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Original Article

Revisiting the Survival Mnemonic Effect in Children

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Abstract: The survival processing paradigm is designed to explore the adaptive nature of memory functioning. The mnemonic advantage of processing information in fitness-relevant contexts, as has been demonstrated using this paradigm, is now well established, particularly in young adults; this phenomenon is often referred to as the "survival processing effect." In the current experiment, we revisited the investigation of this effect in children and tested it in a new cultural group, using a procedure that differs from the existing studies with children. A group of 40 Portuguese children rated the relevance of unrelated words to a survival and a new moving scenario. This encoding task was followed by a surprise free-recall task. Akin to what is typically found, survival processing produced better memory performance than the control condition (moving). These data put on firmer ground the idea that a mnemonic tuning to fitness-relevant encodings is present early in development. The theoretical importance of this result to the adaptive memory literature is discussed, as well as potential practical implications of this kind of approach to the study of memory in children.

Keywords: survival processing, episodic memory, children, evolution, development

Introduction

The idea that our memory systems might have been shaped throughout our evolution has received special attention in recent years. Although this idea has been around for quite some time (e.g., Darwin, 1859; Tooby and Cosmides, 1992), the first empirical work was reported only in 2007 by Nairne, Thompson, and Pandeirada. This first study revealed that when people thought about the relevance of information for an imagined survival situation, one in which their survival was at risk (being stranded in a foreign land without any basic survival materials), their memory for the processed information was better than when the same information was processed under various control conditions (e.g., moving to a foreign land or pleasantness ratings). Many replications of the mnemonic advantage of processing information with respect to this survival situation have followed. It is now established that the "survival processing effect" occurs in both between- and within-subject designs, in both free recall and recognition (e.g., Kang, McDermott, and Cohen, 2008; Nairne et al., 2007), and leads to better memory performance than most of the encoding conditions widely recognized to produce good memory performance (Nairne, Pandeirada, and Thompson, 2008). In addition, the effect does not depend on the type of material used, as it occurs for random word sets (e.g., Nairne and Pandeirada, 2011) and pictures (Otgaar, Smeets, and van Bergen, 2010). Although the effect is quite robust under these conditions, recent studies have failed to find survival processing advantages in more implicit testing conditions, such as source memory (Bröder, Krüger, and Schütte, 2011) and implicit memory tests (Tse and Altarriba, 2010).

From an evolutionary perspective, if this fitness-relevance tuning is indeed a functional and evolutionarily relevant characteristic of our memory systems, one might expect it to occur across the various stages of human development. Indeed, before reaching the reproductive stage when they could pass along their genetic heritage, children have to face many challenges, making this stage of development a strong target of natural selection (e.g., King and Bjorklund, 2010). As Bjorklund and Pellegrini (2000) put it:

> …our ancestors also developed, and before organisms can reproduce to get their genes into the next generation, they must first reach adulthood. For a slow-developing species such as humans, that can be a long and treacherous path. How people develop is important to eventual reproductive success… (p. 1704)

In agreement with this idea, studies in various areas have demonstrated that children are able to acquire knowledge relevant to their survival at a very young age, such as the difference between potential agents and non-agents (Newman, Keil, Kuhlmeier, and Wynn, 2010). Children also seem to prioritize their attention to potential threatening stimuli in complex visual displays such as snakes and threatening faces (e.g., LoBue and DeLoache, 2008; LoBue and DeLoache, 2010). Children are also predisposed to remember the faces of potentially harmful individuals (Kinzler and Shutts, 2008). Even the overestimation children sometimes show for various skills, memory performance included, has been interpreted as having potential adaptive value (Shin, Bjorklund, and Beck, 2007). All of these aspects can be conceptualized as cognitive biases with adaptive value that allow children to thrive through this developmental phase. In the same line, it would be important to explore if children's memory is also sensitive to the fitness-relevant component conveyed in the survival processing paradigm. Better retention of information when it is processed for fundamental aspects of human survival–finding food, shelter, and protection from predators–would certainly increase the chances of children reaching a reproductive phase and passing along their genes to the future generations.

