Adaptive Memory: Is There a Reproduction Processing Effect?

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Abstract

Like all biological systems, human memory is likely to have been influenced by evolutionary processes, and its abilities have been subjected to selective mechanisms. Consequently, human memory should be primed to better remember information relevant to one's evolutionary fitness. Supporting this view, participants asked to rate words based on their relevance to an imaginary survival situation better recall those words (even the words rated low in relevancy) than the same words rated with respect to non-survival situations. This mnemonic advantage is called the ‘survival processing effect,’ and presumably it was selected for because it contributed to evolutionary fitness. The same reasoning suggests that there should be an advantage for recall of information that has been rated for relevancy to reproduction and/or mate-seeking, although little evidence exists to assess this proposition. We used an experimental design similar to that of the original ‘survival processing effect’ study (Nairne, Thompson, & Pandeirada, 2007), and across three experiments tested several newly designed scenarios to determine whether a reproduction processing effect can be found in an ancestral environment, a modern mating environment, and an ancestral environment in which the emphasis was on raising offspring as opposed to finding a mate. Our results replicated the survival processing effect, but provided no evidence of a reproduction processing effect when the scenario emphasized finding a mate. However, when rating items on their relevancy to raising one’s offspring in an ancestral environment, a mnemonic advantage comparable to that of the survival processing effect was found.

Key words: adaptive memory; survival processing effect; reproduction processing effect
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Our brain and its abilities are in large part the result of our evolutionary history and natural selection. Consequently, performance should increase on cognitive tasks that enhance overall evolutionary fitness (e.g., Anderson & Schooler, 2000; Barkow, Cosmides, & Tooby, 1995). Supportive of this position, Nairne, Thompson, and Pandeirada (2007) tested participants’ ability to recall incidentally encoded words after being asked to imagine oneself stranded in a grasslands environment and rating the relevancy of a set of concrete nouns to the task of surviving in this scenario. Recall for these words was significantly higher after participants were asked to rate their relevancy to the grasslands survival scenario relative to when participants were asked to rate the relevancy of these words to a scenario which involved moving to a foreign land or simply rating the words based on pleasantness. Across a large number of experiments implementing a variety of incidental encoding tasks, the ancestral survival processing scenario has produced a consistent mnemonic benefit (for a review, see Nairne, 2010). Several attempts have been made to identify which specific features of the survival scenario encourage the so-called ‘survival processing effect’. Some instances in which comparison groups were asked to imagine themselves in other threatening environments, other high stress environments, or other imagined environments suggest that there is something particularly beneficial to the combination of survival and an ancestral setting (e.g., Röer, Bell, & Buchner, 2013; Bugg & Roediger, 2008; Kang, McDermott, & Cohen, 2008; Nairne et al., 2012; Weinstein, Bugg, & Roediger, 2008); however, this may not be strictly limited to environments of evolutionary adaptation (e.g., Klein, 2013; Kostic, McFarlan, & Clearly, 2012; Olds, Lanska, & Westerman, 2014). The survival processing advantage is robust and also enduring in that it has been seen to persist even 1-2 days after encoding (Raymaekers, Otgaar, & Smeets, 2014), and the
effect has been so frequently replicated that its empirical existence is strongly grounded (for recent reviews, see Kazanas & Altarriba, 2015; Nairne & Pandeirada, 2016).

The proximate mechanisms underlying this effect, however, have been the topic of much speculation. Bell, Röer, and Buchner (2015) reported evidence supporting the view that thinking about the functionality of items (i.e., words) leads to better recall rather than thinking about the emotional value of the same words in the same scenario (e.g., pleasantness ratings), likely because consideration of functionality results in deeper and more elaborative processing (e.g., Craik & Lockhart, 1972). Klein, Robertson, and Delton (2011) also argued that the act of planning may promote the storage of information to be later recalled, which might explain the mnemonic advantage of survival processing.

Inconsistent with these proposed proximate mechanisms, Nairne, VanArsdall, Pandeirada, and Blunt (2012) found that participants who were asked to rate the ease of hunting animals in an ancestral hunting scenario were better able to remember the location of those animals than participants who rated the ease of hunting the same animals in a modern day hunting competition, which suggests that scenarios invoking the environment of evolutionary adaptation (EEA) facilitate subsequent recall. The uncertainty behind the proximate mechanism of the survival processing effect has been reviewed by Erdfelder and Kroneisen (2014) and has also been considered by Nairne (2014) who suggested that a variety of explanations including rehearsal, self-referent processing, and distinctive processing may contribute conjointly to produce this effect. It is also worth noting that proximate explanations are complimentary to an ultimate explanation and the discovering of proximate factors contributing to the survival processing effect does not negate the proposed ultimate explanation (Nairne & Pandeirada, 2016).

Nairne, however, has not focused much of his efforts on the proximate explanations behind the survival processing effect, and instead has maintained a
functionalist approach by emphasizing the important ultimate benefit that this effect presumably has. For instance, Nairne and Pandeirada (2008, p. 239) stated, “Memory evolved to enhance reproductive fitness, and accordingly, its systems are tuned to retain information that is fitness relevant.” This is a claim mirrored in several of Nairne’s reviews of his and others’ work on adaptive memory (e.g., Kazanas & Altarriba, 2015; Nairne, 2010, 2014).

In the present study, like Nairne, we too focused our attention away from proximate causes to further explore the suggested ultimate aspects of adaptive memory. As fecundity trumps all else in evolutionary theory, even survival, we wanted to determine whether a scenario relevant to reproduction would encourage the formation of strong memories, comparable to that of the survival processing advantage, all other factors being equal. Consistent with the expectation that reproduction related processing should also show a mnemonic advantage, Bateson and Healy (2005) argue that memory would have been particularly useful in comparing the fitness value of previously encountered mates. Thus, there are theoretical grounds to suspect that the human memory system would have been selected to provide a recall benefit with respect to mating scenarios.

Although Nairne and others have frequently argued that the cognitive abilities of humans should have evolved to improve inclusive fitness, empirical evidence, using the survival-processing paradigm, only exists to support cognitive benefits in relation to survival and not reproduction. A reproduction processing effect was even predicted by Nairne, Pandeirada, Gregory, and Van Arsdall (2009, p. 745) in arguing why memory is likely to differ in strength as a function of study context: “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.” Despite this claim, without empirical evidence to support a reproduction processing effect, our understanding of the ultimate explanation used to explain the survival processing effect is limited. For operational clarity, we define a reproduction processing effect as an observed mnemonic benefit to recall when items are processed based on their relevancy to a scenario related to explicit reproductive behavior.

The goal of the present experiments was to determine whether a reproduction processing effect, as defined above, exists. There a currently only a small number of studies that have either directly or indirectly attempted to examine this. Derringer, Scofield, and Kostic (2017), Sandry, Trafimow, Marks, and Rice (2013), and a single study in Klein (2013) explored this hypothetical effect. No clear reproduction processing effect was found in any of their experiments, a result we attempted to replicate and expand upon in our Experiment 1a (a more detailed analysis of their experiments is provided in the Discussion of Experiment 1a). Experiment 2a explored whether a modern versus ancestral mating environment elicits a reproduction processing effect and Experiment 2b shifted the focus of reproduction away from mate acquisition and towards rearing offspring in light of the fact that humans are an altricial species, arguably making care giving a larger opportunity for selective pressure than mate selection.

