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Adaptive memory: Temporal, semantic, and rating-based clustering following survival processing

James S. Nairne [a,*], Mindi Cogdill [a], Melissa Lehman [b]

[a] Purdue University, United States
[b] Lynn University, United States

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ABSTRACT

Processing items for their survival relevance often produces a robust memory advantage. The current experiments assessed possible proximate mechanisms responsible for this advantage by assessing output strategies during free recall. Previous research has shown that item clustering during recall can provide diagnostic information about the structure of representations in episodic memory, particularly the encoding of temporal, semantic, and source information. Following survival processing and moving or pleasantness controls, measures of temporal and semantic clustering were generated. A robust recall advantage was found for survival processing, but no evidence for temporal clustering was detected. Above-chance levels of semantic clustering were obtained, but there were no differences between the survival and control conditions. An additional clustering measure based on scenario-based relevance ratings also failed to explain recall differences, as did absolute and relative measures of remembered temporal position. Our results indicate that neither enhanced temporal coding nor increased semantic processing among the items on the study list can easily explain the oft-replicated survival processing advantage. Our results also suggest that the ubiquitous temporal clustering patterns seen in free recall studies may be a product, in part, of using intentional learning and multiple study trials.

Introduction

The thesis that human memory evolved, subject to the constraints of natural selection, is noncontroversial. Just as the organs of the body were sculpted over generations to solve specific problems (such as pumping or filtering blood), human memory almost certainly evolved because it helped solve adaptive problems, ones that were highly relevant in ancestral environments (Klein, Cosmides, Tooby, & Chance, 2002; Nairne & Pandeirada, 2008). The ability of an organism to remember the location of food and to recognize potential predators and prey, as well as to recognize and remember possible mating partners, likely enhanced our ancestors' survival chances. Such reasoning led Nairne, Thompson, & Pandeirada (2007; see Nairne, 2010, for a review) to propose that memory may be biased or "tuned" to the processing and retention of information relevant to survival and reproductive fitness. In support, Nairne et al. (2007) found that items processed with respect to an imagined survival scenario produced particularly good long-term retention.

In the original survival processing paradigm, participants were asked to imagine themselves stranded in the grasslands of a foreign land without any basic survival materials. People were told that over the next few months they would need to find food and water and protect themselves from predators. The task was to rate the relevance of

* Corresponding author at: Department of Psychological Sciences, Purdue University, 703 Third Street, West Lafayette, IN 47907-2081, United States. Fax: +1 (765) 496-1264.

E-mail address: nairne@purdue.edu (J.S. Nairne).

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a list of unrelated words (that is, the concepts represented by the words) to this imagined survival scenario. A surprise free recall test followed, and processing words for survival-relevance led to better memory than processing words for a control scenario (moving to a new home in a foreign land), self-reference (personal experience), or a standard deep processing control (pleasantness ratings; Nairne et al., 2007).

Since its original demonstration, the survival processing advantage has been widely replicated, using a variety of control procedures and survival scenarios (see Erdfelder & Kroneisen, 2014; Kazanas & Altarriba, 2015; Nairne, 2010, for reviews). Nairne, Pandeirada, Gregory, and VanArsdall (2009) used a matched design in which participants generated relevance ratings about activities related to hunting or gathering food, but based in either a survival or a game-based context (e.g., gathering food for survival or to win a scavenger hunt). Ratings were made about the same activities in both groups, and the observed ratings did not differ, but the survival framing led to significantly better recall. Thus, it is something about the survival context, rather than the rating task itself (e.g., its difficulty or familiarity), that produces the memory advantage. Some boundary conditions have since been identified—for example, survival processing advantages may not extend to the processing of stories (Seamon et al., 2012) or faces (Savine, Scullin, & Roediger, 2011) or indirect tests of retention (Tse & Altarriba, 2010)—but the effect has proven robust across various age groups, stimuli, and experimental designs.