Most of the research on the survival processing effect has been conducted in young adults, although the effect has also been reported in elderly populations (Faria, Pinho, Gonçalves, and Pandeirada, 2009; Nouchi, 2011; Pandeirada, Pinho, and Faria, 2014). The hypothesis that the survival advantage is developmentally invariant, particularly if it can be observed in children, has been explored in a couple of previous papers. Otgaar and Smeets (2010, Experiment 2) tested the survival processing effect in children (8 and 11 years-old), and also measured whether survival processing leads to differential levels of false recall as compared to the control conditions. In their experiment, children were asked to rate thematically related lists of words adopted from the Deese-Roediger-McDermott paradigm (e.g., Roediger and McDermott, 1995) in one of three conditions: survival, moving, or pleasantness. Higher correct recall was obtained for the survival rated words as compared to the two control conditions. However, the false alarm rate for the critical lures was also higher for survival than for the controls; this pattern of results occurred for the overall intrusion rate as well (but only for the older children). When net accuracy was used as the dependent measure, no survival advantage was obtained. It is worth noting, however, that the use of theme-related lists of items could have affected the extent to which survival processing affected memory performance. Some studies have obtained the survival processing effect in young adults when lists of semantically related items are used (Nairne and Pandeirada, 2008a), but others have not (Burns, Burns, and Hwang, 2011).

More recently, Aslan and Bäuml (2012) reported two within-subject experiments in which children from three different age groups (4-6years, 7-8 years, and 9-10 years) rated the usefulness of random words to the typical survival scenario and to a variety of control conditions. In the first experiment, survival was compared to a pleasantness-rating condition and a word-length rating task. The results on a final surprise yes-no recognition test were consistent across the three age groups and revealed better memory performance for the pleasantness condition as compared to the word-length rating task, replicating the traditional levels-of-processing effect (Craik and Lockhart, 1972). Importantly, survival processing produced the best memory performance. In their second experiment, the survival scenario was compared to two other forms of schematic processing: an “overnight” and a “forgotten” scenario. In the first, participants were asked to rate the relevance of words to packing a bag to go spend the night at a friend’s house. In the second, participants rated the relevance of words to a situation where they had been forgotten by their parents at school/kindergarten; they were also asked to imagine being hungry, thirsty, and a bit scared. Once again, a strong survival advantage was obtained in a recognition task across all age groups.

It is important to note, however, that none of these studies have used a free-recall test of unrelated words, as is frequently the case in the survival processing experiments. Given that children’s memory performance is often sensitive to both the type of material and the nature of the memory test (e.g., Lindberg, 1980; Pressley, 1982), testing the survival processing effect under these conditions would be an important addition to the establishment of this phenomenon in children. Previous studies with adults using semantically related lists of items have revealed somewhat conflicting findings. Using a semantically related list of items, Nairne and Pandeirada (2008a) obtained a correct recall advantage after survival processing, but also an increase in false recall, even though the number of intrusions overall was very low (Nairne and Pandeirada, 2008a, Experiment 1);

a similar pattern was found in Experiments 1 and 3 of Otgaar and Smeets (2010). However, in Burns et al. (2011, Experiment 2), correct recall of categorized lists of items was similar after survival processing and a pleasantness rating task (no intrusion data were presented in this work). These mixed results when categorized/theme-related lists of items are used is presumably due to the semantically related nature of the material, which can affect the extent to which the information is processed for the respective encoding condition. For example, participants might become aware of the semantic structure or common theme of the material during encoding, which could distract them from the specific encoding task. Also, by realizing the semantic structure or common theme of the material, later on, participants can rely on it as a recall strategy (e.g., "I remember there were fruits, animals…"), thus limiting the influence of the encoding task on final performance.

The current study was designed to explore the survival processing effect in children using unrelated word lists and free recall as the main memory measure. Our study also included a control condition that differs to some extent from the controls used in the previous studies in children. We used a moving scenario (see Nairne et al., 2007), as did Otgaar and Smeets (2010), but the tasks involved in the two scenarios were different: In our case, children were asked to rate the relevance of the words to "organizing and storing all your toys such that none will get broken nor lost during the moving process to the new home" and, in their scenario, children were asked to rate the relevance of words to making new friends and learning a new language in the context of moving to a foreign land with their parents. We believe the tasks involved in our scenario are more familiar and self-relevant to our participants, thus providing another demonstration of the effect in a somewhat different context. The current study was also conducted in Portugal, a different culture from the ones used in previous studies (which included children from Germany and the Netherlands). Demonstrating that the effect occurs across a wide variety of cultures, and thus, is potentially universal, strengthens the idea that this memory tuning might indeed result from our evolutionary history (Tooby and Cosmides, 2005).

