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Adaptive memory: Is survival processing special?

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ABSTRACT

Do the operating characteristics of memory continue to bear the imprints of ancestral selection pressures? Previous work in our laboratory has shown that human memory may be specially tuned to retain information processed in terms of its survival relevance. A few seconds of survival processing in an incidental learning context can produce recall levels greater than most, if not all, known encoding procedures. The current experiments further establish the power of survival processing by demonstrating survival processing advantages against an encoding procedure requiring a combination of individual-item and relational processing. Participants were asked to make either survival relevance decisions or pleasantness ratings about words in the same categorized list. Survival processing produced the best recall, despite the fact that pleasantness ratings of words in a categorized list has long been considered a "gold standard" for enhancing free recall. The results also help to rule out conventional interpretations of the survival advantage that appeal to enhanced relational or categorical processing.

Introduction

The capacity to remember, to recover the past in anticipation of the future, almost certainly evolved (Darwin, 1859). Nature shaped the characteristics of our memory systems, primarily through natural selection, because fitness advantages accrued as a consequence of memory's operation (see Klein, Cosmides, Tooby, & Chance, 2002; Tooby & Cosmides, 1992). Yet, to what extent do the operating characteristics of memory continue to bear the imprint of ancestral selection pressures? Are our memory systems "tuned" to achieve specific ends, particularly those related to survival and reproduction? Or, did memory evolve as an all-purpose machine, defined more by its flexibility than by its inherent constraints?

Our laboratory has maintained that human memory likely does contain functional specialization (see Barrett & Kurzban, 2006). More specifically, we have suggested that memory is biased or tuned to remember fitness-relevant information (Nairne & Pandeirada, 2008; Nairne, Thompson, & Pandeirada, 2007). It is unlikely that memory evolved to be domain-general, or insensitive to content, because not all events are equally important to remember. For example, it is usually more important to remember the location of a food source, or a predator, than it is to remember random events. This is not to suggest that our brains come pre-equipped with content-specific knowledge (e.g., edible versus inedible plants), but rather that fitness-relevant encodings are remembered particularly well.

In support of this proposal, Nairne et al. (2007) found that memory was significantly enhanced relative to traditional deep processing controls (Craik & Lockhart, 1972) when random words were processed in terms of their relevance to a survival scenario. Participants were asked to imagine themselves stranded in the grasslands of a foreign land, without any basic survival materials, and to rate the relevance of words to finding steady supplies of food and water and protection from predators. Surprise free recall tests revealed an advantage for survival processing over a pleasantness rating task, typically considered to be one of the best deep encoding procedures (e.g., Packman & Battig, 1978), as well as over an alternative schematic control (moving to a foreign land) and to a condition requiring self-referential processing. More recently, we compared

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survival processing to a host of deep processing controls—including forming a visual image, generation, and intentional learning—and survival processing produced the best recall (Nairne, Pandeirada, & Thompson, 2008).

Mnemonic advantages for survival processing have now been demonstrated in other laboratories as well using alternative control scenarios (Kang, McDermott, & Cohen, in press; Weinstein, Bugg, & Roediger, 2008). For example, survival processing produced better memory than a control scenario involving the planning and execution of a bank heist (Kang et al., in press).The bank heist scenario was chosen to match the novelty and potential excitement of the survival scenario, something that may have been lacking in the moving control scenario used by Nairne et al. (2007). Our laboratory has also found survival advantages compared to scenarios in which (a) people were asked to imagine themselves vacationing at a fancy resort with all of their needs taken care of, (b) eating dinner at a restaurant, and (c) planning a charity event with animals at the local zoo (Nairne & Pandeirada, 2007; Nairne et al., 2007; Nairne et al., 2008). At this point, we believe, appealing simply to the schema-like properties of the survival scenario, or to its coherence or novelty, is unlikely to explain these advantages.

Instead, these experiments support the hypothesis that it is the fitness-relevance of the processing that is important to memory. Information encoded as a consequence of fitness-based processing is especially accessible and memorable—more memorable, in fact, than that produced by most (if not all) known encoding procedures, at least when free recall is used as the retention measure. At the same time, these experiments have revealed very little about the proximate mechanisms that actually produce the survival benefit. Is survival processing special, arising from the action of some kind of special mnemonic adaptation, or can we explain the advantage using traditional explanatory tools? For example, one might claim that survival processing is simply another form of "deep processing", albeit a particularly good one, leading to enhanced elaboration or distinctive encodings (see Hunt & Worthen, 2006).

