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Brief article

Adaptive memory: Young children show enhanced retention of fitness-related information

Alp Aslan *, Karl-Heinz T. Bäuml

Department of Experimental Psychology, Regensburg University, 93040 Regensburg, Germany

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ABSTRACT

Evolutionary psychologists propose that human cognition evolved through natural selection to solve adaptive problems related to survival and reproduction, with its ultimate function being the enhancement of reproductive fitness. Following this proposal and the evolutionary-developmental view that ancestral selection pressures operated not only on reproductive adults, but also on pre-reproductive children, the present study examined whether young children show superior memory for information that is processed in terms of its survival value. In two experiments, we found such survival processing to enhance retention in 4- to 10-year-old children, relative to various control conditions that also required deep, meaningful processing but were not related to survival. These results suggest that, already in very young children, survival processing is a special and extraordinarily effective form of memory encoding. The results support the functional-evolutionary proposal that young children's memory is "tuned" to process and retain fitness-related information.

1. Introduction

Memory research has traditionally focused more on the *whats* and *hows* of human memory (i.e., its structure and proximate mechanisms) than on the question of *why* memory operates exactly the way it does (i.e., its ultimate function). A notable exception is a recent research program conducted by Nairne and colleagues (for an overview, see Nairne, 2010). Approaching memory from a functional-evolutionary perspective, these authors argued that human memory evolved to solve adaptive problems related to survival and reproduction, with its ultimate function being the enhancement of reproductive fitness. In particular, Nairne and colleagues hypothesized that, as a result of ancestral selection pressures, human memory should be specifically "tuned" to process and retain fitness-related information, i.e., information that helped our forefathers deal with recurrent ancestral requirements such as capturing prey, evading predators, avoiding toxic plants and animals, or finding the location of food and water.

Nairne, Thompson, and Pandeirada (2007) tested this hypothesis using the *survival-processing task*. In this incidental-learning task, participants are asked to imagine themselves being stranded in the grasslands of a foreign land where they would have to secure food and water and protect themselves from predators. Processing words in terms of their survival value in this imagined scenario enhanced participants' retention relative to other deep encoding procedures, such as rating (the same) words for pleasantness or relevance to moving to a foreign land, which is consistent with the functional-evolutionary view on memory. Extending the finding, Nairne, Pandeirada, and Thompson (2008) compared survival processing with the "who is who" of powerful encoding procedures, including pleasantness rating, self-referential processing, and intentional learning. Again, survival processing produced the highest levels of retention (see also Kang, McDermott, & Cohen, 2008; Weinstein, Bugg, & Roediger, 2008).

Like evolutionary psychology in general, research on survival processing has focused on adult participants.

* Corresponding author.
E-mail address: alp.aslan@psychologie.uni-regensburg.de (A. Aslan).

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However, if humans have an evolved bias to remember fitness-related information particularly well, this bias might be present already early in life. Indeed, evolutionary developmental psychologists emphasize that ancestral selection pressures operated not only on reproductive adults, but also on pre-reproductive children (e.g., Bjorklund & Pellegrini, 2000; Volk & Atkinson, 2008). The proposal is that our ancestors had to survive their pre-reproductive ontogenetic stages before becoming sexually mature adults, and thus, any inborn or early-developing feature of the cognitive system that promoted survival early in life should have conferred a (delayed) reproductive advantage and been favored by natural selection. Specifically, (ancestral) children showing a bias towards preferential remembering of fitness-related information should have been more likely to survive into adulthood, reproduce, and pass along their genetic record, than children not showing such bias.

Adopting a functional-evolutionary perspective, the present study explored the developmental origins of adaptive memory, examining whether young children show enhanced retention of fitness-related information. In two experiments, kindergartners, and younger and older elementary school children rated the relevance of random words to a fictive survival scenario and, later, received a surprise recognition test on the rated items. Recognition performance in the survival condition was compared to performance in various control conditions. If children's memory is "tuned" to process and retain fitness-related information, in both experiments, survival processing should produce the highest levels of retention. Finding a survival-processing advantage in young children who should have only limited knowledge about or experience with survival-related situations would provide particularly strong evidence for a deeply rooted, evolved adaptation in human memory.

