative and neutral items in line with previous research (Blaxton, 1989; Cleary 2004). For example, the nonword *ingory* corresponded to the studied negative item *injury*, and *corndext* to the neutral item *context*. Nonword test cues were equated on length, number of letters altered from study to test, and number of syllables. In creating test cues, first and last letters of study word counterparts were preserved.

Study and test stimuli were separated into four study-test blocks, and emotion was manipulated between-subjects. In the negative condition, each study session contained fifteen negatively valenced words. In the neutral condition, each study session contained fifteen neutral words. Test sessions for each condition contained twice as many (30) nonword cues. Of these nonword counterparts, half (15) orthographically resembled studied items and half (15) were new. Study-test presentation and block were fully randomized.

Procedure. All stimuli were presented visually using E-Prime software (PST Inc.) on Dell PCs in our laboratory. After signing consent forms explaining the nature of the experiment, participants read detailed instructions on the computer screen. Each study item was presented in the upper left corner of the computer screen for 2 seconds. After completing the first study list, participants were presented with a nonword test cue and asked "do you recall a word from the study list that resembles this item?" Participants were asked to attempt to recall a word from study that resembled the nonword cue, and they were then prompted to type the studied word in a response box. After attempting recall, participants were asked to provide a rating indicating how likely it was that the current nonword cue resembled a word from the previously studied list. Ratings were made using a 0-10 (0= definitely not studied, 10= definitely studied) scale. After the familiarity rating, participants were given a second chance to recall a similar item from study, and they were encouraged to guess during this stage. This second chance was to eliminate any recall that came to mind after the first chance expired. This procedure was repeated for all 120 test stimuli across four blocks. Data were coded by hand prior to analysis and spellchecked to assure that any misspellings were binned in the correct identification category.

Results and Discussion

For this experiment, an alpha significance criterion of $p < .05$ was set, and effect sizes are reported. Our first analysis compared the proportion of targets recalled as a function of emotion. An independent samples *t*-test comparing the proportion of studied items recalled for negative versus neutral corresponding test cues did not reach significance. These proportions may be found in Table 8.2. The primary focus of Experiment 2 was on ratings given to cues resembling studied items versus cues that did not in the absence of recollection. A 2 X 2 Valence (positive vs. negative) X Study Status (similar cue vs. dissimilar cue) mixed repeated measures ANOVA revealed a significant main effect of study status, [$F(1, 22) = 20.57$, $MSE = .118$, $p\eta^2 = .483$]. Paired samples *t*-tests confirmed that cues resembling studied items were rated significantly higher than new cues for both neutral [*t* (11) = 3.28, Cohen's *d* = .99] and negative conditions [*t* (11) = 3.17, Cohen's *d* = .95]. This indicates the presence of a reliable RWCR effect in both emotional conditions. The means for this effect are plotted in Figure 8.1. The ratings given in all conditions are displayed in Table 8.3.

An interaction between study status and emotion did not reach significance (F<1), which indicates that negative valence did not impact familiarity-based discrimination in the absence of cued-recall. Finally, a main effect of valence was not significant for unrecalled items (F<1) suggesting the emotional bias found in Experiment 1 was no longer present.

Our final analysis in Experiment 2 concerned ratings given to nonword cues that were identified at test even when their corresponding word had not been studied. In other words, we examined ratings given to cues for which participants correctly guessed the target. Our nonword test cues all correspond to real words in the English language. Therefore it is possible to identify these real words and falsely attribute the solution as having been studied within the context of the experiment. We conducted a one-way ANOVA on familiarity ratings given to identified targets that were unstudied to assess the degree to which emotion may enhance or reduce these false attributions. These means are presented in Table 8.4. A significant main effect of emotion emerged, [*F* (1, 22) = 4.28, *MSE* = 3.42, $p\eta^2$ =.16]. An independent samples *t*-test confirmed that the ratings given to identified yet nonstudied targets were significantly higher for negatively valenced than neutral cues [*t* (22) = 2.070, Cohen's *d* = .88].

Table 8.1
Stimulus ratings by emotion and dimension for Experiments 2 and 3.

Dimension	Negative Valence *M*	*SD*	High Arousal *M*	*SD*	Neutral *M*	*SD*
Valence	2.43*	*0.49*	4.93	*2.46*	5.18	*0.84*
Arousal	5.08	*0.70*	6.76*	*0.63*	5.03	*0.62*
Word Frequency	22.2	*36.2*	27.5	*38.9*	28.5	*39.2*
Word Length	6.49	*1.65*	6.54	*1.82*	6.24	*1.58*
Cue Length	6.64	*1.63*	6.60	*1.78*	6.40	*1.51*
Syllables	2.03	*0.84*	2.06	*0.81*	1.95	*0.73*
Letters Altered From Study to Test	1.64	*0.61*	1.70	*0.64*	1.73	*0.56*

* mean differences between emotional words and neutral words at p <.001 or below. All other differences p < .12.

Table 8.2.
Mean proportion of targets recalled per emotional condition for Experiments 1 and 2.

