Adaptive Memory: Fitness-Relevance and the Hunter-Gatherer Mind

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Abstract

Recent studies suggest that our memory systems are "tuned" to remember information that is processed in terms of its fitness value. When people are asked to rate the relevance of words to a survival scenario, surprise retention levels exceed those obtained by a veritable "who's who" of known encoding techniques. The present experiments explored scenarios that mimic the division of labor thought to characterize early hunter-gatherer societies. Researchers have suggested that "foraging-related cognitive specializations" might manifest themselves when males and females perform sex-specific tasks: gathering for females and hunting for males. Males and females were asked to rate the relevance of random words to prototypical hunting and gathering scenarios. Surprise retention tests revealed superior memory for the rated words, compared to words rated under matched non-fitness-relevant control scenarios (gathering food on a scavenger hunt or as part of a hunting contest), but no sex differences were found in memory performance.

Central to the functionalist agenda in human memory research is the recognition that our memory systems are functionally designed (e.g., Klein, Cosmides, Tooby, & Chance, 2002; Nairne, 2005; Sherry & Schacter, 1987). Like other biological systems, memory likely evolved to enhance fitness (survival and/or reproduction) and, accordingly, its systems may be specially "tuned" to retain information that is fitness relevant. In support of this proposal, we and others have shown that thinking about the relevance of information to a survival situation produces excellent long-term retention (Kang, McDermott, & Cohen, in press; Nairne, Thompson, & Pandeirada, 2007; Weinstein, Bugg, & Roediger, 2008); in fact, a few seconds of survival processing produces better free recall than virtually all known memory-enhancement techniques (Nairne & Pandeirada, 2008a; Nairne, Pandeirada, & Thompson, 2008).

In the prototypical survival experiment, participants are asked to imagine themselves stranded in the grasslands of a foreign land, without any basic survival materials. Participants are told that over the next few months they will need to find steady supplies of food and water and protect themselves from predators. Randomly-selected words are presented and the participant's task is to rate the relevance of each word to this imagined scenario. In a later surprise memory test, people typically remember the rated words better than words rated in matched encoding scenarios that are not fitness-relevant (e.g., moving to a foreign land or spending time at a vacation resort). "Survival-based" retention is also better than that obtained through traditional "deep" processing tasks (Craik & Tulving, 1975), such as thinking about the meaning of an item or forming a visual image.

Yet as a product of natural selection, memory ultimately evolved because it enhanced fitness in particular "environments of evolutionary adaptedness" (Bowlby, 1969; Tooby & Cosmides, 1992). Evolutionary products are rooted in the past, by definition, and are likely to reflect the environmentally-determined selection pressures faced by our ancestors. Evolutionary psychologists generally believe that the majority of cognitive "sculpting" occurred during the Pleistocene era—from approximately 1.8 million years ago to 10,000 years ago—during which the human species lived largely as foragers or hunter-gatherers (e.g., Symons, 1992). Consequently, memory processing should bear the imprint of the selection pressures faced by our foraging ancestors; memory should be geared toward retaining information that is relevant to the specific adaptive problems faced in hunting and gathering environments.[1]

At present, we know little about the evolutionary determinants of human memory although some relevant research does exist (e.g., Anderson & Schooler, 1991; O'Gorman, Wilson, & Miller, 2008). For example, it has been suggested that sex differences in spatial abilities, including object location memory, may have an evolutionary basis (Sherry, Jacobs, & Gaulin, 1992; Silverman & Eals, 1992). Silverman and Eals (1992) suggested that the division of labor typically found in hunter-gatherer societies—men hunt and women gather—may have led to unique foraging-related cognitive specializations between the sexes (for related arguments in a non-human domain, see Gaulin & FitzGerald, 1986). Indeed, men generally outperform women on tasks thought to tap hunting skills (e.g., navigation and orientation) whereas women often show an advantage in tasks requiring memory for objects stored in fixed locales (Voyer, Postma, Brake, & Imperato-McGinley, 2007). The data are somewhat controversial, and subject

to alternative explanations, but are broadly consistent with selection-based cognitive tunings.

Participants in the present experiments were asked to rate the relevance of words to scenarios that were specifically designed to tap prototypical hunting and gathering activities. Following the rating tasks, everyone received a surprise recall test for the rated words. Our intent was to design scenarios that were congruent with ancestral priorities, but also with the division of labor thought to exist between the sexes during the environment of evolutionary adaptedness. The empirical questions were twofold: First, would hunter/gatherer processing yield enhanced retention relative to appropriate controls, a finding consistent with the proposal that our memory systems are tuned to remember fitness-relevant information? Second, would males show relative mnemonic advantages after processing "hunter" scenarios and females after "gathering" scenarios?

