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Source Memory Enhancement for Emotional Words

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The influence of emotional stimuli on source memory was investigated by using emotionally valenced words. The words were colored blue or yellow (Experiment 1) or surrounded by a blue or yellow frame (Experiment 2). Participants were asked to associate the words with the colors. In both experiments, emotionally valenced words elicited enhanced free recall compared with nonvalenced words; however, recognition memory was not affected. Source memory for the associated color was also enhanced for emotional words, suggesting that even memory for contextual information is benefited by emotional stimuli. This effect was not due to the ease of semantic clustering of emotional words because semantically related words were not associated with enhanced source memory, despite enhanced recall (Experiment 3). It is suggested that enhancement resulted from facilitated arousal or attention, which may act to increase organization processes important for source memory.

Emotional or arousing stimuli can influence memory in a variety of ways. Indeed, the integration of cognitive, biological, and social psychology has significantly advanced our understanding of emotions (for a review, see Cahill & McGaugh, 1998; Posner, Rothbart, & Harman, 1994). In many situations, such stimuli enhance or facilitate learning and memory. For example, in a positron emission tomography (PET) study, Hamann, Ely, Grafton, and Kilts (1999) assessed memory for emotional versus neutral pictures. Emotional pictures were better remembered than neutral pictures, and this effect was correlated with amygdala activation during encoding (see also, LaBar & Phelps, 1998; Phelps et al., 1998). In another study (Cahill, Prins, Weber, & McGaugh, 1994), propranolol hydrochloride, a β-adrenergic antagonist, reduced memory for a story presented in an emotional context but not for a story presented in a neutral context. Thus, an antianxiety drug abolished a memory enhancement effect normally associated with emotional stimuli. These findings, as well as those obtained in animal studies, suggest that emotions enhance learning and memory by engaging biological systems that include the amygdala and adrenergic mechanisms (for a review, see LeDoux, 1996; Metcalfe, 1998).

In contrast, other researchers have proposed that heightened emotion can impair or even repress associated memories (Brewin, 1997; for a review, see Christianson, 1992; Read & Lindsay, 1997). The *trauma-memory* argument, as described and viewed cautiously by Kihlstrom (1995), suggests that severe emotions elicited by a trauma can cause amnesia for that event. Of course, the events capable of inducing such amnesia may not be amenable to experimental manipulation. However, even the kinds of emotional stimuli available to empirical investigations may disrupt certain aspects of memory. For example, as implied by Easterbrook (1959), attentional focus toward emotional stimuli may occur at the expense of attention, and hence memory, for contextual or source information (see also Safer, Christianson, Autry, & Oesterlund, 1998).

Source memory refers to the episode or context in which some information was presented (for a review, see Johnson, Hashtroudi, & Lindsay, 1993). In everyday situations, source memory can include such things as the location where the information was encountered or the individual who presented the information. Such information can be obtained incidentally or with the intention to learn. Jurica and Shimamura (1999) observed an *item-source memory tradeoff* in which enhanced item memory occurred at the expense of source memory. In that experiment, item memory

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was boosted by having participants generate answers to topical questions (e.g., "What types of sports are commonly watched on television?"). Memory for these items was compared with memory for items simply read as statements (e.g., "Many people think that dogs make great pets"). Questions and statements were presented by one of three faces on a computer screen. Although a positive generation effect occurred for items presented as questions, a negative generation effect occurred for source memory. That is, memory for the person associated with an item was poorer when items were presented as questions than when they were presented as statements. In this case, enhancement of item memory was associated with an impairment of source memory.

To what extent will emotional enhancement of item memory affect source memory? In Experiment 1, neutral and emotional words were presented for study. Half of the words were colored yellow, and half of the words were colored blue. During testing, we assessed free recall for the items and source recognition memory. In the source test, participants were asked to determine whether a test word was originally presented in yellow or in blue, or whether it was a new word. If emotional stimuli boost memory for the entire episode, then emotional enhancement of item memory will lead to an enhancement of source memory—that is, improvements in memory for the appearance of the words (blue vs. yellow). Alternatively, an item-source tradeoff may occur in which enhancement of emotional items leads to a degradation in source memory.

Experiment 1

Method

Participants. Twenty-four undergraduates (8 men and 16 women) from the University of California, Berkeley, were recruited and received course credit for their participation. The participants averaged 19.6 years of age and 13.4 years of education.