Another possibility is that rating words for survival mimics a categorization task. Perhaps participants essentially encode the rated words into an "ad hoc" category representing "things that are relevant in a survival situation." Once primed by the rating task, the category structure could support an accessible and efficient retrieval plan (Tulving & Pearlstone, 1966). Put more generally, one can conceive of the survival rating task as inducing a form of relational processing. As people rate the items, they process ostensibly unrelated words along a common dimension of similarity—relevance to a survival context. It is well-established that relational processing of unrelated items leads to improved free recall, partly because the encoded dimension of similarity helps to restrict the set of possible recallable items at the point of test (Hunt & McDaniel, 1993; Nairne, 2006). Note this is a completely conventional account of the survival advantage: Survival ratings induce people to encode target items into a categorical structure that is particularly accessible during retrieval.

Such an account generates an obvious prediction: If the to-be-rated words are inherently related (e.g., if the list is categorized) then any relational processing induced by the survival rating task should be less useful to retention (see Burns, 2006; Mulligan, 2006). A number of studies have found that relational processing of items in a related list, such as sorting items from an obviously categorized list into categories, produces no particular mnemonic advantages, at least when compared to identical processing of words in an unrelated list (e.g., Burns, 1993; Einstein & Hunt, 1980; Hunt & Einstein, 1981). The category structure inherent in the list affords a sufficient retrieval "plan" for use in recall (e.g., the list contained pieces of furniture, weapons, and so on) so further relational processing is redundant (although see Engelkamp, Biegelmann, & McDaniel, 1998). In fact, encoding procedures that draw attention to the unique characteristics of the to-be-recalled items (such as rating items for pleasantness or familiarity) promote the best recall when lists are categorized. The list structure enables one to restrict the target search set effectively, and the individual-item processing helps one discriminate items within the search set that did or did not actually occur on the memory list (see Nairne, 2006). Researchers have been able to explain a variety of mnemonic phenomena by appealing to trade-offs between item-specific and relational processing (e.g., Hunt & Seta, 1984; Klein, Kihlstrom, Loftus, & Aseron, 1989; Klein & Loftus, 1988; Mulligan, 1999; Mulligan, 2001); it is certainly possible that similar logic can be used to explain the advantages seen after survival processing.

The current experiments were designed to test these ideas, as well as to compare the mnemonic value of survival processing against yet another powerful encoding procedure: Individual item processing of words presented in a categorized list. In all three experiments, participants were asked to make rating decisions about words in a categorized list prior to a surprise free recall test. Experiment 1 used a between-subject design to compare the effects of survival processing to a prototypical individual-item processing task—rating items for pleasantness. Experiment 2 replicated the results of Experiment 1 using a within-subject design. Finally, in Experiment 3 a non-fitness-relevant scenario, vacationing at a fancy resort in a foreign land, was used instead of the survival scenario.

Experiment 1

In Experiment 1, participants were required to make survival relevance decisions about items in an obviously categorized list. To enhance the salience of the category structure, we blocked the category items during presentation and used categories that seemed inherently survival-related (animals, fruits, vegetables, and human dwellings). In a separate control condition, participants were asked to make pleasantness ratings about exactly the same items prior to the surprise recall test. Again, individual-item processing of items in a categorized list is generally thought to be the best procedure for maximizing free recall (Hunt & McDaniel, 1993). If survival processing simply induces a form of relational processing—e.g., fitting words into an ad hoc category of survival relevance—then we would expect the typical survival advantage to disappear or even reverse in the current experiment.

Method

Participants and apparatus

Eighty Purdue undergraduates participated in exchange for partial credit in an introductory psychology course. Participants were tested individually in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and design

Stimulus materials were drawn from the updated Battig and Montigue norms (Van Overschelde, Rawson, & Dunlosky, 2004) and consisted of eight exemplars from four unique categories: Four-footed animals, fruits, vegetables, and a type of human dwelling. The 32 words were presented blocked by category (e.g., all eight animals were presented together) but exemplar order within each category was randomly determined. Four different orders of category presentation were created to ensure that each category occurred equally often in each list quartile across participants. Order of exemplar presentation within each category was the same in all versions. Two items from an additional two categories (a natural earth formation; an article of clothing) were selected to use as practice items.

