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Basic And Evolutionary Survival Effects In Adaptive Memory Of Younger And Older Adults

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BASIC AND EVOLUTIONARY SURVIVAL EFFECTS IN ADAPTIVE MEMORY OF YOUNGER AND OLDER ADULTS

by

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Abstract

Adaptive memory is a memory advantage for stimuli encoded in a survival scenario (e.g., stranded in grasslands) relative to a control scenario (Nairne, Thompson & Pandeirada, 2007). Basic (survival vs. non-survival scenarios) and evolutionary survival effects (high-evolutionary survival vs. low-evolutionary survival scenarios) in adaptive memory were explored in two age groups. Little research has been done with older adults. An extensive pilot study was conducted to select best matched control scenarios. Experiment 1 explored age differences in adaptive memory with a within-subjects manipulation of scenarios and found an age-equivalent basic survival effect. Experiment 2 replicated the basic survival effect in younger adults with a between-subjects design. Considering the age-related preference for processing positive information in older adults, Experiment 3 examined the survival effect with a positive control scenario. Similar results to the previous experiments were found. Overall, the data demonstrated a robust but age-equivalent basic survival effect.

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Basic and Evolutionary Survival Effects in Adaptive Memory in Older and Younger Adults

Introduction

Adaptive memory refers to a memory advantage for information processed in a survival-related context. It has been consistently found with younger adults in an emerging body of studies (Kang, McDermott & Cohen, 2008; Nairne et al., 2007; Nairne Pandeirada & Thompson, 2008; Nairne & Pandeirada, 2008a, b; Nairne, Pandeirada, Gregory & Van Arsdall, 2009; Otgaar, Smeets & Gergen, 2010; Weinstein, Bugg & Roediger III, 2008). In these studies, younger adults encoded unrelated words by rating how each word was relevant to a survival scenario (i.e., stranded in foreign grasslands without basic survival materials) versus a control scenario (e.g., moving to a foreign land or going on an extended vacation) or using other effective encoding strategies (e.g., rating for self-relevance or pleasantness). A subsequent incidental memory test (e.g., recognition or free recall) showed that words encoded in the survival scenario were better remembered than those encoded in the control scenario or using other encoding strategies (Nairne et al., 2008).

Adaptive Memory Studies

In the well-cited study that first documented the survival effect (Nairne et al., 2007), 150 participants were randomly assigned to one of three rating conditions: (a) relevance to a survival scenario ("grasslands"), (b) relevance to a non-survival scenario ("moving") or (c) degree of pleasantness ("pleasantness"). In the "grasslands" scenario, participants were told to imagine that they were "stranded in the grasslands of a foreign land without any basic survival materials. Over the next few months, [they] need to find steady supplies of food and water and protect [themselves] from predators". They were shown a list of words and rated each word on its relevance to the scenario. Similar instructions were given for the "moving" scenario, except that they were told to imagine that they were “planning to move to a new home in a foreign land. [They] need to locate and purchase a new home and transport [their] belongings”. They were asked to rate a list of words for their relevance to this scenario. In the “pleasantness” condition, participants viewed a list of words and were asked to rate the pleasantness of each word. This task was used as a standard meaningful processing control. In all the conditions, after rating the last word, participants completed a digit recall task, in which they were required to recall seven digits ranging from zero to nine for 2 minutes. The digit recall task was followed by a surprise memory test in which participants were asked to write down all the words they could remember from the rating task for 10 minutes. The results indicated that the words rated in the survival “grasslands” scenario were better recalled than words rated in the “moving” scenario and “pleasantness” condition. This effect was termed the ‘survival effect’ or ‘adaptive memory survival advantage’. It was attributed to thinking about words in terms of their ultimate survival value.

Nairne and colleagues (2008) further tested the survival advantage by comparing the survival scenario with other traditional deep encoding conditions: “pleasantness”, “imagery”, “self-reference”, “generation” and “intentional learning” with a between-subjects design. These conditions were considered deep encoding strategies because they have typically been found to produce better subsequent memory performance than shallow encoding strategies such as focusing on the perceptual properties (i.e., the number of letters) in study words. The survival “grasslands” and “pleasantness” conditions were exactly the same as those in the well-cited study described above (Nairne et al., 2007). In the “imagery” condition, participants were asked to rate a list of words on how easily they aroused mental images. In the “self-reference” condition, participants were told to think of personal experiences and to rate how easily the list of words brought to mind an important personal experience. In the “generation” condition, the first two letters of each word were reversed (e.g. RTUCK) and participants were asked to mentally switch the two letters before rating the pleasantness of each word. Finally, in the “intentional learning” condition, participants were instructed to try to remember the list of words for a later memory test. They completed a 2-minute digit recall task and then a free recall memory test. The results demonstrated a superior recall of words from the survival “grasslands” condition compared to all the other conditions, which further supported that survival processing had an enhancing effect on memory.

This finding has been replicated using pictures (Otgaar et al., 2010) and videos (Kang et al., 2008) as stimuli as well as other variations of control scenarios (Kang et al.; Nairne et al., 2009; Weinstein et al., 2008). Adaptive memory is an emerging topic in memory research. Although the exact underlying mechanisms are still unclear, a series of studies have been done to rule out some factors that potentially contribute to or modulate the effects. For example, in Kang and colleagues’ study (2009), participants viewed video clips of the show *Survivor* as the survival scenario and *Inside Man* (a movie about a bank heist) as the control scenario in an attempt to match the two scenarios on arousal, novelty and media exposure. Participants were asked to rate words for their relevance to the characters in the movie clips. More words rated for the survival video clip were remembered than those rated for the bank heist video clip. Although Kang and colleagues attempted to control for arousal, novelty and media exposure, no pilot or manipulation check was conducted to ensure these variables were in fact matched. Furthermore, they did not control for valence and familiarity of the scenarios.

Another component in the scenarios that has been investigated by Nairne et al. (2009) was whether being alone (e.g., stranded alone in the grasslands) versus being in a group (e.g., moving to a foreign land) contributes to the survival advantage. One could argue that being alone in the “grasslands” scenario seemed more negative and hopeless than being in other control scenarios because there was no chance of rescue or access to social support. To control this variable, Nairne and colleagues (2009) modified the survival scenario completely into hunter/gatherer scenarios in which participants were asked to imagine that they were a part of a tribe and were in charge of gathering food or contributing meat by hunting. The control scenario was a scavenger hunt in the first experiment and a hunting contest in the second experiment. Both survival and control scenarios implied being part of a group. The results replicated the survival advantage with a better recall for words rated in the survival scenario relative to the control scenarios. However, the authors did not explicitly control for other dimensions, such as valence, arousal, novelty or familiarity.

A common criticism of the survival advantage has been that the “grasslands” scenario encouraged a special type of schematic processing, in which participants used a survival schema to remember the words they rated. Weinberg et al. (2008) tested the schematic processing hypothesis by creating a new control scenario, “city”, that differed from “grasslands” on only two words. The “city” scenario read, “Imagine you are stranded in the city 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 attackers”. Theoretically, “city” would invoke the same level of schematic processing as “grasslands”. They again replicated the survival advantage in that more words rated for “grasslands” were remembered than those rated for “city”, and overall more words rated in these two survival scenarios were remembered than those in the control “moving” scenario. The memory advantage in “grasslands” over “city” was attributed to the high evolutionary value of “grasslands”. The evolutionary value was mainly determined by the historical time line of the scenario context, with a higher evolutionary value for those that simulated the environment in which our ancestor lived (e.g., “grasslands” or savannah). This evolutionary survival effect was observed even after controlling for schematic processing. However, it could be noted that relative to “grasslands”, the “city” scenario may sound less negative, less arousing, less novel, and more familiar. Nevertheless, the findings of these studies suggest an overall basic survival memory advantage, in which information processed in a survival mode were better recalled than that in non-survival modes.

In summary, the survival effect has been demonstrated in studies using various control scenarios and encoding strategies. However, one limitation of the reviewed studies is the lack of explicit control for potential confounding effects, such as emotional valence, arousal, novelty and familiarity levels between survival and control scenarios. It is still unclear whether these factors contribute to the survival effect.

