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Neutral Details Associated with Emotional Events are Encoded: Evidence from a Cued Recall Paradigm

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Abstract

Enhanced emotional memory often comes at the cost of memory for surrounding background information. Narrowed-encoding theories suggest that this is due to narrowed attention for emotional information at encoding, leading to impaired encoding of background information. Recent work has suggested that an encoding-based theory may be insufficient. Here, we examined whether cued recall – instead of previously used recognition memory tasks - would reveal evidence that non-emotional information associated with emotional information was effectively encoded. Participants encoded positive, negative, or neutral objects on neutral backgrounds. At retrieval, they were given either the item or the background as a memory cue and were asked to recall the associated scene element. Counter to narrowed-encoding theories, emotional items were more likely than neutral items to trigger recall of the associated background. This finding suggests that there is a memory trace of this contextual information and that emotional cues may facilitate retrieval of this information.

Keywords

Emotion; cued recall; memory; retrieval; scenes; narrowed-encoding

Emotional information is often prioritized in memory. This prioritization has been proposed to come at the cost of remembering surrounding information (Reisberg & Heuer, 2004; Levine & Edlestein, 2009). For instance, enhanced recognition of emotional components of scenes can co-occur with reduced recognition of the background context, an effect termed an emotion-induced memory trade-off (Kensinger, Piguet, Krendl, & Corkin, 2004; Kensinger, Garoff-Eaton, & Schacter, 2007; see also Burke, Heuer & Reisberg, 1992).

Because emotional information captures attention (Anderson, 2005) and negative stimuli are associated with a narrow field-of-view (Nobata, Hakoda & Ninose, 2009), it has been proposed that the trade-off may be driven by enhanced attention towards emotional stimuli

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during encoding. Based on Easterbrook's (1959) classic research on the narrowing of attention under high arousal conditions, the memory trade-off was formerly described by the "focusing hypothesis" (Kebeck & Lohaus, 1986), proposing that focused attention at encoding drives the effect.

Recent studies have suggested the need for alternate explanations to these narrowed-encoding theories. Eye-gaze during encoding, a metric of visual attention, does not predict the emotion-induced memory trade-off (Kim, Vossel, & Gamer, 2013; Mickley Steinmetz & Kensinger, 2013; Riggs, McQuiggan, Farb, Anderson, & Ryan, 2011). Moreover, even if attention is restricted at encoding by allowing only a single eye fixation on the critical slide (Christianson, Loftus, Hoffman, & Loftus, 1991) or by dividing attention (Mickley Steinmetz, Waring, & Kensinger, 2014) the emotion-induced memory trade-off still occurs to the same degree.

Most previous research on the emotion-induced memory trade-off has used a recognition memory test, separately cuing memory for emotional and nonemotional content (e.g. Burke, Heuer, & Reisberg, 1992; Kensinger, et al., 2007; Riggs, et al., 2011; Yegiyan & Lang, 2010). For example, participants may encode composite scenes that include emotional or neutral items placed on neutral backgrounds. Subsequently, studied items and backgrounds are presented separately, and participants are asked to distinguish those studied components from novel ones. Typically, emotional items are better remembered than neutral items, but backgrounds previously associated with emotional items are more likely to be forgotten than backgrounds previously paired with neutral items.

When using this recognition memory test, memory for emotional components of prior events is cued using emotional information, while memory for neutral information is not. This design may exaggerate the enhancements in memory for the emotional content of the scenes relative to the other components because the emotional retrieval cues may facilitate early neural changes (Daselaar, Rice, Greenberg, Cabeza, LaBar, & Rubin, 2008) that enhance recognition of that content. Neutral backgrounds, on the other hand, may be less likely to be recognized when previously paired with a negative item (compared to a neutral item) because of the incongruity between the cue content (neutral) and the affect potentially triggered by the prior pairing (Jaeger, Johnson, Corona, & Rugg, 2009). While this type of recognition memory is relevant to some real-world situations (e.g., identifying a perpetrator in a lineup), other times, the goal of retrieval is not only to recognize a re-presented piece of information but also to use that information to retrieve other details of a past event (e.g., viewing the perpetrator cues memory for the getaway car). In addition, in real-world settings, the emotional content is often no longer present at the time of retrieval, and it is a neutral context (e.g., a forest) that triggers memory for an emotional event (e.g., an encounter with a snake).