A simple between-subject design was used: Participants in each group were asked to rate the same words, presented in the same random orderings, in one of the two rating scenarios ($N = 40$ in each group). The rating task was followed immediately by a short digit recall task prior to a final unexpected free recall task. Except for the rating scenario, all aspects of the design, including timing, were held constant across participants.

Procedure

On arrival in the laboratory, participants were randomly assigned to one of the two rating scenarios with the following instructions:

Survival. In this task we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation. Some of the words may be relevant and others may not—it's up to you to decide.

Pleasantness. In this task, we are going to show you a list of words, and we would like you to rate the pleasantness of each word. Some of the words may be pleasant and others may not—it's up to you to decide.

Stimuli were presented individually, centered on the screen, for five s apiece and participants were asked to rate the words on a five-point scale, with one indicating totally irrelevant (unpleasant) and five signifying extremely relevant (pleasant). The rating responses, one through five, were displayed just below the presented stimulus and participants responded by selecting the button that corresponded to the rating of their choice. Everyone was cautioned to respond within the five s presentation window and no mention was made of a later retention test. A short practice session, containing four to-be-rated words, preceded the actual rating task.

After the last word was rated, instructions appeared for the digit recall task. For this task, seven digits, ranging between zero and nine, were presented sequentially for one s apiece and participants were required to recall the digits in order by typing responses into a text box. The digit recall task proceeded for approximately two min. Recall instructions then appeared. Participants were instructed to write down the earlier-rated words, in any order, on a response sheet. The final recall phase proceeded for 10 min and participants were asked to draw a line on the recall sheet, under the last recalled word, after each min of recall. A clock was displayed on the computer monitor and a "beep" sounded every min signaling the participants to draw the line.

Results and discussion

Cumulative recall functions for the survival and pleasantness groups are shown in Fig. 1. During the first two mins of recall the groups performed similarly, but a reliable survival advantage emerged by the five min mark [$F(1,78) = 5.207$, $MSE = 12.10$, $p < .03$]. During the second half of the recall period, on average, very few additional items were recalled (survival = 1.6; pleasantness = 1.8); a separate analysis on the number of item gains between five and 10 mins revealed no significant difference between groups [$F(1,78) < 1.0$]. Overall, for the entire 10 min recall period, a survival advantage was present (survival = .67; pleasantness = .62) but only marginally significant using a two-tailed test [$F(1,78) = 3.70$, $MSE = .012$, $p < .06$].[1]

The top half of Table 1 presents category clustering data for recall using the adjusted ratio of clustering, or ARC score (Roenker, Thompson, & Brown, 1971). The ARC score measures the extent to which members of the same category tend to be recalled together and is often used as a measure of relational processing (see Burns, 2006). An ARC score of 1.00 indicates perfect clustering and a score of zero indicates chance-level clustering. As expected, the ARC scores were well above zero, but no significant differences were found between the survival and pleasantness conditions [$F(1,78) = 1.87$, $MSE = .04$. $p > .10$].

Table 1 reports intrusion data as well, or the extent to which participants recalled items that were not on the list. The mean number of intrusions was low for both groups, but significantly more intrusions occurred in the survival group [$F(1,78) = 15.31$, $MSE = 1.51$, $p < .001$]. Thus,

[1] The fact that the survival advantage was highly significant after five-mins and only marginally significant after 10 mins might have been due, in part, to the fact that participants tended to recall slightly more new items in the pleasantness condition during the second half of the recall period. Such a pattern may signify relatively more individual-item processing in the pleasantness condition because steady increases in the recovery of new items (item gains) can be one hallmark of individual-item processing. However, the difference in item gains was not statistically significant between groups and assumptions about individual-item processing and item gains may depend importantly on whether list items are related (see Burns, 1993).

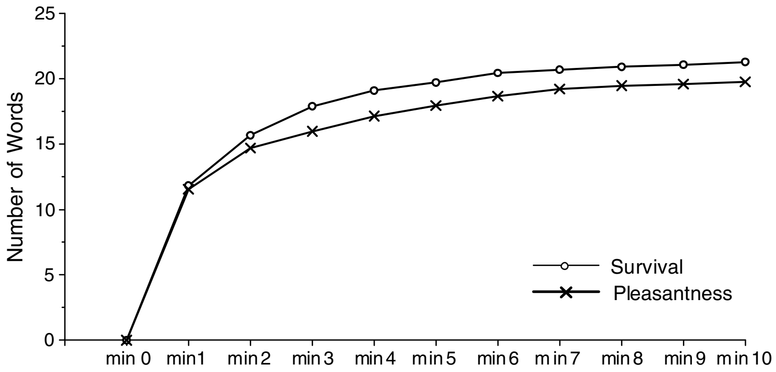

Fig. 1. Cumulative recall curve for each condition.