Mechanisms of Adaptive Memory

Psychological adaptations are designs in our neural circuitry that at one point in evolution were important for solving adaptive problems faced by our human ancestors (Tooby & Cosmides, 2005). For example, early humans lived in small groups and gathered food. Through random mutations and chance, some members of the group would have neural circuits that were better at detecting poisonous fruits than other neural circuits. Those with the better “poison detectors” would be more likely to survive because they would avoid the harmful fruits and pass on their genes to their offspring. Those with poor “poison detectors” would be more likely to ingest the poisonous fruits and die, thus eliminating their chance of passing on their genes. Over many generations, the humans with the good “poison detectors” would survive, and eventually, those with bad “poison detectors” would die off. This process is natural selection (Tooby &

Cosmides, 2005). The neural circuits for detecting poisonous fruits were an adaptation that formed through evolutionary history. Following this line of reasoning and the framework in a previous study (Weinberg et al., 2008), the evolutionary value of a particular scenario could be defined by its historical time line, with a higher evolutionary value for those related to the adaptive problems faced by our ancestors (e.g., survive in “grasslands”) than those related to modern contexts (e.g., survive in a “city”).

Most researchers would favour an interpretation from an evolutionary perspective for the survival effect in memory. For example, evolutionary psychologists propose that cognition has adaptive value designed to increase the likelihood of survival in humans (Tooby & Cosmides, 1992; 2005). Cognition is thought to be a psychological adaptation that has evolved because it helps solve problems that are related to survival (Confer et al., 2010). For example, humans may have evolved heightened attention to threatening or survival-related stimuli (Weinstein et al., 2008). Similarly, our memory system could also be adaptive to remember certain kinds of information that are important for survival. However, it remains unclear whether this adaptive mnemonic advantage occurs spontaneously and automatically, without recruiting any cognitive resources or whether it is a controlled, effortful and resource-demanding process.

The aging-and-memory literature may be informative for understanding the mechanisms in adaptive memory. For example, age-related differences found in controlled, resource-demanding tasks are typically attributed to older adults having fewer cognitive resources (Craik & McDowd, 1987). Thus, if the survival advantage is based on controlled, resource-demanding processes, then we would expect older adults to show a reduced survival effect compared to younger adults. Furthermore, we may also expect the survival advantage to change across the emotional valence of the stimuli considering the well documented age-related bias for positive information (i.e., positivity shift) has been mainly shown in older adults with higher cognitive control (Mather & Knight, 2005). On the other hand, a lack of age differences in the survival advantage would suggest that adaptive memory is dependent on mechanisms that function automatically, or other types of processes.

Basic versus Evolutionary survival effects

Although studies of adaptive memory adopt an evolutionary interpretation, it is unclear whether it is survival relevance generally, or evolutionary relevance more specifically, that underlie the adaptive memory survival advantage. How does evolutionary value contribute over and above the basic survival effects? In other words, is there more memory enhancement for information encoded in survival scenarios with high evolutionary value, as opposed to scenarios with low evolutionary value? As described earlier (Weinstein et al., 2008), the general survival advantage in younger adults could be further divided into two components: a basic survival advantage effect (i.e., survival vs. non-survival control), and an evolutionary survival advantage effect (i.e., survival scenario with high-evolutionary value vs. survival scenario with low-evolutionary value). Specifically, Weinstein et al. (2008) assigned high-evolutionary value to the survival scenario that had survival significance to our ancestors (e.g., stranded in a foreign grasslands without basic survival materials) and low-evolutionary value to the survival scenario that was more relevant to modern contexts (e.g., stranded in a foreign city without basic survival materials). The reasoning for the difference in evolutionary value between the two scenarios was that the "grasslands" scenario was more similar to an environment in which our ancestors lived, while the "city" scenario was an environment set in modern times. The memory advantage of the "grasslands" encoding over the "city" encoding implied an evolutionary survival advantage that is beyond the basic survival advantage (i.e., more memory enhancement for information encoded in low-evolutionary survival contexts than in non-survival contexts). This evolutionary survival advantage has also been demonstrated in the literature on specific phobias that suggested people were more likely to fear threatening stimuli such as spiders or snakes that had evolutionary survival significance to our ancestors than to fear realistic vehicles in modern times, even though in reality, more people would be killed in car accidents than by spiders or snakes (De Silva, Rachman & Seligman, 1977; Marks, 1994).

However, as mentioned earlier, the valence, arousal, novelty and familiarity levels of the two scenarios were not explicitly controlled. Therefore, it is still questionable how much evolutionary value contributes to the survival advantage after these variables are taken into account. The current study explored whether these two components could be disentangled using well matched scenarios. To minimize the confounding effects, a carefully designed pilot study was conducted to ensure the control scenarios were matched with the critical survival scenario ("grasslands") on valence, arousal, novelty and context familiarity (i.e., how familiar the scenario is in modern context).

It should also be noted that in previous studies, the survival scenarios involved two survival-threatening components: lack of basic survival materials (e.g., water and food), and the presence of "predators" (in the "grasslands" scenario) or "attackers" (in the "city" scenario). So it was unclear whether the advantage was due to the lack of survival materials or the presence of threatening objects. Based on common sense, it could be expected that the lack of basic survival materials may be the core of basic survival. Therefore, the current study focused specifically on the effect driven by lack of basic survival materials. To this end, "predators/attackers" were removed from the corresponding survival scenarios. This manipulation allowed us to assess the adaptive function of memory at a very primary level of survival.

Adaptive Memory in Older Adults

Although adaptive memory has been well documented in younger adults, little is known about its manifestation in older adults. To our knowledge, all the existing studies on adaptive memory involved only younger adults and none of them explicitly controlled for the potential confounding variables. The present study aims to expand on previous studies to test age differences in adaptive memory, after controlling for potential confounding variables. The results of the study would also provide evidence for whether adaptive memory is based on basic and automatic processes or controlled and resource-demanding processes. Age differences in adaptive memory performance, as indicated by a reduced survival advantage in older adults, would suggest an effortful and controlled process in the survival effect. Whereas a lack of age differences in adaptive memory would suggest an automatic process.

Literature in emotional memory and evolutionary psychology strongly suggests that older adults may differ from younger adults in adaptive memory. According to the socioemotional selectivity theory (SST), goal selection depends fundamentally on the perception of time left in life (Carstensen, 2006). Older adults perceive time as limited, and consequently tend to prioritize emotionally meaningful goals as opposed to knowledge-related goals. On the other hand, younger adults perceive time as open-ended, and subsequently tend to focus on knowledge-related goals. This motivation shift with age also affects the cognitive processing of emotional stimuli. Literature consistently demonstrates that younger adults attend to or remember a greater proportion of negative than positive/neutral information, an effect generally referred as negativity bias (Baumeister, Bratslavsky, Finkenauer & Vohs, 2001; Rozin & Royzman, 2001). In contrast, older adults often show a substantially reduced or even eliminated negativity bias (e.g., Murphy & Isaacowitz, 2008). Sometimes older adults even show a bias favoring positive information (i.e., positivity shift), (Charles, Mather & Carstensen, 2003; Knight, Maines, & Robinson, 2002; Mather & Carstensen, 2003). This positivity shift is considered a controlled process, as older adults who perform best on executive functions tests are most likely to show the positivity bias (Mather & Knight, 2005). It appears that older adults strategically put more effort into remembering more positive and/or less negative information. Furthermore, the reduced evolutionary pressures on older adults (i.e., they have already passed the reproductive age) may also make them less likely to focus on survival-related information (Carstensen & Lockenhoff, 2003). Thus, if the survival effect is based on a similar resource-demanding process, older adults may show a reduced survival advantage considering their age-related decline in cognitive resources and minimized evolutionary pressure.

Study objectives and predictions

The objectives of this study were: (a) to explore age differences in the survival advantage, (b) to disentangle basic and evolutionary survival advantages and (c) to control for potential confounding factors. Both younger and older adults were recruited to examine possible age-related changes in the survival advantage. A pilot study and three experiments were conducted. The purpose of the pilot study was to select the best-matched control scenarios to the survival scenario. Experiment 1 focused on age differences in basic survival and evolutionary survival advantages in adaptive memory using a high-evolutionary survival scenario, low-evolutionary survival scenario and non-survival scenario in a within-subjects design. Because no study has tested the survival effect in older adults, the prediction related to age differences in adaptive memory was open. No age differences were expected if the survival effect was based on automatic or other types of processes. However, if the survival effect was based on controlled processes, then older adults would show a reduced general survival advantage, as a result of their limited cognitive resources, coupled with the age-related reduction in evolutionary selection pressures. If the general survival advantage indeed consisted of a basic survival advantage and an evolutionary advantage, we predicted that participants would perform better in the high-evolutionary survival scenario than in the low-evolutionary survival scenario, which in turn would be better than the non-survival control. Experiment 2 was conducted to replicate the results of Experiment 1 using a between-subjects design in younger adults to investigate whether the order of scenario presentation in the within-subjects design contributed to the survival advantage. It was predicted that if the general survival advantage could be further divided into a basic survival advantage and an evolutionary survival advantage, then participants would remember more words rated in the high-evolutionary survival scenario than in the low-evolutionary scenario. They would demonstrate the basic survival effect by remembering more words rated in the survival scenarios than in the non-survival scenario. Experiment 3 examined the interaction of emotionality and age differences in the basic survival advantage with a positively valenced control scenario. The positivity shift in older adults is based on intentional, controlled processing. If the survival advantage is also based on controlled processes, then the positivity shift may take effect and counteract the survival effects. As a result, older adults would show a reduced survival advantage compared with younger adults when the survival scenario was presented alongside a positively valenced non-survival scenario. Otherwise, if the survival effect occurs automatically, then no age differences or emotion effects would be expected in the survival effects.

