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Emotional arousal does not enhance association-memory

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ABSTRACT

Emotionally arousing information is remembered better than neutral information. This enhancement effect has been shown for memory for items. In contrast, studies of association-memory have found both impairments and enhancements of association-memory by arousal. We aimed to resolve these conflicting results by using a cued-recall paradigm combined with a model-based data analysis method (Madan, Glaholt, & Caplan, 2010) that simultaneously obtains separate estimates of arousal effects on memory for associations and memory for items. Participants studied sequentially presented words in pairs that were pure (NEGATIVE–NEGATIVE or NEUTRAL–NEUTRAL) or mixed (NEGATIVE–NEUTRAL or NEUTRAL–NEGATIVE). Cued recall tests had NEUTRAL or NEGATIVE probes and NEUTRAL or NEGATIVE targets. We found impaired memory for associations involving negative words despite enhanced item-memory (more retrievable targets). A category-list control condition explained away the item-memory enhancement but could not explain the impairment of association-memory due to arousal. A second experiment with identical structure but using higher-arousing taboo words revealed increased cued recall of taboo than neutral words. However, this was exclusively mediated by item-memory effects with neither enhancement nor impairment of association-memory. Thus, cued recall was lower for pure negative pairs and higher for pure taboo pairs, but our modeling approach determined a different locus of action for these memory impairing or increasing effects: Although item memory was increased by arousal, association-memory was impaired by negative words and unaffected by taboo words. Our results suggest that previous results reporting an enhancement of association-memory due to arousal may have instead been solely driven by enhanced item-memory.

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1. Introduction

Cued recall is often used as a test of association-memory. However, cued recall requires one not only to remember the relationship between items (association-memory) but also the items themselves (item-memory). Thus, verbal cued recall is influenced by item-memory for the probe and target words in addition to (or even instead of) memory for the association itself. Single-word properties can act at any of these levels. We recently demonstrated this with the word properties of imageability and word frequency (Madan, Glaholt, & Caplan, 2010). Briefly, imageability is a measure of how conducive a word is to mental imagery (e.g., high-imageability: BIKE; low-imageability: CLAIM), whereas word frequency is a measure of the probability of occurrences of a word (e.g., high-frequency: AREA; low-frequency: MICA). We found that in both manipulations, cued recall accuracy was better for pure high pairs (pairs in which both words were high-imageability or high-frequency, respectively) than for pure low pairs (pairs in which both words were low-imageability or low-frequency,

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respectively). However, in "mixed" pairs, which consisted of one high item and one low item, we found different effects for each word property. In the imageability manipulation, accuracy for the mixed pairs was symmetrical regardless whether high/low words were probes or targets and fell between accuracy for the pure high and pure low pairs. In the word frequency manipulation, accuracy for the mixed pairs was asymmetric, with better performance when the cued recall target was a high-frequency word than if it was a low-frequency word. However, even by including all possible types of pairs, cued recall accuracy is still dependent on both item- and association-memory processes. To systematically disentangle the influences of item- and association-memory producing these patterns of results across manipulations, we then applied a model-based approach. This approach simultaneously obtains formal estimates of the influence of single-item properties (i.e., imageability and word frequency) on item- and association-memory. By including all possible probe and target combinations (i.e., high–high, high–low, low–high, low–low), we were able to obtain estimates of the cued recall target's retrievability (model parameter: t), the probe word's effectiveness (model parameter: p), and strength of the memory for the relationship between the two items (model parameters: r_1, reflecting any difference in memory between high–high and mixed pairs, and r_2, reflecting any difference in memory between mixed and low–low pairs.) Both relationship model parameters depend only on pair type but not upon which item was used as the probe or target in cued recall. Thus, one could imagine that memorizing pairs of dissimilar items (i.e., mixed pairs) is more challenging than memorizing pairs of similar items. Our model can test then, if and how the item manipulation (e.g., high/low imageability) interacts with such basic differences between pure and mixed pair recall. For each of these parameters, a value greater than one signifies that the process is enhanced due to the manipulation, whereas a value below one signifies an impairment of that process due to the manipulation. (For more detail on our modeling approach, see page 17.) Despite finding no difference between word frequency and imageability in cued recall performance in pure pairs, with our modeling approach we found that imageability primarily enhanced association-memory (r_1 and $r_2 > 1$) and that word frequency primarily enhanced target retrievability ($t > 1$; also reported by Criss, Aue, & Smith, 2011). We therefore extend the use of this cued recall paradigm and modeling approach to an important topic of memory research: the influence of arousal on association-memory.