It is also appropriate for us to explicitly state why the existence of a reproduction processing effect is worth exploring, besides its having been proposed as a feature of a domain-specific memory system. There are clear data that aspects of human mating can influence memory. Baker, Sloan, Hall, Leo, and Maner, (2015) found that memory performance was enhanced by the presence of mating cues at the time of retrieval, and that this enhancement was not caused by mood or arousal. However, the primary focus of the survival processing task is on the encoding phase. Thus, it seems reasonable to extrapolate this to suggest that encoding stimuli based on its relevance to mate acquisition and/or offspring rearing might improve recall. Additionally, Horgan,
Broadbent, McKibben, and Duehring (2015) found that female undergraduates who watched a short video of a man introducing himself remembered more about his physical features than the verbal statements about himself if they had been first told to consider the man as a short-term mate. In contrast, if the female participants were told to consider the man as a potential long-term mate before watching the video, they better remembered his verbal statements than his physical appearance, a reversal that is consistent with theories of evolutionarily-based mate choice by females. Similarly, Smith, Jones, Feinberg, and Allan (2012) tested visual object memory in female students and found enhanced memory for items that were accompanied by a masculinized male voice during the encoding phase, compared to those items being accompanied by a feminized male voice. Such studies suggest that there is an influence of reproductive benefits on memory. Whether such an influence can be detected using a survival processing paradigm has been directly tested thus far only by Derringer et al. (2017), Klein (2013), and Sandry et al. (2013), and their results suggest that reproduction processing does not produce the same benefit as survival processing in this paradigm.

Given that survival is irrelevant to evolutionary fitness in the absence of reproduction, if the human memory system has been optimized to perform on tasks that increase overall individual fitness, we see a need to seek evidence for a reproduction processing effect. In the present series, we assessed whether rating words with respect to their relevance to various scenarios related to reproduction would produce a mnemonic advantage similar to that of a grasslands survival scenario. In light of the importance of reproduction to overall evolutionary fitness, we reasoned that participants told to imagine themselves in a scenario that focuses on mate acquisition or child rearing should exhibit enhanced recall compared to appropriate control conditions.

**Experiment 1a**
This between-subjects experiment assessed the potential mnemonic advantage of reproduction processing by contrasting a scenario that involved imagining oneself seeking potential mates against the original survival scenario. Additionally, we included a novel control scenario that involves the planning of a non-survival related task (building a spiritual monument) in which thinking about object functionality should have been as pertinent as in the survival and mate seeking scenarios. Each scenario was cast in the same ancestral landscape. Although the monument building scenario was included to assess the possibility that planning and thinking about object functionality is a proximate source of the survival processing advantage, this scenario also served as point of comparison for the survival and reproduction scenarios in a similar manner as scenarios used in prior studies that involved moving to a foreign land or planning a bank robbery (Nairne et al., 2007; Kang et al., 2008). As an additional control condition, participants in a pleasantness-rating condition were primed with the same ancestral setting but simply asked to rate the words on pleasantness. As this ancestral prologue is a novel addition to the typical pleasantness-rating task, we included the pleasantness rating condition without this novel addition in the subsequent experiments reported here, and found no appreciable differences in performance based on whether the ancestral phrasing was present or absent, p > .17. Critically, our focus at this time was not so much on identifying underlying proximate mechanisms, but whether operational ‘reproduction processing’ is as effective as operational ‘survival processing’ in enhancing recall and how any such enhancement might compare to other planning scenarios cast in an ancestral environment. This experiment and all subsequent ones were approved by SUNY-Binghamton’s IRB.

**Method**

**Participants.**
A total of 200 Binghamton University undergraduate students (70 males and 130 females, age range 17-28) volunteered to take part in this study to fulfill part of a course requirement. Participants were evenly and otherwise randomly assigned to one of the four groups (n = 50), which we refer to by their respective scenarios: Survival, Reproduction, Monument, and Pleasantness. The number of participants reflects estimated power based on planned two-group comparisons in Nairne et al. (2007, Experiment 1).

**Materials.**

Instructions and the word stimuli were presented on individual computer screens and sessions lasted less than 30 minutes. All participants were presented with the same ancestral grasslands introduction, but the assigned task in the grasslands was manipulated between participants. One of the four task descriptions in Table 1 was shown to each participant prior to their being presented with a common list of 35 unrelated concrete nouns. The 35 nouns were taken directly from the original Nairne et al. (2007) study; most but not all came from their Experiment 1. Words not taken from that experiment came from their Experiments 2, 3, and 4. To minimize congruity effects (i.e., differential degrees of relatedness of the noun items to the different scenarios, which might have influenced recall), a 23-participant pilot study was conducted to ensure no appreciable differences in relevancy ratings were obtained between the Reproduction and Monument scenarios relative to Nairne at al.’s survival scenario and pleasantness task. The survival scenario and pleasantness task were excluded from the pilot study in light of there being relevancy ratings of the words with respect to these two scenarios from frequent prior replications using the original word list (Nairne et al., 2007). In the present experiment, following exposure to their respective scenarios, participants were asked to rate the 35 nouns on their relevancy to the participant’s scenario (with the exception of the Pleasantness scenario in which the pleasantness of the word was
rated). The same 35 words were used in all four scenarios and were presented in the same randomized order in each scenario. The ratings and recall data for the first 5 words rated were treated as practice and removed from any subsequent data analysis. The remaining 30 words that were critically assessed for recall are provided in Table 2.

The Survival scenario was taken verbatim from the original adaptive memory experiment with the exception of an added description of time frame – *thousands of years ago* (Nairne et al., 2007). This time frame reference in the first line of every scenario was added to enhance participants’ mindset of an ancestral environment, which might also increase effectiveness of processing (Nairne et al., 2011). The Reproduction scenario used the same format as the Survival scenario, but a few critical phrases were appropriately modified to switch the focus from survival to reproduction and specifically mate acquisition (Table 1). The Monument Building scenario also used the same format as the Survival scenario but focused on the planning of a non-survival related task (i.e., monument building). The Pleasantness scenario (i.e., task) was a basic processing task based on word pleasantness; however, it was slightly modified from Nairne et al. (2007) to include the beginning reference to the ancestral grasslands setting that was included in the other three scenarios.

**Procedure.**

Before the rating phase, participants were asked to read and sign an informed consent form and enter their age and gender. Each participant was then presented on screen with the scenario to which they had been randomly assigned for 30 s. Following presentation of the assigned scenario, Participants were next asked to rate on a scale of 1-5 how relevant (or pleasant) each of the 35 words was (1 = very irrelevant or very unpleasant; 5 = very relevant or very pleasant). This was accomplished by sequentially presenting each of the words for 5 s in a random order that was the same for all participants. The rating of each word needed to occur within the 5-s presentation;
otherwise the word disappeared and no rating was recorded. Stimuli remained on screen for the full 5 seconds, regardless of whether a rating had been entered. The intertrial interval from offset of one word to onset of the next word was 250 ms.