General Methods

Overview

In the reported experiments, I adopted the paradigm described in previously published adaptive memory studies (Nairne et al., 2007; Nairne et al., 2008). It consisted of a study phase in which participants rated words for their relevance to various scenarios, followed by a test phase in which they recalled the rated words. In light of the emerging empirical evidence for survival effects in adaptive memory (Kang et al., 2008; Nairne et al., 2007; Nairne et al., 2008; Nairne & Pandeirada, 2008a, b; Nairne et al., 2009; Otgaar et al., 2010; Weinstein et al., 2008), it was predicted that participants would recall more of the words rated in the survival scenarios than of those rated in the non-survival scenarios.

Stimuli

A pilot study was conducted to determine the scenarios used in these experiments (described in detail below). A word pool of 48 target words and 9 practice words was chosen from the stimuli used in Nairne et al. (2007), Weinstein et al. (2008) and the Affective Norms for English Words (ANEW, Bradley & Lang, 1999).

Procedure

The stimuli were presented on a 16" laptop computer screen through E-prime program version 1.1. The words were presented one at a time at the centre of the monitor screen. All stimuli were presented in 30 Arial font size in black against a white background. Each word appeared for 5 seconds along with a corresponding five-point rating scale in 20 font size (presented below the word) with 1 meaning "totally irrelevant" and 5 meaning "extremely relevant". In between each word was a fixation "+" interval that lasted 1 second. On each trial, participants responded by pressing the corresponding number keys on the keyboard to rate how relevant each word was to the assigned scenario. Stickers labeled as “1” through “5” were placed on the c, v, b, n and m keys to represent the five response keys respectively. Participants were asked to respond within the 5-s window and to try to use the full rating scale when making their responses. Following the instructions for the rating task, participants completed three practice trials to familiarize themselves with the task and the assigned scenario(s). The practice trials were followed by the scenario information presented again as a reminder. The rating task lasted about 15 min. After the rating task, participants completed a motor-perceptual speed task, the Digit Symbol task (Wechsler, 1997), for 2 minutes. The Digit Symbol task was used as a nonverbal filler task to prevent rehearsal and reduce recency effects. Then they completed a surprise recall test in which they were asked to write down as many words as they remembered from the earlier rating task, in any order, on a blank piece of paper. Participants were given 10 minutes to complete this free recall task.

Following the recall task, a questionnaire was orally administered to assess their awareness of the memory test and exposure to survival-related media. They also completed some paper and pencil tests and questionnaires, including the Shipley vocabulary test (Shipley, 1949), Morningness-Eveningness Questionnaire (MEQ) (Horne & Osberg, 1976) and the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown & Steer, 1988). The Mini Mental State Exam (MMSE) was administered to older adults as a cognitive impairment screening test (Folstein, Folstein & McHugh, 1975). These measures were used to better match our samples.

Data Analysis

Mixed analyses of variance (ANOVAs) were conducted on the recall data in Experiment 1 and 3. One-way ANOVAs were conducted in the between-subjects design in Experiment 2. Significant effects were followed up with the Sidak tests or paired sample *t*-tests. Relevance ratings and reaction times (RTs) during the rating task were also analyzed. Only recorded trials were used in the RT analyses. Missed trials (no responses were made or recorded) were removed from the final analyses.

Pilot study

A pilot study was conducted to ensure that the survival and control scenarios were comparable with respect to the potential confounding variables, including valence, arousal, novelty, and familiarity. The higher the rating, the more negative, arousing, novel and familiar the scenarios were. Twenty younger adults (aged 18 to 28, M = 22.10, SD = 7.53) completed and rated 8 scenarios on a 9-point Likert-type scale on the following dimensions: valence, arousal, novelty and context familiarity (see Appendix). The “grasslands”, “moving”, “vacation” and “city” scenarios were modified from previous studies (Nairne et al., 2007; Weinberg et al., 2008). Repeated-measures ANOVAs and Sidak tests were conducted to select control scenarios that were not significantly different from the “grasslands” scenario on each of these dimensions.

Low-evolutionary survival scenario

We performed three sets of repeated ANOVAs. Experiment 1 and Experiment 2 examined the relative contribution of the evolutionary survival effect (i.e., *high-evolutionary survival* vs. *low-evolutionary survival* scenarios) and the basic survival effect (i.e., *low-evolutionary survival* vs. non-survival scenario), therefore, the first set of analyses focused on the survival scenarios “grasslands”, “mountain”, “desert” and “city”. Among them, “grasslands” has been traditionally used as the *high-evolutionary survival* scenario because it simulated an environment in which our ancestors lived, and all the other 3 scenarios represented *low-evolutionary survival* scenarios because they all simulated a context that was more common in modern life. The purpose of the analysis was to find the best-matched *low-evolutionary survival* scenario for the “grassland” scenario. The results showed that “mountain” was the best *low-evolutionary survival* scenario because it did not differ from “grasslands” on any of the dimensions (ps > .12). Paired-samples t tests revealed that “city” (M = 3.05, SD = 2.21) differed marginally from “grasslands” (*M* = 2.20, *SD* = 1.24), *t* = -2.03, *p* = .056, on valence. “City” was also marginally more familiar than “grasslands”, *t* = -2.01, *p* = .059, (*M* = 5.15, *SD* = 2.03 and *M* = 2.20, *SD* = 1.36, respectively). On the familiarity scale, “desert” (*M* = 3.20, *SD* = 2.17) was also more familiar than “grasslands” (*M* = 2.2, *SD* = 1.36), *t* = -2.52, *p* = .02. Finally, on the novelty scale, “city” (*M* = 6.45, *SD* = 1.67) was significantly less novel than “grasslands” (*M* = 7.35, *SD* = 1.39), *t* = 2.16, *p* = .04.

Non-survival scenario

To explore the basic survival effect (i.e., low-evolutionary survival vs. non-survival), the second set of analyses were conducted to determine the best matched *non-survival* control scenario from the “cruise” and “moving” scenarios. They were both negatively valenced but lacked the survival component (e.g., “lack of basic survival materials”). The second set of analyses compared “mountain”, “moving” and “cruise” The results showed that “cruise” was the better *non-survival negatively valenced* scenario because it did not differ from “mountain” on any of the rated dimensions (*p*s > .65). Pairwise comparisons (Sidak) showed that “moving” (*M* = 4.30, *SD* = 2.05) was significantly less negative than “mountain” (*M* = 2.2, *SD* = 1.15), *p* < .001. “Moving” (*M* = 5.10, *SD* = 2.49) was also marginally less novel than “mountain” (*M* = 6.85, *SD* = 1.93), *p* = .047. Finally, on the familiarity scale, “moving” (*M* = 4.80, *SD* = 2.57) was more familiar than “mountain” (*M* = 2.85, *SD* = 1.63), *p* = .01.

Positively valenced non-survival scenario

Experiment 2 aimed to explore whether the positivity shift in older adults would affect their adaptive memory performance if a positive scenario was used. Therefore, the third set of analyses was conducted to determine the best matched *non-survival positively valenced* scenario by comparing “mountain”, “vacation” and “lottery”. Once again, “mountain” was used to represent a *low-evolutionary survival scenario* and “vacation” and “lottery” were used as two candidate *non-survival positively valenced control* scenarios. As expected, both “vacation” (*M* = 7.35, *SD* = 1.73) and “lottery” (*M* = 8.50, *SD* = 0.76) were significantly more positive in valence than “mountain” (*M* = 2.20; *SD* = 1.15), *p*s < .001. Nevertheless, “lottery” was the better *non-survival positively valenced* scenario because it was equivalent on the other dimensions (*p*s > .07) whereas “vacation” was more novel (*p* = .02) and more familiar (*p* < .001) than “mountain”. See Table 1 for the descriptive data from the pilot with younger adults.

