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Effects of Emotion on Associative Recognition: Valence and Retention Interval Matter

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Abstract

In two experiments, we examined the effects of emotional valence and arousal on associative binding. Participants studied negative, positive, and neutral word pairs, followed by an associative recognition test. In Experiment 1, with a short-delayed test, accuracy for intact pairs was equivalent across valences, whereas accuracy for rearranged pairs was lower for negative than for positive and neutral pairs. In Experiment 2, we tested participants after a one-week delay and found that accuracy was greater for intact negative than for intact neutral pairs, whereas rearranged pair accuracy was equivalent across valences. These results suggest that, although negative emotional valence impairs associative binding after a short delay, it may improve binding after a longer delay. The results also suggest that valence, as well as arousal, needs to be considered when examining the effects of emotion on associative memory.

Keywords

emotional valence; emotional arousal; associative binding

An essential feature of episodic memory is the ability to bind together disparate elements of an experience into an integrated representation that includes an ensemble of features. The memory of last night's dinner, for example, is likely to include information about who was seated at the table and what food was served. The ability to connect the people, places, and objects comprising an event into a coherent memory has been referred to as associative or relational binding (e.g., Cohen et al., 1999; Naveh-Benjamin, 2000), a terminology that highlights the requirement for an episodic memory to include information not only about individual elements of an experience but also about the way in which those elements are linked together.

It has been debated how emotion affects this binding process. What if we are not remembering the people and the food at last night's dinner, but instead are recalling the shattered glass and the blood at the scene of an accident, or the balloons and the champagne during a celebratory party? Does the emotional salience of these components change the effectiveness with which we can bind them together into an associative representation?

There have been two recent theories that have been put forth to explain the effects of emotion on associative memory, each making a different prediction for the direction of the effect. On the one hand, the "prioritized binding" hypothesis (MacKay et al., 2004) has proposed that arousal preferentially induces binding mechanisms that allow the arousing stimulus to be bound together with information presented concurrently. By this account, the presence of emotionally arousing information should facilitate associative binding. On the other hand, the "object binding" theory (Mather, 2007; see also Kensinger, 2009; Reisberg & Heuer, 2004 for related concepts) has suggested that emotion may facilitate the binding of

intra-item features but may impair the binding of inter-item features. According to this theory, emotional information should be less likely than neutral information to become bound to independent items that are presented concurrently, consistent with earlier proposals suggesting that arousal may impair associative binding (e.g., Jacobs & Nadel, 1998; Payne, Nadel, Britton, & Jacobs, 2004). Both of these theories, however, have emerged from a literature in which a single arousing item is presented in a context (or with another item) that is of a nonemotional nature. In this circumstance, it is likely that another mechanism is at play, a mechanism that does not have to do with binding per se, but rather with the way that information is attended at the outset. It is often true that attention is narrowed onto information that elicits arousal, with processing resources diverted away from other information that is presented concurrently (reviewed by Levine & Edelstein, 2009; Reisberg & Heuer, 2004). If attention is focused on the arousing item, and not on the nonarousing information, then memory for the conjunction of those elements may suffer. This decrement would not reflect an impairment in binding specifically, but rather an impairment in attending to the two event components in order to encode a relation between them. Indeed, for a theory such as the “object binding” theory, it is difficult to tease apart the effects due to attention allocation at encoding and those due to subsequent effects on the way that the information is maintained as a bound representation.

The present study sought to examine the effect of arousal on associative binding under a set of circumstances in which this type of attentional “trade-off” would not be likely to occur: when an arousing word is presented alongside a second arousing word. In this circumstance, any effect of emotion on associative memory would be likely to reflect an effect on binding processes rather than an effect on the way in which attention was allocated during encoding. Under these conditions, two alternative outcomes seemed plausible. If the binding of the arousing information occurs because of the devotion of resources allocated toward the processing of one particular item (MacKay et al., 2004), it is possible that when there are two such items presented—and thus processing resources are divided across the information—that competition for resources will minimize the beneficial effect of arousal on associative binding. Alternately, presenting two arousing items concurrently could lead to a large beneficial effect on binding, either because of the summation of arousal level reached by having two words presented concurrently or because each of the arousing words will trigger a binding mechanism and will therefore boost the likelihood that the relational information is encoded. If the effects of arousal on binding processes are due to the systemic increase in arousal-related neurotransmission (e.g., McGaugh, 2000), then this second outcome would seem likely. The present study adjudicated between these alternatives by asking whether two arousing verbal stimuli will be more likely to be bound together than two neutral stimuli, or whether the presence of arousal will curtail the ability to assemble disparate items into a cohesive representation.