The inclusion of pre-school children into our study also permits to examine whether the memorial advantage of survival processing may be due to more basic memory processes, like enhanced elaborative processing (Kroneisen & Erdfelder, in press), rather than being due to the fitness-relevance of the employed scenario. Pre-school children are often considered "nonstrategic rememberers", typically showing reduced elaboration in memory tasks, compared to older (school-aged) children (Ornstein, Haden, & San Souci, 2008). Thus, if the survival-processing advantage reflects enhanced elaboration, the advantage might be present in older (school-aged) children, but be reduced or eliminated in younger (pre-school) children. In contrast, if it is the fitness-relevance of the survival scenario that matters, one might expect the survival-processing advantage to be present even in young, "nonstrategic" kindergartners. To date, there is only one study that applied the survival-processing task to a children sample. Otgaar and Smeets (2010) found improved memory in the survival condition compared to a pleasantness and a moving control condition in 8- and 11-year-old school children.[1] Including "nonstrategic" kindergartners, the present study goes beyond this prior work, thus providing a particularly strong test of the view that the memorial advantage in the survival-processing task is due to the fitness-relevance of the employed task.

2. Experiment 1

Experiment 1 examined the memorial effects of survival processing in 4- to 10-year-old children, using *pleasantness-rating* and *word-length rating* as control tasks. Pleasantness rating represents a standard deep (semantic) encoding procedure known to produce exceptionally high levels of retention (e.g., Packman & Battig, 1978). Word-length rating represents phonemic processing, typically leading to more shallow encoding and thus to comparatively poorer retention (e.g., Gardiner, Brandt, Vargha-Khadem, Baddeley, & Mishkin, 2006). The word-length condition was included as a baseline for the pleasantness condition to rule out that any observed advantage of survival processing over pleasantness rating was due to the latter's failure to improve memory in young children (e.g., Ghatala & Levin, 1982).

2.1. Method

2.1.1. Participants

Twenty-four kindergartners (4–6 years; $M = 5.4$), 24 younger (7–8 years; $M = 7.5$), and 24 older (9–10 years; $M = 9.4$) elementary school children participated in the experiment.

2.1.2. Materials

The item pool consisted of 120 concrete nouns drawn from a German norm for children (Hager & Hasselhorn, 1994). Half of the items served as to-be-rated target words, the other half served as distractor words in the recognition test. The 60 target words were randomly divided into three lists of 20 items.

2.1.3. Design and procedure

The experiment consisted of an initial rating phase, a distractor phase, and an unexpected test phase. In the rating phase, the 60 target words were presented auditorily at a 5-s rate by the experimenter. The 20 items of a list were presented in succession, each list preceded by one of the following three instructions (corresponding to three different encoding conditions):

2.1.3.1. Survival condition. I would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. You are hungry and thirsty, and you have to protect yourself from wild animals. I am going to read you a series of things now, and I would like you to tell me whether these things would be useful for you in this survival situation.

2.1.3.2. Pleasantness condition. I am going to read you a series of things now, and I would like you to tell me whether you find these things pleasant.

[1] Otgaar and Smeets (2010) did not examine whether the size of the survival-processing advantage differed across age groups.

2.1.3.3. Word-length condition. I am going to read you a series of things now, and I would like you to tell me whether the words describing these things sound long.

For each item, children were asked to give a quick "yes" or "no" response, according to the corresponding list instruction. The order of the three conditions (survival, pleasantness, word length) was counterbalanced across participants, as was the assignment of lists to conditions.

Following the last to-be-rated word, participants engaged in an irrelevant painting task for 3 min, after which a surprise old/new recognition test was administered. Children were auditorily presented 60 previously rated target words, randomly intermixed with 60 previously non-rated distractor words, and were asked to decide whether each presented item was "old" or "new". Children were given as much time as they needed to make their verbal responses.

2.2. Results and discussion

False alarm rates were generally low, and did not differ reliably across age groups (kindergartners: 8.1%; younger school children: 7.9%; older school children: 5.1%), $F(2,69) = 2.3$, $p > .10$.

Regarding correct recognition (see Fig. 1), a 3 × 3 repeated-measures ANOVA with the between-subjects factor of *age group* and the within-subjects factor of *condition* revealed significant main effects of *age group*, $F(2,69) = 11.3$, $p < .001$, $\eta_p^2 = .25$, and *condition*, $F(2,138) = 76.5$, $p < .001$, $\eta_p^2 = 53$, but no interaction between the two factors, $F(4,138) = 1.6$, $p > .10$. Subsequent Fisher's LSD tests revealed more accurate recognition in older than in younger school children (85.1% vs. 80.0%), $p < .05$, who, in turn, showed more accurate recognition than kindergartners (80.0% vs. 74.2%), $p < .05$. More importantly, although pleasantness rating led to considerably better recognition than word-length rating (81.9% vs. 69.4%), $p < .001$, it was still outperformed by survival processing which produced the highest levels of retention (88.1% vs. 81.9%), $p < .001$. The advantage of survival processing over pleasantness rating was present in all three age groups, all *ps* < .05.

