

Fig. 1. (A) Regions more active for emotional than for neutral pictures. (B) Percent signal change in the amygdala. (C) Regions more active for remembered emotional than for remembered neutral pictures. (D) Percent signal change in the amygdala and hippocampus. Activations are displayed at $p < .005$, uncorrected. R, remembered; TR, repetition time.

Discussion

The main result of the study was the finding that both the amygdala and the hippocampus were more activated for remembered emotional than for remembered neutral pictures. This finding provides strong support for the modulation hypothesis. Neural activity of these two structures paralleled the difference in memory performance, which was greater for emotional than for neutral pictures. These results suggest that emotional stimuli exert their beneficial effect on memory performance by enhancing activity in the medial–temporal lobe system.

A second finding of the present study is that, when the emotional stimuli are equated for arousal, the amygdala is involved in the processing of both positive and negative emotions. At the same time, the finding that the right amygdala was more activated for unpleasant than for pleasant pictures is consistent with evidence suggesting that the amygdala is particularly sensitive to negative emotions (Davidson & Irwin, 1999). Thus, the present results suggest that the amygdala is involved in the processing of both positive and negative emotions, and that the right amygdala may have some preference for negative emotions.

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35. Effect of divided attention on the memory benefit for negative as compared to neutral words

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Individuals are better able to remember in rich detail (“recollect”) negative as compared to neutral stimuli. No studies have addressed whether divided attention alters this benefit. We examined the effect of divided attention on memory for negative versus neutral words. Divided attention at encoding reduced the ability to recollect negative words (Experiments 1 and 2) and to remember source information (Experiment 3); divided attention at retrieval had no effect. Even with divided attention at encoding, however, memory for negative words was better than for neutral words. Automatic and attention-demanding processes at encoding may contribute to the memory benefit for negative items.

Report

Background and motivation

Declarative memory is typically better for negative than neutral stimuli. This benefit may result from an increased ability to remember, in rich detail, negative as compared to neutral stimuli. Thus, Ochsner (2000) found that negative stimuli are better recollected (i.e., participants feel they are re-experiencing the item when they encounter it on a recognition test) than neutral stimuli. Similarly, Doerksen and Shimamura (2001) found that individuals remember more “source” information (i.e., contextual details of an item’s presentation) for negative than neutral words.

No study has investigated whether processes at encoding or retrieval contribute to this enhanced memory for negative as compared to neutral items. Nor has any study addressed whether automatic or intentional processes at encoding enhance recollection of negative stimuli. Automatic (non-conscious) orienting toward emotional items (Williams, Mathews, & Spencer, 1996), or intentional semantic or autobiographical elaboration (Doerksen & Shimamura, 2001; Phelps, Labar, & Spencer, 1997) could contribute to the recollective enhancement effect.

Divided attention, particularly at encoding, reduces subsequent memory for emotionally neutral items. Specifically, it reduces the ability to recognize words based on detailed recollections, while leaving relatively intact the ability to recognize items based on more automatic assessments of familiarity. To date, no studies have examined whether this effect of divided attention extends to emotionally negative items.

Present study

We report results of three behavioral experiments examining how attentional modulation affects memory for negative and neutral words. We asked whether the recollective enhancement for negative items was affected by adding a distractor task at encoding or retrieval, and whether the two manipulations had an additive effect. The divided attention manipulation also allowed us to investigate whether automatic processes (not disrupted by divided attention) contribute to the enhancement effect.

Experiment 1

Methods

At encoding, 18 participants (ages 18–30) saw either negative or neutral words (matched for word frequency, familiarity, and imageability), which they rated as highly negative, somewhat negative, or neutral. Participants concurrently performed either an “easy” auditory discrimination task (i.e., two rhythmic patterns were clearly distinct and easy to discriminate) or a “hard” task (i.e., two rhythmic patterns were similar and difficult to discriminate); they were asked to press a button every time the pattern changed. Encoding was performed in 30-s blocks, and participants were informed before each block whether the auditory discrimination would be easy or hard. At retrieval, participants saw previously presented words and an equal number of new words. They were asked to indicate whether they “remembered” the word from the list (had a detailed recollection or feeling of re-experience), “knew” the word was on the list (without specific recollection), or believed the word to be “new” (not presented). While retrieving words, they performed the easy or hard discrimination task, as during encoding.