The current experiments examined whether, when the emotionality of the cue and target were separated, emotion would help or hinder memory. In Experiment 1, a cued recall design was used so that the emotional content from a scene is either the retrieval cue or the memory target, but not both. In Experiment 2, a similar design was used, except non-studied information was presented along with studied information, requiring participants both to

determine which cues had been studied and then to use those cues to trigger associated memories.

Experiment 1

Method

Participants—Thirty-six Boston College students (24 women) participated for $10 or course credit. Participants were native English speakers, reported no history of a neuropsychological or current psychiatric disorder, and had normal or corrected-to-normal vision. Materials and methods were approved by the Boston College Internal Review Board (IRB).

Materials—Scenes were adapted from those used in previous studies (Mickley Steinmetz & Kensinger, 2013; Waring, Payne, Schacter, & Kensinger, 2010). Scenes were constructed by taking a background (e.g., an airplane aisle) and placing a positive (e.g., a flight attendant), a neutral (e.g., a piece of luggage), or a negative (e.g., a vomiting man) item into the scene in approximately the same location, using Adobe Photoshop to make the composite scene as realistic as possible (see Figure 1). Based on existing normative data, negative and positive items were equally arousing ($p>0.15$), and more arousing than the neutral items ($p<0.001$). Negative, positive, and neutral items had similar proportions that included people, animals, and objects and were as similar in size as possible. In a previous pilot study, backgrounds were deemed neutral by naïve raters, with images receiving an average score of 5 or 5.5 on a scale of 1 to 10 (1=extremely negative, 5=neutral, 10=extremely positive; Mickley Steinmetz & Kensinger, 2013).

It was not always possible to find backgrounds that could be realistically combined with a neutral, a positive, or a negative object. Therefore, it was only required that backgrounds be able to be paired with a neutral object and either a negative or a positive object. It was counterbalanced across participants whether any particular background was presented with a neutral object or an emotional (positive or negative) object but not whether the background was paired with a positive or a negative image.

Procedure—At study, participants viewed 60 scenes (20 positive, 20 negative, 20 neutral) for five seconds each and indicated whether they would Approach, Back Away, or Stay the same distance from the scene if they encountered it.

After the study phase, participants performed a distractor task (~5 min), performing 9 math problems. Participants were presented with each problem on the screen and typed the answer. For example, if participants saw 2×3+5−8, they would type the answer of 3. There was no time limit.

Participants then took an unexpected memory test in one of two conditions: a background (item-cued) recall test, or an item (background-cued) recall test. In the background recall test, participants (N=18) were presented with items from previously-studied scenes and were asked to recall the associated background, by typing a brief description. In the item recall test, participants (N=18) were presented with backgrounds from previously-studied scenes

and were asked to recall the associated item, by typing a brief description. No time limit was imposed.

Data Analysis—Recall responses were scored by two raters, with possible scores of 1 (correct response), 0.5 (partial or ambiguous recall response), or 0 (incorrect or absent recall response). For example, if the correct answer was “airplane aisle,” a response such as “airplane aisle” or “plane interior” would receive a 1. A response such as “chairs” would receive a 0.5, as this portion of the associated background would not differentiate it from other backgrounds (e.g., a dining room). Any other type of response would receive a 0. Inter-rater reliability was high (r>.9) on both the background (item-cued) and the item (background-cued) recall test, for both the overall scores for each participant and for the number of scenes awarded a score of 1. The average score of the two raters was used in all analyses. This average score could range from 0 to 1, in increments of 0.25.