The present study further examined whether the valence of the arousing information would impact the results. Although it has been shown that valence alone (in the absence of arousal) is insufficient to enhance the binding of a stimulus to a neutral item or contextual element (Guillet & Arndt, 2009), the valence of high-arousal stimuli may nevertheless impact the likelihood that binding mechanisms operate at an optimal level. It has been shown previously that intra-item features can be more likely to be remembered for negative arousing stimuli than for positive arousing ones (reviewed by Kensinger, 2009), and so the present study examined whether the binding of distinct items would also benefit from the presence of negative compared to positive valence.

Experiment 1

Experiment 1 examined the ability of participants to remember the associations formed between negative arousing words, positive arousing words, or neutral words by asking them to discriminate “intact,” “rearranged,” and “new” pairs of words. Thus, successful performance required memory for the specific pairings of the words that had been encoded (see Glenberg & Bradley, 1979; Humphreys, 1976). By examining participants’ abilities to discriminate these three types of word pairs, we could distinguish general effects of arousal on associative memory (i.e., those effects that should exist for both the negative and positive word pairs) from those effects specific to one valence or the other.

Method

Participants—The participants were 32 Texas A&M University-Commerce undergraduate students (18–37 years of age, $M = 23.3$, $SD = 4.5$) who participated in exchange for partial course credit. Participants consisted of 11 men (18–37 years, $M = 23.4$) and 21 women (18–35 years, $M = 23.3$).

Materials and design—One hundred forty-four words were selected from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999). One third of the words were negative or low in valence ($M = 2.1$, $SD = .01$), one third were positive or high in valence ($M = 7.7$, $SD = .5$), and the remaining third were neutral or medium in valence ($M = 5.4$, $SD = 2.0$). Mean valences for the negative, positive, and neutral words were all significantly different from each other (all p ’s = .001). We equated the negative and positive words on arousal, but arousal for neutral words was lower than for the negative or positive words (negative words, $M = 5.6$, $SD = .5$; positive words, $M = 5.9$, $SD = 1.4$; neutral words, $M = 4.2$, $SD = .2$).

Negative, positive, and neutral words were matched for word frequency (negative words, $M = 19.0$, $SD = 9.2$; positive words, $M = 28.7$, $SD = 20.5$; neutral words, $M = 24.5$, $SD = 31.1$), word familiarity (negative words, $M = 485$, $SD = 19.1$; positive words, $M = 511$, $SD = 17.7$; neutral words, $M = 492$, $SD = 100.4$), concreteness (negative words, $M = 433$, $SD = 19.1$; positive words, $M = 511$, $SD = 17.7$; neutral words, $M = 492$, $SD = 100.4$), and imaginability (negative words, $M = 461$, $SD = 51.6$; positive words, $M = 491$, $SD = 3.5$; neutral words, $M = 464$, $SD = 63.6$) (Coltheart, 1981; Kučera & Francis, 1967). We also equated the three types of stimulus words on connectivity, which reflects the amount of inter-item relatedness among the words (McEvoy, Nelson, & Komatsu, 1999). Connectivity was equated by constructing matrices for each valence type and identifying the presence of a connection for all combinations of study word pairs in each valence type’s matrix, using the Nelson, McEvoy, and Schreiber (1998) word norms. For each word pair, a nonzero connection strength was scored as a 1, and a zero connection strength was scored as a 0. This analysis yielded a total of 6 nonzero connections for each of three valence types (or an average of .12 connections per study word), reflecting low mean connectivity for the study words. The 144 words were divided into two sets of 72 (24 negative, 24 positive, and 24 neutral words). The sets that served as the study list versus the nonstudied distracters were counterbalanced across participants. These sets were further arranged into 36 pairs (12 negative, 12 positive, and 12 neutral), and none of the paired words were associated according to the Nelson et al. (1998) norms.