In addition, importantly, the present experiments offer a significant methodological advance over previous work in this area. Because the activities in the scenarios were specific and focused—hunting and gathering—we were able to design control scenarios that involved the same general activities. In Experiment 1, the hunting and gathering scenarios were compared to a control scenario that involved collecting food on a scavenger hunt. In Experiment 2, the control scenario involved hunting for food, but as part of a hunting contest. In previous work, control scenarios have involved quite different activities, such as moving to a foreign land, spending time at a vacation resort, planning a bank heist, and so on. In the current experiments, everyone rated the relevance of the target words to hunting and gathering food, but under conditions that were fitness-relevant or not. Demonstration of a mnemonic advantage for fitness-relevant processing

under these conditions, as a result, would place the evolutionary account on firmer empirical ground.

Experiment 1

In Experiment 1 all participants were asked to rate and recall exactly the same 30 unrelated words. What differed across the conditions was the processing scenario. In the gatherer condition, participants were asked to imagine themselves in charge of gathering edible food for a tribe (collecting fruits, nuts, vegetables, etc.). In the hunter condition, participants imagined themselves in charge of hunting for food (hunting for big game, trapping small animals, etc.). The control scenario described a scavenger hunt—participants imagined themselves playing a game that required searching for and collecting food items. In each case the task was to rate the relevance of the presented words to the scenario in effect. Note the first two scenarios are fitness-relevant—they refer to situations in which participants are contributing to the survival of the group; the scavenger-hunt scenario taps the same behavior (searching for food items) but in a context that is not fitness-relevant. After completing the rating task, and after a short distraction period filled with digit recall, everyone was given a surprise free-recall test for the rated words.

Method

Participants and apparatus: One hundred and fifty people participated in this experiment. Some participated in exchange for partial credit in an introductory psychology course and others received a small monetary compensation. Participants were tested individually in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and design: A set of 30 concrete nouns (e.g., chair, snow, orange) was used in this experiment (5 additional nouns were used in the practice phase). A simple between-subjects design was used: All participants were asked to rate the same words, presented in the same random ordering, in one of the three rating scenarios (n = 50 in each group). Equal numbers of men and women participated 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 three rating scenarios with the following instructions:

Gatherer: "In this task we would like you to imagine that you are living long ago in the grasslands of a foreign land. As a part of a small group, you are in charge of gathering food for your tribe. You need to scavenge for edible fruits, nuts, vegetables, etc. Gatherers often have to have knowledge about the locations and seasonal availability of edible foods, but no matter what the conditions (extreme heat, flooding, drought), you must gather edible food successfully for your tribe to eat. 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 your attempt to gather edible food successfully and bring it back to your tribe. Some of the words may be relevant and others may not - it's up to you to decide."

Hunter: "In this task we would like you to imagine that you are living long ago in the grasslands of a foreign land. As a part of a small group, you are in charge of contributing meat to the tribe. You could hunt big game, trap small animals, or even fish in a nearby lake or river (if available). Hunters often have to travel great distances in

order to find food, but no matter what the conditions (extreme heat, flooding, drought), you must hunt successfully for your tribe. 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 in your attempt to hunt successfully for food and bring it back to your tribe. Some of the words may be relevant and others may not - it's up to you to decide."

Scavenger-Hunt: "In this task we would like you to imagine that you have been invited to participate in a scavenger hunt. As a part of a team you are in charge of locating food items from the search list for your team (e.g., fruits, meats, etc.). You need to look for clues that might indicate the location of an item, search in various locations, and transport found items to the game center. Members of the team might need to travel great distances to find the items and interpret clues that indicate locations, but no matter what the conditions you must scavenge successfully for your team. 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 in your attempt to scavenge successfully for the food items and bring them back to the game center. Some of the words may be relevant and others may not - it's up to you to decide."

The to-be-rated nouns were presented individually (centered on the screen) for 5 s each, and participants were asked to rate the words on a 5-point scale, with 1 indicating totally irrelevant and 5 signifying extremely relevant. The rating responses were displayed just below the presented stimulus, and participants responded by clicking on their value of choice. Everyone was cautioned to respond within the 5-s presentation window, and no mention was made of a later retention test. A short practice session

containing 5 to-be-rated words preceded the actual rating task. After the practice phase, participants were briefly reminded of the main aspects of the scenario.