Experiment	Condition	*M*	*SD*
Expt. 1	Negative Valence	0.37*	*.07*
	Neutral	0.35	*.06*
Expt. 2.	Negative Valence	0.69	*.11*
	Neutral	0.64	*.14*

* Differences significantly different than neutral cues at p <.05 or below

Table 8.3
Mean familiarity ratings by recall status, study status, and emotion for Expts. 1 and 2

		Recalled				Unrecalled			
		Studied		Unstudied		Studied		Unstudied	
Experiment	Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Expt. 1	Negative	8.78	*0.77*	5.12	*1.98*	2.91	*1.64*	2.58	*1.64*
	Neutral	8.84	*0.81*	4.56	*2.02*	2.71	*1.52*	2.39	*1.51*
Expt. 2	Negative	7.96	*1.50*	5.48	*1.68*	2.38	*0.86*	2.01	*0.86*
	Neutral	7.07	*1.58*	3.91	*2.00*	2.04	*1.58*	1.52	*1.26*

Note: Recalled Unstudied items refer to identified cues corresponding to nonstudied words that were attributed to the experimental context.

Table 8.4
Mean recognition ratings for unstudied identified targets falsely attributed to the study phase by emotion for Experiments 2 and 3.

Experiment	Condition	*M*	*SD*
Expt. 2	Negative Valence	5.48*	*1.68*
	Neutral	3.91	*2.00*
Expt. 3	Negative Valence	4.81	*1.57*
	Neutral	4.32	*1.81*
	High-arousal	5.00*	*1.98*

*Note: * Differences significantly different than neutral cues at p <.05 or below. Experiment 1 means did not differ between negative and neutral.*

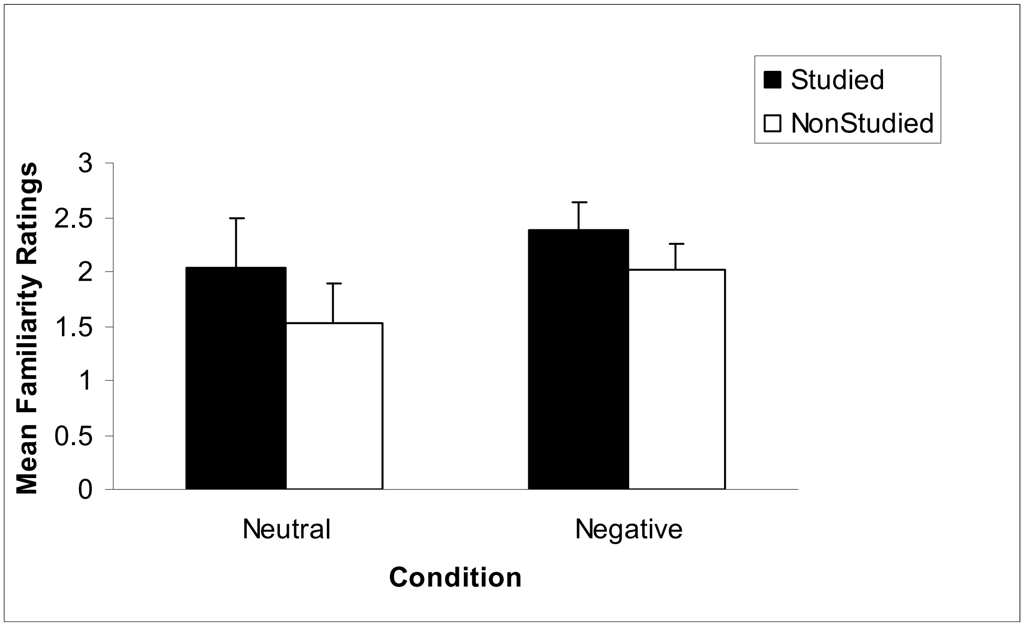

Figure 8.1
Mean familiarity ratings for cues resembling studied items versus cues not resembling studied items in the absence of cued-recall by emotional condition for Expt. 2

Chapter IX

Experiment 3

Thus far, our results suggest that, consistent with prior studies (Sharot, Verfaille, & Yonelinas, 2007; Ochsner, 2000), negatively valenced stimuli enhance recollection but do not impact familiarity. The purpose of Experiment 3 was to examine the hypothesis that negative valence will enhance recollection, while high arousal will enhance familiarity.

In the following experiment, the role of both negative valence and high arousal in recognition are explored using a larger sample and a between-subjects design in an RWCR paradigm similar to Experiment 2. In accordance with both previous experiments, our first hypothesis was a replication of the RWCR effect. The second hypothesis was that negative valence and high-arousal would both lead to higher levels of cued-recall than neutral valence. The third hypothesis was that while positive valence would not affect the magnitude of the RWCR effect, high-arousal would increase the magnitude of the RWCR effect. That is, if arousal impacts familiarity-based recognition, we predicted old-new discrimination in the absence of cued-recall would be larger for cues resembling high-arousal study items than for cues resembling neutral items.

Method

Participants. Two hundred sixty one Colorado State University undergraduates participated in partial fulfillment of a course requirement.

Materials. Study items were 120 negatively valenced (e.g. *cemetery*), highly arousing (e.g. *violent*), and neutral words (e.g. *invest*) once again selected from the ANEW database (Bradley & Lang, 1999). The full list of study words and test cues are presented in Appendices C, D, and E. Mean valence ratings differed significantly between negative and neutral items [t (238) =31.41, Cohen's $d = 4.07$] whereas mean arousal ratings did not differ significantly between these two. Mean arousal ratings differed significantly between high-arousal and neutral items, [t (238) =21.20, Cohen's $d = 2.74$] whereas mean valence ratings did not differ between these two. Test cues orthographically and phonologically resembled negative, high-arousal, and neutral items (e.g. *cenefery* for the studied positive item *cemetery*, *vialomt* for the high-arousal word *violent*, and *imwest* for the neutral item *invest).* Study words and test cues were equated for word frequency, word length, number of letters altered from study to test, and the number of syllables (See Table 9.1) In creating the test cues, first and last letters were preserved from their corresponding study word.