For the associative recognition test, 72 pairs were constructed from the study list. Twelve pairs of each valence type were randomly selected to be intact pairs, with words from the remaining 36 pairs serving as rearranged pairs. In addition, 12 pairs of each valence type were taken from the nonstudied list to serve as distracters. Therefore, the recognition test consisted of 108 pairs, and as before, the rearranged pairs were chosen so that the paired

words were not associated. Rearranged word pairs always consisted of two words of the same valence and were presented so that the first word was the first word of a pair that was studied previously and the second word was the second word of a pair that was studied previously. Words were presented on a computer in lower case letters in Times New Roman, 48-point black font for the study pairs and 40-point black font for the test pairs. Word pairs were presented in the middle of the screen, separated by a dash.

Procedure—Participants were tested in small groups of one to three. They were told they would see a series of word pairs on the computer screen that they would need to link together because their memory for the pairs would be tested later. To help link the words in each pair, participants were instructed to silently create a sentence that included both words. Participants were further instructed to make a judgment after creating each mental sentence regarding the difficulty of the task. They were told to press the *Easy* key if the sentence was easy to generate and the *Hard* key if the sentence was difficult to generate. The entire encoding task was self-paced and participants were given as much time as they needed to create the mental sentences. After pressing one of the two keys, the next study pair appeared.

Upon completion of the study phase, participants were given a 15-min distractor task in which they completed a series of mazes. A task was given during the delay interval to reduce variability in how participants filled the time, and the maze completion task was chosen because it would not create verbal interference. After the distractor task, participants were given instructions for the associative recognition test. They were told that they would see a series of word pairs on the computer. Some of the pairs would be presented exactly as they were studied, and for these intact pairs, participants were instructed to press the key labeled *Studied Together*. Other pairs would consist of two words, each of which had been studied previously, but with different words. For these rear-ranged pairs, participants were instructed to press the key labeled *Studied Differently*. Yet other pairs consisted of words that had not been studied previously, and for these new pairs, participants were instructed to press the key labeled *Never Studied*. After ensuring that participants understood the instructions, they were told to begin the test. After completing the test, participants were debriefed, thanked, and dismissed.

Results and Discussion

Participants' responses to the intact, rearranged, and new test pairs as a function of emotional valence are depicted in Table 1. We first examined memory accuracy for the intact pairs. A repeated measures ANOVA with the factor of valence type (negative, positive, neutral) showed no difference in accurate identification of intact pairs as function of valence ($F < 1$). Accuracy for the rearranged pairs, however, showed that there was a main effect of valence type, $F(2, 62) = 5.63, p < .01$, partial $\eta^2 = .15$. Planned comparisons revealed that negative rearranged pairs were correctly recognized at a lower rate than were neutral rearranged pairs, $F(1, 31) = 14.62, p < .01$, partial $\eta^2 = .32$. Participants were also poorer at correctly recognizing negative rearranged pairs than positive rearranged pairs, although the difference was only marginally significant, $F(1, 31) = 3.76, p = .06$, partial $\eta^2 = .11$. Performance on the positive and neutral rearranged pairs did not differ, $F(1, 31) = 1.61, p = .2$. For the nonstudied (i.e., new) word pairs, no significant difference was found across the valence types, $F(2, 62) = 2.33, p = .10$.