Table 1

Pilot study ratings

Scenario	Valence ratings M (SE)	Arousal ratings M (SE)	Novelty ratings M (SE)	Familiarity ratings M (SE)
Grasslands	2.20 (0.28)	7.40 (0.31)	7.35 (0.31)	2.20 (0.30)
Mountain	2.20 (0.26)	7.20 (0.29)	6.85 (0.43)	2.85 (0.22)
Desert	2.00 (0.28)	7.45 (0.51)	6.70 (0.46)	3.20 (0.42)
City	3.05 (0.49)	7.35 (0.39)	6.45 (0.37)	3.15 (0.41)
Moving	4.30 (0.46)	6.55 (0.29)	5.10 (0.56)	4.80 (0.54)
Cruise	2.10 (0.26)	7.45 (0.34)	6.85 (0.36)	3.40 (0.44)
Vacation	7.35 (0.39)	5.70 (0.45)	5.20 (0.54)	4.80 (0.42)
Lottery	8.50 (0.49)	7.25 (0.52)	7.15 (0.42)	4.00 (0.59)

Based on the pilot results, the “mountain” scenario was chosen as the *low-evolutionary survival* scenario and the “cruise” scenario was chosen as *non-survival* control for Experiment 1 and 2. The “lottery” scenario was chosen as the *positively valenced non-survival* control for Experiment 3.

To confirm whether this scenario selection based on the pilot results with young adults also applied to older adults, we asked 20 older adults (aged 60 to 80, *M* = 70.05, *SD* = 2.53) to rate the 8 scenarios on the four scales later on. The same sets of analyses were conducted and revealed similar patterns. For older adults, “mountain", “cruise” and “lottery” were the best-matched control scenarios as well. However, it should be noted that in the repeated-measures ANOVA for the *non-survival negatively-valenced* control, the familiarity ratings for both "cruise" (*M* = 3.45, *SD* = 1.96) and "moving" (*M* = 4.25, *SD* = 2.43) were significantly different from "mountain" (*M* = 1.95, SD = 1.00), *p*s < .01. However, "cruise" was still a better matched scenario than "moving".

In the analyses for the *non-survival positively valenced* control, "vacation" (*M* = 6.95, SD = 1.61) and "lottery" (*M* = 8.10, *SD* = 0.64) were significantly more positive in valence than "mountain" (*M* = 2.40, *SD* = 1.10), *p*s < .001. Similar to the younger adults' results, "lottery" was equivalent to "mountain" on arousal and novelty (*p*s > .75). "Vacation" (*M* = 5.85, *SD* = 2.01) was less novel than "mountain" (*M* = 8.25, *SD* = 1.25), *p* <.001. However, the familiarity ratings for both "lottery" (*M* = 3.70, *SD* = 2.64) and "vacation" (*M* = 5.70, *SD* = 1.89) were also significantly different from "mountain" (*M* = 1.95, *SD* = 1.00), *p*s < .02. Nonetheless, "lottery" was still a better matched *non-survival positively valenced* scenario based on the mean scores.

Experiment 1

Experiment 1 explored age differences in the two components of adaptive memory effect, a basic survival effect (i.e., survival vs. non-survival) and an evolutionary survival effect (i.e., high-evolutionary survival vs. low-evolutionary survival), using a within-subjects design.

Participants

Thirty-six older adults (aged 65-87, *M* =73.61, *SD* = 6.24) from the community and 36 younger adults (aged 18-29, *M* = 22.14, *SD* = 3.03) from the Ryerson University psychology participant pool were recruited to participate in Experiment 1. The sample sizes were determined through a power analysis using G*Power version 3.0.1 for a-priori power of .80, effect size of .22 and an α of .05.

Older adults completed the Morningness-Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976) over telephone to determine their optimal testing time. Participants were asked five multiple-choice questions and based on their score, they were categorized as either a *Morning* (above 18.5), *Neutral* (11.5 – 18) or *Evening* (below 11) person. *Morning* types were tested from 9am to 11am, *Neutral* types were tested between 12pm to 2pm and *Evening* types were tested between 3pm to 5pm. Younger adults were not able to do the pre-screening to determine their optimal testing time, but completed the MEQ after they completed the study. Analyses showed that the results did not change after removing 15 younger and 3 older participants who were not tested at their optimal time.

Exclusion criteria included a prior history of neurological or major psychiatric conditions, uncontrolled diabetes, and uncontrolled cardiovascular conditions, or a low vocabulary (i.e., scored below 20 on the Shipley Vocabulary test). Younger participants learned English before the age of 6. Older participants learned English within at least the past 40 years. Three older adults were replaced due to technical problems with the computer program during testing. Older adults were screened for potential dementia-related cognitive impairments with the Mini Mental State Exam (MMSE) (Folstein et al., 1975), and all the older participants scored above 26 (*M* = 28.86, *SD* = 1.15). See Table 2 for the sample's basic characteristics.

Table 2

Participant characteristics

Measures	Experiment 1		Experiment 2	Experiment 3	
	Young M(SD)	Old M(SD)	Young	Young M(SD)	Old M(SD)
Years of education	14.94 (1.92)	16.53 (3.28)	12.65 (1.35)	12.58 (1.06)	16.58 (2.89)
Digit Symbol	90.44 (14.17)	60.89(10.70)	90.6 (14.02)	85.21 (10.27)	65.25 (12.20)
Shipley vocabulary	27.36 (3.29)	37.28 (2.35)	28.28 (3.73)	26.29 (3.90)	37.25 (2.27)
Beck Anxiety Inventory	14.64 (10.60)	5.93 (6.29)	14.25 (9.70)	18.08 (10.08)	5.50 (4.65)
Morningness-Eveningness Questionnaire	12.56 (3.20)	28.86 (2.96)	N/A	13.23 (3.01)	17.69 (4.20)
Gender ratio (male: female)	9:27	8:28	10:16	7:17	1:23

Materials and Design

Experiment 1 adopted a 2 (Age: younger vs. older) × 3 (Encoding scenario: high-evolutionary survival, low-evolutionary survival, non-survival control) mixed design, with encoding scenario as a within-subjects variable. All participants went through an incidental study (encoding) phase and a memory test phase. At the incidental encoding phase, they were asked to rate a series of words for their relevance to one of the three scenarios, that were assigned to three distinct blocks. The order of the scenarios was counterbalanced across participants. The *high-evolutionary survival scenario* (i.e., "grasslands"*)* was described as: "In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water to meet your basic needs." The *low-evolutionary survival scenario* (i.e., "mountain") read, "In this task, we would like you to imagine that you are stranded on a mountain in a foreign land during an adventure expedition, without any basic survival materials. Over the next few months, you will need to find steady supplies of food and water to meet your basic needs." Finally, the *non-survival control scenario* (i.e., "cruise") was depicted as: "In this task, we would like you to imagine that you were accidently left behind in a foreign land during a cruise. Your passport and possessions were left on the ship. Over the next few months, you will need to reapply for a new passport and find a way to support yourself."

From the word pool, three sets of 16 pre-randomized words and 3 practice words were chosen from previous studies or the ANEW database. The three sets were matched on concreteness, word frequencies and word length. Each set was presented equally often in each of the three counterbalanced scenario encoding blocks. This resulted in 9 counterbalanced versions. In each encoding block, participants rated 16 words on their relevance in the context of one scenario (i.e., "grasslands", "mountain" or "cruise"). After the words were rated, there was a short retention interval of 2 min followed by a surprise free-recall test.

Procedure

Participants rated three blocks of words for their relevance to the scenarios on a 5-point scale (see the "general method" section for details on timing parameters and the meaning of the scale). Immediately following the last block, they were given 2 minutes to do the Digit Symbol task and were asked to complete it as accurately and quickly as possible. They were then given a blank piece of paper and told to write down as many words as possible that they could remember from the computer task. They were told that they had 10 minutes for the recall task and that they could take their time.

Following the memory test, they were asked how aware they were of the memory test when they studied the words on a 3-point scale (1 = completely unaware, 2 = somewhat aware and 3 = aware). Two participants answered somewhat aware but stated that they did not try to remember the words, suggesting the study/encoding was largely incidental. Analyses conducted without these participants did not alter the results. Participants also rated how often they watched survival-themed movies or television shows on a 5-point scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = all the time). Finally, they rated how often they have been on a cruise based on the same 5-point scale. None of these three measures correlated with the memory scores. Participants then completed the other selected paper-and-pencil questionnaires for about 15 minutes. All participants were given a debriefing sheet that explained the purpose and predictions of the experiment. Younger adults received one bonus credit and older adults received $10/hour monetary compensation for their participation.