In sum, establishing a mnemonic bias towards fitness-relevant encodings in children helps to bolster the proposal that memory continues to bear the "imprint" of ancestral selection pressures. It is highly unlikely that children as young as 4 years old have experienced the fitness-relevant challenges depicted in the survival scenario. However, even if one rejects the evolutionary account, it is still interesting to consider the effects of fitness-based processing in the context of the development of memory (Howe and Otgaar, 2013). Finally, the merits of systematic replication are nowadays widely recognized as essential to strengthen the reliability of a phenomenon (e.g., Roediger, 2012).

In the present study, 40 Portuguese children aged between 10 and 12 years rated a set of unrelated nouns to a survival and a moving scenario. At the end of the task, a surprise free-recall task was administered. We expected memory performance to be better when words were rated for survival than when they were rated for moving.

Methods

Participants and apparatus

Forty Portuguese children aged 10 to 12 years (20 females) attending a school in

Estarreja (town in the district of Aveiro, Portugal) participated in this experiment. Consent to conduct the study at the school was obtained from the school's Principal. Informed consent was also obtained from the parents of each child and, at the beginning of the experimental session, informed consent was also obtained from the child. Sessions were conducted individually in a quiet room and lasted approximately 40 minutes. Stimuli were presented and controlled using E-prime 2.0 software (Schneider, Eschman, and Zuccolotto, 2002) and a 17" monitor laptop.

Materials and design

Thirty-two unrelated concrete and familiar nouns were used (plus six practice items; see the Appendix for the full list of items in European Portuguese and corresponding translation to English). Words were randomly divided into four sets of eight words each. Each participant rated two sets of words for the Survival (S) scenario and the other two for the Moving (M) scenario in an alternated form (within-subject design). Thus, half the participants performed the encoding task in the order SMSM and the other half in the order MSMS. The same randomly determined order of presentation of the words was kept constant across versions. An unrelated visual search task was performed for about 3 minutes between each encoding block (these results will not be presented here as they are not relevant to the memory task). This task also served as a distractor task after the last encoding block and before the surprise free recall task.

Procedure

The experiment was conducted in a quiet room at the participant's school, isolated from potentially distracting elements (e.g., noise). Upon arrival in the room, participants were randomly assigned to one of the counterbalancing versions of the experiment. The initial instruction informed participants they would be rating the relevance of words to two different scenarios using the same 1 to 5 rating scale. The first scenario was then presented; the survival scenario was very similar to the one used by Nairne et al. (2007), but the moving scenario was slightly adjusted to describe a more appropriate and self-relevant set of tasks considering the age of our participants. The specific scenarios were as follows (European Portuguese versions were used):

Survival instructions: Imagine you are lost in a forest of an unknown place without any basic survival materials. Over the next few months you will need to find ways to survive, such as finding food, water, protection from dangerous animals, and finding a shelter. Next, I'm going to show you a list of words. Please rate how relevant each of these words would be for the survival situation just described. Some words might be important and others not, it's up to you to decide.

Moving instructions: Imagine your parents are planning to move to a new home and you do not want to leave any of your toys behind. During the next few months you will have to find a way of organizing and storing all your toys such that none will get broken nor lost during the moving process to the new home. Next, I'm going to show you a list of words. Please rate how relevant each of these words would be for the moving situation just described. Some words might be important and others not, it's up to you to decide.