These results suggest that negative valence 1 impairs the ability to recollect that words were studied previously with different words. However, when studied pairs are represented at test (i.e., intact pairs), emotional valence appears to have no effect on recognition. To understand why negative valence would impair recognition of rearranged pairs but would not impair

recognition of intact pairs, it is necessary to consider the different processes that may be utilized in the two instances. We describe these processes in terms of a dual-process model of memory, in which recollection and familiarity underlie recall and recognition (see Yonelinas, 2002, for a review). Recollection refers to the retrieval of various types of information relating to an event, including perceptual details, source information, and emotions (Light, Patterson, Chung, & Healy, 2004). In contrast, familiarity refers to a feeling of “oldness” about an event, without the retrieval of specific details (Gallo, Sullivan, Daffner, Schacter, & Budson, 2004). When a test pair is intact, both recollection and familiarity may work together to produce an “intact” (i.e., correct) response, with familiarity of the individual words sometimes being sufficient to guide the correct response of intact. By contrast, for rearranged pairs, familiarity with the individual items would not be sufficient to guide an accurate response and in fact could lead someone to believe that the pair was intact when in fact it was not. In the case of recombined pairs, then, recollection must be used to oppose the sense of familiarity stemming from the presence of both previously studied words (Jacoby, 1991). To figure out that a pair of words is rearranged, individuals often use a recall-to-reject monitoring strategy, recalling the original pairing of one of the words and using that recollected information to reject the current pairing (e.g., Clark, 1992). The present pattern of results, therefore, suggests that the ability to use recollective processes, such as a recall-to-reject strategy, to counteract item familiarity may be impaired by negative valence. Because the success of a recall-to-reject strategy will depend on how well the two items were bound at encoding, the present results suggest that negative valence may impair this binding process.

An important aspect of the current findings is that the difficulty in recognizing rearranged pairs was not equivalent for negative and positive pairs, despite the fact that these pairs were equated in overall arousal. Thus, the present results suggest that it may not be global, arousal-mediated processes that lead to the present results. Rather, there may be special mechanisms at work when information is both high in arousal and also negative in valence. Negative valence has been shown to restrict attention to local features while positive valence has been shown to broaden attention and to encourage more global processing (e.g., Bless et al., 1996; Forgas, Laham, & Vargas, 2005; Gasper & Clore, 2002). As compared to more global or integrative processing, the local processing encouraged by negative valence might convey a disadvantage on an associative memory task.

It is also possible that the effects specific to negative high- arousal items overshadowed the more general effects that would also extend to positive high-arousal items because memory was tested after such a short retention interval. The short delay interval may have prevented us from detecting the more general effects of arousal on memory consolidation, leaving the main effects to be those that were exerted at encoding (such as the attentional effects just described). Experiment 2 addressed this possibility by assessing memory after a longer delay.

Experiment 2

The results of Experiment 1 showed that, after a short delay (15 minutes), associative recognition for rearranged pairs was worse for negative pairs than for positive or neutral pairs, suggesting that negative valence impairs associative binding. In Experiment 2, we asked how valence affected the maintenance of bound representations over a much longer delay between study and test. Previous studies have shown that whereas recognition memory accuracy for neutral stimuli declines over time, accuracy for arousing stimuli remains fairly constant, and sometimes shows an increase over time (LaBar & Phelps, 1998; Sharot & Phelps, 2004). Moreover, the beneficial effects of arousal often emerge only after a delay (e.g., Kleinsmith & Kaplan, 1963), presumably because of the influence of arousal on

memory consolidation processes (e.g., McGaugh, 2004). Although these prior studies have focused either on the effect of arousal on retention of single items (LaBar & Phelps, 1998; Sharot & Phelps, 2004), or of items presented with nonemotional information (Kleinsmith & Kaplan, 1963), arousal may also help to consolidate memory for pairs of items, both of which are arousing. Experiment 2 examined this possibility.

Method

Participants—Thirty-two Texas A&M University-Commerce undergraduate students (18–34 years of age, $M = 21.8$, $SD = 3.8$) participated in exchange for partial course credit. Participants consisted of 14 men (18–25 years, $M = 20.3$) and 18 women (18–34 years, $M = 23.0$).

Materials and design—We used the same stimulus materials and design as in Experiment 1.

Procedure—The procedure was identical to that used in Experiment 1, except that participants returned one week after the study phase to take the associative recognition test.