Results and conclusions

Negative items were associated with more “remember” responses and “recollective” responses (computed following Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998) than neutral items in the “easy” encoding and retrieval condition (t test, $p < .01$). This result with words, together with the results of Ochsner (2000) with pictures, suggests that the recollective benefit for negative information is present across stimulus types.

During encoding, reaction times to the rhythmic pattern changes were slower when they occurred during the presentation of a negative as compared to a neutral word (t test, $p < .05$). In studies using only negative words, others have reported slowing of the secondary task at retrieval compared to encoding. Researchers have taken this slowing as evidence that retrieval requires obligatory processes that cannot be switched to the secondary task. Following this logic, we suggest that the slower reaction times to the change in rhythmic pattern that occurred during encoding of negative words may signify obligatory processes (perhaps automatic orienting toward negative stimuli) that do not occur with neutral stimuli.

Although this reaction time difference contributes to our understanding of the types of processes that occur when encoding negative as compared to neutral stimuli, the confound between reaction time and stimulus valence prevented a direct comparison of the effect of divided attention on negative as compared to neutral stimuli.

Experiment 2

Methods

The 18 participants (ages 18–30) were shown neutral and negative words, randomly intermixed, and were asked to rate each as “abstract” or “concrete.” They were told that it was important to pay attention to the auditory task, and to press a button whenever the pattern changed. Other encoding and retrieval methods were identical to Experiment 1.

Results and conclusions

Reaction times were similar for neutral and negative words, allowing comparison of the effects of divided attention. Participants who encoded and retrieved words with the easy distractor task responded “remember” or “recollected” (Yonelinas et al., 1998) a significantly greater proportion of negative than neutral items ($p < .05$, Fig. 1). This effect became a trend ($p < .10$) when items were encoded with the difficult distractor task. Retrieving words with the hard versus the easy distractor task did

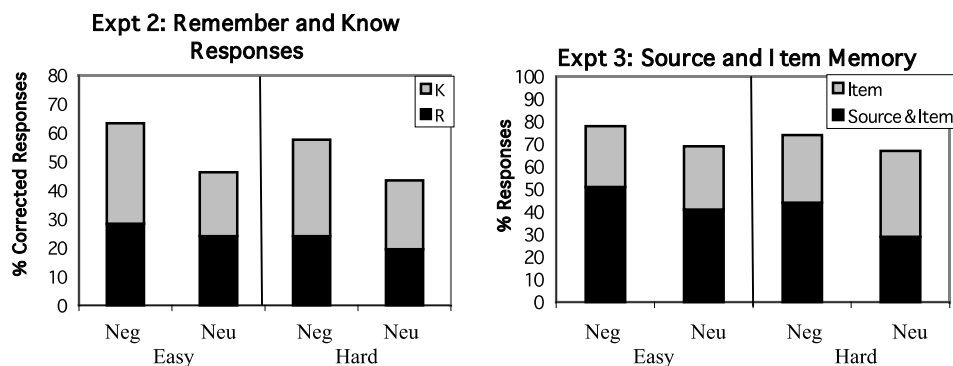


Fig. 1. Encoding words with the hard versus the easy discrimination task (collapsing across retrieval condition, top) reduced the ability to recollect negative and neutral stimuli. It also disrupted memory for source information (bottom). It did not, however, eliminate the memory benefits for negative as compared to neutral items.

not affect performance, regardless of the encoding condition. Anova conducted for “r” or “recollection” responses indicated a significant effect of the easy versus the hard condition (fewer “r” or “recollection” responses with divided attention at encoding, $p < .05$), an effect of valence (more “r” or “recollection” responses for negative words, $p < .05$), but no interaction between condition and valence. Corrected recognition (hits—false alarms) was greater for the negative than neutral stimuli in all conditions ($p < .01$). Anova indicated a significant effect of valence (better memory for negative than neutral stimuli, $p < .01$), condition (poorer memory in hard encoding conditions, $p < .01$), and no interaction between valence and condition.