Results

Recall Memory—A mixed 2×3 ANOVA was conducted on cue-prompted recall memory. Cue Type (Item, Background) was a between-subjects factor and Scene Valence (Positive, Negative, Neutral) was a within-subjects factor (see Figure 2). The ANOVA revealed a significant main effect of Cue Type, $F(1,34)=11.46$, $p<.005$, $\eta_p^2 = .25$, such that item cues were more likely to prompt correct recall of their backgrounds ($M = 0.63$, $SE = 0.03$) than background cues were to provoke recall of the paired item ($M = 0.48$, $SE = 0.03$; $t(34) = 3.386$, $p=.002$). There also was a main effect of Valence, $F(2,33) = 11.02$, $p<.001$, $\eta_p^2=.40$, such that cues from negative ($M = 0.62$, $SE = 0.03$) and positive ($M = 0.54$, $SE = 0.03$) scenes led to better recall than cues from neutral scenes ($M = 0.49$, $SE = 0.02$) and cues for negative scenes led to better recall than cues for positive scenes (positive>neutral: $t(35) = 1.945$, $p = .06$; negative>neutral: $t(35) = 4.656$, $p<.001$; positive<negative: $t(35) = 3.438$ $p<.001$). There was no Cue by Valence interaction, $F(2,33) = 0.27$, $p=0.77$, $\eta_p^2=.01$.

Discussion

The results of Experiment 1 revealed a beneficial effect of emotion on memory: Participants were better able to recall information when the retrieval cues had come from an emotional scene. This effect generalized to positive and negative stimuli, consistent with prior literature revealing robust effects of arousal on memory (e.g. Yegiyan & Lang, 2010), although the effects were stronger for negative stimuli, which may reflect a negativity bias often shown in younger adults’ memories (Taylor, 1991).

These results demonstrate that participants often encode the neutral context that accompanies emotional information. Further, they suggest that memory trade-offs, which often occur in recognition memory (Reisberg & Heuer, 2004; Levine & Edelstein, 2009), do not emerge as readily when the emotionality of the retrieval cue is separated from the emotionality of the memory target. Thus, retrieval methods impact whether emotion helps or hinders memory for non-emotional details of events, an important finding both for theories of emotional memory and for understanding how emotion influences memory in real-world situations.

Experiment 2

Experiment 2 modified three aspects of the design of Experiment 1, to examine the generality of the findings. First, cue type (item, background) was manipulated within-subject in Experiment 2, reducing a participant-level source of variability and improving the ability to compare item and background memory accuracy in a manner more comparable to prior studies revealing an emotional memory trade-off. Because every participant saw two retrieval cues (item, background) for each studied scene, the effect of cue order (first cue, second cue) could also be assessed. Of particular interest was whether this factor would interact with valence, such that the prior cuing might disproportionately affect the accessibility of content from valenced scenes. Second, the retrieval task was modified to include novel as well as studied items. With this design, participants could not assume that all retrieval cues had been studied, an assumption that is not typically made in the real-world nor in many studies of emotional memory. Third, both items and backgrounds were presented; this meant that for each scene, one of those types of cues would be presented first, with the second type of cue following later in the test list. In addition to ensuring that memory for all scene components were queried, this design allowed an examination of the effect of cuing order (first cue, second cue) on recognition and cued recall performance. If the associative links between the elements of emotional scenes persist over short delays, then the beneficial effects of emotion may be exaggerated with the second cues as compared to the first cues. Fourth, a recognition memory test was included in addition to the recall test. This allowed us to mimic previous paradigms that utilize recognition memory tests and to enhance ecological validity, when it can rarely be assumed that a retrieval cue has previously been encountered.

Method

Participants—Forty-five Wofford College students (20 women, ages 18 to 22, $M = 20.79$, $SD = 1.19$) participated for course credit or a $50 raffle. All participants were native English speakers, had no history of a neuropsychological or current psychiatric disorder, and had normal or corrected-to-normal vision. Materials and methods were approved by the Wofford College IRB.