Table 1
Averages and standard deviation of the ARC scores, number of intrusions, rating and response time

	Survival		Pleasantness	
	M	*SD*	*M*	*SD*
Clustering	0.47	0.21	0.53	0.18
Intrusions	1.58	1.45	0.50	0.961
Rating	3.21	0.48	3.07	0.44
Response time (ms)	2274.4	449.4	2154.4	307.4

although there is no evidence for differential relational processing between the groups, it is possible that survival processing effectively lowered the threshold for response output (for unknown reasons). In a follow-up analysis we examined performance exclusively for participants who failed to commit an intrusion. A survival advantage was still detected in overall proportion correct recall (Survival = 0.69; Pleasantness = 0.63), but the difference was significant only in a one-tailed *t*-test [$t(56) = 1.87$].

The bottom half of Table 1 shows the mean rating and response time data for each group. The average rating was slightly higher when items were processed for survival relevance, but the difference did not approach statistical significance [$F(1,78) = 1.67$, $MSE = .21$]. Similarly, people took slightly longer to decide about survival relevance, compared to a pleasantness decision, but the difference once again was not statistically significant [$F(1,78) = 1.94$, $MSE = 148230.8$]. Previous work in our laboratory has shown that neither average ratings nor response times are capable of explaining survival processing advantages in recall (e.g., Nairne et al., 2007); a similar conclusion seems appropriate here.

Overall, then, the results of Experiment 1 provide another demonstration of the power of fitness-relevant processing. Processing items for their survival relevance produced better retention than a standard deep processing control (rating items for pleasantness). More importantly, the present control condition—individual item processing in a categorized list—is thought generally to maximize free recall because it affords both relational and distinctive information to encoding (Hunt & McDaniel, 1993). Previous work in our laboratory has shown that a few seconds of survival processing produces recall levels that exceed the "best of the best" of the known encoding procedures, including the formation of a visual image, generation, and intentional learning (Nairne et al., 2008). Our conclusion, that survival processing is one of the best—if not the best—encoding procedures yet identified in human memory research, receives further support from the present experiment.

The results of Experiment 1 also help to rule out one possible interpretation of the survival advantage. As discussed earlier, processing items for their survival relevance may induce a form of relational processing. When unrelated items are processed in terms of a common theme (survival relevance), it is conceivable that participants encode similarities among the items, or fit the items into an accessible category structure. In the present case, the list possessed a salient category structure, and the categories were selected to be survival-relevant, so further relational processing should have been redundant and of little additional use in recall. A survival advantage was still obtained, and the measure of category clustering suggested equivalent amounts of relational processing across the groups.

Experiment 2

Experiment 2 was designed to replicate the results of Experiment 1 using a within-subject design. Once again, participants received a list of blocked category items, but on a random half of the trials they were required to make either a pleasantness or a survival rating. Within each category half of the items were rated for survival and the other half for pleasantness. The rating task was followed by a surprise free recall test for the rated items.

The use of a within-subject design in this context is important for two reasons. First, because people are making both survival and pleasantness decisions about items in exactly the same categories, any enhancing effect that either form of processing might have on category accessibility should benefit items equally in both conditions. Second, the intrusion data in Experiment 1 suggested that survival processing may have lowered the response output threshold relative to the pleasantness condition. In the present experiment, because of the within-subject design, any such tendency would be expected to affect the recall of items in both the survival and pleasantness conditions.

Method

Participants and apparatus

Thirty-two Purdue undergraduates participated in exchange for partial credit in an introductory psychology course. Participants were tested individually in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and design

As in Experiment 1, stimulus materials were drawn from the updated Battig and Montigue norms (Van Overschelde et al., 2004) and consisted of eight exemplars from four unique survival-relevant categories: Four-footed animals, weather phenomenon, vegetables, and a type of human dwelling. The 32 words were presented blocked by category and exemplar order within each category was randomly determined. Four different orders of category presentation were created to ensure that each category occurred equally often in each list quartile across participants. Order of exemplar presentation within each category was the same in all versions. Two additional words from each category were selected to be used as practice items.

A within-subject design was employed: For a random half of the items in each blocked category, participants were instructed to make either a survival or a pleasantness rating decision. Task order was also counterbalanced across participants to ensure that each word was rated equally often for survival and pleasantness.