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 1 s each, and participants were required to recall the digits in order by typing responses into a text box. The digit-recall task proceeded for approximately 2 min. Recall instructions then appeared. Participants were instructed to write down the earlier rated words, in any order, on a response sheet. They were also instructed to write down a line for each minute of recall after the word they just finished recalling. The final recall phase proceeded for 10 min.

Results and Discussion

The significance level for all of the statistical comparisons was set at $p < .05$. Participants had little difficulty providing the relevance ratings for the individual stimuli within the allotted time. Ratings were provided for over 99% of the presented words, and the number of unrated words (no response within 5 s) did not differ significantly across groups. Because of the small number of unrated trials, and to avoid item selection problems, the retention data were left unconditionalized.

The data of main interest are shown in Figure 1, which presents average proportion correct recall for the three rating conditions. An overall analysis of variance (ANOVA) on the data revealed a significant main effect of condition, [$F(2, 144) = 6.05$, $MSE = .017$, $\eta_p^2 = .078$]. Post-hoc tests, using the Tukey honestly significant difference test, revealed no significant differences between gatherer and hunter conditions, but both led to better recall performance than the scavenger-hunt condition. Sex of the participant

was also included as a factor in the analysis, but no significant main effect was found [$F(1, 144) < 1$], nor did sex interact with condition [$F(2, 144) < 1$]. Exactly the same pattern of results was obtained in an item analysis, in which item rather than subject was used as the unit of analysis.

It is also of interest to examine the rating and response time data among the conditions (see Table 1). It is possible, for example, that fitness-relevant processing is more effortful than control processing which, in turn, could account for the retention advantages found for the hunter and gatherer conditions. However, the response time analysis produced no significant differences among scenario conditions [$F(2, 144) = 1.10$; $MSE = 168732.7$] or between males and females [$F(1, 144) < 1$]. Significant response time differences were detected among the scenarios in the item analysis [$F(2, 116) = 4.86$; $MSE = 44794.3$; $\eta_p^2 = .077$], but post-hoc tests revealed that participants simply took significantly longer to rate words in the scavenger-hunt condition—this condition, however, led to the worst recall performance.[2] Analyses of the rating data indicated a significant effect of scenario as well [$F(2, 144) = 8.95$; $MSE = .177$; $\eta_p^2 = .11$]; post-hoc tests revealed significantly lower ratings for the hunter condition, compared to the gatherer and scavenger-hunt conditions (which did not differ). As a consequence, like the response time data, the rating data provide little insight into the memory differences obtained between the scenario conditions. No sex-based rating differences were found in either the subject or the item analyses.

Overall, these data provide strong support for the contention that fitness-relevant processing enhances subsequent retention. Processing information from the perspective of survival-based hunting and gathering activities enhanced subsequent free recall

compared to food gathering in a scavenger hunt. Note, importantly, all three scenarios required participants to rate the relevance of words to the same activity—collecting food—but memory was significantly enhanced only when the activity was perceived as relevant to fitness. At the same time, Experiment 1 produced no sex differences in memory performance; males and females remembered roughly the same amount, regardless of whether the orienting scenario tapped hunting (Males = .56; Females = .54) or gathering (Males = .54; Females = .56).

Experiment 2

Experiment 1 demonstrated mnemonic advantages for fitness-relevant hunting and gathering scenarios relative to participation in a food-gathering scavenger-hunt. Given that the latter seems more relevant to gathering than to hunting, Experiment 2 was designed to test a survival-based hunting scenario against a virtually identical hunting scenario that was not fitness-relevant. In the new control condition, participants were asked to imagine that they were part of a team participating in a hunting contest. All other aspects of the scenario (e.g., the need to hunt big game, trap small animals, or even fish in a nearby lake or river) remained the same across the two conditions.

Method

Participants and apparatus: One hundred people participated in this experiment. Participants received partial credit in an introductory psychology course and were tested individually in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and design: The same list of words as in Experiment 1 was used. All participants were asked to rate the same words, presented in the same random ordering, in

one of the two rating scenarios (n = 50 in each group); equal numbers of men and women were assigned to each group.