Results and Discussion

Memory accuracy for the intact, rearranged, and new pairs as a function of emotional valence is reported in Table 2. Analysis of the intact pairs revealed a main effect of valence type, $F(2, 62) = 8.95$, $p = .001$, partial $\eta^2 = .22$. Planned comparisons showed that intact negative pairs were correctly recognized more often than were intact neutral pairs, $F(1, 31) = 20.61$, $p < .001$, partial $\eta^2 = .40$, and were also recognized more often than intact positive pairs, $F(1, 31) = 5.80$, $p < .05$, partial $\eta^2 = .16$. There was no significant difference in performance between intact positive and intact neutral pairs, $F(1, 31) = 2.58$, $p = .12$. For the rearranged pairs, no differences as a function of valence type were found, $F(2, 62) = 1.12$, $p = .33$. However, correct rejection of new pairs did differ across valence types, $F(2, 62) = 17.35$, $p < .001$, partial $\eta^2 = .36$. Planned comparisons showed that correct rejection of new negative pairs was lower than that of new neutral pairs, $F(1, 31) = 22.63$, $p < .001$, partial $\eta^2 = .42$, and also lower than that of new positive pairs, $F(1, 31) = 25.12$, $p < .001$, partial $\eta^2 = .45$. Correct rejection of new positive and neutral pairs did not differ, ($F < 1$).

These results point to three notable effects of a longer delay on emotional associative recognition. First, after a long delay, negative valence increased the tendency for participants to make errors in the classification of new pairs. When the distribution of responses to new pairs was examined, it became clear that participants became more likely to judge new negative pairs as intact relative to neutral and positive pairs (see Table 2). Further evidence in support of this conclusion comes from directly comparing the results of Experiments 1 and 2. Analysis of the change in intact responses to new pairs between a same-day and a 1-week delay showed that the increase in such errors was greater for negative pairs than for neutral pairs, $F(1, 62) = 4.40$, $p < .05$, partial $\eta^2 = .07$, and was also greater for negative than for positive pairs, $F(1, 62) = 5.06$, $p < .05$, partial $\eta^2 = .08$. Second, a lengthy delay enabled participants to increase their relative accuracy in recognizing intact negative pairs compared to neutral or positive pairs; in other words, the memory accuracy advantage for identifying intact negative pairs increased across the delay. This relative increase in accuracy for negative pairs persisted even when participants' tendency to call test items intact (i.e., response bias) was taken into account. We subtracted incorrect intact responses to rearranged test pairs from correct intact responses to intact pairs and then compared this measure across experiments. Analysis of these corrected scores across the 1-week delay showed that they declined more for neutral than for negative pairs,

$F(1, 62) = 4.58, p < .05$, partial $\eta^2 = .07$. There was no significant difference between negative and positive corrected scores, $F(1, 62) = 1.90, p = .17$, nor did positive and neutral scores differ, ($F < 1$). Finally, a lengthy delay appeared to increase the relative accuracy in correctly recognizing negative rearranged pairs compared to neutral pairs. Again, we analyzed the decline in performance across the delay, which revealed that correct recognition of negative rearranged pairs declined less than it did for neutral pairs, $F(1, 62) = 5.01, p < .05$, partial $\eta^2 = .07$. Recognition of negative rearranged pairs also declined less than it did for positive pairs, although this difference was only marginally significant, $F(1, 62) = 3.19, p = .08$. The decline in performance for neutral and positive rearranged pairs did not differ, ($F < 1$).

The results of Experiment 2 reveal that the beneficial effects of emotion become apparent after a long delay. However, even after the week-long delay, the benefits do not seem to reflect general arousal effects that extend equally to negative and positive high- arousal items. Rather, the effects of emotion are exaggerated for negative valence as compared to positive valence, suggesting that valence, as well as arousal, may influence the retention of associative information. The combined results of Experiments 1 and 2 also reveal that whether negative valence enhances or hinders associative memory depends on the delay after which memory is assessed. Although associative recognition was impaired for negative items following a short delay (Experiment 1), the negative word pairs were more accurately recognized after a long delay (Experiment 2). The implications of these findings will be expanded upon in the General Discussion.