After rating the 35 words, participants were asked to perform a distraction task (simple algebraic problems with paper and pencil) for 2 min. After 2 min, the screen flashed for 10 s to orient participants back to the next instruction screen on which they were asked to perform a free recall test on all 35 of the previously rated words. Participants were given 10 minutes to write as many recalled words as possible on a piece of lined paper. Participants were asked to stay for the entirety of the recall task, and after the 10 minutes they were thanked for their participation and debriefed.

Two research assistants graded the completed recall sheets. Each assistant selected items from the presented list that they thought best matched the participants’ responses. Responses were only considered valid if both assistants chose the same word. The valid words were then recorded along with the participants’ relevance/pleasantness ratings for all of the words excepting the first five words that were presented during the relevancy rating (i.e. encoding) phase.

Results and Discussion

The threshold for significance of all statistical tests was set at $p < .05$. Ninety-seven percent of all presented words were rated within the 5-s presentation time, and the number of unrated words did not differ significantly across groups. To avoid selection biases and because no condition produced a significantly higher or lower number of unrated words than other conditions, the recall data described below was in no way constrained.

Recall and rating scores.

Figure 1 summarizes the results of greatest interest to our research question; that is, it presents proportions of correctly recalled words (out of 30) within each
experimental condition (i.e., scenario type). A one-way analysis of variance (ANOVA) revealed an effect of condition, $F(3, 196) = 3.66$, $p < .015$, Cohen’s $f = .21$, 90% confidence intervals (CIs) = .08, .33. CIs were calculated using a free noncentral distribution calculator (Steiger, 2004).

Consistent with past studies of adaptive memory, words rated in the Survival scenario were better recalled than words rated in similarly worded alternative scenarios and the baseline Pleasantness group. Planned contrasts supported this mnemonic advantage for words rated in the Survival scenario relative to the Monument Building scenario, $F(1, 196) = 5.37$, $p < .03$, the Pleasantness scenario, $F(1, 196) = 3.82$, $p = .052$ (only marginally significant), and also relative to the Reproduction scenario, $F(1, 196) = 10.30$, $p < .01$. Central to the interest of this experiment, we found no significant recall advantage for words that had been rated on their relevancy to mate acquisition (Reproduction scenario) compared to the Pleasantness scenario, $F(1, 196) = 1.56$, $p > .21$, or the Monument Building scenario, $F(1, 196) = 0.79$, $p > .37$. Given the ambiguity in interpreting null results using ANOVA, we computed JZS Bayes odds ratios to assess potential support for the null hypothesis (Rouder, Speckman, Sun, Morey, & Iverson, 2009) and found a JZS odds ratio of 6.1 in favor of the null between the Reproduction and Pleasantness scenarios and a JZS odds ratio of 4.5 in favor of the null between the Reproduction and Monument Building scenarios. Of additional interest, no significant difference in recall was detected between males and females for any of the scenarios.

Despite our preliminary within-subject experiment with 23 participants failing to detect significant differences in relevancy ratings of items across scenarios, a one-way ANOVA of the present ratings revealed a significant effect of condition on relevancy ratings, $F(3, 197) = 6.94$, $p < .01$, Cohen’s $f = .31$, 90% CIs = .18, .43 (see Figure 2). Planned contrasts revealed that the mean relevancy rating of words rated in the Monument Building scenario was significantly lower than the same words rated in the
Survival scenario, $F(1, 196) = 7.15, p < .01$, the Reproduction scenario, $F(1, 196) = 5.14, p < .03$, and the Pleasantness scenario, $F(1, 196) = 20.57, p < .01$. Note, comparing relevancy ratings to pleasantness ratings is not totally appropriate given the differing nature of these two tasks. This difference in mean relevancy rating is troubling due to the possibility that words viewed as being of higher relevancy may have been more deeply processed or have more context appropriate functionality and hence better recalled (Bell et al., 2015; Craik & Tulving, 1975). Additionally, the lower relevancy ratings in the Monument Building scenario may have reduced recall due to a reduced congruity effect (Schulman, 1974). Thus, it might be appropriate for us to qualify any conclusions concerning survival processing yielding better recall than the processing resulting from the Monument Building scenario because potential differences in depth of processing and congruity are confounds. We consider this issue in greater depth by analyzing the relationship between relevancy ratings and recall of words in the section Adjusted Recall and Rating Scores below. It is also worth noting that our Pleasantness scenario was slightly modified from the standard one ordinarily used to include an ancestral grassland pretense, which was done to control for the possibility of the EEA serving as a proximate factor in influencing survival processing. It is possible that a standard pleasantness scenario would have yielded different ratings; however, a standard pleasantness scenario was used in Experiments 2a and 2b, and no appreciable difference was observed compared to this experiment, $p > .17$. Sex differences with respect to recall within conditions were analyzed. No significant differences were found in any of the conditions with the largest difference in recall being females in the survival scenario recalling more words than males, $p > .16$.

Recall as a function of rating scores.

Mean relevancy ratings of words were nearly identical for the Survival and Reproduction scenarios (see Figure 2), $p > .68$; yet, as noted above, recall was
significantly better for items in the Survival scenario than the Reproduction scenario. Moreover, relevancy ratings were significantly higher for the baseline Pleasantness condition compared to the Reproduction scenario, $F(1, 196) = 5.15, p < .03$, and nearly significantly higher compared to the Survival scenario, $F(1, 196) = 3.47, p < .07$; yet, recall was better for the Survival scenario than the Pleasantness condition. Thus, variability in mean congruency of the 30 words across the different scenarios seems unable to explain the observed survival processing effect or the lack of an analogous effect in the Reproduction scenario. Consequently, Experiment 1a provides additional evidence in support of the survival processing effect, while failing to provide support for a reproduction processing effect from a mate acquisition scenario. This study also speaks to the hypothesis that thinking about item functionality and planning are contributing proximate causes of the survival processing effect, as has been suggested by Bell et al. (2015) and Klein, Robertson, and Delton (2011). The absence of enhanced recall in the Monument scenario, which required planning to do something unrelated to survival or reproduction, suggests that the observed enhancement of recall with the Survival scenario was not a product of participants thinking functionally about the items in general. It remains possible however, that thinking about object functionality relevant to survival is fundamentally different than thinking about object functionality relevant to monument building.

Unfortunately, lower relevancy ratings in the Monument scenario admits the possibility that the low proportion of words recalled in this condition may simply be the result of depth-of-processing or congruity effects (but see Butler et al., 2009; Nairne & Pandeirada, 2011). That is, words that are processed at a deeper level or are more congruent with one another in a given situation are often recalled more accurately than words rated irrelevant to a situation; thus, a scenario provides a basis for binding among items when many of the items are relevant to the scenario. To determine whether these
effects may have impacted recall in the Monument Building condition relative to the Survival condition, we calculated the proportion of correctly recalled words for each experimental condition at each relevancy rating level. Simply put, for each participant we counted how many words were rated as a 1, 2, 3, 4, or 5 for relevancy to the participant’s scenario, and then computed the proportion of those words that were correctly recalled at each rating level by that participant. Figure 3 depicts the mean proportion of words recalled correctly at each rating level. A 4 (conditions) x 5 (rating levels) mixed measures ANOVA was performed for words rated (1-5) in each scenario and revealed a main effect of condition, $F(3, 196) = 2.89, p < .04$, Cohen’s $f = .18$, 90% CIs = .04, .31, and an effect of rating, $F(4, 784) = 20.80, p < .01$, Cohen’s $f = .32$, 90% CIs = .26, .38. Unfortunately, this same analysis revealed a significant interaction between rating and recall, $F(12, 784) = 1.84, p < .04$, Cohen’s $f = .12$, 90% CI’s = .03, .19, which creates difficulty in interpreting the difference in percent of words recalled across experimental conditions. The interaction is likely due to congruity effects that differentially impacted recall by the different conditions at relevancy levels at which the greatest differences in number of words rated at those levels occurred, notably rating level 5 (see Figure 3). It appears that the patterns for words rated in the Pleasantness and Monument scenarios are principally responsible for this interaction as both recall proportions appreciably increased from items with ratings of 4 to items with ratings of 5.