Procedure. All data collection procedures were identical to Experiment 2. The only difference in this experiment was the addition of high arousal study items as a third emotional stimulus type.

Results and Discussion

For this experiment, an alpha significance criterion of p <.05 was set, and effect sizes are reported. All mean recognition ratings and standard deviations for Experiment 3 are listed in Table 6.

The first data of interest in Experiment 3 concerned the proportion of targets recalled, and whether or not this differed as a function of emotional condition. A one-way

ANOVA revealed a significant main effect of emotion, [F (2, 258) =16.157, η^2=.11). Post-hoc tests confirmed that both high-arousal and negatively valenced cues elicited a significantly higher proportion of cued-recall than neutral cues (Tukey's HSD, Scheffe). These means and standard deviations are contained in Table 9.2. The difference in proportion of targets recalled based on high-arousal and negative cues was not significant.

Next, we examined recognition ratings given in the presence of cued recall in relation to emotion. A one-way ANOVA revealed a significant main effect of Emotion, [F (2,258) = 4.055, MSE = 1.56, pη^2 =.03]. Post-hoc tests revealed that recognition ratings given in the presence of cued recall were significantly higher for cues corresponding to high-arousal words than cues corresponding to both negative and neutral words (Tukey's HSD, Scheffe). These means and standard deviations are contained in Table 9.3. Ratings between negative and neutral cues did not differ reliably.

To examine RWCR, the primary data of interest are conditionalized on unrecalled items. A 2 X 3 Study Status (old vs. new) X Emotion (negative vs. high arousal vs. neutral) mixed repeated measures ANOVA revealed a main effect of study status [F (2, 258) =151.53, MSE= .50, pη^2 =.372)]. In the absence of cued-recall, ratings given to cues resembling studied items were significantly higher than ratings given to cues not resembling studied items. This indicates an RWCR effect. These means and standard errors are plotted in Figure 9.1, and mean recognition ratings and standard deviations are displayed in Table 9.3. An interaction between Study Status and Emotion did not reach significance (F =1.18). This finding is crucial to the interpretation of our results, as it suggests that emotion does not significantly affect the RWCR effect[1].

To further explore the lack of an interaction between Study Status and Emotion for nonstudied cues, we examined ratings given to studied cues that elicited cued-recall versus ratings given to studied cues that did not elicit cued-recall (recognition with versus without cued-recall). The purpose of this analysis was to determine if the effect of emotion on recognition with cued-recall interacted with the lack of an effect in RWCR. A 2 X 3 Recall Status (recalled vs. unrecalled) X Emotion (high-arousal vs. neutral vs. negative) mixed repeated measures ANOVA revealed an expected main effect of recall status, such that ratings given to studied items during cued-recall were significantly higher than ratings given to studied items in the absence of cued-recall [F (2,258) =2289.92, MSE=1.77, $p\eta^2$ =.899]. In addition, an interaction between Recall Status and Emotion emerged at marginal significance [F (2,258) =2.552, MSE =1.77, p=.08, $p\eta^2$ =.019]. To further explore this interaction, we conducted separate ANOVAs for negative valence and high-arousal cues, given that the primary effect of emotion on recognition with cued-recall involved the high arousal dimension. Indeed, a significant interaction was found for the arousal dimension, [F (1,272) = 4.848, MSE=1.85, $p\eta^2$ =.027], but not for the negative valence condition ($F < 1$). The interaction for the arousal dimension suggests that even if the null effect of arousal on RWCR had been due to insufficient power (see Footnote 1), arousal had a stronger impact on recognition with cued-recall than on RWCR (as the effect of arousal on recognition with recall differed significantly from the lack of an effect of arousal on RWCR). In short, arousal has a stronger effect on recognition with than without cued-recall.

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[1] We conducted a post hoc power analysis with the program *G*Power3* (Buchner, Erdfelder, Faul, & Lang 2008) to determine whether our experimental design had enough

power (1 - β) to detect this interaction. The effect size of this interaction was computed at .09, a small effect (Cohen, 1992). The power to detect an interaction with this effect size was determined to be 0.33 in Experiment 3. Our observed *F* value was *F* (258) = 1.18, *p* = .33, and the critical value was *F* (258) = 3.03. In order to reach a power level of .80 at a significance level of α = .05, we would have needed a sample size of *N* =1064.

The final analysis of Experiment 3 explored the presence of an effect for identified unstudied targets falsely attributed to the experimental study phase. We conducted a one way ANOVA on familiarity ratings for identified unstudied targets to assess the degree to which emotion may enhance or reduce these false attributions. These means are presented in Table 9.4. We found a significant main effect of emotion, [*F* (2,254) =3.23, $p\eta^2$ =.02]. Post-hoc analyses indicated a significant difference existed between the high-arousal and neutral conditions (Tukey's HSD). An independent samples *t*-test confirmed that the ratings given to cues of identified nonstudied targets were significantly higher for cues of high-arousal targets than for cues of neutral targets [*t* (166) =2.290, Cohen's *d* =.35]. Comparisons between negative versus neutral items and high-arousal versus negative items did not differ reliably for unstudied identified items.

Table 9.1
Stimulus ratings by emotion and dimension for Experiments 2 and 3.