General Discussion

The general pattern of results revealed across the two experiments is consistent with prior evidence that the beneficial effects of emotion often become apparent only after a delay (e.g., Kleinsmith & Kaplan, 1963; LaBar & Phelps, 1998). Emotion did not convey a memory advantage after a short delay (Experiment 1), whereas it did enhance associative memory after a long delay (Experiment 2). Moreover, comparisons between the experiments revealed that emotion led to less of a degradation in memory over time than occurred for the neutral items.

In contrast to prior proposals that have described the effects of emotion in terms of arousal-mediated influences, the present study suggests that valence may need to be considered. None of the effects revealed in the present study extended equally to the negative and the positive high-arousal items. In Experiment 1, the detrimental effects of emotion were apparent only for negative items and not for positive ones, and in Experiment 2, the advantage conveyed for emotional items was much greater for the negative items than it was for the positive items. Because the negative and positive words were equated for arousal, this pattern of results makes it unlikely that the effects revealed here were due solely to the influence of arousal on memory. Neither the “prioritized binding” theory nor the “object binding” can explain these findings, because both focus on general effects of arousal which should extend to items of both positive and negative valence. Whereas these theories have focused on how general arousal affects associative binding of an emotional item to a nonemotional item, the present findings suggest that when two emotional items must be bound together, valence must also be considered in order to understand how emotion affects that binding process. Some of these valence-specific effects could be related to divergent processes at encoding. It is well documented that positive and negative emotions can have different effects on information processing. Positive emotions often lead to a broadening of attention and to global and heuristic processing. Negative emotions, by contrast, tend to encourage more local, item-based processing. These differences may be particularly influential when memory is assessed over a short interval (as in Experiment 1). It is,

therefore, possible that negative valence impaired performance for the rearranged pairs after the short delay (Experiment 1) because negative valence encouraged each item to be processed in isolation, a type of strategy that would be counterproductive to formation of an associated representation.

After a longer delay, the valence-specific effects likely have more to do with how information is consolidated and maintained in a bound representation over time. If negative high-arousal information undergoes differential consolidation, this would explain why memory for negative items would be enhanced after a long delay compared to a short one. Although most models of emotion's effects on consolidation have focused on general arousal-based processes (e.g., McGaugh, 2004), there have been recent studies that have suggested that some types of consolidation processes (e.g., those that occur during sleep) may be particularly likely to select *negative* information for consolidation (see Walker & Stickgold, 2006 for evidence that sleep deprivation can differentially affect negative vs. positive information). The present results may represent the behavioral outcome of those differential consolidation processes.

Although our discussion has focused on the effect of negative valence on recognition accuracy, it is important to note that negative valence also seems to lead to a bias to believe that new word pairs have previously been studied. This finding is consistent with prior research suggesting that emotion leads to response biases and can yield confident memories even for events that have never occurred (e.g., Dougal & Rotello, 2008; Sharot, Delgado, & Phelps, 2004; Windmann & Kutas, 2001). The finding also is consistent with literature suggesting that such biasing effects may be particularly pronounced when items are both negative in valence and also high in arousal, perhaps because the negative items tend to be processed more fluently than neutral items, leading to a misplaced sense of familiarity (e.g., Kitayama, 1990; Windmann & Kutas, 2001).

Perhaps because these changes in perceived item familiarity would not affect the likelihood that participants could discriminate intact from rearranged pairs, the effects of negative arousal on associative recognition appear to exist despite the effects on response bias. Thus, it may be that negative arousal yields two distinct effects: one on response bias and another on associative binding. Although future research will be needed to examine whether the mechanisms supporting these effects are indeed dissociable, the present research suggests that this will be a worthwhile avenue for further study.