Rating the relevance of random words to a fictive survival scenario enhanced memory for these words relative to pleasantness rating, an encoding procedure widely considered one of the most effective mnemonic techniques (Packman & Battig, 1978). The size of this survival-processing advantage did not vary between kindergartners and school children, indicating that the advantage is fully developed very early in ontogeny. Notably, the above results held while all three children groups showed a typical levels-of-processing effect (i.e., higher retention after semantic than phonemic encoding), confirming that pleasantness rating represented a "deep" encoding procedure even for the youngest children. The results are consistent with the proposal that children's memory is "tuned" to remember fitness-related information.

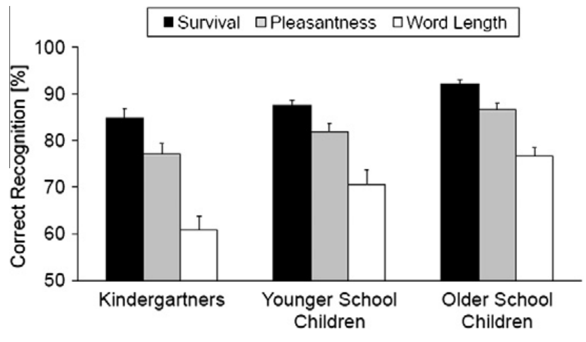

Fig. 1. Proportion of correct recognition as a function of age group (kindergartners, younger elementary school children, older elementary school children) and encoding condition (survival, pleasantness, word length) in Experiment 1. Error bars represent standard errors.

3. Experiment 2

Instructing participants to rate the relevance of words to an imagined survival scenario likely induces schematic and self-referential processing, and these forms of processing are known to improve memory (Bransford & Johnson, 1972; Challis, Velichkovsky, & Craik, 1996). To rule out that children's survival-processing advantage in Experiment 1 was simply the result of such schematic and/or self-referential processing, Experiment 2 pitted the survival condition against two control conditions which, tapping child-friendly scenarios (*staying overnight at a friend's home*; *being forgotten at school/kindergarten*), involved both schematic and self-referential processing. If the survival-processing advantage reflected enhanced schematic and/or self-referential processing, the advantage should disappear when thematically rich and self-relevant control scenarios are employed. In fact, because children should be more familiar with the two control scenarios than the survival scenario, one might even expect better recognition in the former than the latter (Ornstein et al., 2008). Alternatively, if it is the fitness-relevance of the survival scenario that matters, and the survival-processing advantage reflects a deeply rooted, evolved adaptation (e.g., Nairne, 2010), retention should be highest in the survival condition.

3.1. Method

3.1.1. Participants

Twenty-four kindergartners (4–6 years; $M = 5.5$), 24 younger (7–8 years; $M = 7.9$), and 24 older (9–10 years; $M = 9.5$) elementary school children participated in the experiment.

3.1.2. Materials, design, and procedure

Except for the use of slightly more items (3 × 25 = 75 to-be-rated target words; 75 distractor words) and two new control conditions, materials, design, and procedure were identical to Experiment 1. The instructions for the control conditions were as follows:

3.1.2.1. Overnight condition. I would like you to imagine that you are packing your bag for an overnight stay at your best friend's home. I am going to read you a series of things now, and I would like you to tell me whether these things may be useful for your overnight stay.

3.1.2.2. Forgotten condition. I would like you to imagine that your parents have forgotten to pick you up from school/kindergarten, and you are all alone in front of the entrance. You are hungry and thirsty, and you are also a bit scared. I am going to read you a series of things now, and I would like you to tell me whether these things may be useful for you in this unpleasant situation.

3.2. Results and discussion

Again, false alarm rates were low, and did not differ reliably across age groups (kindergartners: 5.2%; younger school children: 3.9%; older school children: 4.0%), $F(2,69) < 1$.