Procedure: All aspects of Experiment 1 were replicated in this experiment with the exception of the scenarios that were as follows:

Hunter: "In this task, please imagine that you are living long ago in the grasslands of a foreign land. As a part of a small group, you are in charge of contributing meat to feed your tribe. You will need to hunt big game, trap small animals, or even fish in a nearby lake or river. Hunters often have to travel great distances, pursue animals through unfamiliar terrain, and successfully return home. Whatever the conditions, you must hunt successfully to feed your tribe. 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 in your attempt to hunt successfully for food. Some of the words may be relevant and others may not - it's up to you to decide."

Hunting contest: "In this task, please imagine that you have been invited to participate in a hunting contest. As a part of a team, you are in charge of contributing captured game to the team effort. You will need to hunt big game, trap small animals, or even fish in a nearby lake or river. Members of the team often have to travel great distances, pursue animals through unfamiliar terrain, and successfully return to the contest center. Whatever the conditions, you must hunt successfully to help your team win the contest. 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 in your attempt to hunt successfully. Some of the words may be relevant and others may not - it's up to you to decide."

Results and Discussion

Participants had little difficulty providing ratings within the allotted time. Ratings were provided for over 99% of the presented words, and the number of unrated words (no response within 5 s) did not differ significantly across the groups.

The data of main interest are shown in Figure 2, which presents average proportion correct recall for the two rating conditions. The overall ANOVA revealed a highly reliable main effect of scenario [$F(1, 96) = 9.04$; $MSE = .014$; $\eta_p^2 = .09$], a marginally significant effect of sex [$F(1, 96) = 3.05$; $MSE = .014$, $p < .09$; $\eta_p^2 = .03$], and no significant condition X sex interaction [$F(1,96) < 1$]. Females tended to recall slightly more items than men in both scenario conditions (overall averages were .57 and .53 for females and males, respectively), a result that is inconsistent with the pattern predicted by the evolutionary analysis. The item analysis also revealed a strong main effect of scenario [$F(1, 58) = 18.15$; $MSE = .008$; $\eta_p^2 = .24$], but neither the main effect of sex [$F(1, 58) < 1$], nor the interaction was significant [$F(1, 58) = 1.38$; $MSE = .008$] in this analysis.

The rating and response time data are shown in Table 2. None of the response time differences approached significance in either the subject or the item analyses. For the rating data, there were no significant main effects of condition or gender in either the subject or the item analyses (all Fs <1), although both analyses revealed significant condition X gender interactions [subject: $F(1, 96) = 4.70$; $MSE = .122$; $\eta_p^2 = .05$; item: $F(1, 58) = 3.14$; $MSE = .222$; $\eta_p^2 = .05$]. Men tended to produce higher relevance ratings in the hunter scenario ($\overline{X} = 2.71$ and $\overline{X} = 2.54$, for males and females, respectively) and the ratings for women were slightly higher in the hunting contest condition ($\overline{X} = 2.61$ and $\overline{X} = 2.75$, for males and females, respectively). Given that similar patterns were not found

in the recall data, and the overall recall advantage for the hunter condition was not reflected in the rating data (ratings for hunter and hunter contest were equivalent), the interaction provides little insight into the hypothesis of main interest.

General Discussion

The proposal that human memory evolved, sculpted by the processes of natural selection, is accepted widely. Most scholars would acknowledge that memory is an evolved adaptation (e.g., Paivio, 2007), although the precise nature of that adaptation remains controversial. Psychologists typically appeal to general memory processes, such as encoding, storage, and retrieval, and assume similar operating characteristics across materials and domains (e.g., Neath & Surprenant, 2003). What determines retention is the richness of the initial encoding and, ultimately, the degree of "match" between the conditions present at encoding and those existing at the point of the retrieval query (Tulving, 1983). Some situations may engender richer or more elaborate memory records, and thus create records that are more likely to be matched in later environments, but the memory processes themselves are assumed to be domain-general, or insensitive to content.

From an evolutionary perspective, though, it seems more reasonable to propose memory mechanisms that are domain-specific, or sensitive to content (Klein et al., 2002; Nairne & Pandeirada, 2008b). Not all events are equivalent from a fitness perspective—e.g., it is usually more important to remember a predator, a food source, or a potential mating partner—so it is easy to imagine memory "tunings" that are directed toward helping us solve adaptive problems related to reproduction and survival. Indeed, processing information in terms of its relevance to survival leads to strikingly good

retention, at least compared to traditional encoding strategies such as forming a visual image or processing meaning (Nairne et al., 2008).

