Emotionally arousing stimuli survive taxation of processing resources.

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Introduction

Understanding the complex relationship between emotion and memory has been an ongoing research endeavor for quite some time. According to the research on flashbulb memories, sometimes an emotional event can be so powerful that it is encoded with above average clarity and detail. Events do not always have to be from a negative event. Ulric Neisser (1982) found flashbulb memories for the resignation of President Nixon.

One mechanism that is often used to explain the memorial advantage accruing to emotional items is the process of elaboration. As Kensinger and Corkin (2003) have noted, this elaboration could be semantic or more idiosyncratic and autobiographical. Emotional words may be more easily associated with other self-relevant items, thus improving memory by means of the self-reference effect. Alternatively, the elaboration could take the form of further semantic processing of an emotional item after its presentation. One interesting way to explore such a theory is with what is referred to as an *attentional blink*. During a rapid serial visual presentation paradigm, items to be encoded are displayed at a very quick pace, often with a very short interstimulus interval. Whenever a participant encounters an item that takes additional processing, such as an emotional item, attention can become stuck on that trial when the next item is presented. Anderson (2005) used this paradigm to study the attention capturing nature of emotional items. He argued that emotional items would hold attention and thus impair the identification of a subsequent item. Indeed, he found the arousal of the word was a strong predictor of the attentional blink.

Some researchers have proposed that arousing items occupy a special position within the brain when it comes to encoding and retrieval. Cahill and McGaugh (1990) were the first to propose a link between arousal and amygdala activation. Interestingly, while processing of any stimuli is likely to involve the prefrontal cortex, arousing stimuli may have a special link to amygdala activation (Kensinger & Corkin, 2004). In that study, the authors show a correlation between successful encoding of arousing information and amygdala activation. This finding motivates the current study. If successful encoding and retrieval of an item generally requires attention, and control of attention is mediated by the prefrontal cortex, then successful encoding and retrieval require activation of the prefrontal cortex. These attentional processes of the prefrontal cortex are largely strategic and thus under the control of the participant. Strategic processes, such as attention, can be disrupted by the use of a concurrent task to divide attention. On the other hand, arousing items do not seem to be handled by the PFC, and thus may not be susceptible to a reduction of attention. If negative items experience a benefit in memory over neutral items as a result of a strategic process of elaboration, then dividing attention should theoretically reduce or eliminate this advantage. Furthermore, if arousing items are processed through additional amygdalar activation, then one could predict the deficit from divided attention to be less pronounced because amygdalar activation is an automatic process immune to disruption.

Methods

•Participants: All 130 participants were University of Georgia undergraduate students who volunteered in exchange for partial fulfillment of a research appreciation requirement.

•Materials: Words were chosen from the Affective Norms for English Words (Bradley & Lang, 1999). Words were chosen that were affectively neutral or negative based on these ratings. Furthermore, the negative words were subdivided into those that were arousing and those that were not. Neutral and negative non-arousing words did not differ in their arousal levels ($p > .05$) but did differ in subjective valence ($p < .001$). Similarly, negative non-arousing and negative arousing words did not differ in valence ($p > .05$) but did differ in arousal levels ($p < .001$). Forty-eight words were chosen for each class of item, with half randomly presented at study. All item classes were presented intermixed and randomized anew for each participant tested.

•Experiment 1: After reading instructions pertaining to word learning, participants in conditions with Divided Attention next read instructions for a concurrent Random Number Generation (*Note*: Divided Attention vs. Full Attention was fully crossed at both Study and Test). Following this, participants either began practicing random digits or were engaged in a distractor task consisting of 3-digit multiplication problems. All words were randomly presented in the center of the computer monitor for two seconds. A total of 72 words were presented during the study phase (24 each of the three classes of items), with the remaining 72 used as distractors during the recognition test.

•Experiment 2: Materials were identical to Experiment 1 except that instead of Divided Attention, participants were made aware that some words would be presented for a short duration (250 msec) and others would be presented for longer (2000 msec). This long duration of two seconds was used to replicate the study conditions in Experiment 1. Upon completing the study phase, all participants read instructions for the *remember-know* procedure (Tulving, 1985).