Materials—Scenes were selected from the same stimulus sets used in Experiment 1. Negative and positive items were equally arousing ($p>0.15$), and were more arousing than the neutral items ($p<0.001$). As in Experiment 1, items were balanced across valence for the number of people, animals, and objects; the size, location, and scene placement of the items was kept as consistent as possible across scenes of different valences. The composite scenes were divided into two different study sets, while the same recognition list was administered to all participants; this balanced the items that served as studied targets or novel foils at recognition.

Procedure—At study, participants viewed 90 randomly presented scenes (30 positive, 30 negative, 30 neutral) for three seconds each with the same instructions as Experiment 1. Participants were connected to an electroencephalogram (EEG) cap during encoding, though these data will not be described here. After completion of the practice and study phase,

participants underwent a delay of 30 minutes; to standardize the information presented during the delay, participants were given a series of cognitive assessments and questionnaires (e.g., digit span, Beck Depression Inventory, Beck Anxiety Inventory).

After the delay, participants underwent an unexpected memory test in which items and backgrounds were presented separately. These images included the 90 items and 90 backgrounds from the study list, 90 new items (30 from each valence), and 90 new backgrounds. Participants indicated whether they had studied each object or background during the encoding phase (recognition memory). For each image identified as "old," the participant reported which background or item it had previously been paired with during the encoding phase (recall memory), or pressed a question mark. If the image was rated as new, they pressed a key to move on to the next image. No time limit was given. Recall data were scored as described in Experiment 1, with two different raters. Inter-rater reliability was high (r>.9) for both the overall scores for each participant and for the number of scenes awarded a score of 1. The items and backgrounds were sorted into those that were the First Cue for a scene and those that were the Second Cue for a scene (i.e., occurring after the First Cue for the scene had been presented).

Results

Recognition Memory—A Cue Type (Item, Background) by Scene Valence (Positive, Negative, Neutral) by Cue Order (First, Second) ANOVA was conducted on the hit rates (correctly recognized items and backgrounds). There was a significant main effect of Cue Type, $F(1,44)=167.258$, $p<.001$, $\eta_P^2 = .792$, such that items ($M=0.819$, $SD=0.016$) were better recalled than backgrounds ($M=0.596$, $SD=0.023$), $t(44)=7.824$, $p<.001$. There was also a significant main effect of Valence, $F(2,88)=25.661$, $p<.001$, $\eta_P^2=.368$, such that components of negative scenes were remembered best ($M=0.741$, $SD=0.016$), followed by positive ($M=0.720$, $SD=0.021$) and neutral ($M=0.660$, $SD=0.021$).

These main effects were qualified by a Cue Order by Cue Type interaction, $F(1, 44)=15.297$, $p<.001$, $\eta_P^2=.258$, by a Cue Type by Valence interaction, $F(2,88)=29.438$, $p<.001$, $\eta_P^2=.401$, and by a Cue Type by Valence by Cue Order interaction, $F(2,88)=4.968$, $p=.009$, $\eta_P^2=.101$. Post-hoc paired samples t-tests indicated that for background cues, there was no effect of valence for First Cues (all t's<1.5, ps>.14). However, for Second Cues, backgrounds of negative scenes were more likely to be recognized than backgrounds of neutral scenes ($t(44)=2.023$, $p=0.049$). For item cues, the cuing order did not affect the pattern of results: post-hoc t tests indicated that positive and negative items were better remembered than neutral items both when they were First Cues (positive>neutral: $t(44) = 6.387$, $p<.001$, negative>neutral: $t(44)=5.145$, $p>.001$ and when they were Second Cues (positive>neutral: $t(44)=4.600$, $p<.001$, negative>neutral: $t(44)=5.559$, $p<.001$).