Dimension	Negative Valence *M*	*SD*	High Arousal *M*	*SD*	Neutral *M*	*SD*
Valence	2.43*	*0.49*	4.93	*2.46*	5.18	*0.84*
Arousal	5.08	*0.70*	6.76*	*0.63*	5.03	*0.62*
Word Frequency	22.2	*36.2*	27.5	*38.9*	28.5	*39.2*
Word Length	6.49	*1.65*	6.54	*1.82*	6.24	*1.58*
Cue Length	6.64	*1.63*	6.60	*1.78*	6.40	*1.51*
Syllables	2.03	*0.84*	2.06	*0.81*	1.95	*0.73*
Letters Altered From Study to Test	1.64	*0.61*	1.70	*0.64*	1.73	*0.56*

* mean differences between emotional words and neutral words at p <.001 or below. All other differences p < .12.

Table 9.2
Mean proportion of targets recalled per emotional condition for Experiment 3

Condition	*M*	*SD*
Negative Valence	0.80*	*.11*
Neutral	0.72	*.12*
High-arousal	0.81*	*.09*

* Differences significantly different than neutral cues at p <.05 or below

Table 9.3
Mean familiarity ratings by function of recall status, study status, and emotion for Expt. 3

	Recalled				Unrecalled			
	Studied		Unstudied		Studied		Unstudied	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Negative	8.48	*1.09*	4.81	*1.57*	2.86	*1.70*	2.05	*1.34*
Neutral	8.45	*1.59*	4.32	*1.81*	3.21	*1.39*	2.36	*1.24*
High-arousal	8.93	*0.96*	5.00	*1.98*	3.05	*1.77*	2.41	*1.43*

Note: Recalled Unstudied items refer to identified cues corresponding to nonstudied words that were attributed to the experimental context.

Table 9.4
Mean recognition ratings for unstudied identified targets falsely attributed to the study phase by emotion for Experiments 2 and 3.

Experiment	Condition	*M*	*SD*
Expt. 2	Negative Valence	5.48*	*1.68*
	Neutral	3.91	*2.00*
Expt. 3	Negative Valence	4.81	*1.57*
	Neutral	4.32	*1.81*
	High-arousal	5.00*	*1.98*

*Note: * Differences significantly different than neutral cues at p <.05 or below. Experiment 1 means did not differ between negative and neutral.*

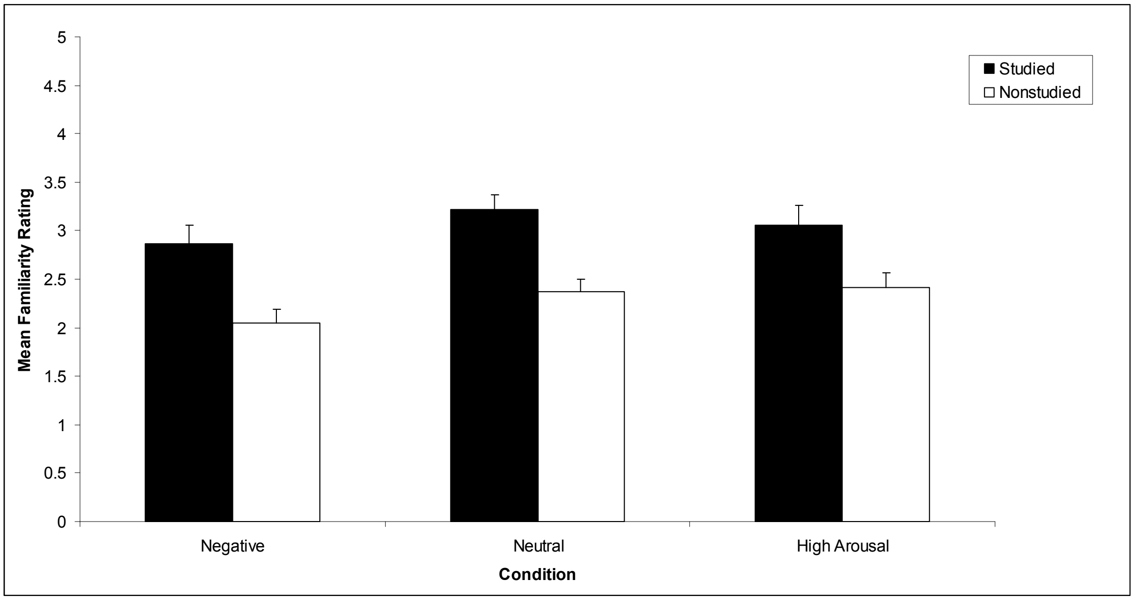

Figure 9.1.
The recognition without cued-recall effect across emotional conditions for Experiment 3.

Chapter X

General Discussion

In the present study, there are five primary findings of interest. The first finding of interest is a replication of the RWCR effect using nonword cues that orthographically and phonologically resemble study items. The second finding of interest is an increase in the proportion of targets recalled based on resemblance to emotional study items. The third finding of interest is that emotion did not impact old-new discrimination that occurred in the absence of cued-recall, despite that it affected recognition in the presence of cued-recall. The fourth finding is an emotional ratings bias for identified extraexperimental targets that were falsely attributed to the study phase. The final finding of interest is an emotional ratings bias for unrecalled targets in our within-subjects experimental design.

Experiment 1 manipulated emotion by using test cues that resembled both negatively valenced and neutral words in a within-subjects design. This experiment used approximately half of the number of stimuli used in the original RWCR paradigm by Cleary (2004) in order to manipulate emotion within each block. Experiment 1 demonstrates an increase in the proportion of targets recalled when resemblance was to negative study items compared to when it was to neutral study items. Despite this increase in cued-recall itself, valence did not interact with old/new discrimination in the absence of cued-recall. Experiment 1 also demonstrated an emotional bias for unrecalled cues resembling negative versus neutral words.