To provide a more meaningful analysis, which was less influenced by this interaction, we discarded the data from extremely relevant (rated 5) and extremely irrelevant (rated 1) words (see the bold parts of Figure 3). By doing so, we were able to analyze the proportion of words recalled for each scenario as a function of relevancy rating (2, 3, and 4 only), thereby avoiding rating levels at which relevancy ratings differed most across conditions. Note that a specific subset of words was not deleted for this experiment, as which words subjects rated as highly relevant or irrelevant varied greatly
across individual subjects and the conditions they were assigned to. The resultant ANOVA conducted on the group mean proportions of words correctly recalled from words ranked 2-4 revealed a main effect of condition, \( F(3, 196) = 4.45, p < .01 \), Cohen’s \( f = .24 \), 90% CIs = .11, .36, and an effect of relevancy rating, \( F(3, 196) = 4.45, p < .01 \), Cohen’s \( f = .24 \), 90% CIs = .11, .36. Additionally and critically, no significant interaction between ratings and recall was found, \( F(6, 392) = 1.27, p < .26 \), JZS odds ratio = 9.0 in support of the null. Planned contrasts revealed that the proportion of words recalled from those rated 2-4 in relevancy (pooled across ratings of 2, 3, and 4) in the Survival scenario resulted in significantly higher recall than the Reproduction scenario, \( F(1, 196) = 11.87, p < .01 \), the Pleasantness scenario, \( F(1, 196) = 6.91, p < .01 \), and the Monument Building scenario, \( F(1, 196) = 6.44, p < .02 \). Consistent with our initial analysis, words rated 2-4 in the Reproduction scenario did not statistically differ from words rated 2-4 in the Monument condition, \( F(1, 196) = .82, p < .36 \), JZS odds ratio = 4.4 in favor of the null, and words rated (2-4) in the Pleasantness condition, \( F(1, 196) = .67, p < .41 \), JZS odds ratio = 4.8 in favor of the null.

The significantly higher proportion of words recalled following the Survival scenario task relative to the Monument Building task suggests that the overall difference in recall between these two scenarios was not a consequence of differences in depth-of-processing or congruity. Critically, the Reproduction condition can be seen in Figure 3 to exhibit no appreciable benefit compared to the Monument and Pleasantness conditions.

To reduce the potential impact of differences across conditions in the relevancy of the items to each scenario, we eliminated all words rated extremely irrelevant (1) and extremely relevant (5) from our analysis of proportion recalled. As previously stated, a significant effect of condition was still found for words rated 2-4 (pooled across these three ratings), and planned contrasts revealed that words rated in the Survival scenario had a significantly higher proportion of words recalled than all three other experimental
conditions, including the Monument Building scenario. Additionally, analyzing words rated 2-4 removed the interaction between condition and relevancy rating, which was found when analyzing words pooled from ratings 1-5. This detailed analysis further supports our finding of a strong survival processing effect, which is neither the result of thinking of object functionality nor depth of processing/congruity effects.

The visualization of this analysis (Figure 3) more vividly demonstrates the relationship between relevancy ratings and subsequent recall than methods conventionally used in the survival processing literature (i.e., separate bar graphs for mean recall and mean rating of items), and is novel from other analyses in that it facilitates direct comparisons of recall as a function of relevancy rating across scenarios rather than an examination of recall as a function of mean relevancy rating (Nairne et al., 2007, but see Butler et al., 2009; Nairne & Pandeirada, 2011). However, there are several limitations of this approach that deserve attention. The first is that a bias may have been introduced because item selection differed appreciably across scenarios as well as across individual subjects. This analysis matched items on subjective ratings of relevancy but allowed items to differ on other attributes that may have influenced recall (i.e., imagery, concreteness, emotionality). For example, an analysis of all items rated a ‘4’ does not control for these item characteristics because ratings were likely influenced both by individual subject differences and scenario differences (Nairne et al., 2007). Additionally, the number of items assigned to each rating category was also out of our experimental control although the problems potentially introduced by this factor were attenuated by our elimination of highly relevant and highly irrelevant items that largely drove observed differences across scenarios in mean relevancy scores. Lastly, this analysis assumes that relevancy ratings are comparable across scenarios, which may be inherently flawed because relevancy ratings for items in a scenario are likely scaled to each scenario and are also likely differentially influenced by order of presentation.
With respect to the potential for a reproduction processing effect, the present results suggest a conclusion similar to that of Derringer et al. (2017), Klein (2013), and Sandry et al. (2013). However, our reproduction processing scenario differed importantly from all three studies and, arguably, most effectively tests potential reproduction processing. Klein (2013) had subjects imagine they were, “looking for a new partner to have sex with. It is important to identify partners who would sexually satisfy you,” before rating words. The null result observed in their study may possibly have arisen from the few number of challenges presented to the participants in this scenario. Kornesen and Erdfelder (2011) found a reduced survival processing with a scenario that focused only on the singular task of finding water. Our reproduction scenario is perhaps most similar to that used by Sandry et al. (2013) although they begin their scenario asking subjects to imagine that, “you are stranded in the grassland of a foreign land, without someone to mate with.” This contrasts with our scenario that asked subjects to imagine, “that you are living, thousands of years ago, in the grasslands of a foreign land, and are looking to find a mate.” Although this is seemingly a subtle difference, the implication that one is ‘stranded’ versus ‘living’ in a foreign environment may have influenced how subjects envisioned the imagined encoding scenarios or how subjects perceived the importance of finding a mate in each particular situation. Lastly, Derringer et al., (2017) had participants rate traits based on their desirability in a potential mate and compared subsequent recall to that when participants rated traits based on their desirability in a potential coworker and also recall by a control group that rated the perceived pleasantness of those traits. As those authors noted, the novelty of using traits (i.e., adjectives) instead of concrete nouns is potentially problematic due to the fact that adjectives and nouns differ in terms of visualizability and concreteness, not to mention familiarity and arousal, all of which are factors that could potentially influence recall. In Derringer et al.’s Experiment 3, the authors did use nouns and had participants assess
various “gifts” on the “goodness” of each gift as either a housewarming gift or a gift for a romantic partner. However, this approach does not account for the influence of the EEA on mediating recall, and its relevance to the ultimate goals of reproduction are questionable. Most importantly, none of their three experiments included a survival processing control group to establish that their items and procedures were in fact sensitive to enhanced recall. The omission of a control condition to demonstrate sensitivity is a serious concern given their central conclusion hinges on null results.