Regarding correct recognition (see Fig. 2), a 3 × 3 repeated-measures ANOVA with the between-subjects factor of *age group* and the within-subjects factor of *condition* revealed significant main effects of *age group*, $F(2,69) = 12.8$, $p < .001$, $\eta_p^2 = .27$, and *condition*, $F(2,138) = 17.2$, $p < .001$, $\eta_p^2 = 20$, but no interaction between the two factors, $F(4,138) < 1$. Subsequent Fisher's LSD tests revealed poorer recognition in kindergartners than both in older (64.4% vs. 85.7%), $p < .001$, and younger school children (64.4% vs. 79.8%), $p = .001$. More importantly, recognition performance in the survival condition was reliably higher than both in the overnight condition (81.1% vs. 75.3%) and the forgotten condition (81.1% vs. 73.4%), $ps < .001$. The survival-processing advantage was present in all three age groups, relative to both control conditions, all $ps < .05$.

Experiment 2 replicates and extends the survival-processing advantage of Experiment 1 using control conditions that matched the survival condition in terms of schematic and self-referential processing. Again, the size of the survival-processing advantage did not vary with age, suggesting that the advantage is fully developed very early in ontogeny. The results support the proposal that children's memory is "tuned" to remember fitness-related information.

3.3. Further analyses

To examine whether children's initial ratings influenced their later memory performance, we conditionalized recognition data on the rating responses given to the items ("yes" vs. "no"). Consistent with previous levels-of-processing work (Schulman, 1974), in both experiments, recognition was significantly higher for items given "yes"-responses than items given "no"-responses, both $ps < .001$. Importantly, in both experiments, rating did not interact with any other variable, indicating that the recognition advantage for "yes"-rated items was comparable across age groups and encoding conditions, all $ps > .05$. The survival-processing advantage observed in both experiments thus was not affected by children's rating behavior (see Nairne et al., 2007, for similar results).

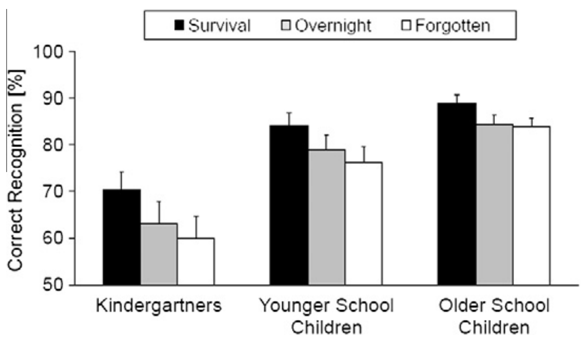

Fig. 2. Proportion of correct recognition as a function of age group (kindergartners, younger elementary school children, older elementary school children) and encoding condition (survival, overnight, forgotten) in Experiment 2. Error bars represent standard errors.

3.4. General discussion

The present study is the first to demonstrate a memorial advantage of survival processing in children younger than school age. In two experiments, we found that encoding words in terms of their survival value led to exceptionally high levels of retention, improving recognition performance in 4- to 10-year-old children relative to various control conditions that also required meaningful processing, but were not related to survival. These control conditions included a prototypical deep encoding procedure (Experiment 1), as well as encoding procedures designed to be particularly child-friendly and match the survival condition in terms of schematic and self-referential processing (Experiment 2). These results suggest that, already in very young children, survival processing is a special and extraordinarily effective form of memory encoding.

The present results are consistent with a functional-evolutionary view on human memory. Evolutionary psychologists assume that human memory evolved to solve adaptive problems related to survival and reproduction, with its ultimate function being the enhancement of reproductive fitness (Nairne et al., 2007). In particular, it is proposed that human memory has been shaped by ancestral selection pressures that confronted our hunter–gatherer forefathers in the so-called *environment of evolutionary adaptedness* (from about 1.8 million to 10,000 years ago; Nairne, 2010). Following this proposal, modern human's memory should bear the imprints of these ancestral selection pressures and be specifically "tuned" to remember fitness-related information. The results of many previous studies with adults and the present experiments with young children agree with this view.

Although this work was motivated from a functional-evolutionary perspective, it imposes important restrictions on possible proximate mechanisms of the survival-processing advantage. In particular, in line with previous work, our results indicate that the memorial advantage of survival processing cannot be (entirely) attributed to basic memory processes, like enhanced schematic or self-referential processing (e.g., Weinstein et al., 2008). In addition, the present finding of a survival-processing advantage in supposedly "nonstrategic rememberers" such as kindergartners (Ornstein et al., 2008) challenges recent explanations of the effect in terms of "strategic mechanisms", like enhanced elaborative processing (Kroneisen & Erdfelder, in press).