Recall Memory—A Cue Type (Item, Background) by Scene Valence (Positive, Negative, Neutral) by Cue Order (First, Second) ANOVA was conducted on cue-prompted recall memory. As in Experiment 1, there was a significant main effect of Cue Type, $F(1,44)=54.894$, $p<.001$, $\eta_P^2=.555$, such that item cues were more likely to prompt correct

recall of their background pairs (*M*=0.379, *SD*=0.017) than background cues were able to provoke recall of their item pairs (*M*=0.304, *SD*=0.017).

As in Experiment 1, and supporting the hypothesis that emotional cues may enhance recall, there was also a significant main effect of Valence, $F(2,88)=24.032$, $p<.001$, $\eta_P^2=.353$, such that negative (*M*=0.397, *SD*=0.019) cues provoked the best recall, followed by positive cues (*M*=0.335, *SD*=0.018), and neutral cues, (*M*=0.292, *SD*=0.018.

There was also a main effect of Cue Order, $F(1,44)=73.255$, $p<.001$, $\eta_P^2=.625$, where Second Cues (*M*=0.375, *SD*=0.018) were better remembered than First Cues (*M*=0.308, *SD*=0.015).

These main effects were qualified by a Cue Type by Valence interaction, $F(2,88)=18.362$, $p<.001$, $\eta_P^2=.294$, a Cue Type by Cue Order interaction, $F(1,44)=10.703$, $p=.002$, $\eta_P^2=.196$, and a Cue Type by Valence by Cue Order interaction, $F(2,88)=4.036$, $p=.021$, $\eta_P^2=.084$ (see Figure 2). The three-way interaction provided evidence for an exaggerated benefit from valence for the second cues as compared to the first cues only when the cues were backgrounds. For background cues, there were no valence differences in the First Cue condition (all *t*s<1.1; all *p*s>.2). But in the Second Cue condition, background cues were more likely to trigger item memory if the item was positive or negative as opposed to neutral (positive>neutral: $t(44)=3.277$, $p=.002$; negative>neutral: $t(44)=4.405$, $p<.001$).

For item cues, there was an effect of valence regardless of whether the items were the First or Second cue. For First Cues, items were most likely to trigger background memory if the cues were negative (vs. neutral: $t(44)=6.247$, $p<.001$; vs. positive: $t(44)=3.158$, $p=.003$) and positive cues were more effective than neutral ($t(44)=3.842$, $p<.001$). For Second Cues, item cues were more likely to trigger background memory if the cue was negative as opposed to positive or neutral (negative>positive: $t(44)=4.943$, $p<.001$; negative>neutral: $t(44)=5.276$, $p<.001$).

General Discussion

Across two experiments, elements from negative and positive scenes were more likely to be recalled than elements from neutral scenes, regardless of whether those elements were items or backgrounds. This finding is counter to a “narrowed-encoding” explanation, which should lead the backgrounds of emotional scenes to be less likely to be encoded, and thus retrieved, than backgrounds of neutral scenes. Instead, the results suggest that the emotional memory trade-off may be exaggerated on standard recognition memory tests because the retrieval cue and the memory target either both contain, or both are void, of emotional content.

The results of the present study are important for two main reasons. First, they confirm that emotional memory enhancements can exist even when retrieval cues are neutral. All background cues were neutral, so any emotional memory advantage in that condition could not have been due to the emotionality of the retrieval cue itself. Instead, these results seem consistent with theories suggesting that the background cue – although ostensibly neutral – may be able to take on emotional valence because it was paired with an emotional item at encoding. For example, Bower’s (1981) Associative Network Theory suggests that

emotional information may form a network with neutral information that allows the emotional information to be evoked at retrieval. In addition, studies have found enhanced neural activity at retrieval for neutral objects learned in emotional contexts (Jaeger, Johnson, Corona, & Rugg, 2009; Jaeger & Rugg, 2012).