Derringer et al.’s (2017), Klein’s (2013), Sandry et al.’s (2013), and our reproduction scenarios emphasized only initial mate selection and acquisition, which is merely one component of human reproduction that contributes to reproductive fitness. We suspect that other features related to human reproduction could have greater influence on subsequent recall. We explored this possibility in subsequent experiments. But first, we were inclined to examine our scenarios in greater detail to determine whether they differed on a variety of attributes that might produce variability in recall and confound our intended manipulations.

**Experiment 1b**

Experiment 1a used two novel scenarios of potential interest (Reproduction and Monument) and one slightly modified control scenario (Pleasantness) that are new to the adaptive memory literature. Additionally, Experiments 2a and 2b include newly generated scenarios. Therefore, we felt it necessary to assess our scenarios on several descriptive metrics, in order to determine whether certain unintended factors of our newly created scenarios were potentially contributing to benefits or deficits in recall. In Experiment 1b, we asked participants to rate our scenarios based on how interesting, imaginable, arousing, familiar, aversive, and challenging they considered these scenarios to be. Most of these attributes were previously used by Sandry et al. (2013) to compare attributes of a variety of different encoding scenarios of possible adaptive
value, though we added questions in regards to how aversive, and challenging the scenarios were and omitted Sandry et al.’s emotionality and usualness metrics. Of greatest importance with respect to Experiment 1a was how the Reproduction scenario compared to the original Survival scenario on these attributes.

Method

Participants.

Sixty Binghamton University undergraduate students (26 males and 34 females, age range 18-26) volunteered to take part in this study to fulfill part of a course requirement. These participants had not taken part in any of this lab’s previous adaptive memory studies and they were not asked to recall any items.

Materials.

This experiment presented ten unique scenarios to each subject. Presentation order of the ten scenarios was counterbalanced using a Latin square. The counterbalancing was done so that each of the ten scenarios never appeared in the same position of presentation more than once. Additionally, the scenarios were systematically separated so that scenarios we deemed to be similar were never presented in immediate sequence. That is, we identified clusters of scenarios that were so similar that exposure to one might have influenced the ratings of the next if they were presented one right after the other. Although ratings for ten scenarios were measured in this experiment, we only report on six of them here because four scenarios that were assessed were of interest only with respect to future experiments. The scenario attribute data for the four additional scenarios will be presented within the results sections of Experiments 2a and 2b below.

Six questions were asked of each participant for each scenario.

The six questions (interesting, imaginable, arousing, familiar, aversive, and challenging) were asked in the same order for all participants. This may have allowed earlier questions to influence answers to later questions, but our interest was not in
cross-question comparisons within scenarios, but cross-scenario ratings of the same question. To the extent that using a fixed order of questions may have influenced ratings of later questions, it should at least have had a similar impact of ratings of the same question across scenarios. The 1-5 Likert scale used for the ratings was displayed horizontally and participants were asked to make a rating using the keyboard.

**Procedure.**

Participants were randomly assigned to one of the ten conditions that collectively counterbalanced scenario order, and each condition was completed by a total of six participants. Before being exposed to any scenarios, participants were first asked to self-report their age and gender. Participants were then given instructions on how to make ratings and asked to press the space bar to continue.

Participants were next shown the first scenario for a total of 30 s. After the 30 s, participants were prompted to press the space bar. This caused a new slide to emerge with the scenario occupying the top third of the screen, the first question occupying the middle third (see Table 3 for a list of questions), and the Likert scale the bottom third. Participants were given as much time as needed to make their rating. After a rating was made, there was a 1-s intertrial interval (ITI; gray screen) followed by the next question and scale which replaced the existing question and scale, while the original scenario remained in its initial position. This continued until all six questions and scales had been presented for that scenario. This sequence was then repeated for the remaining nine scenarios.

**Results and Discussion**

The mean ratings of the descriptive metrics measured in each of the six scenarios are depicted in Table 4. Separate ANOVAs were conducted for each metric (i.e. arousing, aversive, challenging, familiar, imaginative, and interesting) to analyze whether scenarios differed on any of these qualities. We report the comparisons
between different scenarios for each descriptive metric when appropriate in the result sections of the experiments to follow. The results of this study in relation to Experiment 1a are reported immediately below.

Of greatest interest with respect to Experiment 1a is that the Reproduction scenario, when compared to the Survival scenario, did not differ in ratings of how aversive, familiar, imaginative, or interesting they were considered to be, \( ps > .08 \). However, the Reproduction scenario was rated as more arousing, \( F(1, 354) = 8.42, p < .01 \), and less challenging, \( F(1, 354) = 25.0, p < .001 \), than the Survival scenario. That the Reproduction scenario was rated as less challenging and more arousing than the Survival scenario but not any less aversive, familiar, imaginative, or interesting suggests that these are fairly appropriate scenarios to compare to each other. The suggestion that participants find the task of finding a mate to be less challenging than the task of survival leads to the possibility that the observed difference in recall may have been influenced by how challenging a given scenario is perceived to be. However, in experiments not reported in this paper, we have observed encoding scenarios that, despite being perceived as highly challenging, fail to produce a benefit in recall.

Of additional interest, the Monument scenario was rated as less arousing, \( F(1, 354) = 4.19, p < .05 \), challenging, \( F(1, 354) = 10.53 p < .001 \), and interesting, \( F(1, 354) = 10.17, p < .01 \), than the Survival scenario. But the two scenarios did not statistically differ on ratings of how aversive, familiar, or imaginable they were perceived to be. It is possible then that part of the difference in recall between these two scenarios might have been due to the Survival scenario being a more arousing, challenging, and interesting processing condition.

**Experiments 2a and 2b**

The following experiments were designed to extend our investigation into the
potential memory benefit of reproduction related scenarios. We addressed two ways in which the mate-acquisition scenario of Experiment 1a could have been insufficient. First, in Experiment 2a, we assess whether mate acquisition in an ancestral environment was too dissimilar from modern mating strategies. Then, in Experiment 2b, we explored additional factors that contribute to human reproductive success by shifting the focus of reproduction away from mate acquisition and towards child rearing.

Life history theory characterizes successful reproduction strategies as a mix of survival, mate acquisition, and parental effort (MacArthur & Wilson 1967). Various species devote varied degrees of effort into each of these components to achieve stable reproduction. Humans in particular devote a vast amount of resources into rearing their offspring. Thus, expecting selective pressures to enhance memory for features of mate acquisition may not accurately reflect the central focus of human reproductive strategy.