The present two experiments provide what is perhaps the strongest evidence yet that our memory systems may be tuned to retain information that is processed for fitness. Rating the relevance of words to ancestrally-relevant hunting and gathering activities improved memory compared to tasks that required participants to rate the relevance of items to essentially the same general activities. For example, in Experiment 2 both rating scenarios described the same hunting activities—what differed was whether participants imagined themselves hunting for survival or as part of a hunting contest. Activating a context that was fitness relevant led to significantly greater later retention. This design represents a significant methodological advance over most previous research which has used control scenarios that, although schematic and matched on numerous dimensions, used different activities from those activated by survival processing (e.g., moving to a new home, vacationing at a resort, or planning a bank heist).

More speculative was the proposal that sex-based cognitive specializations might be tapped by our hunter-gatherer scenarios. As noted earlier, there is some evidence that men outperform women on skills thought to be relevant to hunting generally (e.g., navigation) whereas women excel on tasks pertinent to retaining the locations of food resources within a constrained environment. To demonstrate the latter, for instance, New and colleagues recently showed that women are more accurate than men at pointing to newly-learned spatial locations (in an outdoor market) if those locations contain nutritional resources (New, Cosmides, & Tooby, 2007). To the extent that men and women have mnemonic tunings for hunting and gathering respectively, we anticipated

sex-based differences in retention for the hunting and gathering scenarios. This prediction was not supported by the data—we found no evidence in either experiment for scenario-specific sex differences in recall performance. Of course, null effects are notoriously difficult to defend, but our experiments employed relatively large numbers of participants and the data offered little, if any, statistical support for the predicted interaction.

Still, the discovery that fitness-relevant processing represents a particularly effective form of encoding reinforces the value of adopting a functional/evolutionary perspective on remembering. Memory researchers rarely consider function as an important determinant of the design and operation of memory systems. Even if it turns out that memory performance is shaped primarily by current or developmentally-based selection pressures, rather than by ancestral priorities, the act of remembering will still be goal-directed and purposeful. Adopting a functionally-driven agenda can lead to the discovery of new empirical phenomena, as the current experiments demonstrate, and may ultimately provide a clear path toward understanding both “how” and “why” we remember.

Footnote

[1] This reasoning is simplistic in some respects—e.g., our knowledge about ancestral environments is limited; forager "problems" undoubtedly varied across disparate environments—yet it is possible to generate hypotheses based on a hunter-gatherer model and attempt resolution in the empirical domain.

[2] Of course, response times represent only one metric for cognitive effort and do not definitively rule out "effort" interpretations of fitness-based advantages.

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Table 1. Averages (Standard Deviation in parenthesis) of the Rating and Response Time for each condition.

	Rating	Response Time
Hunter	2.537 (0.425)	2389.01 (385.59)
Gatherer	2.806 (0.404)	2444.34 (368.10)
Scavenger	2.873 (0.426)	2510.77 (464.19)

Table 2. Averages (Standard Deviation in parenthesis) of the Rating and Response Time for each condition.

	Rating	Response Time
Hunter	2.625 (0.393)	2387.78 (340.56)
Hunting contest	2.680 (0.310)	2372.75 (338.04)

Figure 1. Average proportion correct recall for each condition in Experiment 1 (error bars indicate 95% confidence interval).

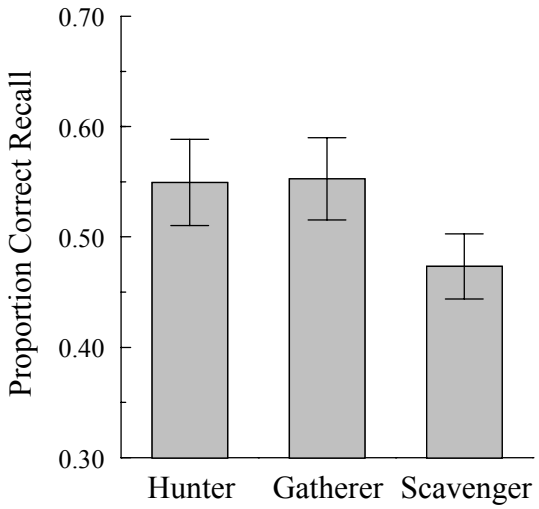

Figure 2. Average proportion correct recall for each condition in Experiment 2 (error bars indicate 95% confidence interval).