Experiment 2 once again used cues resembling negative and neutral study words, but this experiment used a between-subjects design with the same number of stimuli used in the original RWCR paradigm by Cleary (60 items at study, 120 cues at test). Though a significant RWCR emerged in this experiment, the lack of a significant increase in cued-recall due to emotion was likely due to a small sample size (N =12 per condition). The bias to give higher ratings to cues corresponding to emotional targets in the absence of recall found in Experiment 1 disappeared in Experiment 2, but a new bias emerged. We found a significant bias to provide higher familiarity ratings to cues of negative targets relative to cues of neutral targets that were not studied in the context of the experiment.

Experiment 3 was a between-subjects design using a larger sample (N= 261) that incorporated neutral, negative, and high-arousal study stimuli. A significant increase in the proportion of targets recalled was found for high-arousal and negative cues compared to neutral cues. Thus, emotion affected cued- recall performance itself. Emotion also interacted with ratings given in the presence of cued-recall, such that ratings were higher for high-arousal cues compared to negative and neutral cues. A significant RWCR effect demonstrated reliable old/new discrimination in the absence of cued-recall, but emotion did not interact with this old/new discrimination. Finally, a false attribution bias similar to the one found in Experiment 2 emerged, such that ratings given to cues of identified nonstudied targets increased as a function of arousal. Unstudied yet identified targets were more likely to be attributed to the experimental context when they corresponded to high-arousal words than when the they corresponded to negative or neutral words.

Emotion impacts recall but not familiarity

An RWCR effect emerged across all experiments in the current study. Experiment

1 demonstrated this RWCR effect using a truncated number of stimuli in a within-subjects design, though the effect only reached marginal significance in that situation. Experiments 2 and 3 utilized a between-subjects design that elicited a robust RWCR effect with the same number of stimuli found in the original paradigm used by Cleary (2004). The current study replicates and extends the work of Cleary (2004). This study also provides further support for the fact that similarity in appearance and sound (orthography and phonology) can give rise to old/new discrimination in the absence of cued-recall even when using novel nonword test cues.

Experiments 1 and 2 demonstrated that cue resemblance to negatively valenced study items did not impact familiarity based discrimination. One of our a priori hypotheses for Experiment 3 was that high stimulus arousal would increase this old/new discrimination. Though we found statistically reliable increases in cued-recall as a function of both high-arousal and negative valence, we found no reliable effect of these emotional dimensions in old/new discrimination occurring in the absence of recall.

The lack of any significant interaction between the RWCR effect and emotion, taken together with the fact that emotion impacts recall, suggests that high-arousal and negative valence impact recollection but not familiarity. An additional analysis in Experiment 3 compared ratings given to studied items in the presence of cued-recall to those given in the absence of cued-recall. This additional analysis revealed a significant interaction, such that high-arousal impacted recognition with but not without recall. More specifically, resemblance of test cues to high-arousal study items increased ratings given in the presence of cued-recall compared to neutral study items. However, in the absence of cued-recall, ratings given to cues resembling high-arousal items did not differ from those given to cues resembling neutral items. The impact of high-arousal and negative valence in recall but not familiarity supports previous findings of a benefit for emotion in recollection but not familiarity-based recognition memory (Ochsner, 2000; Sharot et al., 2007; Kensinger & Corkin, 2003). Furthermore, these findings provide support for dual process theory.

Support for dual process theory and the Remember/Know approach

The effect of emotion on cued-recall and recognition with cued-recall but not recognition in the absence of cued recall provides evidence for a unique functional dissociation in support of dual process theories of recognition memory (e.g. Diana et al., 2006; 2007). This is similar to several behavioral dissociations shown for emotion using the Remember/Know procedure. For instance, Ochsner (2000) found that negative valence and high arousal increase "remember" responses but do not affect "know" responses. Similarly, Sharot et al. (2007) found that aversive (negative highly-arousing) items increased "remember" but not "know" responses. Our results map well onto these existing R/K data. "Remember" responses and cued-recall are both believed to reflect recollection, whereas "know" responses and recognition without cued-recall reflect familiarity. These data contribute to previous literature showing other functional dissociations outside the domain of emotion using R/K as well, such as those found by Rajaram (1993) and Gardiner & Parkin (1990). Ours are the first experiments using the RWCR paradigm to show differential effects of emotion on separate processes within recognition memory.

False attribution: Emotional biases for extraexperimental items

Another unique finding from the present study is the increase in ratings given to unstudied targets in the emotional conditions relative to the neutral conditions. The RWCR paradigm necessarily includes cues that resemble both studied items (old) and nonstudied items (new). In Experiment 1, ratings for cues corresponding to unstudied extraexperimental words did not differ between negative and neutral conditions. In Experiment 2, cues that resembled negatively-valenced extraexperimental words were rated significantly higher than cues resembling extraexperimental neutral words. In Experiment 3, this same effect was found for cues resembling high-arousal words.