Towards answering these questions, three new scenarios were created and compared to the original Nairne Survival Scenario and Pleasantness rating task. Two of these newly created scenarios involved maintaining a conversation with someone at a modern day party. These two scenarios were identical except that in one scenario, the participants were told that they were physically attracted to that person and were trying to start a sexual relationship with him/her (henceforth referred as Modern Mating Scenario), and in the other, participants were told that they were not physically attracted to that person but were interested in starting a friendship with him/her (henceforth referred as Modern Friendship Scenario). The other newly created scenario involved providing care and nourishment to an imaginary child whom the participant was told he/she had parented in an ancestral environment (henceforth referred as Parenting Scenario).
In sum, Experiment 2 as a whole consisted of five scenarios and addresses two relatively different questions. Experiment 2a focused on features of typical modern courtship behaviors, whereas Experiment 2b assessed the potential effect of a scenario that emphasized child rearing rather than mate acquisition, both of which are factors in reproductive success. The Modern Mating and Modern Friendship scenarios were compared to each other as well as to the original Pleasantness rating task (Experiment 2a), and the Parenting scenario was compared to the Survival scenario and Pleasantness rating task (Experiment 2b). Thus, what unites these two experiments is that they used the same Pleasantness control group, and that participants in all five conditions were run concurrently. In the results and discussion section of Experiment 2, we analyzed the data from Experiment 2 as two separate studies (2a and 2b) because their questions are distinct, although they shared common a control condition (i.e., Pleasantness).

Method

Participants.

A total of 250 Binghamton University undergraduate students (110 males and 140 females, age range 18-26) volunteered to take part in this study to fulfill part of a course requirement. Participants were evenly and otherwise randomly assigned to one of the five groups: Survival, Modern Mating, Modern Friendship, Parenting, and Pleasantness (ns = 50).

Materials.

The general design of Experiment 2 follows that of Experiment 1a with one procedural change. Forty-five nouns instead of 35 were presented to participants; all words were still taken directly from the original Nairne et al. (2007) study. Again, the first 5 words rated were treated as practice and consequently were discarded from analysis.
of rating scores and recall performance. The increase in number of words was intended to allow us the flexibility of eliminating words that significantly swayed mean rating data; however, we ultimately decided against using this technique as it was realized that the elimination of words based on their relevancy ratings might disproportionately affect recall rates across scenarios. Thus, we assessed recall rates using all 45 words to which participants were exposed to, except for the first 5 presented during relevancy rating which served as practice words (for the word list, see Table 5).

The Survival scenario was taken verbatim from Experiment 1a and the Pleasantness rating scenario was taken verbatim from Nairne et al. (2007). The Parenting scenario used the same format as the Survival scenario, but a few critical phrases were appropriately modified to switch the focus from survival to parenting (see Table 6). Both the Modern Mating and Modern Friendship scenarios used a slightly different format than that of the Survival scenario. Though the overall phrasing was similar, participants were asked to rate words on their relevance to maintaining a conversation with either a potential mate or potential friend. That these two scenarios have participants imagining themselves maintaining a conversation rather than performing physical activities makes it difficult to draw conclusions from comparing either scenario to the Survival scenario; thus, the central comparison in Experiment 2a is between the Modern Mating and Modern Friendship scenarios, although they were also compared to the Pleasantness scenarios as a point of reference. The full description of each scenario is provided in Table 6.

Procedure.

The procedure for Experiment 2 was identical to that of Experiment 1a, except for 45 words being presented instead of 35. Thus, the experiment lasted approximately 50 seconds longer than Experiment 1a. Participants were still given 10 minutes to recall as many of the words as possible.
Results and Discussion

Experiment 2a.

Recall and rating scores.

In Experiment 2a, 98% of all presented words were rated within the 5-s presentation time, and number of unrated words did not differ significantly across groups. To avoid selection biases and because no condition produced a significantly higher or lower number of unrated words than other conditions, the recall data described below was in no way constrained.

Figure 4 summarizes the mean proportion of words recalled (out of 40) for Pleasantness, Modern Mating, and Modern Friendship conditions. A one-way ANOVA revealed no significant effect of condition, $F(2, 147) = 2.14, p > .12$, JZS = 5.38 in favor of the null.

Figure 5 represents mean ratings of relevancy between conditions. Unfortunately, a one-way ANOVA of the present ratings detected an effect of condition, $F(2, 147) = 68.83, p < .001$, Cohen’s $f = .95$, 90% CIs = .79, 1.12. Planned contrasts revealed that the mean relevancy rating of words cast in the Pleasantness scenario was significantly lower than the same words rated in the Modern Mating scenario, $F(1, 147) = 122.06, p < .001$, and the Modern Friendship scenario, $F(1, 147) = 80.00, p < .001$. Of central interest to this experiment, we found a difference in relevancy ratings between the Modern Mating and the Modern Friendship scenarios, $F(1, 147) = 4.43, p < .04$. This difference in mean relevancy admits to the possibility that the recall data may have been influenced by congruity effects that could have obscured differences between the Modern Mating and Modern Friendship conditions. Thus, we analyzed recall as a function of ratings as we did for Experiment 1a (see next section). No significant sex differences with respect to recall within conditions was found, with the largest difference being females recalling more words than males in the Pleasantness scenario, $p > .19$. 
Recall as a function of rating scores.

Figure 6 depicts the mean proportion of words recalled correctly at each rating level. A 3 (conditions) x 5 (rating levels) mixed measures ANOVA of ratings in each scenario revealed no significant main effect of condition, $F(2, 147) = .55, p > .57$, JZS odds ratio = 11.76 in favor of the null. A significant effect of rating was also found, $F(4, 588) = 39.16, p < .001$, Cohen’s $f = .51$, 90% CI’s=.43, .58, again demonstrating the influence of relevancy rating on recall.

The lack of a significant difference in recall between the Modern Mating and Modern Friendship scenarios is another failed attempt to find a reproduction processing effect, only this time one that focused on mate acquisition in a more familiar (i.e., Modern) scenario. Thus, Experiment 2a is a conceptual replication of the negative findings of Experiment 1a as well as Derringer et al. (2017) and Sandry et al. (2013). Lastly, it is interesting to note that the modern mating scenario was rated by far as the most arousing and interesting scenario and was also rated the second most familiar and imaginative. Despite these high ratings, recall performance was considerably worse in this processing scenario than the pleasantness control group.

Experiment 2b.

In Experiment 2b, 99% of all presented words were rated within the 5-s presentation time and number of unrated words did not differ significantly across groups. Figure 7 represents the mean recall by condition. A one-way ANOVA revealed an effect of condition, $F(2, 147) = 4.24, p < .02$, Cohen’s $f = .22$, 90% CIs = .08, .36. As with Experiment 1a, planned contrasts revealed words rated in the Survival scenario were recalled better than words rated in the Pleasantness scenario, $F(1, 147) = 7.74, p < .01$, thereby once again replicating the original Survival processing effect. However, words rated in the Survival scenario were not recalled any better than words rated in the Parenting scenario, $F(1, 147) = .41, p > .52$, and words rated in the Parenting scenario
were recalled better than words rated in the Pleasantness scenario, \( F(1, 147) = 4.57, p < .05 \), suggesting a reproduction processing effect so long as the emphasis is on child rearing as opposed to mate acquisition. This potential effect is further supported by the fact that no main effect of rating was found across the three conditions, \( F(2, 147) = 1.93 \), \( p > .14 \) (see Figure 8). As we found no statistically significant difference in mean relevancy ratings across scenarios in Experiment 2b, JZS odds ratio = 5.96 in favor of the null, there was no reason to perform a recall as a function of ratings analysis such as we did for Experiments 1a and 2a to adjust for differences in mean relevancy ratings across scenarios. Lastly, we note that the parenting and survival scenarios used in Experiment 2b did not differ on any of the descriptive metrics gathered in Experiment 1b, with the exception of the Survival scenario being rated as more interesting than the Parenting scenario, \( F(1, 354) = 6.25, p < .02 \). Again, no sex differences with respect to recall within conditions were found, with the largest difference being females recalling more words than males in the Pleasantness scenario, \( p > .16 \). We note that throughout all of the experiments reported here, we failed to find any significant gender differences; however, the number of male participants in each experiment was relatively small which reduced our sensitivity to gender differences.