Results and Discussion

A 2 (Age) × 3 (Scenario) mixed ANOVA revealed a significant scenario effect, $F(2, 140) = 6.52$, $p = .002$, $\eta^2 = 0.10$. Paired sample *t*-tests revealed that a higher proportion of words were recalled (total number of words recalled divided by number of words per block) in the "grasslands" scenario ($M = 0.40$, $SD = 0.17$) and in the "mountain" scenario ($M = 0.40$, $SD = 0.17$) than those in the "cruise" scenario ($M = 0.32$, $SD = 0.17$), ts > 2.80, ps < .007. "Grasslands" and "mountain" were not significantly different, $p = .75$. There were no main effects of age or interactions (ps > .17). The recall data are displayed in Figure 1.

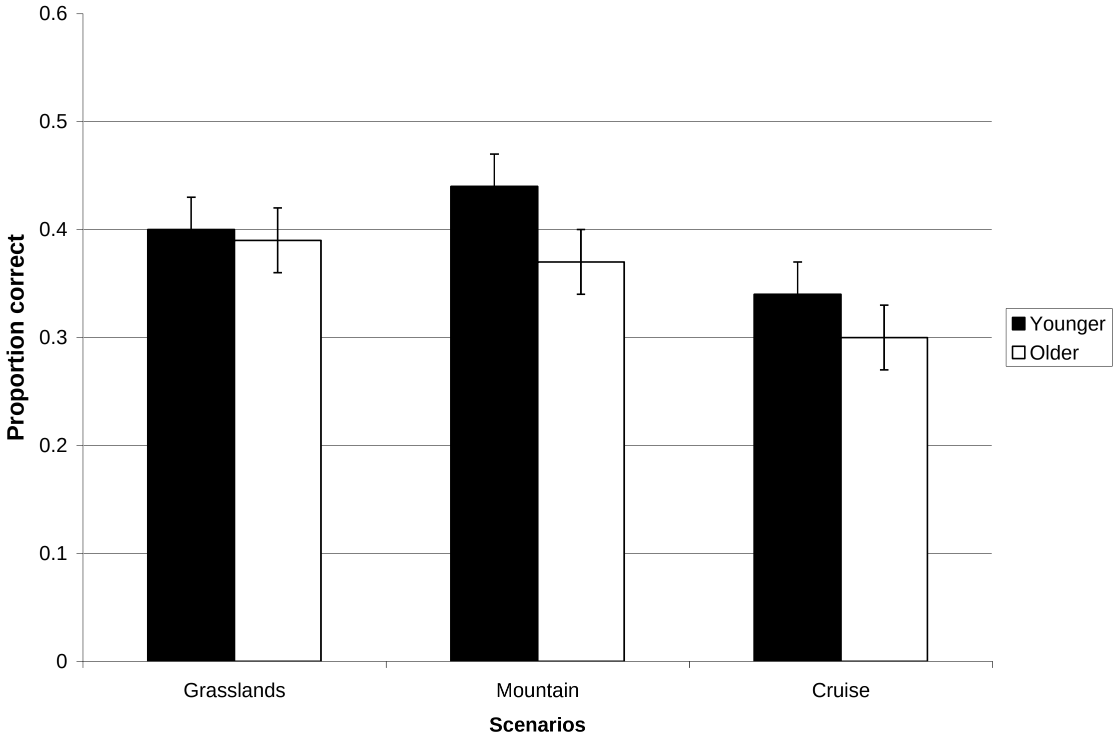

Figure 1. Proportion of words correctly recalled for Experiment 1.

The results replicated the survival effect reported in literature by showing a better memory performance in both survival scenarios (“grasslands” and “mountain”) compared to the non-survival control scenario (“cruise”). However, this effect was not enhanced with the evolutionary value of the survival scenarios, as demonstrated in the equal recall performance for the *high-evolutionary* scenario (“grasslands”) and *low-evolutionary* scenario (“mountain”). Going beyond previous findings, this study extended the basic survival effect to older adults.

The lack of the evolutionary effect suggested that evolutionary value, as it was defined in the current timeline (i.e., ancient vs. modern) framework, did not contribute beyond the basic survival effect. This finding contrasted that of Weinberg et al. (2008), in which they found a survival advantage in their high-evolutionary survival scenario “grasslands” over their low-evolutionary survival scenario “city”. However, our pilot revealed that “city” was not a well-matched scenario for “grasslands” on valence, novelty or familiarity. Any of these differences may have contributed to the original finding. Furthermore, the concept of evolutionary survival effect was defined solely based on the timeline framework proposed in Weinberg et al. (2008). More research and solid evidence is needed to evaluate this definition. Alternatively, perhaps we did not find an evolutionary survival effect because “grasslands” and “mountain” did not differ in terms of critical evolutionary value that was not captured by the modern-ancient timeline dimension. In addition, although “mountain” was created to reflect modern contexts (with the inclusion of “adventure expedition” information), it may still have resembled an environment that our ancestors inhabited.

No age differences in the survival effect were detected despite the literature on age-related cognitive resources and/or decreased evolutionary selection pressures (Carstensen & Lockenhoff, 2003; Knight, Maines, & Robinson, 2002; Mather & Carstensen, 2003; Mather & Knight, 2005). This finding was novel because no study to date has examined adaptive memory in older adults. A lack of age differences in the survival advantage may suggest (although not definitively) that it involve basic processes, such as an increase in autonomic arousal, that occur spontaneously and does not require cognitive resources. Such a basic, automatic process would remain stable across all ages, regardless of reproductive age. Older adults may strategically tend to focus less on negative information in general, but when the information is relevant for their survival, they may still automatically encode it.

Data from the rating task at the encoding phase were also analyzed. The rating reaction time trials (RTs) were trimmed by removing the RTs that were 2.5 standard deviations away from the mean. As a result, 0.57% of the trials were removed. There was a main effect of age, $F(1, 70) = 22.31$, $p < .001$, $\eta^2 = 0.24$, in that older adults ($M = 3961.26$, $SD = 578.30$) were significantly slower than younger adults (*M* = 3244.43, *SD* = 702.76). The ANOVA on RTs did not reveal significant main effect of scenario or interactions (*p*s > .46). The ANOVA on the ratings revealed a significant main effect of scenario, $F(2, 140) = 19.75$, $p < .001$, $\eta^2 = 0.22$. A follow-up analysis showed that words in “grasslands” (*M* = 3.19, *SD* = 0.61) and “mountain” scenarios (*M* = 3.25, *SD* = 0.66) were rated higher in relevance than words in “cruise” scenario (*M* = 2.77, *SD* = 0.71), *ps* < .001. However, the correlation analysis suggested that the ratings were not significantly correlated with the recall scores (*p*s > .33). In summary, although the ratings showed a similar pattern as the memory scores, there did not appear to be a relationship between the ratings and the memory performance.

Another surprising finding was that when order sequence of the scenarios was included as a covariate, the scenario effect disappeared. There were three sequences: (a) grasslands-mountain-cruise, (b) mountain-cruise-grasslands and (c) cruise-grasslands-mountain. A closer look revealed that the survival advantage was not evident in sequence (a), in which “cruise” was the scenario presented last, *p* = .11. It was possible that the last presented “cruise” scenario had taken on a “survival quality” through priming effects of the previous two survival scenarios. In other words, “cruise” was no longer encoded as a non-survival scenario. Although previous studies have replicated the survival effect in within-subjects designs, no study has discussed order effects (Nairne et al., 2007; Weinberg et al., 2008). In order to further understand the order effect found in Experiment 1, a follow-up study (Experiment 2) was conducted using a between-subjects design, in which each participant was exposed to only one scenario and thus no order effect was possible. This experiment intended to examine whether the survival effect was robust and could be extended to a between-subjects design after controlling for the order effect revealed in Experiment 1.

Experiment 2

To control for possible order effects in the survival advantage found in Experiment 1, a between-subjects design was used in Experiment 2, with only younger participants. In this experiment, each participant viewed only one scenario, and thus it was not possible for the non-survival control scenario to be contaminated with the carry-over survival tone from the prior survival scenarios, as shown in the first experiment. The results were expected to replicate the survival effects detected in Experiment 1.

Participants

Seventy-two younger adults aged 18-29 (*M* = 19.33, *SD* = 2.06) were recruited from the Ryerson University psychology participant pool. They received one bonus course credit in exchange for participation. They were screened with the same exclusion criteria as those of Experiment 1. All participants were tested after 12 pm because typically younger adults were either neutral or evening types. See table 2 for detailed participant characteristics.

Materials and Design

A between-subjects design was adopted with three levels of the encoding scenario: *high-evolutionary survival*, *low-evolutionary survival*, *non-survival control*. Two lists from Experiment 1 were merged to form one list of 32 words in Experiment 2. The instructions for scenarios were the same as those in Experiment 1. Participants rated all 32 words for their relevance to a specific scenario based on a 5-point scale.