According to the source misattribution hypothesis (McCabe & Geraci, 2009), in the R/K procedure, both remember hits and remember false alarms involve recollection. Whereas remember hits involve recollecting contextual details from within the experimental episode, remember false alarms involve recollection of details from outside of the experimental episode. In the RWCR framework, nonword cues orthographically and phonologically resembling both old and new words are presented at test. For instance, if the high-arousal words *hostile* and *pistol* appear at study, their corresponding cues *husfile* and *pigtol* would appear at test along with the new cues *nigktmore* and *turnabo*. Our data suggest that participants are sometimes able to solve *nigktmore* and *turnabo* as *nightmare* and *tornado* despite the targets not appearing on the study list. In this event, ratings indicating the likelihood that these new high-arousal cues did correspond to study items are significantly higher than ratings for new neutral words such as *scissors* or *rock.* Use of a within-subjects design reduces this effect, which is presumably due to having both emotional items and neutral items present. In sum, these data provide support for the source misattribution account of false remembering (McCabe & Geraci, 2009) using a novel paradigm. They further suggest that the source of high arousal items is more likely to be misattributed than the source of neutral items. This could have implications for eyewitness accounts of emotional events and for false memory for emotionally charged information.

One additional explanation for extra-list intrusions is attentional in nature. Higham & Vokey (2004) found that by slightly increasing the stimulus exposure durations during the R/K procedure, the likelihood of both "remember" and "know" responses increased for unstudied items, resulting in a form illusory recognition. We did control for stimulus exposure duration during the study phases in the present experiments, but the exposure duration to non-word cues at test was self-paced. That is, upon viewing a nonword cue, the subjects were simply instructed to not take more than a few seconds to provide a response. Therefore it is possible that exposure durations to these nonword cues were longer for highly arousing versus neutral cues corresponding to unstudied items.

Another alternative explanation for this bias is that the physiological arousal brought on by high arousal words may be misinterpreted as higher familiarity, thus the higher ratings for arousing extralist items may be due to the sense of arousal that accompanies identification of high-arousal words. Perhaps a high arousal word must first be identified in order for the physiological arousal to take place. Previous research has suggested that participants do in fact misattribute feelings of arousal to study status (e.g. Goldinger & Hansen, 2005). Therefore it is possible that participants interpreted the arousal of identified high arousal extralist items as familiarity and used this as a basis for misattributing them to the study phase of the experiment.

Our results suggest the presence of an emotional bias that manifests as a form of false remembering, such that cueing extralist items that are either highly arousing or (in some cases) negatively valenced may increase the subjective veracity of this type of false memory. Stated simply, this suggests that similarity of an experience in the present to a highly-arousing event in the past may increase the likelihood of misattributing the source of this experience without explicit awareness.

An emotional bias for unrecalled items (criterion shifting)

An additional bias that we provide evidence for occurs in the absence of cued-recall or target identification. Experiment 1 demonstrated that when cued-recall did not occur, participants were biased to provide higher familiarity ratings to both studied and unstudied cues resembling negative items as compared to those resembling neutral items. Within a signal detection framework of familiarity, some research suggests that this recognition bias arises through adopting a relaxed response criterion for emotional versus neutral items. This shift in criterion increases the likelihood of calling an emotional item "old". This bias is typically seen in old/new recognition paradigms and the R/K procedure (e.g. Windmann & Kutas, 2001; Kapucu, Rotello, Ready, & Seidl, 2008). One possible reason for this shift could be due to top-down control of memory such that emotional items are deemed "important" and thus they are viewed as less likely to be overlooked (Windmann & Kutas, 2001). Windmann, Urbine, & Kutas (2002) provide evidence implicating prefrontal regions in such top-down control. Whether this criterion shift involves just familiarity or recollection is the subject of debate. Dougal and Rotello (2007) report that although emotion may enhance the subjective experience of remembering due to an increase in familiarity and a shift to a more liberal response bias, any increase in actual recollection is illusory. That is, Dougal and Rotello (2007) argued that increased “remember” responses due to emotion in the R/K procedure do not reflect retrieval of contextual details. We have provided evidence to the contrary in the current study by separating response bias from increased recollection. Our data suggests a shift in response criteria may give rise to an emotional bias in the absence of cued-recall such as that found in Experiment 1. However we have also provided clear evidence for emotion enhancing recollection through an increased proportion of targets recalled, as well as recognition ratings given in the presence of recall. In order for cued-recall to occur, contextual details must be recollected.

What is unique about this bias is that orthographic and phonological similarity of emotional study items to nonword test cues is enough to elicit it. This suggests that resemblance to an emotional event experienced in the past may be enough to enhance the subjective experience of familiarity in the present.

The bias for emotion in familiarity-based judgments given in the absence of cued-recall did not replicate in Experiments 2 and 3. One explanation is that Experiment 1 used a within-subjects design while Experiments 2 and 3 were between-subjects designs. In Experiment 1, participants studied both neutral and negative items, and they received cues corresponding to both. Having emotionally neutral items to compare negative items to in the context of the same experiment may be necessary to elicit this kind of bias. In contrast, participants in Experiments 2 and 3 studied words in only one emotional category (neutral, negative, or high-arousal), and they had no additional category upon which to be biased against.

Future Directions

The current study offers evidence that old/new discrimination can occur in the absence of cued recall for words based on orthographic and phonological similarity. Future research should explore the degree to which this kind of this kind of similarity can be capitalized on using real-world pictorial stimuli. Using the RWCR paradigm, Cleary, Ryals, and Nomi (2009) showed that preserved configural similarity to a scene learned in the past can translate to an experience of familiarity in the present. Understanding how similarity to past experiences maps on to experiences in the present may be crucial to understanding subjective phenomena such as déjà vu.