Stimuli and design. Word sets were obtained from a pool of 128 words, which included 64 neutral words and 64 emotional words. Of the 64 emotional words, 32 had a pleasant valence (e.g., *glory, sunrise*) and 32 had an unpleasant valence (e.g., *emergency, slaughter*). Emotional valence was based on pleasantness ratings ranging from 1 (*very unpleasant*) to 7 (*very pleasant*), obtained in a pilot study (criterion: unpleasant ≤2.5, pleasant ≥5.25). The words were divided into two sets (identified as Sets A and B), each consisting of 32 neutral words and 32 emotional words (16 pleasant and 16 unpleasant words). Across the two sets, the words in each condition (neutral vs. emotional words) were matched with respect to word frequency norms (neutral words = 39.7, emotional words = 35.0; Francis & Kucera, 1982).

Study and test phases were presented by using a Macintosh microcomputer. Stimuli were created with Aldus SuperPaint (1991) and presented by using SuperLab software (1992). In the study phase, participants were presented the A or B word set. Half of the words in each word condition (neutral vs. emotional) were colored yellow, and the other half were colored blue (Geneva font, 48 pt.). The order of the words and the determination of which set would be used in the study phase (Set A or B) was randomized.

The test phase began with a surprise free-recall test in which participants were given 5 min to recollect as many of the presented words as possible. A source recognition test followed in which all words from Sets A and B (64 old words and 64 new words) were presented in random order. Test words were presented in black type, and participants were asked to determine whether a test word was originally presented in yellow type or in blue type, or whether it was a new word.

Procedure. For the study phase, participants were instructed to read each word silently as it appeared on the monitor and to remember the color in which it appeared. Each stimulus was presented for 2 s with an intertrial interval of 1 s. To control for primacy and recency effects, we presented three buffer words at the beginning of the list and three buffer words at the end of the list. These buffer words were not included in the analysis of the results.

Prior to the test phase, a 5-min filler task was administered in which participants solved mathematical problems. The free-recall test followed in which participants reported as many words as possible; identification of the original color was not required. Following the recall test, the source recognition test was presented. Participants were instructed to press the *1* key if they thought that a test word was originally colored yellow, the *2* key if they thought that a test word was originally colored blue, and the *3* key if they thought that the test word was a new item.

Results and Discussion

An alpha level of .05 was used for all statistical tests. Participants recalled significantly more emotional words (15.0 ± 7.7%) than neutral words (6.9 ± 6.6%), $F(1, 23) = 37.65$, $p < .01$. Thus, we observed memory enhancement for the emotional items on a free-recall test. In this and subsequent analyses, pleasant and unpleasant words were grouped together as there were no significant differences between these two subgroups.

Data from the source recognition test (see Table 1) were analyzed in two ways. First, for emotional and neutral words, we calculated the mean correct response to the source question (was a word presented in yellow or blue, or was it a new word?). On the basis of these responses, we assessed item (old or new) recognition and source recognition performance. For item recognition, hit rate was defined as old words identified as yellow or blue (i.e., not identified as new). False-alarm rate was defined as the percentage of new words identified as yellow or blue. As indexed by hits minus false alarms, item recognition performance was not significantly different for neutral (51.8 ± 17.4%) and emotional (52.4 ± 18.6%) words, $F(1, 23) = 0.02, p > .05$. This result was also obtained in signal-detection analyses. Specifically, the sensitivity parameter, d', was not significantly different between neutral ($d' = 1.61$) and emotional ($d' = 1.58$) words, $F(1, 23) = 0.08, p > .05$. Source memory performance was determined by the proportion of old items whose associated source information was correctly identified. Source memory for the color associated with a study item was significantly better for emotional words (53.5 ± 16.0%) than for neutral words (45.2 ± 15.9%, chance = 33%), $F(1, 23) = 15.49, p < .01$.

In a second analysis, we developed multinomial models of item and source memory performance (see Batchelder & Reifer, 1990; Bayen, Murnane, & Erdfelder, 1996; Dodson, Prinzmetal, & Shimamura, 1998). In these models, parameters associated with item memory, source memory, and guessing biases can be estimated from the data. In our analysis, we used a modified version of a class of models developed by Batchelder and Reifer (1990). We obtained a model that fit well for both the neutral and emotional data sets. In this case, we used a two–high-threshold variant of Model 6C described by Batchelder and Reifer and modified by Bayen et al. (1996). We then fixed parameters between the data sets for neutral and emotional stimuli (for further details, see Dodson et al., 1998). On the basis of a goodness-of-fit measure, the log-likelihood statistic G^2, the model fit the data well even when we equated the item memory parameter for emotional and neutral stimuli ($G^2 = 1.51, p = .47$). However, when we equated the source memory parameters and freed the item memory parameters, there was a significant discrepancy between the observed data and the model ($G^2 = 9.4, p = .01$). This result affirms the finding that source memory was significantly better for emotional stimuli than for neutral stimuli.