Modulating attention at encoding impacts memory for negative and neutral words, but does not diminish the overall memory benefit for negative as compared to neutral stimuli. It also does not eliminate the recollective benefit for negative stimuli.

Experiment 3

Methods

This experiment used a “source memory” paradigm: the 18 participants (ages 18–30) saw words presented in blue or red ink (half of the words were negative, half were neutral) and rated each as “abstract” or “concrete”. Attention manipulations were identical to experiment 1. Participants then took a recognition test (with no distractor task) in which they (a) indicated whether a word was “old” or “new,” and (b) for words rated “old,” decided whether the word had been written in red or blue ink.

Results and conclusions

Consistent with Doerksen and Shimamura (2001), in the easy encoding condition, participants showed a source memory benefit for the negative as compared to the neutral words ($p < .01$). This benefit remained when words were encoded with the difficult distractor task ($p < .01$). Anova computed either for overall memory (source or item) or source memory indicated main effects of valence (negative, neutral, $p < .01$), and encoding condition (easy, hard, $p < .01$), but no valence by condition interaction.

Encoding words with the hard versus the easy distractor task reduced the ability to remember source information for negative and neutral items. It did not, however, diminish the memory benefit for negative as compared to neutral items.

General conclusions

The results from three experiments clarify (a) whether processes at encoding or retrieval enhance memory for negative stimuli, and (b) whether the memory benefit for negative items results from automatic or attention-demanding processes.

Divided attention at encoding reduced recollection, or source memory, for negative and neutral items; divided attention at retrieval did not. Attention-demanding encoding processes appear critical to memory formation for negative and neutral stimuli. These processes could include semantic (reliant on left inferior prefrontal regions), or autobiographical elaboration (recruits posterior cingulate and orbito-medial frontal regions). Modulation of attention may reduce the processing that occurs in these brain regions.

Despite this overall effect of divided attention at encoding on memory for negative stimuli, attention modulation did not eliminate the memory benefit for negative stimuli. Recognition (summing “remember” and “know,” or “source” and “item” scores), recollection, and source memory were better for negative than neutral stimuli, even with divided

attention. There may be obligatory, or relatively automatic processes, that occur during the encoding of negative stimuli. Such processes could include amygdaloid modulation of lower-level perceptual areas. Amygdaloid modulation of higher-level regions (e.g., hippocampal formation, prefrontal cortices) may also lead to better memory for negative stimuli, even in instances where attentional resources are taxed.

These results suggest that in everyday life, we may be less likely to remember an emotional event vividly if our attention is diverted. Nonetheless, given the same attention-demanding situation, we may be better able to recall emotional than neutral events.

Dividing the attention of young adults can equate their performance with older adults in a full attention condition. Normal aging and divided attention in young adults may therefore have similar effects on memory enhancement for emotional stimuli. Consistent with this view, other data from our laboratory suggest that although older adults show poorer memory than young adults (in full attention conditions), their memory enhancement and recollective benefit for negative stimuli are comparable in magnitude to the effects seen in young adults.

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36. Autobiographical episodic re-experiencing: A prospective fMRI study

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Participants prospectively created a pool of everyday autobiographical episodes by keeping an audio-journal over a 6–8 month period. They were later presented with a random sample of these recordings while being scanned with fMRI. This paradigm provided a higher degree of experimental control than is typical for studies of autobiographical memory. The recordings evoked a strong feeling of autobiographical episodic re-experiencing. This conscious state was associated with a left-lateralized network of medial frontal, ventrolateral frontal, lateral temporal, retrosplenial, and anterior thalamic activations. This pattern was observed when contrasted with conditions controlling for the impersonal narrative aspects of the recordings and undated self-referential information. It therefore indicates the neural correlates of autobiographical mental time travel, a state of consciousness unique to humans.

Report

Withdrawn.