Procedure

The procedure was identical to that in Experiment 1, except for a between-subjects design in which participants were exposed to only one scenario and rated only one list of words. After rating the word list, they completed the Digit Symbol task as a filler task for 2 minutes, and they were then asked to write down as many words as they could from the rating task on a blank piece of paper for up to 10 minutes. Finally, they completed the same set of paper-and-pencil tests and questionnaires as in Experiment 1.

Results and Discussion

A one-way ANOVA revealed a significant main effect of scenario, $F(2, 69) = 5.81$, $p = .005$, $\eta^2 = 0.14$. A Games-Howell multiple comparison showed that more words were recalled in the "grasslands" ($M = 0.52$, $SD = 0.12$) and "mountain" scenario groups ($M = 0.50$, $SD = 0.12$) than in the "cruise" scenario group ($M = 0.42$, $SD = 0.10$), $ps < .05$. "Grasslands" and "mountain" were not significantly different from each other, $p = .82$. This effect is depicted in Figure 2.

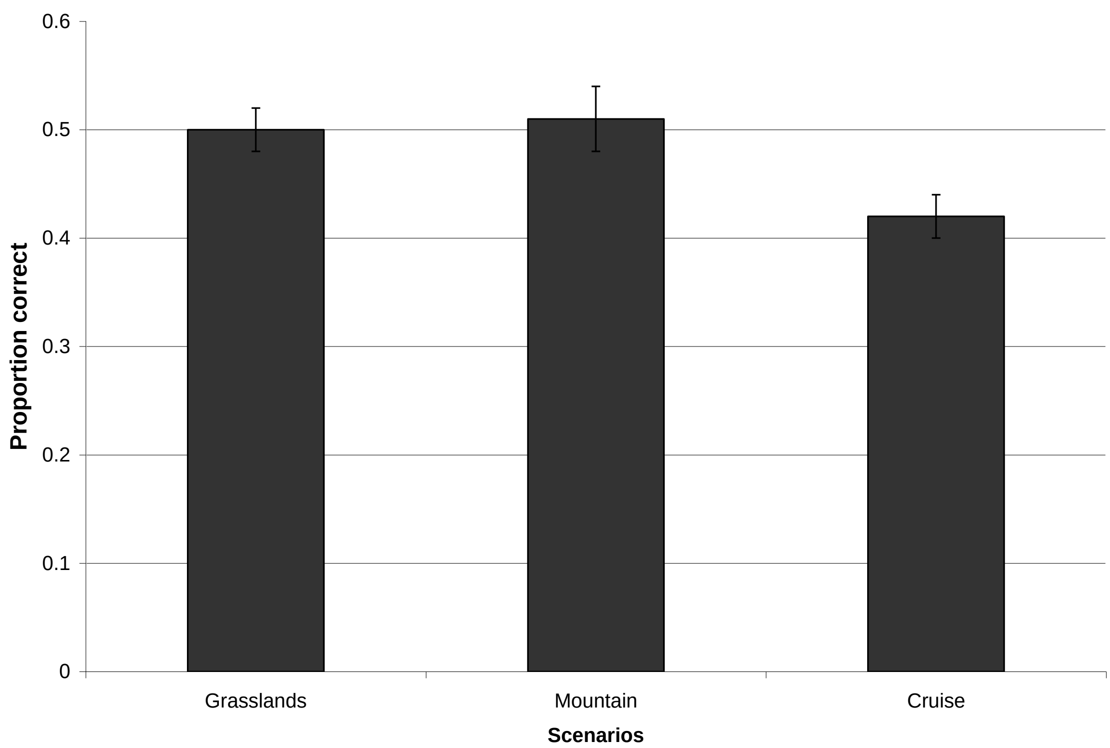

Figure 2. Proportion of correctly recalled words in Experiment 2.

The results replicated the basic survival effect in Experiment 1 in a between-subjects design with younger adults. Therefore, the basic survival effect appeared to be robust and not to be affected by order effects.

Data from the encoding/rating task were also analyzed. RTs that were 2.5 standard deviations away from the mean were trimmed and as a result, 0.95% of the trials were removed from the final analyses. The one-way ANOVA on the RT data did not find any significant effects, $p = .64$. The one-way ANOVA on ratings revealed a significant main effect of scenario, $F(2, 69) = 6.41$, $p < .003$, $\eta^2 = 0.16$. A follow-up analysis showed that words in “grasslands” ($M = 2.77$, $SD = 0.63$) and “mountain” ($M = 2.88$, $SD = 0.48$) were rated higher in relevance than words in “cruise” ($M = 2.34$, $SD = 0.53$), *ps* < .035. A correlation analysis revealed that the ratings were not significantly correlated with the recall scores (*p*s > .32). Similar to Experiment 1, although the ratings showed a similar pattern as the memory scores, there did not appear to be a relationship between them.

Experiment 3

The results from Experiment 1 and 2 replicated the basic survival advantage reported in literature with younger adults and extended it to older adults. Experiment 1 suggested that older adults showed a basic survival advantage when both the survival and non-survival scenarios were negative, but would a positively valenced non-survival scenario alter the pattern?

Nairne et al. (2008) first used a positively valenced non-survival control scenario ("vacation") with younger adults (see pilot in Appendix for "vacation" scenario"). In a within-subjects design, participants rated words for their relevance to the standard "grasslands" survival scenario and the "vacation" scenario. After a brief 2-min delay, participants were given a surprise recall test to write down all the words they could remember. The results showed a significant survival advantage in that more words rated in the survival "grasslands" scenario were recalled than those rated in the non-survival "vacation" scenario. We have since demonstrated with the pilot data that "vacation" was not well-matched with "grasslands" on arousal, novelty and familiarity (see Table 1 for pilot ratings). Thus, it was unclear whether the survival advantage would remain robust if an equivalent positively valenced non-survival scenario was used. Furthermore, results from Experiment 1 and 2 demonstrated age-equivalent basic survival effects using negative survival and non-survival scenarios, suggesting that adaptive memory may be based on automatic processes. However, it was possible that a highly positively valenced control scenario might intentionally shift older adults' attention from the survival information, driven by their intentional controlled positivity shift (Mather & Knight, 2005).

The objectives of Experiment 3 were (a) to examine whether the survival advantage found in Nairne et al. (2008) could be replicated and extended to older adults using a well-matched highly positively valenced non-survival scenario and (b) to investigate whether age differences in adaptive memory would be evident when a highly positively valenced non-survival scenario was used. This addressed the question of whether the survival effects could be modulated by controlled processes (e.g., positivity shift) in older adults under extreme conditions (i.e., when the controlled scenario was highly-positive). If the survival effect was fully automatic, as indirectly suggested by the age-equivalent findings in Experiment 1, then the positivity effect in older adults would not override the survival effect and their performance would remain similar to that of younger adults. However, if the survival effect could be modulated by a controlled and effortful process under extreme conditions, then the positivity shift may reduce the survival advantage in older adults in the context of a highly positive control scenario. Younger adults' performance was not expected to change from the previous two experiments.

Participants

Twenty-four younger adults (aged 18 to 27, $M = 19.13$, $SD = 2.07$) from the Ryerson psychology participant pool and 24 older adults (aged 66 to 83, $M = 73.08$, $SD = 5.49$) from the community were recruited. They were screened with the same exclusion criteria as in Experiment 1.

Similar to Experiment 1, older adults completed the MEQ over telephone to determine their optimal testing time. Younger adults were all tested after 12 pm and completed the MEQ after they completed the study. Separate analyses removed 14 younger participants and five older participants who were not tested at their optimal time and the pattern of results remained the same. Older adults were screened for potential dementia-related cognitive impairments with the

MMSE (Folstein et al., 1975). None of the older participants scored below 26 (M = 28.88, SD = 1.15). See Table 2 for specific participant characteristics.

Materials and Design

Experiment 3 followed a 2 (age: Younger vs. Older) × 2 (Encoding scenario: *low-evolutionary survival* and *positively valenced non-survival*) mixed design. The instructions for the *positively valenced non-survival scenario* were: “In this task, we would like you to imagine you won a large amount of money in a lottery draw. You do not have any pressing financial needs. Over the next few months, you need to figure out how to spend the money and enjoy your life”. The *low-evolutionary survival scenario* was the “mountain” scenario used in Experiment 1.