Of course, it is possible that the observed Parenting processing benefit is simply the result of participants’ processing information on the basis of its relevancy to the survival of another individual. Numerous studies have shown that the survival processing advantage often extends to individuals other than oneself (e.g., Kang et al., 2008; Nairne et al., 2008; Weinstein et al., 2008). Although we acknowledge that a third-person survival effect may have contributed to the improved recall with our Parenting scenario, we point out that the phrasing between the Survival and Parenting scenarios was altered to emphasize child rearing and deemphasize mere survival, respectively. The Survival scenario told participants that they were stranded in the grasslands and that they
needed to “find steady supplies of food and water and protect yourself from predators.” In contrast, the Parenting scenario told participants that they were *living* in the grasslands and, after parenting a child, needed to “provide care and nourishment for your baby and help him/her grow.” Although we cannot be certain how each participant interpreted these directions, we are inclined to think that imagining oneself providing care and nourishment to one’s own child is a distinctly different processing task than imagining oneself being stranded and finding supplies and protection from predators. That said, both processing tasks are highly relevant to one’s evolutionary fitness, and such a mnemonic advantage is thus to be expected if one accepts the view that human memory is inherently predisposed to favor information of greater evolutionary value (Nairne et al., 2008). Lastly, it is also worth noting that hominids were exceptional relative to other primate species in their birthing of offspring with extremely underdeveloped brains on the exposed savannas of Africa. These factors necessitated longer and more effortful parental care than other primates (e.g., Clutton-Brock, 1991). Thus, unique evolutionary pressures on parenting behaviors may be correlated with and perhaps causally related to engagement of select mnemonic abilities as well as increases in hominid brain size.

**Conclusions**

The empirical evidence in support of the survival processing effect is well established, and the experiments we report here provide additional evidence for it. Words rated in the Survival scenario were better recalled than the same words rated with respect to any other scenario in our present experiments, with the notable exception of the Parenting condition. In addition to adaptive memory theory providing an intriguing account of the survival processing effect at at least one level of analysis, it can be construed to additionally suggest there be a reproduction processing effect (Derringer et al., 2017; Nairne & Pandeirada, 2008; Sandry et al., 2013). In fact, much of the adaptive
memory literature has alluded to the idea that this effect should exist, despite the fact that no empirical evidence supports this claim using this basic ‘levels of processing task’ paradigm that has been used to identify the survival processing effect. The goal of this series was to seek possible evidence of, or lack thereof, this effect that we have defined as an observed mnemonic benefit to recall when items are processed based on their relevancy to scenarios related to explicit reproductive behavior.

Experiment 1a found no evidence for a reproduction processing effect when participants were asked to imagine themselves seeking a mate in an ancestral environment, thereby replicating the results of Sandry et al. (2013). Additionally, we also replicated the survival processing effect in this experiment, and, by our having included a monument building scenario in which words were poorly recalled, suggest that thinking about object functionality is not an essential contributing proximate factor in the survival processing effect, as proposed by Bell et al., (2015). Lastly, we introduced a new way of displaying both recall and rating data in one figure (see Figures 3 and 6), that better identifies potential contributions by the effect of congruity on recall within the conventional adaptive memory procedure.

Experiment 2a explored whether a modern day mating scenario would elicit a reproduction processing effect, whereas Experiment 2b shifted the focus of reproduction away from mate acquisition and towards child rearing. In Experiment 2a, no evidence was found indicative of a reproduction processing effect in a modern day mating scenario. To our knowledge, this serves as the fifth experiment (preceded by our Experiment 1a, Derringer et al., 2017, Klein, 2013, and Sandy et al., 2013) that has failed to detect reproduction processing effect when the scenario is oriented towards acquiring a mate. Experiment 2b suggests that a reproduction processing effect may exist when the scenario emphasizes providing care and nourishment for a child that one has recently parented. We are disinclined toward the view that this is just an example of
survival processing with respect to a third person, given how different the instructions of the Parenting scenario were compared to those of the Survival scenario, but surely this possibility is worthy of further examination. Additionally, we note that as the distinctly altricial nature of human offspring certainly shaped parenting behaviors and societal structures of our ancestors, the raising of altricial offspring likely shaped our cognitive abilities as well throughout our evolutionary history. We think that such reasoning fits squarely within an adaptive memory framework.

In summary, the present experiments suggest that processing information based on its relevancy to mate acquisition does not elicit the same kind of mnemonic advantage as processing information based on its relevancy to one’s survival. Despite this finding, when processing information based on its relevancy to providing care and nourishment to one’s child, a mnemonic advantage nearly identical to that of the well established survival processing effect was observed. Because the ultimate goal of reproduction is parenting offspring who bear one’s genetic information into the next generation, we consider this phenomenon suggestive of the reproduction processing effect that has been predicted within the adaptive memory literature. However, we do see a need for replication of this parenting effect and assessment of whether it is the result of a third person survival processing effect or something more specific to reproduction per se and the continuation of one’s genetic lineage. Lastly, we have proposed a novel way of dealing with discrepancies in relevancy ratings across conditions (i.e., conducting contrasts on items that received the same relevancy ratings), and also suggested that the planning of a non-survival related task and thinking about object functionality are not necessary proximate factors in producing the survival processing effect.
References


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doi:10.1037/0096-3445.104.3.268


Table 1. Experiment 1a Scenario Descriptions

<table>
<thead>
<tr>
<th>Scenario Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survival Scenario</strong></td>
</tr>
<tr>
<td>In this task, we would like you to imagine that you are stranded, thousands of years ago, 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.</td>
</tr>
<tr>
<td><strong>Reproduction Scenario</strong></td>
</tr>
<tr>
<td>In this task, we would like you to imagine that you are living, thousands of years ago, in the grasslands of a foreign land, and are looking to find a mate. Over the next few months, you’ll need to find potential mates who would be best for producing the most numerous and healthy offspring. 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 mate-seeking situation. Some of the words may be relevant and others may not—it’s up to you to decide.</td>
</tr>
<tr>
<td><strong>Monument Building Scenario</strong></td>
</tr>
<tr>
<td>In this task, we would like you to imagine that you are living, thousands of years ago, in the grasslands of a foreign land, and are building a spiritual monument. Over the next few months, you’ll need to collect rocks and other materials to complete this monument. 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 monument building situation. Some of the words may be relevant and others may not—it’s up to you to decide.</td>
</tr>
<tr>
<td><strong>Pleasantness Scenario</strong></td>
</tr>
<tr>
<td>In this task, we would like you to imagine that you are living, thousands of years ago, in the grasslands of a foreign land. 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.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>needle</td>
</tr>
<tr>
<td>mountain</td>
</tr>
<tr>
<td>pepper</td>
</tr>
<tr>
<td>disease</td>
</tr>
<tr>
<td>string</td>
</tr>
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</table>
### Table 3. Experiment 1b Question Set