Future studies should also explore the role of valence coupled with high arousal as stimulus qualities that can boost recollection through cued-recall. It has been hypothesized that older adults have an associative binding deficit, whereby cohesion between item information and contextual information is reduced (e.g. Naveh-Benjamin, 2000). Since emotional processing is believed to be preserved in older adults even as recollection declines, it may be possible that valenced and arousing cues can serve to increase binding and aid in recollection (Kensinger, 2009; Nashiro & Mather, 2009). Given that research has suggested a positivity bias in memory for older adults (Mather & Carstensen, 2003), perhaps deeply-encoded associates that are valenced and highly arousing may boost recollection in older populations.

Finally future research should explore the neural basis for the memory biases found in the current study. Understanding how these biases interact with emotion may advance understanding of the susceptibility of memories to distortion. In particular, understanding how memory is modulated by emotionality through these biases may provide valuable insights into eyewitness memory and memory for traumatic events.

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Appendix A: Negatively Valenced Words and Non-Word Cues from Experiment 1.

Study Words		Nonword Test Cues	
abuse	suicide	abduce	soiclide
accident	terrible	acoibent	terligle
ache	tomb	aghe	temb
afraid	tragedy	ablaid	trabody
blind	troubled	blimd	trougled
bored	tumor	borved	tulor
broken	unhappy	braxen	uvhoppy
cancer	upset	carcor	utlet
confused	useless	comfuged	utelass
corpse	victim	cordse	virclim
criminal	violent	crivinal	viulemt
crude	vomit	crube	vopit
cruel		cryal	
debt		dapt	
deceit		dacreit	
defeated		defurted	
depressed		debrepped	
devil		doval	
dirty		dirfy	
disaster		divacter	
divorce		dinorce	
execution		exacition	
fearful		featvul	
funeral		fumenal	
gloom		gloam	
guilty		guirty	
helpless		hepplers	
hurt		hert	
insane		imcane	
jail		jyal	
lice		lirce	
loneliness		lorelivess	
misery		midery	
poverty		pomerly	
prison		pridon	
punishment		ponistnent	
quarrel		quammol	
rejected		revacted	
robber		rodder	
severe		sevyare	
sickness		sirknoss	
slave		slyve	
stupid		stapod	

Appendix B: Neutral Words and Non-Word Cues from Experiments 1

Study Words		Nonword Test Cues	
aggressive	smooth	agbrestive	snoofh
alien	storm	afien	sform
athletics	swamp	athjefics	swonp
bake	swift	bade	swipt
beverage	tamper	beweroge	tanfer
cannon	taste	cammen	tasfe
cliff	tease	chiff	toase
clumsy	trumpet	clomgy	trombet
cold	trunk	celd	tromk
concentrate	volcano	concuntlate	velcamo
contents	voyage	corfents	voylade
curious	wonder	cuniaus	wumber
custom	writer	cuslem	wriler
defiant	yellow	deflant	yettow
dentist		denlipst	
doctor		docfor	
fabric		fadnic	
foam		fuam	
hammer		hamtar	
hawk		homk	
hide		hibe	
highway		hiphmay	
hospital		horbital	
kerosene		kenosane	
legend		lepend	
lion		liron	
medicine		mebisine	
memory		merrory	
mighty		miphly	
mischief		mesctief	
muscular		mugoular	
naked		nahed	
noisy		nolsy	
obsession		odseccion	
passage		posslage	
patriot		pafriat	
plane		plame	
razor		razlur	
rough		ronph	
salute		sahufe	
shotgun		skolpun	
skyscraper		shysrnaper	

Appendix C: Neutral Words and Non-Word Cues from Experiments 2 and 3

Study Words	Test Cues	Study Words	Test Cues	Study Words	Test Cues
activate	acbivate	gender	genvar	repentant	reprotant
aggressive	agbrestive	glacier	gladier	reptile	revbile
alien	aliorn	glass	gless	reunion	reuvion
alley	attley	gossip	gasslip	rifle	rifte
aloof	alarf	hammer	hamtar	rock	reck
appliance	appfience	hard	harld	rough	ronph
avalanche	aralancke	hawk	homk	runner	ruvver
avenue	avabue	heroin	henain	salute	setute
bake	bade	hide	hilde	scissors	scistars
beast	bleast	highway	hiphmay	shadow	skadew
blond	blumd	hospital	horbital	sheltered	shelfared
boxer	bexor	hotel	hofel	ship	shlip
busybody	budybudy	icebox	icadox	shriek	shniek
cannon	connen	insolent	imsotent	skeptical	sheplical
cellar	cettar	invest	imwest	skyscraper	shysrnaper
chance	chamse	irritate	irnilate	spider	sguider
cliff	chliff	kerosene	kerotane	storm	starn
clumsy	clomgy	lawn	lewn	stove	slove
coast	cuast	legend	lepend	swamp	swornp
concentrate	concuntlate	limber	lambar	swift	swipt
consoled	confuled	lion	liron	tamper	tunper
contents	corfents	lottery	loffery	tanks	tonk
context	corndext	manner	monner	tease	toase
curious	cuniaus	medicine	mebisine	tennis	temmis
custom	cuslem	mighty	miphly	theory	thoory
cyclone	cydlome	mischief	mesctief	tool	taal
dagger	dogger	mushroom	mughroam	truck	trusck
defiant	deflant	mystic	myptic	trumpet	trombet
dentist	denlipst	naked	nahed	trunk	tramk
disdainful	dicdaimful	needle	neeble	vanity	vamify
disturb	distunb	neurotic	nouvotic	voyage	voylade
doctor	docfor	news	naws	whistle	whortle
elevator	elapator	nipple	niggle	wine	wilne
employment	emplayvent	obey	odey	wonder	wumber
event	enent	passage	pasroge	writer	wriler
excuse	ekcase	patient	paliemt	yellow	yettow
fabric	fardric	pistol	pigtol	flag	fleg
plane	plame	foam	fuam	pressure	prossure
fragrance	fraprance	python	pivthen	frog	frong
rattle	rapple	garter	gavter	razor	rezur

