Emotion, Not Arousal, Affects Episodic Memory Retrieval: An Event-Related Potential Study

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Introduction

Emotion is generally viewed as consisting of two main components: valence (pleasant to unpleasant) and arousal (calm to exciting). Given the essential role of emotion in many cognitive functions, researchers have been interested in how the brain circuits underlying emotion interact with those that encode, store, and retrieve personal (episodic) memories. It has been shown that positively or negatively valenced material is better remembered than neutral information, although valenced items also generally produce higher false alarm rates. Increased arousal has also been cited as the cause of increased memory consolidation for emotional items in behavioral studies.

Electrophysiological studies of retrieval of items from episodic memory have revealed different patterns of ERP activity that depend on the memory status of the target item. The amplitude differences between the ERPs elicited by correctly identified old items in memory and new (items not in memory) stimuli are referred to as the episodic memory (EM) effect. Most ERP studies of the effects of emotion on EM effects have only compared one valence (i.e., usually negative) to neutral items. However, because such designs vary both emotional valence and arousal at the same time, the argument can be made that some or all of the reported effects of negative emotion on EM effects may be due to the effects of arousal level of the stimuli.

Hence, the purpose of the present experiment was to determine if there are differences as a function of emotional valence (positive or negative) and whether the previously reported differences were due to differences in the arousal value of stimuli, rather than valence.

Methods

Participants

- 15 Right-handed, Native English Speakers (10 Female)
- Mean age: 24.2 (4.1) years old
- Paid $10/hour, Recruited from Queens College
- Written informed consent obtained before experiment

Stimuli

- Words read for valence, and arousal taken from Maddock et al. (2003) and The Balanced Affective Word List Project (Siegel, 1998). Additionally, words from Carroll et al. (1971) were rated by participants from QC’s Psychology 101 Participant Pool.
- 3 lists of 90 words (30 each positive, negative, and neutral) were created, all matched for valence, arousal, imagery, word frequency, word length, and part of speech.

Tasks

- Participants were given their assigned list approximately 1 week prior to the ERP recording session to allow study time
- At the ERP recording session, participants first had to obtain a minimum of 90% accuracy on a recognition task with 90 old and 90 new words, to ensure that the words were part of their memory
- Old/new recognition task (in 2 blocks)
- Old words taken from the assigned list; New words taken from another of the 3 matched lists; 20% catch trials (words “OLD” and “NEW”) (See Johnson et al., 2003)
- Words were presented for 400 ms, with a randomized ISI of 2150-2850 ms

ERP recordings

- Recorded from 32 electrode sites, referred to A1+A2
- Bandpass: 0.01 - 35 Hz
- Sampling rate: 100 Hz
- 2150 ms epoch
- 150 ms baseline

Behavioral Results

Accuracy

Hit rate did not vary as a function of Valence or Arousal, although it was consistently higher for Old than New words (p < .005). Valence produced significantly higher false alarm rates for negative (p < .005) and positive (p < .05) words compared to neutral words. High arousal words also had a significantly greater false alarm rate when compared to low arousal words (p < .005).

Mean Stimuli Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Valence</th>
<th>Arousal</th>
<th>Imagery</th>
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</thead>
<tbody>
<tr>
<td>Positive</td>
<td>2.56 (0.49)</td>
<td>3.92 (0.80)</td>
<td>5.40 (1.03)</td>
</tr>
<tr>
<td>Negative</td>
<td>7.48 (0.62)</td>
<td>5.90 (1.11)</td>
<td>5.80 (1.06)</td>
</tr>
<tr>
<td>Neutral</td>
<td>4.81 (1.41)</td>
<td>6.64 (.73)</td>
<td>5.19 (1.40)</td>
</tr>
</tbody>
</table>

Scales used: Valence: 1 = most pleasant; 9 = most unpleasant
Arousal: 1 = most highly arousing; 9 = not at all arousing
Imagery: 1 = no imagery; 9 = highest imagery

Discussion

Previous studies investigating effects of emotion on memory retrieval have confounded the two main characteristics of emotion: Valence and Arousal. Therefore, we investigated the effect of each on episodic memory retrieval.

We found that the subcomponents of the EM effect were differentially affected by the Valence of the memorized words. For example, Negative words affected familiarity, evidenced by the Early Frontal EM Effect, but not recollection, as indexed by the Parietal EM Effect. In contrast, Positive words affected recollection, but not familiarity.

However, when the data were averaged according to arousal value, there were no significant effects on any of the EM subcomponents. Thus, we conclude that the impact emotion has on episodic memory retrieval processes is due to the valence associated with the stimulus and not to its arousal value.

The scalp topography maps show an effect of emotion, distinct from that of other memory-related activity. This centrally maximal scalp distribution is clearly different than that of the Early frontal, Parietal, or Right frontal EM effects. This suggests that Valence is processed separately in the brain from these retrieval related processes.

ERP Results

Subcomponents of the EM Effect

<table>
<thead>
<tr>
<th></th>
<th>Early Frontal EM</th>
<th>Parietal EM Effect</th>
<th>Medial Frontal Negativity (MFN)</th>
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<tbody>
<tr>
<td>Valence</td>
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<td>Neutral</td>
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<td>Positive</td>
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<td>Negative</td>
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</table>

Valence significantly affected one early frontal component, in that negative words elicited a greater EM effect when compared to positive words (p < .05), though neither differed significantly from neutral. As can be seen, the positive words elicited a significantly smaller Parietal EM (p < .05), when compared to negative and neutral words. Positive words also elicited a significantly smaller MFN (p < .05), which seems to be driven by the decreased amplitude of the new positive words.

Parietal EM Effect: Valence or Arousal?

To isolate the effect of emotion, independent of memory, the old-new difference for positive words was subtracted from the old-new difference for neutral words. Likewise, to isolate the effect of arousal, the old-new difference for high arousal words was subtracted from the old-new difference for low arousal words. The scalp distribution of the remaining activity is shown above. Emotion seems to have a central maximum, the locus which is different from the parietal maximum of this EM effect.

Reaction Time

Consistent with previous results, RTs for Old words were significantly faster than for New words (p < .0005), regardless of Valence or Arousal level. RTs for neutral words were significantly faster than positive (p < .005) and negative words (p < .05). RTs for low arousal words were also significantly faster than high arousal words (p < .0005). There was also a significant Arousal x Stimulus interaction (p < .0005) due to a smaller Old-New difference for the low arousal words.