If this were the only explanation, however, it would be hard to reconcile with past demonstrations of the memory trade-off; it might be expected that the affective tinge associated with the background also would aide memory on those paradigms. Perhaps there also are benefits of emotion in terms of target accessibility (i.e., increased ease of retrieval for the emotional item itself) or associative binding (i.e., increased binding between the emotional item and its background) that could explain the emotional memory benefits in response to a neutral cue (see Madan et al., 2010, for distinction of these components). The effects of cue order in Experiment 2 may provide some evidence for a role of these factors. In Experiment 2, memories for emotional items were more likely to be triggered by neutral background cues than memories for neutral items, but only if those items had been had been seen earlier in the test list (i.e., if the background cues were Second Cues). There was no difference in recall rates for emotional and neutral targets if those items had not been seen earlier in the list (i.e., if the background cues were First Cues). This earlier presentation of the emotional item may have facilitated emotional target accessibility or may have strengthened the association between the emotional item and its background by refreshing it earlier in the test list. This may indicate more generally that previous exposure to emotional information enhances neutral-cued recall, though future studies will be needed in order to determine if these previous presentations do this by strengthening memory accessibility or by strengthening the item-background association.

Second, the findings of the current study counter the strongest versions of narrowed-encoding theories which suggest that arousal narrows attention at encoding, reducing the memory trace for the backgrounds. Critically, there was no evidence of a memory decrement for components of the emotional scenes, even though in other paradigms that have used these stimuli in recognition memory tasks, trade-offs in the form of background memory decrements have been robustly demonstrated (e.g. Kensinger, et al., 2007; Waring, et al., 2010). The current experiments demonstrate that there is a memory trace for the neutral backgrounds that are associated with emotional items, and that these neutral backgrounds can be accessed when given the appropriate retrieval cue. The fact that the backgrounds sometimes were more likely to be accessed when emotional items were cues than when neutral items were cues is particularly surprising based on prior narrowed-encoding theories. However, this enhancement may arise because the emotion-based neural network elicited by the negative and positive item cues may enhance retrieval processes, which may boost the recall rates for the associated backgrounds above the level demonstrated following a neutral item cue (Daselaar, et al., 2008; Siddiqui & Unsworth, 2011). These results reveal boundary conditions for the trade-off and demonstrate that sometimes, emotion can facilitate both object and contextual memory.

A limitation to the current study includes the fact that the study only examined recall tests at relatively short delays (five and 30 minutes). Future studies could investigate if longer delays may influence these effects. If longer-lasting, the results would suggest that, for instance,

when someone hikes along a trail where they previously encountered a snake, they may remember that snake. Alternatively, if that person sees that same snake in a different location, they may remember the trail where it was originally encountered.

Experiment 1 and Experiment 2 differed in a number of ways (see Figure 1). Notably, Experiment 2 asked participants to make a recognition and a recall decision. This recognition-then-recall design shares features with two-step recognition memory tasks, in which participants first determine whether an item is old or new and then, for 'old' items, assess the subjective quality or the source of the memory. The two-step process can lead to a more conservative response bias (Hicks & Marsh, 1999) and can affect memory patterns (Mulligan, Besken, & Peterson, 2010), and may explain some of the differences between the two experiments. The inclusion of the recall task also may explain why the recognition memory task did not yield a detriment in memory for backgrounds previously paired with negative images. Previous studies have shown that the background detriment is more likely to be eliminated by experimental manipulations that increase cognitive control processes, while the negative item enhancement remains robust (e.g. Mickley Steinmetz & Kensinger, 2013). Thus, the cued recall task may have served to increase the cognitive demands of the task. Most importantly, the general conclusion from Experiment 1 – that emotion did not impair recall of any scene elements – was replicated in Experiment 2, despite the differences in design.