Thirty-two target test words and 6 practice words were randomly taken from two of the three lists used in Experiment 1. The words were assigned into 2 sets of 16 pre-randomized words, which were previously matched on concreteness, word frequencies and word length. Participants rated 16 words for their relevance to the “mountain” scenario and the “lottery” scenario on a 5-point scale. Similar to Experiment 1, the order of the two scenario blocks and the two word lists were counterbalanced across participants, resulting in 4 counterbalance conditions.

Procedure

The procedure was exactly the same as that in Experiment 1, except that two scenarios were used in encoding words. After rating the second list of words, they completed the Digit Symbol task for 2 minutes. They were then told to write down all the words they could remember from the rating task on a blank piece of paper for up to 10 minutes. Finally they completed the same set of paper-and-pencil tests and questionnaires as in the two aforementioned experiments.

Results and discussion

Figure 3 displays the recall performance of this experiment.

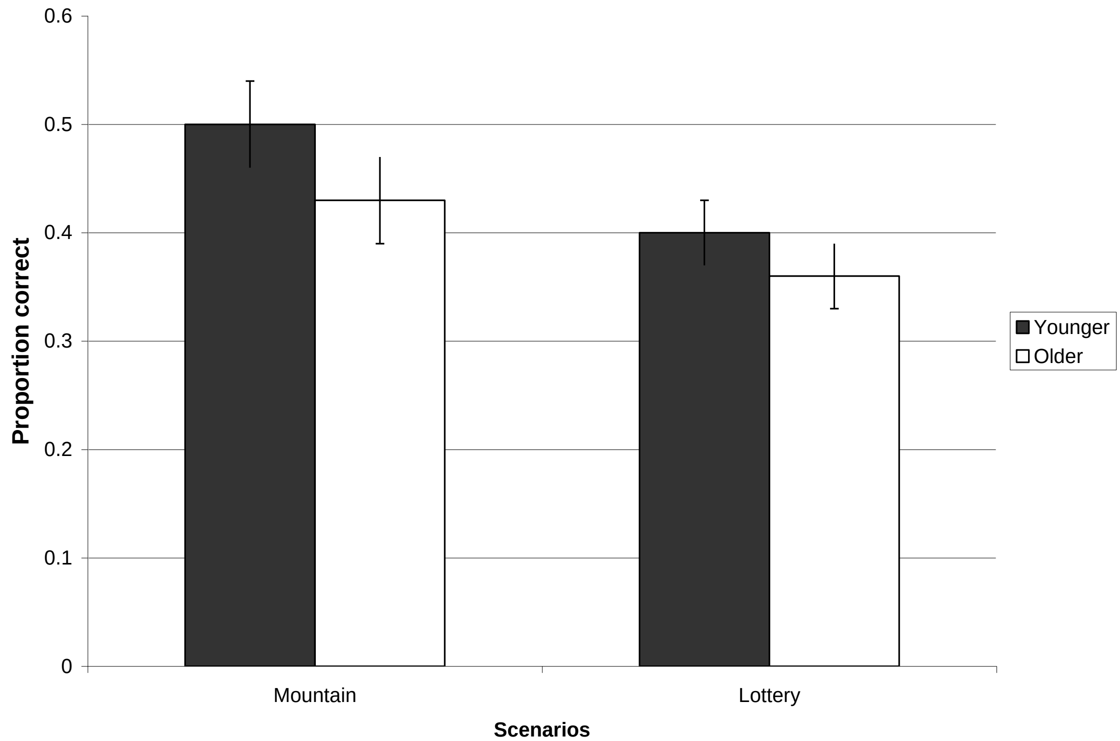

Figure 3. Proportion of words recalled correctly in Experiment 3.

A mixed 2 × 3 ANOVA revealed a significant scenario effect, $F(1, 46) = 8.56$, $p = .005$, $\eta^2 = 0.16$. Paired sample *t*-tests revealed that more words were remembered in the "mountain" scenario ($M = 0.46$, $SD = 0.18$) than in the "lottery" scenario ($M = 0.38$, $SD = 0.15$), $t = 2.95$, $p = .005$. There were no main effects of age or interactions, *p*s > .17.

The basic survival effect detected in Experiment 1 was replicated here with both younger and older adults. More words were remembered in the survival scenario "mountain" than in the non-survival scenario "lottery". The positive valence of the non-survival scenario did not affect the survival effect in older adults. No age differences or interactions were found. It appeared that the positively valenced scenario did not modify the basic survival effects in older adults, which gave further indirect evidence that adaptive memory may involve basic, automatic processing.

Although the results of Experiment 3 supported the idea that the survival advantage may occur automatically, we should note that the paradigm we used did not directly assess the cognitive demands of survival processing. A dual task paradigm, in which participants would engage in a divided attention task while doing the scenario rating task, would be more appropriate in this case. Moreover, in retrospect, a neutral non-survival scenario would have better demonstrated the effect of valence manipulation on the survival advantage. However, the design of the current experiment was based on that of Nairne et al. (2008) because we were primarily interested in replicating the survival effect using a better controlled positively valenced non-survival scenario, and the role that the positivity shift in older adults would play in survival processing.

Data from the encoding task were also analyzed using repeated-measures ANOVAs. Trials with RTs that were 2.50 standard deviations away from the mean were removed. After trimming, 0.46% of the trials were discarded. Although there was no main effect of scenario in the ANOVA (p = .81), there was a main effect of age, $F(1, 46) = 21.08$, $p <.001$, $\eta^2 = .31$. Older adults (M = 2559.03, SD = 500.86) were slower than younger adults (M = 1949.65, SD = 414.74) on the rating task. The ANOVA on ratings showed a main effect of scenario, $F(1,46) = 4.66$, $p <$ .001, $\eta^2 = 0.54$. The relevance ratings for "mountain" (M = 3.23, SD = 0.73) were higher than for "lottery" (M = 2.32, SD = 0.66), $p >.001$. The main effect of age was also significant, $F(1, 46) =$ 4.66, $p = .04$, $\eta^2 = .09$. Older adults rated the scenarios significantly higher than younger adults (M = 2.94, SD = 0.55 and M = 2.61, SD = 0.50 respectively). But there was no significant correlation between the ratings and the free recall scores, $ps > .12$. These results confirmed that although the ratings showed a similar pattern as the memory scores, there did not appear to be a relationship between them.

General discussion

The current study served as an initial effort to use a set of well-controlled scenarios to investigate potential age differences in two components of adaptive memory: a basic survival and an evolutionary survival effect. The results provided insights into understanding the mechanisms of survival effects in memory and furthered our knowledge in age-related changes in emotional and adaptive memory. The basic survival advantage was replicated in all three experiments, suggesting that it was a robust memory enhancement effect, as suggested by previous studies (Kang et al., 2009; Nairne et al., 2007; Nairne et al., 2008; Nairne et al., 2009; Otgaar et al., 2010).

Basic versus Evolutionary Survival Effects

In Experiment 1 and 2, we explicitly attempted to distinguish between basic and evolutionary survival effects. The results clearly revealed a significant basic survival effect between survival scenarios (i.e., “grasslands” and “mountain”) and non-survival scenario (i.e., “cruise”); however, the high evolutionary value of the “grasslands” did not further increase the memory enhancement of the survival advantage, as demonstrated by the equivalent memory recall scores for “grasslands” and “mountain”. Our findings contradicted those of Weinberg et al. (2008), who found both basic and evolutionary survival advantages. However, the evolutionary survival advantage in Weinberg et al. could be driven by the differences in valence, novelty and familiarity because our pilot study suggested that the low-evolutionary survival scenario “city” was not well matched with the high-evolutionary “grasslands” in these dimensions. Our pilot study suggested that “mountain” was a better match to “grasslands” based on these factors. Nevertheless, it was acknowledged that this study followed the same theoretical framework to distinguish evolutionary value based on how close the scenario was in timeline to modern life context. From an evolutionary perspective, people would be more likely to be afraid of things that commonly occurred in ancient natural environment where and when our ancestors lived. Thus the scenarios commonly seen and experienced by our ancestors in ancient time (such as “grasslands”) may expose higher survival threat (and thus carry higher evolutionary value) than those that typically occurred in modern life (e.g., “city”, or “mountain expedition”). For example, spider phobias are more common than car phobia even though the latter may kill more lives in reality (De Silva et al., 1977). This rationale, however, lacks sufficient empirical evidence and thus more work is still needed to clearly distinguish between basic and evolutionary survival effects.