Not surprisingly, investigators have been keenly interested in discovering the proximate mechanisms that drive the advantage. Selection pressures over generations may have tuned our memory systems to work efficiently in survival situations, but the memory mechanisms involved may be familiar (Nairne & Pandeirada, 2016; Nairne et al., 2007). In fact, Nairne and Pandeirada (2016) recently suggested that survival processing may constitute a "front-end" adaptation, meaning a natural tuning that relies on the recruitment of otherwise general processes. Adaptations of this kind are common in the body. For example, the fight-or-flight response "works" via activation of the sympathetic nervous system which, in turn, recruits and coordinates changes in blood pressure, heart rate, blood sugar levels, respiration rates, and so on. As part of a more general survival optimization system, processing information in a survival context might naturally recruit mechanisms that promote good episodic retention. For example, survival processing could induce elaborative processing which, in turn, aids recovery because additional retrieval routes are available (Kroneisen & Erdfelder, 2011; Röer, Bell, & Buchner, 2012). Importantly, however, considerable evidence now suggests that the recruitment of such memory-enhancing mechanisms is driven by the survival mode rather than by some general feature or artifact of the relevance rating task (see Nairne & Pandeirada, 2016, for a detailed account).

In the present case, we were interested in the involvement of a mechanism that has been used to account for a number of phenomena associated with free recall—associations between items and slowly updating contextual information. Kahana (1996) and colleagues (Howard & Kahana, 2002a) have shown that output clustering during recall can provide diagnostic information about the structure of representations in episodic memory, particularly the encoding of temporal, semantic, and source information. Temporal clustering is a common property of free recall: Items studied in neighboring serial positions in a list tend to be reported together during the recall output sequence (known as the temporal contiguity effect). The extent of temporal clustering, in turn, has been used to draw inferences about the formation of associations between studied items and/or with an evolving temporal context (e.g., Howard & Kahana, 2002a; Polyn, Norman, & Kahana, 2009). One can also find semantic clustering—that is, participants may be more likely to transition to a word that is similar in meaning than to one that is less similar. Semantic clustering indexes the role that longstanding semantic associations are playing in recall (Howard & Kahana, 2002b) and the degree to which meaningful relationships among items have been accessed during the retrieval process. Finally, source characteristics can influence clustering patterns as well; people tend to recall items presented in the same modality together (Murdock & Walker, 1969), as they do items of similar emotional valence (Long, Danoff, & Kahana, 2015) and items processed via the same orienting task (e.g., size versus pleasantness judgments; cf. Polyn et al., 2009). Source clustering can indicate the extent to which people have encoded source characteristics and, perhaps, are using source as a retrieval cue during recall.

In short, clustering patterns can serve as "toolkits" for uncovering the dimensions that control performance across various kinds of manipulations. As a case in point, recent research indicates that practicing retrieval of presented information, as opposed to additional study periods, leads to increased temporal-based clustering during later free recall that is representative of a more diagnostic encoding of temporal context (Lehman, Smith, & Karpicke, 2014). More distinctive temporal coding, in turn, enables people to restrict their search during the test period, reducing interference from prior encodings and increasing list discrimination performance (see Chan & McDermott, 2007; Karpicke, Lehman, & Aue, 2014). Thus, variations in contextual encoding, as measured through temporal clustering, present a proximate mechanism through which a well-known empirical phenomenon such as the testing effect can be explained.

In the present case, we were interested in whether an analysis of clustering patterns in free recall might provide useful information about the proximate mechanisms that underlie survival processing advantages. For example, it is conceivable that survival processing leads to more robust encoding of temporal context, as revealed through greater relative amounts of temporal clustering during output. Given that episodic retention relies on the recovery of temporal and spatial occurrence information (see Nairne, 2015), fitness-based "tunings" might well operate through the recruitment of contextual encoding mechanisms. Alternatively, survival processing could lead to enhanced relational processing (Burns, Burns, & Hwang, 2011)—defined as an increase in meaningful connections