Table 1
Mean Performance Rates (in Percentages) for Neutral and Emotional Words in Experiments 1–3

Word group	Free recall	Yes–No recognition (Hits – FA)	Source recognition
Experiment 1			
Neutral	6.9	51.8 (69.8 – 18.0)	44.6
Emotional	15.0	52.4 (73.7 – 21.3)	53.4
Experiment 2			
Neutral	6.1	39.8 (65.8 – 26.0)	44.3
Emotional	12.5	45.4 (73.2 – 28.0)	49.2
Experiment 3			
Neutral	7.3	40.8 (62.0 – 21.2)	42.7
Category	21.1	45.4 (67.1 – 21.7)	45.2

Note. FA = false alarms.

Experiment 2

In Experiment 1, item recall and source memory were enhanced by emotionally valenced word stimuli. Source memory was defined as the physical appearance (i.e., color) of the actual target items. That is, source information was spatially integrated with item information. Thus, it is possible that the focused attention to the emotional items concomitantly focused attention to the source information. To explore this possibility, we conducted another experiment with source information separated and spatially displaced from the items themselves. Emotional and neutral words were presented in black type against a white background. Surrounding the background was a border that was colored blue or yellow. When source information is peripheral to item information, will emotional enhancement facilitate source memory?

Method

Participants. Twenty-four undergraduates (7 men and 17 women) from the University of California, Berkeley, were recruited and received course credit for their participation. The participants averaged 19.9 years of age and 13.3 years of education.

Stimuli and design. The design of this experiment was nearly identical to that used in Experiment 1. The only difference was the manner in which source information was associated with the words. Rather than presenting the words in blue or yellow type, we presented study words in black type against a white rectangular background (18 cm × 14 cm). The background was framed with a blue or yellow border with a width of 1.5 cm. Thus, source information was displaced spatially from the words themselves. In this way, the colors were less central and could be considered more contextual in nature.

Results and Discussion

As in Experiment 1, participants recalled significantly more emotional words (12.5 ± 6.6%) than neutral words (6.1 ± 4.0%), $F(1, 23) = 22.35$, $p < .01$. Also, analyses of the data from the source recognition test (Table 1) revealed the same source memory enhancement effect observed in Experiment 1. Item recognition memory was not significantly different between neutral and emotional items, whether indexed by hit minus false-alarm rates (neutral = 39.8 ± 19.6%; emotional = 45.4 ± 17.8%), $F(1, 23) = 3.71$, $p > .05$) or by signal-detection analyses of d' (neutral words, $d' = 1.30$; emotional words, $d' = 1.40$), $F(1, 23) = 0.63$, $p > .05$. However, source memory for the color associated with study words was significantly better for emotional words (49.2 ± 12.3%) compared with neutral words (44.3 ± 14.8%), $F(1, 23) = 4.74$, $p < .05$.

As in Experiment 1, source memory was also analyzed by using multinomial models of source memory performance. We thus estimated parameters from the recognition data sets associated with item memory, source memory, and guessing biases. We used a two–high-threshold variant of Model 6C (Batchelder & Reifer, 1990; Bayen et al., 1996; Dodson et al., 1998). Once again, when we fixed source memory parameters and freed the item memory parameters, there was a significant discrepancy between the observed data and the model ($G^2 = 9.6$, $p = .01$) Thus, both subject-based and model-based analyses suggest that source memory increased by the presentation of emotional stimuli.

Experiment 3

In Experiments 1 and 2, both item and source memory were enhanced by emotionally laden stimuli. This finding was observed despite the spatial separation of source information (color) from the word (Experiment 2). It may be that this enhancement arose from semantic clustering rather than the emotional valence of the words. That is, benefits in source memory may have resulted from unconsciously clustering the emotional words into the categories "positive" and "negative." To investigate this possibility, we compared source memory associated with category exemplars ("vehicles" and "dwellings") with source memory associated with unrelated neutral words. Free recall for related words is generally superior to unrelated words. To the extent that source memory enhancement is mediated by clustering, the category words should incur benefits in source memory performance. However, if emotional arousal is mediating source memory enhancement, these category words may not produce a source memory enhancement.