In summary, the results of this research reveal that when it comes to remembering two emotional words that were paired together at encoding, there are not global effects of arousal that generalize across valence. Rather, the effects are valence-specific, with negative arousal having the largest impact on associative memory. The direction of this effect depends upon the delay after which memory is tested, with negative arousal initially leading to poorer associative memory than positive arousal (Experiment 1) but resulting in enhanced associative memory as compared to positive arousal after a delay (Experiment 2). These findings emphasize the need to consider both valence and delay interval when examining how emotion affects associative memory, and the results further suggest that there are important differences between the effects of emotion on early phases of memory formation and storage (apparent after a short delay) and on later stages of consolidation (which become relevant after a longer delay).

References

- Bless H, Clore GL, Schwarz N, Golisano V, Rabe C, Wolk M. Emotion and the use of scripts: Does a happy emotion really lead to mindlessness? *Journal of Personality and Social Psychology*. 1996; 71:665–679. [PubMed: 8888596]

- Bradley, MM.; Lang, PJ. Affective norms for English words [CD-ROM]. Gainesville: University of Florida, NIMH Center for the Study of Emotion and Attention; 1999.
- Clark SE. Word frequency effects in associative and item recognition. *Memory & Cognition*. 1992; 20:231–243.
- Cohen NJ, Ryan J, Hunt C, Romine L, Wszalek T, Nash C. Hippocampal system and declarative (relational) memory: Summarizing the data from functional neuroimaging studies. *Hippocampus*. 1999; 9:83–98. [PubMed: 10088903]
- Coltheart M. The MRC psycholinguistic database. *Quarterly Journal of Experimental Psychology*. 1981; 33A:497–505.
- Dougal S, Rotello CM. “Remembering” emotional words is based on response bias, not recollection. *Psychonomic Bulletin and Review*. 2007; 14:423–429. [PubMed: 17874582]
- Forgas JP, Laham SM, Vargas PT. Mood effects on eyewitness testimony: Affective influences on susceptibility to misinformation. *Journal of Experimental Social Psychology*. 2005; 41:574–588.
- Gallo DA, Sullivan AL, Daffner KR, Schacter DL, Budson AE. Associative recognition in Alzheimer’s disease: Evidence for impaired recall-to-reject. *Neuropsychology*. 2004; 18:556–563. [PubMed: 15291733]
- Gasper K, Clore GL. Attending to the big picture: Mood and global versus local processing of visual information. *Psychological Science*. 2002; 13:34–40. [PubMed: 11892776]
- Glenberg AM, Bradley MM. Mental contiguity. *Journal of Experimental Psychology: Human Learning, Memory, and Cognition*. 1979; 5:88–97.
- Guillet R, Arndt J. Taboo words: The effect of emotion on memory for peripheral information. *Memory & Cognition*. 2009; 37:866–879.
- Humphreys MS. Relational information and the context effect in recognition memory. *Memory & Cognition*. 1976; 4:221–232.
- Jacobs WJ, Nadel L. Neurobiology of reconstructed memory. *Psychology, Public Policy, and Law*. 1998; 4:1110.
- Jacoby LL. A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*. 1991; 30:513–541.
- Kensinger EA. Remembering the details: Effects of emotion. *Emotion Review*. 2009; 1:99–113. [PubMed: 19421427]
- Kitayama S. Interaction between affect and cognition in word perception. *Journal of Personality and Social Psychology*. 1990; 58:209–217. [PubMed: 2319441]
- Kleinsmith LJ, Kaplan S. Paired-associate learning as a function of arousal and interpolated interval. *Journal of Experimental Psychology*. 1963; 65:190–193. [PubMed: 14033436]
- Kučera, H.; Francis, WN. Computational analysis of present-day American English. Providence, RI: Brown University Press; 1967.
- LaBar KS, Phelps EA. Arousal-mediated memory consolidation: Role of the medial temporal lobe in humans. *Psychological Science*. 1998; 9:490–493.
- Levine LJ, Edelman RS. Emotion and memory narrowing: A review and goal-relevance approach. *Cognition and Emotion*. 2009; 23:833–875.
- Light LL, Patterson MM, Chung C, Healy MR. Effects of repetition and response deadline on associative recognition in young and older adults. *Memory & Cognition*. 2004; 32:1182–1193.
- MacKay DG, Shafto M, Taylor JK, Marian DE, Abrams L, Dyer JR. Relations between emotion, memory, and attention: Evidence from taboo stroop, lexical decision, and immediate memory tasks. *Memory & Cognition*. 2004; 32:474–488.
- Mather M. Emotional arousal and memory binding: An object- based framework. *Perspectives on Psychological Science*. 2007; 2:33–52.
- McEvoy CL, Nelson DL, Komatsu T. What is the connection between true and false memories? The differential roles of inter-item associations in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1999; 25:1177–1194.
- McGaugh JL. Memory—a century of consolidation. *Science*. 2000; 287:248–251. [PubMed: 10634773]