Procedure

On arrival in the laboratory, participants were told they would be asked to rate words in two ways. For some words they would provide a pleasantness rating; for other words, they would rate the word's relevance to a survival situation. General rating instructions were provided and were identical to those used in Experiment 1. A short practice session preceded the main rating session.

Stimuli were presented individually for five s in the center of the screen. Above each word a question was presented specifying the rating decision for that word ("How PLEASANT is this word?", or "How relevant is this word to the SURVIVAL situation?"). Below each word, the rating scale was presented (ranging from one to five) along with the relevant labels. Participants responded by selecting the button that corresponded to the rating of their choice. The rating tasks were distributed randomly with the constraint that no more than two words were rated on the same dimension in a row. After the rating session, a short distractor task preceded initiation of the surprise free recall test. Both the distractor and recall task were the same as presented in Experiment 1.

Results and discussion

The data of main interest are presented in Fig. 2, which shows proportion correct recall for words rated for survival and pleasantness. Replicating Experiment 1, recall in the survival condition was higher than in the pleasantness condition [$F(1,31) = 4.48$, $MSE = 5.58$, $p < .05$]. Out of the 32 participants, 22 recalled more survival items, nine recalled more items rated for pleasantness, and there was one tie. Because of the within-subject design, with both conditions represented equally in all categories, neither the ARC scores nor the overall intrusion rates are presented.

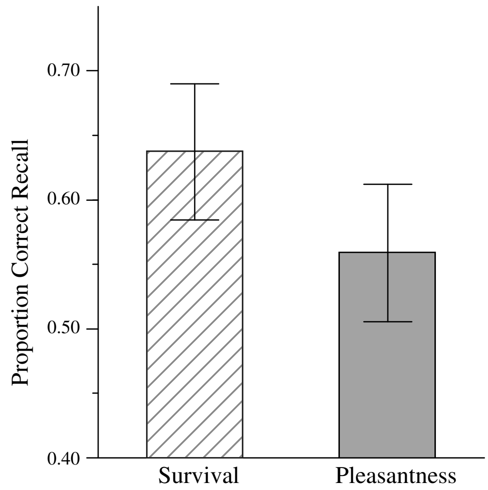

Fig. 2. Average proportion of recall for each condition. Error bars represent 95% confidence intervals (as per Masson & Loftus, 2003).

In Experiment 1, mean relevance ratings and response times favored the survival task, but neither was significant in the statistical analyses. In Experiment 2, however, the mean relevance ratings for survival were significantly higher than the ratings for pleasantness (3.6 vs. 2.8; $F(1,31) = 45.2$, $MSE = .23$); survival ratings also took significantly longer to complete (2950.3 vs. 2805.3; $F(1,31) = 4.33$, $MSE = 77754.1$). Thus, it is conceivable that the survival recall advantage in Experiment 2 is partly attributable to either a congruity effect (i.e., recall is a positive function of the match between the encoding context and the item; Schulman, 1974), or to the fact that survival relevance decisions are more effortful. We think both of these interpretations are unlikely, based on previous work showing strong survival recall advantages without corresponding differences in average ratings or response times (see Experiment 1; also, Nairne et al., 2007).

However, as a further check we performed several additional item-based analyses. First, we calculated the recall and rating data for each item when it was processed for survival or pleasantness. We then looked at the correlation between recall and rating, which was nonsignificant in both cases (Pearson r for survival was 0.19; r for pleasantness was 0.28). Next, we correlated the size of the survival effect (the difference in recall when the item was rated for survival versus pleasantness) with the size of the rating difference (the difference in rating when the word was rated for survival versus pleasantness); this correlation was small and nonsignificant (Pearson $r = .09$). We also performed a median split on the rating differences and looked at the size of the survival effect only for those items that were in the lower half (i.e., those items showing small or no survival rating advantages). For these 16 items, the average rating difference between survival and pleasantness was a nonsignificant 0.20 (Survival = 3.4; Pleasantness = 3.2), yet the overall survival advantage remained in recall (Survival = .66; Pleasantness = .55; $t(15) = 2.80$, $p < .02$).