Method

Participants. Twenty-four undergraduates from the University of California, Berkeley, were recruited and received course credit for their participation.

Stimuli and design. The design was identical to that used in Experiment 2, except the emotionally valenced words were replaced by category exemplars from two categories obtained from Battig and Montague (1969). Thirty-two exemplars were chosen from each of the categories, "vehicles" (e.g., *boat, taxi*) and "dwellings" (e.g., *bungalow, dormitory*). The words were randomly divided such that 16 of the vehicle words and 16 of the dwelling words were placed in Set A, and the remaining words were placed in Set B. Word frequencies were balanced across sets.

Results and Discussion

Participants recalled significantly more related words (21.1 ± 7.4%) than neutral words (7.3 ± 4.3%), $F(1, 23) = 104$, $p < .01$. Thus, categorized words were much better recalled than unrelated words. Item recognition memory was not significantly different between categorized and neutral words with respect to hit minus false-alarm rates (category = 45.4 ± 16.1%; neutral = 40.8 ± 14.0%), $F(1, 23) = 2.309$, $p > .05$, or to signal-detection analyses of d' (categorized words, $d' = 0.77$; unrelated words, $d' = 1.10$), $F(1, 23) = 0.26$, $p > .05$. Interestingly, analyses of source memory performance (Table 1) did not reveal an enhancement for the categorized words. That is, source memory was not significantly different between categorized words (45.2 ± 15.1%) compared with unrelated words (42.7 ± 16.6%), $F(1, 23) = 0.840$, $p > .05$. The findings from this experiment suggest that the source memory enhancement for emotional stimuli cannot be purely explained by the effects of semantic clustering.

General Discussion

Findings from these experiments suggest that emotionally valenced words enhance source memory. Specifically, memory for the color in which words were typed was better for emotional words than for neutral words (Experiment 1). This effect was observed even when the colors were spatially separated as frames that bordered the words (Experiment 2). In both Experiments 1 and 2, emotional stimuli also enhanced free recall, a result that replicates previous findings (Hamann et al., 1999). Item recognition, however, was not significantly enhanced by the emotional content of the words. As shown in Experiment 3, source memory enhancement was not purely the consequence of semantic clustering. In that experiment, semantically related words increased free recall compared with unrelated words, but source memory performance was not comparably enhanced.

The present findings do not support an item–source tradeoff in which emotional stimuli act to increase item-specific memory while reducing source memory. Such views have been proposed to account for the effects of emotional stress on memory (see Burke, Heuer, & Reisberg, 1992; Christianson, 1992). For example, emotional stress has been thought to elicit a kind of "tunnel vision" in which attention is narrowed and awareness of surrounding (source) information is reduced. This notion is inherent in the cue-utilization view proposed by Easterbrook (1959), and was supported in a series of studies by Safer et al. (1998). In the latter set of experiments, Safer et al. found that participants tended to remember emotionally arousing pictures as having narrowed boundaries relative to their original presentation. In contrast, neutral pictures were remembered as having extended boundaries relative to their original presentation. They suggested that the results reflected increased attention to the central details that were the focus of the emotional arousal, while inhibiting processing of peripheral information (see also Pratto & John, 1991).

Although our data appear to contrast this approach, it may be the case that the effect of emotional valence associated with word stimuli (e.g., *jealousy, slaughter*) is somewhat different from the emotional valence associated with pictures. Indeed, emotionally valenced words do not appear to evoke the magnitude or quality of emotional (i.e., autonomic) response that pictures (particularly negatively valenced pictures) tend to evoke. Although interestingly, emotionally valenced words were recently shown to elicit increased activation in the amygdala compared with neutral words (Strange, Henson, Friston, & Dolan, 2000). Perhaps rather mild increases in emotional response or arousal act to enhance source memory up to an optimal point beyond which source memory is disrupted. That is, the effect of emotion on source memory may reflect a form of Yerkes–Dodson law (see Christianson, 1992).