<table>
<thead>
<tr>
<th>Order</th>
<th>Question</th>
<th>Anchor 1</th>
<th>Anchor 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How interesting would you consider the scenario?</td>
<td>Not at All Interesting</td>
<td>Very Interesting</td>
</tr>
<tr>
<td>2</td>
<td>How imaginable would you consider the scenario?</td>
<td>Not at All Imaginable</td>
<td>Very Imaginable</td>
</tr>
<tr>
<td>3</td>
<td>How arousing would you consider the scenario?</td>
<td>Not at All Arousing</td>
<td>Very Arousing</td>
</tr>
<tr>
<td>4</td>
<td>How familiar would you consider the scenario?</td>
<td>Not at All Familiar</td>
<td>Very Familiar</td>
</tr>
<tr>
<td>5</td>
<td>How usual would you consider the scenario?</td>
<td>Not at All Usual</td>
<td>Very Usual</td>
</tr>
</tbody>
</table>
Table 4. Mean ratings and SEM of each scenario for each question asked in Experiment 1b.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Arousing</th>
<th>Aversive</th>
<th>Challenging</th>
<th>Familiar</th>
<th>Imaginative</th>
<th>Interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival (Experiment 1,2a,2b)</td>
<td>2.1 +/- .17</td>
<td>3.1 +/- .17</td>
<td>4.4 +/- .2</td>
<td>1.9 +/- .18</td>
<td>3.2 +/- .14</td>
<td>3.6 +/- .15</td>
</tr>
<tr>
<td>Reproduction (Experiment 1)</td>
<td>2.5 +/- .13</td>
<td>2.7 +/- .13</td>
<td>3.4 +/- .16</td>
<td>2.2 +/- .17</td>
<td>3.2 +/- .15</td>
<td>3.6 +/- .11</td>
</tr>
<tr>
<td>Monument Building (Experiment 1)</td>
<td>1.7 +/- .13</td>
<td>2.7 +/- .15</td>
<td>3.8 +/- .18</td>
<td>1.7 +/- .16</td>
<td>2.8 +/- .15</td>
<td>3.0 +/- .17</td>
</tr>
<tr>
<td>Parenting (Experiment 2b)</td>
<td>1.8 +/- .14</td>
<td>2.9 +/- .16</td>
<td>4.1 +/- .19</td>
<td>1.9 +/- .16</td>
<td>2.9 +/- .14</td>
<td>3.1 +/- .15</td>
</tr>
<tr>
<td>Modern Mating (Experiment 2a)</td>
<td>3.8 +/- .14</td>
<td>2.7 +/- .13</td>
<td>3.5 +/- .13</td>
<td>3.8 +/- .14</td>
<td>4.3 +/- .12</td>
<td>4.1 +/- .13</td>
</tr>
<tr>
<td>Modern Friendship (Experiment 2a)</td>
<td>2.5 +/- .12</td>
<td>2.7 +/- .13</td>
<td>3.0 +/- .14</td>
<td>4.1 +/- .11</td>
<td>4.5 +/- .08</td>
<td>3.9 +/- .12</td>
</tr>
</tbody>
</table>

Note: The numerically greater variance across participants in arousing ratings for each scenario resulted in lower sensitivity to potential differences on this attribute.
Table 5. Experiments 2a and 2b Word List.

<table>
<thead>
<tr>
<th>mountain</th>
<th>emerald</th>
<th>child</th>
<th>tree</th>
<th>tobacco</th>
<th>bed</th>
<th>valley</th>
<th>snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>pepper</td>
<td>silk</td>
<td>lake</td>
<td>liquor</td>
<td>fabric</td>
<td>water</td>
<td>home</td>
<td>disease</td>
</tr>
<tr>
<td>juice</td>
<td>eagle</td>
<td>clothing</td>
<td>fur</td>
<td>horse</td>
<td>lion</td>
<td>river</td>
<td>cat</td>
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<tr>
<td>finger</td>
<td>liver</td>
<td>sugar</td>
<td>dinner</td>
<td>bath</td>
<td>grass</td>
<td>friend</td>
<td>storm</td>
</tr>
<tr>
<td>orange</td>
<td>dirt</td>
<td>lumber</td>
<td>sea</td>
<td>blood</td>
<td>string</td>
<td>stone</td>
<td>son</td>
</tr>
</tbody>
</table>
Table 6. Experiments 2a and 2b Scenario Descriptions

**Survival Scenario**
In this task, we would like you to imagine that you are stranded, thousands of years ago, 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.

**Parenting Scenario**
In this task, we would like you to imagine that you are living, thousands of years ago, in the grasslands of a foreign land, and have just parented a baby. Over the next few months, you’ll need to provide care and nourishment for your baby and help him/her grow. 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 child-rearing situation. Some of the words may be relevant and others may not—it’s up to you to decide.

**Modern Mating Scenario**
In this task, we would like you to imagine that you are at a party and beginning a conversation with the person standing next to you. This person is of the gender that you are most attracted to, and you happen to find this person in particular to be incredibly attractive. You are interested in the conversation and are seriously considering trying to pursue a romantic or sexual relationship with this person. You will need to continue the conversation with this person, convince them that you are worthy of being his/her sexual or romantic partner, and identify topics of conversation that this person will find interesting and impressive. We are going to show you a list of words, and would like you to rate them on how relevant they would be to you in maintaining a conversation with this person whom you are trying to romantically pursue.

**Modern Friendship Scenario**
In this task, we would like you to imagine that you are at a party and beginning a conversation with the person standing next to you. This person is of the gender that you are most attracted to. However, you do not find this person in particular to be attractive. You are interested in the conversation and are seriously considering trying to pursue a lasting friendship with this person. You will need to continue the conversation with this person, convince them that you are worthy of being his/her friend, and identify topics of conversation that this person will find interesting and meaningful. We are going to show you a list of words, and would like you to rate them on how relevant they would be to you in maintaining a conversation with this new acquaintance whom you are trying to befriend.

**Pleasantness Scenario**
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.
Figure 1. Experiment 1a: Mean proportion of items recalled as a function of condition. Error bars represent standard error of the mean.
Figure 2. Experiment 1a: Mean relevancy ratings as a function of condition. Error bars represent standard error of the means.
Figure 3. Experiment 1a: Proportion of items recalled as a function of relevancy rating. Recall of items excluding those with extremely low and high relevancy ratings have been bolded.
Figure 4. Experiment 2a: Mean recall as a function of condition. Error bars represent standard error of the means.
Figure 5. Experiment 2a: Mean relevancy ratings as a function of condition. Error bars represent standard error of the mean.
Figure 6. Experiment 2a: Proportion of items recalled as a function of relevancy rating.
Figure 7. Experiment 2b: Mean proportion of items (out of 40) recalled as a function of condition. Error bars represent standard error of the mean.
Figure 8. Experiment 2b: Mean relevancy of items recalled as a function of condition. Error bars represent standard error of the mean.