In summary, the results confirm that emotional memory enhancements can occur even when retrieval cues are neutral, and participants have access to information about the backgrounds accompanying emotional scenes. These results provide strong evidence that a narrowed-encoding explanation is not sufficient to explain the emotion-induced memory trade-off patterns previously observed with complex scenes. Instead, when used as a retrieval cue, emotional information can act to facilitate memory for contextual information.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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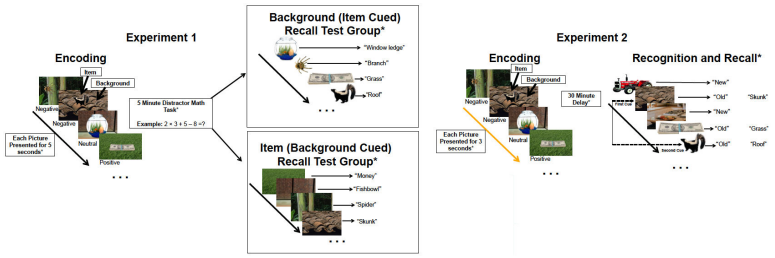

Figure 1.

Experimental design for Experiment 1 and Experiment 2. Composite pictures that included positive, negative, or neutral object on neutral background were shown at encoding. Differences between the two experiments are highlighted with an asterisk and include: encoding time (Expt. 1 = 5 seconds/picture; Expt. 2 = 3 seconds/picture), study/test delay (Expt. 1 = 5 min delay; Expt. 2 = 30 min delay), and retrieval design (Expt. 1 = between subjects, participants see only objects or only backgrounds as recall cues. All cues are old; Expt. 2 = within subjects, intermixed object and background cues, recognition and recall task, includes both old and new images). In Experiment 2, cues from a particular scene were sorted based on whether they came first or second. In this hypothetical example, in the studied scene that included the skunk on the roof, the roof was the first cue, while the skunk was the second cue.

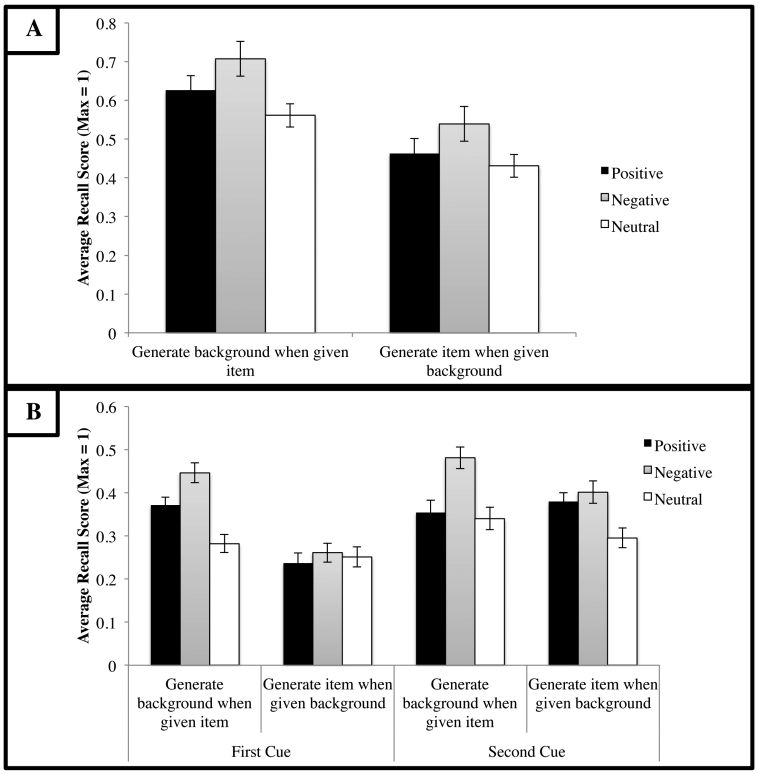

Figure 2.

Recall scores for items and background cues. A) Experiment 1. Since all backgrounds were neutral, the shaded bars indicate the valence of the item that was either the cue (left side) or the target (right side). Error bars indicate standard error of the mean. B) Experiment 2. The "First Cue" bars on the left indicate that the associated item or background had not appeared earlier on the list. The "Second Cue" bars on the right indicate that the associated item or background had appeared earlier on the recognition list. Since all backgrounds were neutral, the shaded bars indicate the valence of the item that was either the cue or the target. Error bars indicate standard error of the mean.