Another possibility for the lack of evolutionary survival advantage in our studies may be due to the similarity between “grasslands” and “mountain”. We did not have any explicit measure to control for the evolutionary value of the two scenarios. It was assumed that “mountain” was closer to modern life than “grasslands” because it involved going on “an adventure expedition”. Furthermore, our human ancestors are typically thought to have originated on the African savannahs, which resembles closer to the “grasslands” description than that of “mountain” (Tooby & Cosmides, 2005). However, our ancestors may have also lived in similar mountain terrains (though not for adventure) and over time, and these environments became relevant for our survival. That being said, from an evolutionary psychology perspective, the environment of evolutionary adaptedness (EEA) is not a specific place or time, but instead refers to the combination of selection pressures that cause the evolution of an adaption (Tooby & Cosmides, 2005). Different adaptations can have different EEA. For example, terrestrial illumination formed the EEA of the eye for hundreds of millions of years, whereas hunter-gatherer living conditions formed the EEA for human males to care for their children in the past two million years (Tooby & Cosmides, 2005). Although the timeline distinction proposed by Weinstein et al. (2008) is appealing, it may not be the best method to distinguish between high and low-evolutionary survival. Hence, it would be necessary, though extremely difficult, to include a scenario that is distinct from "grasslands" in evolutionary perspective, yet matched with the "grasslands" in all other relevant dimensions (e.g., valance, arousal, novelty, familiarity), to draw a solid conclusion on the basic versus evolutionary survival effects.

Adaptive Memory and Older Adults

There were also no age differences found in adaptive memory. Older adults showed similar survival effects as younger adults even when a positive-valenced non-survival scenario, intended to trigger a positivity shift, was included as a control scenario. However, due to little research on adaptive memory with older adults, it was difficult to predict their performance. Even though there is some literature that found a reduced negativity bias and/or enhanced positivity bias in older adults (Charles et al., 2003; Knight et al., 2002; Mather & Carstensen, 2003), the evidence is divergent and involves a multitude of factors (Kensinger, 2008). Furthermore, the positivity bias in older adults is considered to be a controlled process and older adults with good executive control show the strongest positivity bias (Mather & Knight, 2005). Therefore, our findings suggest that the survival advantage may be based on automatic processes as opposed to controlled processes. Due to reduced cognitive resources in older adults, they typically perform worse than their younger counterparts on tasks that require controlled processes (Craik & McDowd, 1987; Hasher & Zacks, 1979). Furthermore, when compared to younger adults, older adults are less able to utilize controlled processes to counteract proactive interference on an implicit memory task (Ikier, Yang & Hasher, 2008). It has also been demonstrated that some robust memory effects occur only in controlled cognitive tasks as opposed to automatic tasks. For example, time-of-day effects (i.e., performance is better during one's optimal time of day or peak times than off-peak times) were found during controlled retrieval but not during automatic retrieval in older adults (Yang, Hasher & Wilson, 2007).

We had predicted a reduced survival effect in older adults because they were past their reproductive age, and were thus, less affected by natural selection pressures. However, it is possible that basic survival is important for older adults regardless of their level of selection pressures. It should be noted that the survival scenarios in the experiments focused on finding food and water to meet basic needs. They did not explore other goals related to enhancing one's survival (e.g., passing on one's genes or avoiding predators). Thus, the reduced selection pressures in older adults might not affect their survival advantage for scenarios related to finding food or avoiding predators.

Limitations and Future Research

One limitation of the experiments is that "cruise" may be associated with being in a city with other people, thus having an additional social aspect over the survival scenarios. However, a recent study by Nairne and colleagues (2009) used a hunter-gatherer versus scavenger hunt paradigm and found a basic survival advantage by using social groups in both scenarios. It does not appear that the survival advantage is affected by the availability of social support.

Future studies should address some of the limitations of this study. A better low-evolutionary survival scenario that explicitly controls for evolutionary value is needed to tease apart the basic and evolutionary survival advantages. One of the problems with "grasslands" is that it is low in familiarity. Although it was matched on novelty with the other scenarios, it is a very typical survival scenario that is unique and unlike other "stranded" scenarios. This unique quality can make “grasslands” stand out during the encoding phase, and convolute the interpretation of the survival advantage.

Another direction is to further examine the automatic versus controlled processes in adaptive memory. If survival processing is automatic, then it can be tested with implicit memory paradigms. Participants can be primed with the survival scenarios and be asked to detect blurred faces with different facial expressions. Detection of angry faces have generally been considered to be important for survival in social contexts (Stein, Goldin, Jitender, Eyler-Zorrilla & Brown, 2002), and participants who are in survival mode may be faster at detecting them. Furthermore, as mentioned earlier, a dual task paradigm can directly assess the attentional demands of survival processing by using divided attention tasks during the encoding phase.

Conclusion

In summary, the basic survival advantage was replicated in all three experiments, and thus proved to be a robust memory effect. The findings were also generally consistent with those in the adaptive memory literature, which showed that memory for information encoded in survival contexts is superior to information encoded in other contexts. Although our results did not show an evolutionary survival effect, more research is needed to fully understand the mechanisms of basic versus evolutionary survival advantages. This study was the first to examine age differences in adaptive memory. The results suggested that older adults displayed a basic survival advantage similar to that of younger adults. Age differences in emotional memory and reduced evolutionary pressures in older adults did not appear to alter or influence the basic survival effect. Furthermore, even when a positively valenced control scenario was used, older adults showed a similar basic survival advantage despite their tendency to shift their attention to more positive information. The present findings provided support for an automatic model of the survival advantage in adaptive memory, which does not require intentional effort or cognitive control resources. Future studies will need to further explore the mechanisms in adaptive memory by using other paradigms, such as dual-task manipulation, that could directly distinguish between automatic and controlled processing.

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Appendix

Scenario Rating Scale

This survey is to investigate how people respond to different scenario narratives. Please read each of the scenarios on the next page carefully and rate them on the four different scales provided below:

Emotional Valence Scale: (How does the scenario make you feel on the unhappy-happy dimension?)

1	2	3	4	5	6	7	8	9
Completely Unhappy, annoyed, unsatisfied, melancholic, despaired, or bored	Very unhappy	Moderately unhappy	Slightly unhappy	Neutral (neither happy nor sad)	Slightly happy	Moderately happy	Very happy	Completely happy, pleased, satisfied, contented, or hopeful

Emotional Arousal Scale: (How does the scenario make you feel on the calm-aroused dimension?)

1	2	3	4	5	6	7	8	9
Completely calm, relaxed, sluggish, dull, or sleepy	Very calm	Moderately calm	Slightly calm	Neutral (neither aroused nor calm)	Slightly aroused	Moderately aroused	Very aroused	Completely aroused, highly excited, stimulated, frenzied, jittery, or wide-awake

Novelty Scale: (How likely does the scenario occur on the common-novel dimension?)

1	2	3	4	5	6	7	8	9
Completely common ordinary, or mundane	Very common	Moderately common	Slightly common	Neutral (neither novel nor common)	Slightly novel	Moderately novel	Very novel	Completely novel, new, unusual, innovative, or unique

Context Familiarity Scale: (How familiar do you feel with the context of the scenario on the unfamiliar-familiar scale?)

1	2	3	4	5	6	7	8	9
Completely unfamiliar or unusual in modern time	Very unusual	Moderately unusual	Slightly unusual	Neutral (neither familiar nor unusual)	Slightly familiar	Moderately familiar	Very familiar	Completely familiar, or likely to occur in modern times

Please write one of the numbers from the corresponding scales on the blank following each scenario to indicate how the scenario makes you feel. Thank you!

no	Scenarios	Ratings
1	Imagine that you are enjoying an extended vacation at a fancy resort in a foreign land. Over the next few months, you will need to find different activities to pass the time and maximize your enjoyment of the vacation.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
2	Imagine that you are stranded on a mountain in a foreign land during an adventure expedition, without any basic survival materials. Over the next few months, you will need to find steady supplies of food and water to meet your basic needs.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
3	Imagine that you moved to a foreign land. You do not speak the dominant language and you do not know anyone there. Over the next few months, you will need to become accustomed to the culture and support yourself.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
4	Imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you will need to find steady supplies of food and water to meet your basic needs.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
5	Imagine that you were accidently left behind on a foreign land during a cruise. Your passport and possessions were left on the ship. Over the next few months, you will need to reapply for a new passport and find a way to support yourself.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
6	Imagine you are stranded in the desert of a foreign land during a trip, without any survival materials. Over the next few months, you will need to find steady supplies of food and water to meet your basic needs.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
7	Imagine you won a large amount of money in a lottery draw. You do not have any pressing financial needs. Over the next few months, you need to figure out how to spend the money and enjoy your life.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______
8	Imagine that you are stranded in the city of a foreign land, without any basic survival materials. Over the next few months, you will need to find steady supplies of food and water to meet your basic needs.	Emotional valence rating: ______ Emotional arousal rating: ______ Novelty rating: ______ Context familiarity rating: ______