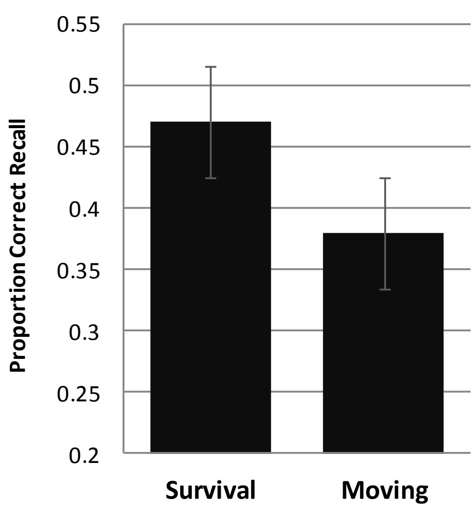
At the beginning of the first and second blocks of the encoding task, participants received the scenario instructions followed by three practice trials. After practice, participants were reminded of the scenario and then continued to the set of eight scored trials. Words were presented individually on the screen for 5 seconds each (ITI among words of 250 ms). Participants were cautioned to respond within this time window. Below the word, the 5-point rating scale was presented along with labels for the extreme and middle values: a value of 1 corresponded to a rating of "not relevant," a value of 3 to "more or less relevant," and a value of 5 to "extremely relevant." The rating scale was the same in both encoding conditions. Participants provided their responses by clicking on the number of their choice on the keyboard. After each encoding block, participants performed an unrelated visual search task, lasting approximately 3 minutes; this task served as a distractor task. After the fourth encoding block and the distractor task, the surprise free-recall instructions appeared, instructing participants to recall as many items as they could in any order they wished during a 5-minute period. Responses were written in a sheet of paper by the participant. A minute countdown was shown on the computer screen during the recall task.

Results

The level of statistical significance was set at $p < .05$. Participants rated over 98% of the words in both conditions [$F(1, 39) < 1$], indicating that participants had no difficulty rating the words within the available time. Given the small amount of non-rated items and to avoid item-selection concerns, we present the data unconditionalized.

The proportion of correct recall for each condition presented in Figure 1 reveals that participants recalled more survival-encoded words than moving-encoded words. A repeated measures ANOVA confirmed this reliable difference, $F(1, 39) = 7.23$, $MSE = .020$, $\eta_p^2 = .16$. Given the within-subject nature of the design, no separate intrusion data can be presented by condition. Overall, the number of intrusions was very low averaging less than 1 intrusion per participant.

Figure 1. Proportion correct recall for each condition



Note: Error bars represent 95% confidence intervals

It is also important to consider the relevance ratings provided during encoding, given the debate on the role congruity might play in the survival mnemonic advantage (e.g., Nairne and Pandeirada, 2011). Participants rated the words as significantly more relevant to the survival scenario than to the moving scenario, $F(1,39) = 8.87$, $MSE = .12$, $\eta_p^2 = .19$. The specific rating values obtained in each condition are presented in Table 1. In order to rule out this variable as a potential mediator of the survival advantage, additional analyses were performed. First, the difference in rating between the two conditions was calculated for each participant; two groups were then created based on this difference: a group of participants with a rating difference smaller or equal to |.5| (similar ratings group; $n = 26$), and a group with survival ratings higher than .5 as compared to the moving ratings (higher survival ratings group; $n = 13$); only one participant rated the words as more relevant to the moving scenario than to the survival scenario. The descriptive data for the ratings and recall by group are presented in Table 2. A mixed ANOVA with condition as a within-subject variable and group (similar ratings group and higher survival ratings group) as a between-subjects variable revealed a significant main effect of condition, $F(1, 37) = 6.65$, $MSE = .02$, $\eta_p^2 = .15$, but neither the main effect of group, nor the interaction, were significant, $F(1, 37) = 1.51$, $MSE = .02$, $\eta_p^2 = .039$, and $F(1, 37) = .044$, $MSE = .02$, $\eta_p^2 = .001$, respectively. Importantly, even if only the group with similar ratings is considered, despite the smaller sample size, the survival mnemonic advantage remains significant, $F(1, 25) = 4.60$, $MSE = .02$, $\eta_p^2 = .16$. Additionally, considering all participants, the correlation between rating and recall for each condition was non-significant for both scenarios, and was actually negative for survival (survival: $r = -.10$, $p = 0.50$; moving: $r = .19$, $p = .24$). These results make it unlikely that the survival mnemonic advantage can be explained by differences in the relevance ratings.