- McGaugh JL. The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience*. 2004; 27:1–28.
- Naveh-Benjamin M. Adult age differences in memory performance: Tests of an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2000; 26:1170–1187.
- Nelson, DL.; McEvoy, CL.; Schreiber, TA. The University of South Florida word association, rhyme, and word fragment norms. 1998. Retrieved from <http://www.usf.edu/FreeAssociation>
- Payne, JD.; Nadel, L.; Britton, WB.; Jacobs, WJ. The biopsychology of trauma and memory. In: Reisberg, D.; Hertel, P., editors. *Emotion and memory*. Oxford, England: Oxford University Press; 2004. p. 76-128.
- Reisberg, D.; Heuer, F. Remembering emotional events. In: Reisberg, D.; Hertel, P., editors. *Memory and emotion*. New York: Oxford University Press; 2004. p. 3-41.
- Sharot T, Phelps EA. How arousal modulates memory: Disentangling the effects of attention and retention. *Cognitive Affective Behavioral Neuroscience*. 2004; 3:294–306.
- Sharot T, Delgado MR, Phelps EA. How emotion enhances the feeling of remembering. *Nature Neuroscience*. 2004; 7:1376–1380.
- Walker MP, Stickgold R. Sleep, memory and plasticity. *Annual Review of Psychology*. 2006; 57:139–166.
- Windmann S, Kutas M. Electrophysiological correlates of emotion-induced recognition bias. *Journal of Cognitive Neuroscience*. 2001; 13:577–592. [PubMed: 11506658]
- Yonelinas AP. The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory & Language*. 2002; 46:441–517.

Table 1

Participant Responses for Test Pairs in Experiment 1 as a Function of Pair Type and Valence

Test pair type	Valence type		
	Negative	Positive	Neutral
Intact			
Intact	.90 (.03)	.90 (.02)	.89 (.03)
Rearranged	.07 (.02)	.07 (.02)	.07 (.02)
New	.03 (.02)	.03 (.02)	.04 (.02)
Rearranged			
Intact	.22 (.03)	.22 (.04)	.11 (.03)
Rearranged	.68 (.04)	.76 (.05)	.82 (.04)
New	.09 (.02)	.03 (.01)	.07 (.02)
New			
Intact	.03 (.02)	.00 (.00)	.02 (.01)
Rearranged	.14 (.03)	.10 (.03)	.10 (.03)
New	.83 (.04)	.89 (.03)	.89 (.03)

Note. Standard errors of the mean are in parentheses.

Table 2

Participant Responses for Test Pairs in Experiment 2 as a function of Pair Type and Valence

Test pair type	Valence type		
	Negative	Positive	Neutral
Intact			
Intact	.69 (.05)	.56 (.05)	.47 (.05)
Rearranged	.24 (.04)	.33 (.04)	.35 (.04)
New	.05 (.02)	.11 (.03)	.17 (.03)
Rearranged			
Intact	.38 (.04)	.38 (.04)	.27 (.04)
Rearranged	.48 (.04)	.41 (.05)	.45 (.04)
New	.15 (.03)	.21 (.04)	.28 (.04)
New			
Intact	.18 (.04)	.06 (.03)	.08 (.03)
Rearranged	.40 (.03)	.29 (.04)	.27 (.04)
New	.42 (.05)	.65 (.04)	.65 (.05)

Note. Standard errors of the mean are in parentheses.