Results

Table 1

Recognition Accuracy in Experiment 1

Study Manipulation		Hits NegNA	Hits NegA	Hits NeuNA	False Alarms NegNA	False Alarms NegA	False Alarms NeuNA	Corrected Recognition NegNA	Corrected Recognition NegA	Corrected Recognition NeuNA
Full Attention	*M*	.76	.79	.68	.23	.20	.31	.54	.59	.36
	SE	(.03)	(.03)	(.04)	(.04)	(.03)	(.04)	(.07)	(.06)	(.07)
DA @ Study	*M*	.61	.66	.50	.40	.34	.50	.21	.31	.01
	SE	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	(.06)	(.06)	(.07)
DA @ Test	*M*	.73	.78	.69	.27	.22	.31	.46	.55	.39
	SE	(.02)	(.02)	(.03)	(.02)	(.02)	(.03)	(.05)	(.04)	(.05)
DA @ Both	*M*	.64	.67	.59	.36	.33	.41	.28	.33	.17
	SE	(.03)	(.03)	(.04)	(.03)	(.03)	(.04)	(.07)	(.06)	(.07)

Memory measure and item type

Note. Standard errors are in parentheses.
Corrected Recognition = Hits - False Alarms.

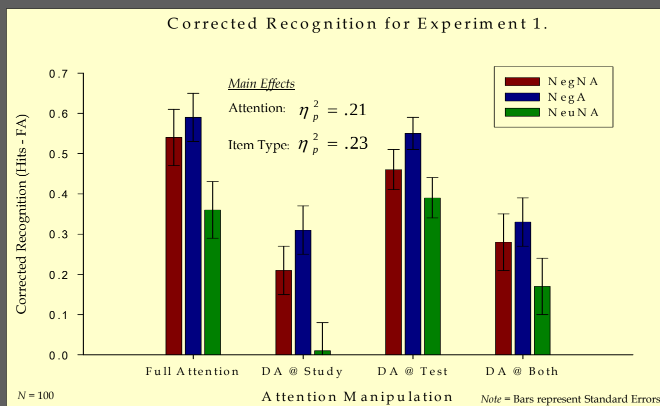


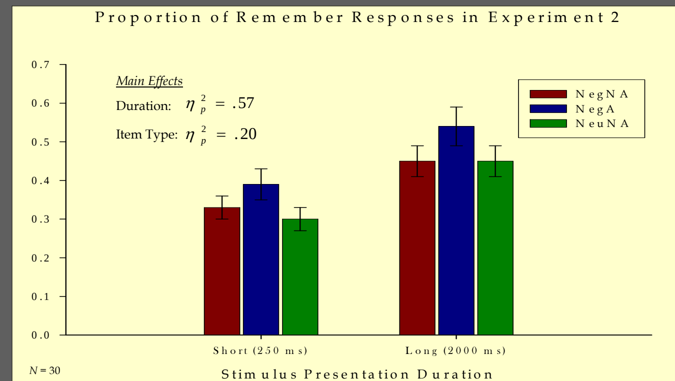
Table 2

Proportion of Remember, Know, & New Responses in Experiment 2

Response Type	Short (250 msec) NegNA	Short (250 msec) NegA	Short (250 msec) NeuNA	Long (2000 msec) NegNA	Long (2000 msec) NegA	Long (2000 msec) NeuNA
Remember	.33	.39	.30	.45	.54	.45
	(.03)	(.04)	(.03)	(.04)	(.05)	(.04)
Know	.35	.32	.30	.34	.30	.28
	(.03)	(.04)	(.03)	(.03)	(.03)	(.03)
New	.32	.29	.40	.21	.16	.28
	(.03)	(.03)	(.03)	(.02)	(.03)	(.03)

Study Duration and item type

Note. Standard errors are in parentheses.



Discussion

The empirical outcomes of this study demonstrate that both the emotional enhancement effect due to valence and the additional benefit of arousal on memory survive divided attention at both encoding and test. Moreover, the additional benefit of arousal appears to occur very early in the information processing stream because it can occur with study conditions as rapid as 250 ms. Although others have found the benefit of valence to be localized to remember responses (i.e., recollection; Dewhurst & Parry, 2000; Kensinger & Corkin, 2003) we found that only the arousing items showed heightened remember responses.

Because both the emotional enhancement effect and the arousal effect survive divided attention, we believe that is relatively unlikely that the memorial benefit of processing valenced items is due to more elaborate encoding or additional processing resources being devoted to them. The pace of the RNG task was quite rapid and many of our participants expressed frustration over the difficulty of the task. Although it is tempting to say that the effect of valence is owing to conscious resources and the effect of arousal is due to more automatic amgydalar activation (Kensinger & Corkin, 2004), the present results argue quite strongly that there is strong automatic component to both the effect of arousal and valence on subsequent memory. This point is important because it shows that there are tasks and conditions where an emotional enhancement effect can be obtained even when more elaborative encoding and assessment cannot reasonably be applied. Therefore, although we do not disagree that there are indeed two routes for emotion to affect memory, even when the more conscious route is severely constrained, the more automatic route can occur as a consequence of both valence and arousal.

Selected References

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Additional references available upon request