Appendix D: Negatively Valenced Words and Non-Word Cues from Experiments 2 and 3

Study Words	Test Cues	Study Words	Test Cues	Study Words	Test Cues
accident	accoibent	gangrene	ganbrone	punishment	pumishrent
ache	ashe	germs	gerns	putrid	pufrid
addicted	abbipted	gloom	gfoom	robber	rodder
alone	alove	grief	grielf	rotten	rettan
anguished	anduiched	guilty	guirty	discouraged	digcounaped
blind	blimd	handicap	hambigap	scum	scoam
blister	blicter	hardship	hurdshap	selfish	serfich
bored	bered	headache	hendacke	severe	sevene
broken	brohen	hell	holl	shamed	shoped
bullet	buttet	helpless	holpfess	sickness	sirknoss
burial	bunial	hurt	hort	slave	slanve
cemetery	cenefery	ignorance	ipnovance	slum	sfum
coffin	corfan	illness	ifmess	smallpox	snalfgox
confused	comtlused	impotent	ingotent	starving	scorving
corpse	cordse	infection	impection	stench	sfonch
coward	cevvard	injury	ingory	stupid	stapod
crime	crine	insane	imcane	suffocate	suflocote
criminal	crivinal	insecure	injecore	suicide	soiclide
crisis	crislis	jail	joil	syphilis	syghitis
crude	crube	lice	lince	terrible	terligle
cruel	cnuel	lonely	lomely	tomb	temb
crushed	crusked	loser	lober	toothache	torthiche
damage	darrage	lost	loast	tragedy	trabody
death	deanth	maggot	mappot	trash	trush
debt	dobt	malaria	matavia	troubled	troogled
defeated	defurted	massacre	messagre	ugly	uply
delayed	dehayed	menace	memace	unhappy	umhoppy
depression	debpreppion	messy	mevvy	upset	ugslet
deserter	degerter	misery	midery	useless	utelass
devil	dovil	mistake	miztafe	victim	virclim
dirty	dirly	mold	mord	vomit	vopit
disappoint	disaquoint	morgue	mongue	waste	woste
disgusted	disjusfed	neglect	neglest	weary	weamy
dreadful	dreabtul	obesity	odesity	wounds	wovnds
execution	exacition	offend	ollend	disaster	divacter
false	folfse	overcast	onersast	discomfort	dipconfurt
failure	foilture	paralysis	parobysis	fever	fonver
penalty	pamalty	filth	filjh	pity	pilty
flabby	fladdy	poison	poivon	foul	fovl
poverty	pomerly	funeral	fumenal	prison	privon

Appendix E: High-arousal Words and Non-Word Cues from Experiment 3

Study Words	Test Cues	Study Words	Test Cues	Study Words	Test Cues
Abuse	abduce	exercise	ekeroise	passion	passlon
adventure	abemture	fame	feme	profit	pnolit
afraid	ablaid	fear	feur	promotion	pronolion
alert	afert	feeble	feedle	quick	quilk
ambulance	amdufanse	festive	festine	rage	roge
anger	anper	fight	fipht	rescue	roscune
annoy	ammoy	fire	fime	revolt	reyolt
anxious	arkious	fireworks	fliremorks	roach	rooch
aroused	anouced	flirt	flivt	romantic	ramanfic
assassin	assesgin	graduate	gnabuate	scared	scaned
assault	assauft	happy	haggy	scream	scroom
astonished	aslonisked	hate	hafe	sexy	seky
bees	boos	holiday	halibay	shark	shamk
betray	bafray	horror	hannor	shotgun	shofpun
birthday	blirthpay	hostage	horlage	slap	slep
blackmail	blorknail	hurricane	hurnigame	snake	smeke
bomb	bemb	idiot	ibiat	startled	slarfled
breast	breest	infatuation	imfaluation	stress	struss
brutal	brufal	intercourse	infencoarse	surgery	surgeny
cash	coash	intimate	intirrate	surprised	sunphised
chaos	chleos	intruder	imfnuder	tense	tevse
christmas	chrigstnas	joke	johe	terrified	ferniflied
controlling	canfolling	killer	kiffer	terrorist	temorlist
corrupt	connupt	kiss	kloss	thief	thaef
couple	conple	laughter	lanphter	thrill	thnill
crash	crask	lightning	liphting	tornado	turnabo
crucify	crugity	loved	loned	trauma	trauna
danger	domger	lucky	lurcky	treasure	treazune
demon	derron	lust	lurst	triumphant	triuphont
desire	desline	miracle	minadle	tumor	tulor
destroy	dosfroy	nervous	nenvaus	vampire	vonphire
disloyal	digfoyal	nightmare	nigktmore	vandal	vanbel
drown	dromn	noisy	nolsy	victory	visfory
ecstasy	egstagy	nude	nube	vigorous	viporous
education	edlucafion	obsession	odseccion	violent	vialomt
elated	efated	orgasm	onpasm	volcano	velcamo
engaged	emgoged	outrage	ofunage	weapon	woapen
enraged	envaged	overwhelmed	onerwhelwed	madman	medran
erotic	eronfic	pain	poin	evil	eril
panic	pomic	excitement	exotemunt	party	pavty