As indicated above, evolutionary psychology has traditionally focused on identifying psychological adaptations in young adults. This focus likely reflects the (mis)belief that selection pressures are exerted primarily on those members of a species that reproduce (the *sine qua non* of evolutionary success; Bjorklund & Pellegrini, 2000) and, to a lesser extent, if any, on those that do not (yet). It is only recently that evolutionary-oriented psychologists have begun to address adaptations in children's cognition, acknowledging that, not only adulthood, but also infancy and childhood should have been intense periods of selection. In fact, Volk and Atkinson (2008) highlighted the role of child death as a major driving force of human evolution, suggesting that the high rates of child mortality throughout human history should have exerted an enormous evolutionary pressure to select for psychological adaptations that promoted survival especially in the early years of life. The present finding of a survival-processing advantage in young children's memory is consistent with this evolutionary-developmental suggestion.

The present findings from children's episodic memory are also in line with very recent developmental work reporting evidence for evolved adaptations in other areas of children's cognition. For instance, LoBue (2009) found that young children detect angry or frightened faces more quickly than happy or neutral faces, suggesting an evolved attentional bias for threat-signaling information. Similarly, young children detect evolutionary relevant stimuli, like snakes, more readily than evolutionary less relevant control stimuli (LoBue & DeLoache, 2008), and they seem to have an evolved predisposition to rapidly learn to fear moving snakes (DeLoache & LoBue, 2009). The present study complements these previous findings on young children's attentional and learning capabilities, suggesting that our cognitive system evolved, and is specifically ''tuned'', to detect, learn, and retain fitness-related information at a very early stage of ontogeny.

References

Bjorklund, D. F., & Pellegrini, A. D. (2000). Child development and evolutionary psychology. *Child Development, 71*, 1687–1708.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning & Verbal Behavior, 11*, 717–726.

Challis, B. H., Velichkovsky, B. M., & Craik, F. I. M. (1996). Levels-of-processing effects on a variety of memory tasks: New findings and theoretical implications. *Consciousness & Cognition, 5*, 142–164.

DeLoache, J. S., & LoBue, V. (2009). The narrow fellow in the grass: human infants associate snakes and fear. *Developmental Science, 12*, 201–207.

Gardiner, J. M., Brandt, K. R., Vargha-Khadem, F., Baddeley, A., & Mishkin, M. (2006). Effects of level of processing but not of task enactment on recognition memory in a case of developmental amnesia. *Cognitive Neuropsychology, 23*, 930–948.

Ghatala, E. S., & Levin, J. R. (1982). Orienting versus learning instructions in children's free recall: New evidence. *Journal of Experimental Child Psychology, 33*, 504–513.

Hager, W., & Hasselhorn, M. (1994). *Handbuch deutschsprachiger Wortnormen*. Göttingen, Germany: Hogrefe.

Kang, S., McDermott, K. B., & Cohen, S. (2008). The mnemonic advantage of processing fitness-relevant information. *Memory & Cognition, 36*, 1151–1156.

Kroneisen, M., & Erdfelder, E. (in press). On the plasticity of the survival processing effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

LoBue, V. (2009). More than just another face in the crowd: superior detection of threatening facial expressions in children and adults. *Developmental Science, 12*, 305–313.

LoBue, V., & DeLoache, J. S. (2008). Detecting the snake in the grass – Attention to fear-relevant stimuli by adults and young children. *Psychological Science, 19*, 284–289.

Nairne, J. S. (2010). Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (pp. 1–32). Burlington: Academic Press.

Nairne, J. S., Pandeirada, J. N. S., & Thompson, S. R. (2008). Adaptive memory: The comparative value of survival processing. *Psychological Science, 19*, 176–180.

Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 33*, 263–273.

Ornstein, P. A., Haden, C. A., & San Souci, P. (2008). The development of skilled remembering in children. In H. L. Roediger, III (Ed.). *Cognitive psychology of memory. Learning and memory: A comprehensive reference* (Vol. 2, pp. 715–744). Oxford: Elsevier.

Otgaar, H., & Smeets, T. (2010). Adaptive memory: Survival processing increases both true and false memory in adults and children. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*, 1010–1016.

Packman, J. L., & Battig, W. F. (1978). Effects of different kinds of semantic processing on memory for words. *Memory & Cognition, 6*, 502–508.

Schulman, A. I. (1974). Memory for words recently classified. *Memory & Cognition, 2*, 47–52.

Volk, T., & Atkinson, J. (2008). Is child death the crucible of human evolution. *Journal of Social, Evolutionary, and Cultural Psychology, 2*, 247–260.

Weinstein, Y., Bugg, J. M., & Roediger, H. L. (2008). Can the survival recall advantage be explained by basic memory processes? *Memory & Cognition, 36*, 913–919.