Previous research has shown that emotional arousal enhances memory for single items or events, a finding that has been replicated with many different paradigms and materials, including arousing words and pictures, as well as more realistic events like flashbulb memories (e.g., Berntsen & Rubin, 2004; Bradley, Greenwald, Petry, & Lang, 1992; Brown & Kulik, 1977; Christianson, 1992; Mather & Sutherland, 2011). Previous studies of arousal effects on association-memory have used a variety of paradigms in which two elements (typically an arousing item paired with a neutral item) had to be bound together in memory. If those elements coincide, association-memory is often enhanced (e.g., font color of a presented word; Doerksen & Shimamura, 2001; Kensinger & Corkin, 2003, but see Davidson, McFarland, & Glisky, 2006). If the two elements do not coincide, association-memory appears to be reduced due to arousal (e.g., peripheral neutral line drawings in the presence of central arousing scene pictures; Touryan, Marian, & Shimamura, 2007). These findings have been derived from paradigms with a number of potentially problematic characteristics. Almost all previous studies in this area used incidental encoding instructions and dissimilar items to-be-bound in memory. Under these circumstances, several ill-controlled factors could account for a differential formation of associations with arousing compared to non-arousing items in memory. For example, when presenting an arousing and neutral item together, attention will likely be drawn to the arousing item if there is no explicit instruction to encode the association between the two. This may then influence later memory for the neutral item. Such impairment may not reflect impaired binding of elements in memory *per se*, but rather an effect of unequal attention to the two components, which may then impair encoding of the relation between them. An unequal attention distribution could be further amplified by using dissimilar assemblies of central arousing and peripheral neutral elements. Four published studies avoided some of these ambiguities by using intentional encoding instructions with pairs of items that were of the same kind (word–word pairs). To test memory for associations, two of them used associative recognition at retrieval (Onoda, Okamoto, & Yamawaki, 2009; Pierce & Kensinger, 2011), and two used cued recall (Guillet & Arndt, 2009; Zimmerman & Kelley, 2010). In Onoda et al. (2009), participants learned pairs of words that were either both negative or both neutral. Subsequently, on associative recognition tests, words were either presented with their original associate ("intact"), or with a word from another pair ("rearranged"). Participants were more accurate on neutral than negative pairs. Pierce and Kensinger (2011) presented participants with pairs of words that consisted of either two negative words, two neutral words, or two positive words. When tested immediately, memory for negative pairs was worse than for neutral pairs, as well as for positive pairs (Pierce & Kensinger, 2011 Experiment 1). When a longer study–test delay was used, memory was enhanced for negative compared to neutral/positive pairs (see Pierce & Kensinger, 2011 Experiment 2).

Arguably, associative recognition is a more direct test of association-memory than cued recall, and that it is unaffected by item-specific information. However, recent evidence has shown that associative recognition is in fact also susceptible to manipulations of item strength (Buchler, Light, & Reder, 2008; Criss & Shiffrin, 2005; Kelley & Wixted, 2001). Thus, it is possible that prior findings of an impairment of association-memory due to arousal may instead have been primarily driven by arousal effects on item-memory, even in associative recognition. In this case we will expect that more arousing pairs will have higher false alarm rates than neutral pairs, rather than a reduced hit rate. Indeed, Pierce and Kensinger (2011) found that negative pairs had higher false alarm rates than neutral pairs. False alarm rates were also higher for positive pairs than for neutral pairs, but this difference was not

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