We performed the same item analyses for the response times. Again, there was a nonsignificant correlation between the task-based response times and the survival effect in recall (Pearson $r = -.23$). We also once again looked at the 16 items that showed the smallest (or no) survival response time advantages. For these items, average response times were actually longer for the pleasantness task (Survival = 2738.9; Pleasantness = 2932.0), yet the survival advantage remained in recall (Survival = .73; Pleasantness = .61; $t(15) = 2.58$, $p < .03$). Consequently, as in our earlier reports, differences in average ratings or response times cannot fully explain the survival advantages seen in free recall (Nairne et al., 2007).

With respect to free recall, the results of Experiment 2 replicate those of Experiment 1. A reliable survival advantage was obtained, even though the target list was categorized and the control condition was designed to engage a combination of individual item and relational processing. The list structure should have minimized any mnemonic effect of relational processing, yet a survival advantage still emerged. The survival benefit is even more convincing in Experiment 2 because a within-subject design was employed. To the extent that survival processing simply increased accessibility of the list categories, or lowered the response output threshold, then related performance effects should have occurred for both survival and pleasantness items.

Experiment 3

In the existing literature, it is extremely difficult to find examples of encoding procedures that produce superior free recall to a condition requiring pleasantness ratings in a categorized list. The results of the first two experiments, as a consequence, strongly establish the power of fitness-relevant processing compared to traditional encoding tasks. Yet, the survival rating procedure used in our experiments is unusual in the sense that processing occurs within the context of a relatively rich and cohesive cover scenario (survival in the grasslands of a foreign land). Although we have compared the survival scenario to other control scenarios, such as moving to a foreign land, it is possible that any schema-based encoding produces better recall than individual-item processing in a categorized list. Experiment 3 was designed to examine this possibility.

Experiment 3 was an exact replication of Experiment 2, except that the survival scenario was replaced with a conceptually rich, but non-fitness-relevant, alternative scenario. Participants were asked to rate the relevance of words to a vacation scenario (see also Nairne et al., 2008). If schema-based processing of words in a categorized list is sufficient to induce superior retention, then we expect to replicate the pattern seen in Experiment 2—a recall advantage for the scenario condition over the pleasantness condition. On the other hand, if the important dimension is the fitness-relevance of the processing, then we anticipate the more traditional result—the best recall for a condition requiring individual-item processing in a categorized list.

Method

Participants and apparatus

Thirty-two Purdue undergraduates participated in exchange for partial credit in an introductory psychology course. Participants were tested individually in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and design

The materials and design employed in Experiment 2 were used in Experiment 3, with the exception that the vacation scenario was substituted for the survival scenario.

Procedure

All aspects of the procedure mimicked those of Experiment 2 except for the use of the following vacation scenario:

Vacation. In this task, we would like you to imagine that you are enjoying an extended vacation at a fancy resort in the grasslands of a foreign land. All your basic needs are taken care of but, over the next few months, you'll want to investigate your surroundings and find different activities to pass the time and maximize your enjoyment. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this vacation situation. Some of the words may be relevant and others may not—it's up to you to decide.

Results and discussion

The final free recall results are shown in Fig. 3, presented as a function of encoding condition. An ANOVA re-

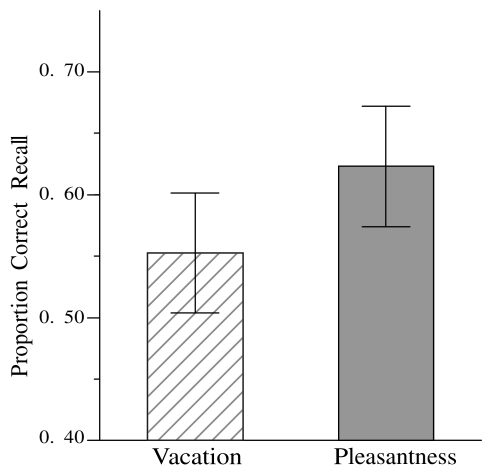

Fig. 3. Average proportion of recall for each condition. Error bars represent 95% confidence intervals (as per Masson and Loftus, 2003).

vealed a significant effect of condition [$F(1,31) = 4.25$, $MSE = .02$, $p < .05$]. Importantly, however, in this case rating items for pleasantness produced the best recall, reversing the pattern found in Experiment 2. For the 32 participants, 12 recalled more items rated under the vacation scenario, 17 recalled more items rated for pleasantness, and there were three ties.