Table 1. Average rating and response times, in milliseconds (and standard deviations), for each condition

	Survival	Moving
Rating	2.7 (.63)	2.5 (.59)
Response Time	2318.7 (360.5)	2249.7 (424.1)

Table 2. Average ratings and proportion correct recall (and standard deviations) for the similar ratings group and higher survival ratings group, for each condition

		Survival	Moving
Rating	Similar ratings group	2.53 (0.60)	2.53 (0.60)
	Higher survival ratings	3.06 (0.55)	2.28 (0.53)
Recall	Similar ratings group	45% (0.12)	37% (0.14)
	Higher survival ratings	42% (0.14)	32% (0.18)

Finally, we considered the time participants took to rate the words during the initial encoding task, as it might indicate differences in difficulty to make a decision. The response time data for each condition (see Table 1) indicate that participants took slightly more time to provide their ratings for the survival scenario than for the moving scenario. However, the difference was not statistically significant, $F(1, 39) = 3.01$, $MSE = 31629.0$, $p = .09$, $\eta_p^2 = .07$.

Discussion

The present experiment reveals that children's memory performance is sensitive to the processing of information in the fitness-relevant context of survival. Aslan and Bäuml (2012) previously reported this same conclusion. However, Otgaar and Smeets (2010) questioned this conclusion based on the fact that survival processing not only increased correct recall but also false recall when theme-related lists of items were used. In the current study, we revisited this question while also extending the survival phenomenon in children using a new procedure (a free-recall test of unrelated material) and a new control scenario (a moving scenario that implicated different activities than the one used by Otgaar and Smeets, 2010). The test of the survival processing effect in children under new procedural conditions is important, as children's memory is often sensitive to procedural changes, as noted in the introduction. This study also expands the demonstration of a mnemonic advantage to a fitness-relevant context in children of a different culture, providing some support for an evolutionarily-based account of this phenomenon. Additionally, the critical importance of replication is well recognized in psychology, and researchers have been strongly encouraged to replicate previously published findings (e.g., Roediger, 2012). As Pappas and Friedman (2012) put it: "Without replicability, cumulative knowledge, which is the essence of science, is not possible" (p. 364). Given the novelty of this finding in children and the existence of only three experiments published, we believe the present systematic replication adds reliability to this phenomenon.

From an evolutionary perspective, one can anticipate that humans faced strong selection pressures from a very young age (e.g., Bjorklund and Sellers, 2011). Thus, one would expect our cognitive systems, and in particular memory, to be sensitive to elements that might somehow affect the chances of survival from an early age. The present study adds to the growing body of evidence for survival-based mnemonic tunings in children when different memory tests and materials are used, as well as in comparison to a variety of control conditions. Furthermore, the demonstration of the effect in a new cultural context also supports the idea of an evolutionarily-driven memory bias (Tooby and Cosmides, 2005). Still, some would argue that this phenomenon is relevant more from a developmental perspective than an evolutionary one; specifically, experiments of this type provide information about the mnemonic strategies that arise during development. Howe and Otgaar (2013) have suggested that the survival processing effect is driven by general mechanisms, ones that are developmentally invariant, and demonstrations of the effect in children simply reflect the usage of those mechanisms. One example is the involvement of both item-specific and relational strategies. Although these authors argue that these strategies arise very early in development, others have shown that they are typically acquired around the age of 5-6 years (e.g., Murphy, McKone, and Slee, 2003). Another example is the use of elaboration—some researchers would question whether elaborative strategies are naturally present in children as young as 4 (e.g., Bjorklund, Dukes, and Brown, 2009; Pressley, 1982). Thus, in our view, the demonstration of survival processing advantages in children as young as 4 (Aslan and Bäuml, 2012) lowers the chances that such proximate mechanisms can explain the effect, at least in children.

Furthermore, such mechanisms (e.g., elaborative processing) also fail to provide a general explanation of the survival processing advantages in young adults. Studies that have failed to obtain the survival processing effect using implicit memory tests provide evidence that the effect is not solely mediated by elaboration or distinctiveness, as these processes usually confer mnemonic advantages in implicit as well as in explicit memory (McBride, Thomas, and Zimmerman, 2013; Tse and Altarriba, 2010). Emotionality could also be considered a potential proximate mechanism of the survival processing effect (see Sellers and Bjorklund, in press, for a discussion of this possibility). However, emotionality effects are also usually observed in implicit memory (Kensinger and Schacter, 2008), and that seems not to be the case with the survival processing effect, at least with young adults.