Another difference between mild and more significant forms of emotional stimuli surrounds the distinction between arousal and valence. Some researchers argue that these two aspects of emotion embody two orthogonal dimensions that account for most of the variance in presentations of emotional stimuli (e.g., Russell, 1980). Safer et al. (1998) used stimuli that were both negatively valenced and arousing. Because emotionally valenced words are not generally viewed as intensely arousing, the effect of enhanced source memory may be less related to significantly activated autonomic responses and more related to the activation of memory representations that are associated with personal emotional memories. For example, emotionally valenced words, such as *jealousy,* may activate related autobiographical memories, enhancing both item and source memory for the presented word. That is, such words induce activations that are specifically clustered or associated with personal experiences rather than clustered in terms of purely semantic associations. By this view, the effect of autonomic and limbic (i.e., amygdala) responses associated with arousal may not be adequate in accounting for source memory enhancement associated with emotionally valenced words. This view is consistent with findings by Phelps, LaBar, and Spencer (1997), who found that patients with unilateral medial temporal lobe lesions (including the amygdala) were not differentially impaired at remembering emotionally valenced words compared with neutral words. These patients, however, were impaired in a fear-conditioning paradigm.

It is important to note that attentional effects for emotional stimuli appear to be qualitatively different from other effects associated with selective attention or cue utilization. Indeed, Jurica and Shimamura (1999) observed an item–source tradeoff by using the robust phenomenon of the generation effect to focus attention on item memory. In that study, enhanced memory for items that were generated resulted in a decrement (i.e., a negative generation effect) for source memory. In the present study, emotional words enhanced item free recall and additionally enhanced source recognition.

The lack of an emotional effect for item recognition suggests that not all aspects of memory are enhanced by emotional stimuli. The selective benefit to free recall and source recognition implies that emotional words may be facilitated by organizational or elaborate processes (similarly suggested by Phelps et al., 1997). However, this facilitation is not simply a byproduct of enhanced interitem (semantic) organization or item memorability alone (Experiment 3). We suggest that the organization factor may be the association of emotionally valenced words to personal or autobiographical memory (rather than semantic memory). One useful metaphor by which to characterize the distinction between arousing, autonomic, or limbic factors and autobiographical or personal factors associated with emotional stimuli is to use Metcalfe's (1998) notion of "hot" and "cool" aspects of memory. Metcalfe proposed that the amygdala is associated with hot aspects of memory, whereas the hippocampus is associated with cool aspects of memory. In our view, there are also hot (autonomic or amygdala) and cool (memory representations) aspects associated with emotions.

Interestingly, both the anterior and posterior cingulate cortex has been implicated as part of the neural circuitry involved in emotions. Bush, Luu, and Posner (2000) reviewed evidence suggesting that the anterior cingulate cortex mediates attentional mechanisms associated with processing emotional stimuli. With respect to the posterior cingulate cortex, Maddock (1999) conducted a meta-analysis of neuroimaging studies that compared conditions using emotionally valenced words with conditions using neutral words. The posterior cingulate cortex (often referred to as the *retrosplenial cortex*) was particularly active during presentation of emotional stimuli (see also Vogt, Absher, & Bush, 2000). This brain region has also been associated with activation during episodic memory retrieval (see Maddock, 1999). One possibility is that the posterior cingulate is involved in the integration of emotional and autobiographical memory.

Finally, it is important to consider ways in which source memory is construed in experimental paradigms. In the present study, source memory was defined as color information associated with a study item. Features of a learning event (e.g., color of stimuli, location of stimuli, voice used to present stimuli) have been typical aspects of source memory used in cognitive studies (Dodson & Shimamura, 2000; Nolde, Johnson, & D'Esposito, 1998; Wilding & Rugg, 1997). These aspects of an event reflect the kinds of contextual information generally viewed as part of the source or episode around which information is learned. There are, however, other, more general ways in which to construe source information. For example, source memory could be viewed as the global scene or spatial context surrounding an event. Additionally, the manner in which source information becomes the focus of an episode may influence the degree to which such information is remembered. For example, in the present study, participants were asked to learn both items and associated source information (i.e., intentional learning of source information). In real-life situations, such as being a witness to a crime, source information is often learned in an incidental manner. In previous studies of source memory, intentional learning instructions have been used, but they do not necessarily link item memory with source memory. As mentioned earlier, Jurica and Shimamura (1999) observed a negative effect on source memory when participants focused attention on item information. In that study, participants were given intentional learning instructions to associated item and source information. It remains, however, an important question whether effects of emotional stimuli on source memory are affected by manipulations of the intention to learn.

In summary, these experiments suggest that the emotional valence of words can act to facilitate source memory and that this effect cannot be explained by semantic clustering effects. We propose that such emotional effects may be mediated by two processes. First, autonomic and limbic (i.e., amygdala) activity may enhance memory for both item and source information. Second, such effects may be related to aspects of autobiographical clustering, wherein emotionally valenced words are related to personally relevant memories. The resultant organizational influences aid memory for both the word and the surrounding context.

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