Analysis of the rating data revealed no significant differences between the two encoding conditions (Vacation = 2.6, Pleasantness = 2.6; $F(1,31) < 1.0$). Note that the average relevance ratings for the vacation condition, although identical to the ratings given for pleasantness, were lower than those given for the survival condition in Experiment 2. Given that the list was categorized, and the categories were selected to be survival-related, this finding is not particularly surprising. We have directly compared survival processing with a comparable "vacation" control in previous work, using a list of random words, and a significant survival advantage was obtained with little or no differences in average ratings (Nairne et al., 2008). It is also interesting to note that the recall levels for the words rated for pleasantness were higher than those seen in Experiment 2, even though exactly the same design and materials were used. We have no explanation for this finding, although the pattern across experiments could be interpreted as an example of a list strength effect (Tulving & Hastie, 1972). However, the survival advantage seen in Experiment 2 was also seen in Experiment 1, which used a between-subject design, so one cannot account for the effect overall by appealing to encoding variable interactions (e.g., list strength effects, differential output interference, etc.).

For the response time data, participants took significantly longer to generate a rating in the vacation condition [Vacation = 2907.1, Pleasantness = 2658.8; $F(1,31) = 18.84$, $MSE = 52333.6$, $p < .001$]. This finding is important because it further dissociates response time and recall performance. In this case, the more "effortful" encoding task—processing the relevance of items to a vacation scenario—was associated with poorer free recall performance. As noted throughout, it is unlikely that any simple appeal to rating or response time differences will be able to explain the encoding-based differences in recall seen in these experiments.

Overall, the results of Experiment 3 conformed to the expectations of conventional memory theory. It is widely acknowledged that free recall performance benefits greatly from encoding procedures that induce a combination of individual item and relational processing. Both are necessary in order to (a) restrict the memory search set and (b) discriminate effectively among items within the set that either did or did not occur (e.g., Hunt & McDaniel, 1993; Nairne, 2006). In the present case, rating items for pleasantness in an obviously categorized list led to the best recall, compared to a "scenario" condition that presumably induced primarily relational processing. As a result, the data lower the chances that the survival advantages seen in Experiments 1 and 2 can be attributed simply to the use of scenario- or schema-based processing.

General discussion

The crux of the functionalist agenda is the recognition that memory is functionally designed (Nairne, 2005; Sherry & Schacter, 1987). As a product of evolution, we can assume that our ability to remember has been sculpted by natural selection to achieve specific ends, much like the heart is functionally designed to pump blood, or the kidneys to filter impurities (Klein et al., 2002; Nairne & Pandeirada, 2008). Although few question the adaptive value of memory, or that the ability to remember arose as a product of evolution, whether human memory continues to bear the footprints of ancestral selection pressures remains an open, and ultimately empirical, question.

Our laboratory has suggested that memory may be tuned to process and retain fitness-relevant information—that is, information that is relevant to survival and ultimately to reproduction. Not all information is equally important from a fitness perspective, so it is reasonable to assume that our memory systems show domain-specificity, or sensitivity to information content. In empirical support of this idea, we have found that processing information in terms of its survival relevance leads to particularly good retention (Nairne et al., 2008)—better retention, in fact, than most, if not all, known encoding techniques (e.g., imagery, self-reference, generation, intentional learning), at least when free recall is used as the retention measure.

The current experiments were designed with two primary goals in mind. First, we were interested in comparing the effectiveness of survival processing to yet another powerful encoding technique, one that encourages individual-item processing of words in a categorized list. Lots of studies have found that item-based encoding tasks, such as rating an item for pleasantness, lead to especially good recall when a list is categorized because such processing yields distinctive encodings in a context of similarity (Hunt & McDaniel, 1993; Hunt & Smith, 1996). Despite the recognized superiority of such an encoding procedure, a few seconds of survival processing produced higher levels of free recall in both Experiments 1 and 2 of the present report.

Second, we were interested in testing one possible, and conventional, interpretation of the survival advantage. Processing items in terms of their survival relevance can be conceived as a form of relational processing. Items are processed with respect to a single context, surviving in the grasslands, and it is possible that participants encode the items into a relevant ad hoc category that is particularly accessible at retrieval. In the present experiments, however, survival processing of words in a categorized list, one containing blocked and salient survival-related categories, continued to produce a reliable survival advantage compared to pleasantness processing. In such a context, any survival-based categorical processing should have been redundant with the information afforded by the list structure and therefore of limited usefulness in recall.