As Howe and Otgaar (2013) acknowledge, survival processing seems to "recruit(s) a powerful set of memory processes"; the ultimate question is: Why does this happen? Why does processing information in this fitness-relevant scenario naturally recruit such powerful mnemonic processes? As Nairne and Pandeirada (2010) note, the survival processing paradigm was developed to test an *a priori* prediction of an evolutionary account, not to determine the proximate mechanisms that underlie the effect. This same question guided the current study: Could a mnemonic tuning be systematically identified early in development? From an evolutionary perspective, one that acknowledges the relevance of survival to children, we predicted that survival processing advantages would extend to younger populations of participants, regardless of the proximate mechanisms that may underlie the effect.

The functional / evolutionary approach that led to the development of the survival processing paradigm has been extended beyond the survival scenario, focusing instead on the fitness-relevance of the situation or context engendered by the encoding condition (e.g., Nairne, Pandeirada, Gregory, and Van Arsdall, 2009). It has also been applied to the investigation of other forms of memory. For example, it has been shown that the spatial location of items (pictures) is best retained when it is processed in a fitness-relevant context (e.g., having to collect food items or capture animals in order to survive), as compared to a non-fitness relevant context (e.g., the same tasks were involved but now in the context of a game) (Nairne, VanArsdall, Pandeirada, and Blunt, 2012).

Other fitness-relevant aspects, such as animacy, have also been shown to affect our cognitive processes. One example is the visual attention priority to animate motion (Pratt, Radulescu, Guo, and Abrams, 2010). Another one, using young adults, is an increased retention of items processed as animates, or of animate items, as compared to inanimate items. In the first case, memory for nonwords encoded as animates was better than when these were encoded as inanimates (VanArsdall, Nairne, Pandeirada, and Blunt, 2012). In the second case, a set of animate items was recalled better than a set of carefully matched inanimate items (Nairne, VanArsdall, Pandeirada, Cogdill, and LeBreton, 2013). This mnemonic tuning is consistent with the predisposition children have to acquire knowledge related to this dimension and also to the living / non-living aspect of objects (e.g., Gelman, 1990; Newman et al., 2010; Pratt et al., 2010). Therefore, a strong case for the adaptive nature of memory has been developing over the last few years, suggesting that the way our cognitive systems work (and particularly memory) is sensitive to conditions that affect the individuals' chances of survival and/ or reproduction. Employing the functional and evolutionary reasoning to investigate these cognitive processes can indeed be a fruitful avenue, as it can promote the discovery of new phenomena (e.g., Nairne and Pandeirada, 2008b, 2010).

Recognizing the potential effects of evolution in children has motivated the development of new theoretical areas that specifically explore the connections between evolutionary theory and human development—evolutionary developmental psychology is such an example (e.g., Bjorklund and Sellers, in press; King and Bjorklund, 2010). Furthermore, researchers aim to make the best usage of evolutionary theory in specific contexts to provide the most successful developmental and learning experiences to children. For example, evolutionary educational psychology seeks to use children's biases acquired throughout the evolutionary process in learning and motivation to develop cultural and educational environments that will maximize academic performance (e.g., Geary, 2008, 2010). In the same vein, exploring the conditions in which memory performance can be optimized is also of potential practical importance, namely in educational settings. Given the results so far, we believe the functional and evolutionary approach to human memory is leading to the discovery of new effective memory strategies.

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Appendix

Words used in the experiment in European Portuguese, and corresponding translation to English (presented in alphabetical order)

European Portuguese	English
águia	eagle
apartamento	apartment
atum	tuna
bola	ball
cadeira	chair
caixa	box
camião	truck
carro	car
chocolate	chocolate
couves	cabbage
espada	sword
flauta	flute
futebol	football
gasóleo	diesel
igreja	church
lápis	pencil
laranja	orange
lençol	sheet
livro	book
mão	hand
martelo	hammer
meia	sock
montanha	mountain
neve	snow
porta	door
puzzle	puzzle
rio	river
saco	bag
sapatos	shoes
sumo	juice
tia	aunt
urso	bear