The survival advantage was obtained as well in a within-subject design, one in which participants made both survival and pleasantness decisions about items in exactly the same categories. The survival advantage is important in this context because any effect that survival processing might have had on category salience or accessibility should have contributed to recall of both the survival and pleasantness-rated items. The data of both Experiments 1 and 2, as a result, significantly lower the chances that enhanced relational (or categorical) processing is responsible for the demonstrated survival advantage. Moreover, in Experiment 3 participants were asked to rate the relevance of words to a vacation scenario, one that presumably also induced relatively greater amounts of relational processing than the pleasantness task, yet no recall advantage was obtained. Instead, the more typical result was obtained—enhanced memory for the pleasantness rating task, presumably because it led to combined individual-item and relational processing.

Do the results of these and other experiments indicate that survival processing is special? Certainly from an empirical perspective survival processing is a powerful encoding technique, leading to better free recall than a variety of standard encoding techniques. In addition, the survival advantage is easily obtained in both within- and between-subject designs, unlike a number of other encoding-based mnemonic phenomena (e.g., the generation effect, word frequency effect, the effect of bizarre imagery, emotionality, etc.). The typical interpretation of such effects is that the encoding task leads people to focus attention on the individual attributes of the item at the expense of noting relationships among the items (e.g., as indexed by poorer memory for temporal order; see McDaniel & Bugg, 2008, for a review). We have yet to examine the effect of survival processing on the retention of temporal order, but the current experiments revealed no differential relational processing between conditions. Clearly, any detrimental effects that survival processing may have on order memory are compensated by other mnemonic advantages.

Perhaps the simplest "explanation" of the survival advantage is that it leads to more item-based elaboration, or "spread of processing" (e.g., Craik & Tulving, 1975). Similar appeals are commonly used to explain the advantages of semantic or deep processing—i.e., processing the meaning of an item leads to more connections between the target item and other information in memory. More elaboration, in turn, increases the chances that appropriate retrieval cues can be accessed in free recall environments. However, there is no obvious reason to expect survival processing, which is a relatively novel task, to produce more elaboration than other procedures that have more relevance to everyday experiences (e.g., moving, restaurant, or vacation scenarios). One of the failings of modern memory theory is the absence of easily—applied and independent indices of elaboration, so "elaboration" accounts remain speculative and difficult to test at this point.

Regardless of the proximate mechanism, it is clearly adaptive for people to retain fitness-relevant material. Selection advantages could easily have accrued from a memory system tuned to remember the location of food or predators, although it is exceedingly difficult to establish the existence of true cognitive adaptations (Andrews, Gangestad, & Matthews, 2002; Williams, 1996). Whether humans evolved functionally specialized circuitry for remembering fitness-relevant material, or whether retention advantages for fitness-relevant processing arise as a by-product of other more general mnemonic mechanisms, remains unclear. At the same time, it is naïve to assume that our memory systems lack functional design. The capacity to remember evolved because of the selection advantages it provided; consequently, we should anticipate that memory contains features that are selectively tuned to solving adaptive problems related to fitness (Klein et al., 2002; Nairne, 2005; Rozin, 1976).

Still, one might not expect recall advantages of the type demonstrated in the current experiments for all kinds of fitness-relevant materials. Free recall requires a search engine, or retrieval process, that accesses stored information using a criterion of recent occurrence. It is an episodic task, one that requires people to generate items that occurred at a specified time, in a specified location, as defined by the experimental context (Nairne, 1991; Tulving, 1983). From a functional perspective, the need to remember some fitness-relevant material, such as the location of food, water, or a possible predator, is often likely to be time-dependent. In fact, Anderson and Schooler (1991) have shown that forgetting functions often mimic the way that events occur and recur temporally in the environment. Other kinds of fitness-relevant information, such as social and personal characteristics (e.g., is that person a cheater?), may not show the same kinds of sensitivities to occurrence (see Barclay & Lalumière, 2006; Mehl & Buchner, 2007).

Conclusion

Our laboratory has made the strong claim that survival processing represents one of the best—if not the best—encoding procedures yet discovered in the memory field (Nairne et al., 2008). Is such a claim justified? Empirically, we believe the case is strong: Not only does a simple survival rating produce better free recall than a veritable "who's who" of known deep encoding procedures, but it also produces better memory than the prototypical combination of individual-item and relational processing (pleasantness ratings in a categorized list). As noted above, survival processing is one of the few techniques ever shown to produce higher levels of recall than a task requiring pleasantness ratings in a categorized list. Regardless of one's ultimate interpretation of the survival advantage, then, adopting a functional perspective can lead to novel empirical findings that may challenge existing perspectives on retention.

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