Is the survival processing memory advantage due to richness of encoding?

Jan P. Röer

Raoul Bell

Axel Buchner

Heinrich-Heine-Universität Düsseldorf

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Corresponding Author:

Jan Philipp Röer

Institut für Experimentelle Psychologie

Heinrich-Heine-Universität Düsseldorf

40225 Düsseldorf, Germany

E-Mail: jan.roeer@hhu.de

Abstract

Memory for words rated according to their relevance in a grassland survival context is exceptionally good. According to Nairne, Thompson, and Pandeirada's (2007) evolutionary-based explanation of the phenomenon, natural selection processes have tuned the human memory system to prioritize on processing fitness-relevant information. The survival processing memory advantage has been replicated numerous times, but very little is known about the proximate mechanisms behind it. The richness-of-encoding hypothesis (Kroneisen & Erdfelder, 2011) implies the assumption that rating the usefulness of items in a survival context leads to the generation of a large number of ideas that may be used as retrieval cues at test to boost recall. In Experiment 1, the typical survival processing recall advantage was obtained when words were rated according to their usefulness in one of three fictional contexts. In Experiment 2, participants were asked to write down any ideas that came to mind when thinking about the usefulness of the words. Consistent with the richness-of-encoding hypothesis, participants generated more ideas in the survival condition than in the fitness-irrelevant control conditions. In Experiment 3, it was examined whether the richness-of-encoding hypothesis can explain the recall advantage for congruent words that has been previously obtained in the survival-processing paradigm (Butler, Kang & Roediger, 2009). To this end, participants were required to generate ideas for congruent and incongruent words in either a grassland survival or a bank robbery context. The typical congruency effect on recall was replicated. Importantly, participants generated more ideas for words that fitted better into the fictional context. In both experiments the number of ideas that were written down predicted future recall performance well. Our results provide further evidence for the assumption that richness of encoding is an important proximate mechanism involved in memory performance in the survival processing paradigm.

Keywords: survival processing, adaptive memory, elaboration, levels of processing, fitness relevance

Is the survival processing memory advantage due to richness of encoding?

In the course of evolution natural selection processes gave direction to the forming of the human mind and its cognitive functions. Within evolutionary psychology it is often claimed that human memory has been shaped in order to successfully solve specific adaptive problems our hunter-gatherer ancestors have been confronted with in the Pleistocene (Cosmides & Tooby, 1987; Klein, Cosmides, Tooby & Chance, 2002). While this view's advantage is that it focuses on the function of memory processes in the accomplishment of biologically relevant goals such as foraging for food (New, Krasnow, Truxaw & Gaulin, 2007), mating (Buss & Schmitt, 1993), and recognizing cheaters (Bell et al., 2012), it has also attracted criticism for being difficult to falsify (e.g. Buller, 2005). A recent example how recurrent adaptive problems may have impacted human memory functioning is the survival processing advantage (Nairne et al., 2007) which refers to the phenomenon that information processed according to its fitness value is exceptionally well remembered.

In Nairne et al.'s initial study (2007) participants imagined themselves being stranded in the grasslands of a foreign land without any survival materials, deprived of food and water and in danger of predators. Participants then rated words according to their relevance in that survival scenario. A surprise memory test yielded that processing words in a survival-related context led to better retention than processing words in a number of control conditions that are usually associated with mnemonic benefits, such as rating words according to their pleasantness and self-relevance (Nairne et al., 2007). Recall in the survival processing condition is even better than in a condition in which the participants were explicitly asked to remember the words (Nairne, Pandeirada & Thompson, 2008).

The survival processing advantage has been replicated frequently. To control for schematic processing, the survival grassland condition has often been compared to a moving control condition in which the participants imagine moving to a new home in a foreign land (Butler et al., 2009; Howe & Derbish, 2009; Nairne, 2010; Nairne & Pandeirada, 2008; Nairne et al., 2008; Otgaar & Smeets, 2010; Tse & Altarriba, 2010). Survival processing has led to better recall than a range of other novel and exciting scenarios including vacationing at a fancy resort (Nairne & Pandeirada, 2008), being an Alzheimer's patient in a nursing home (Otgaar et al., 2011), and planning and executing a bank heist (Kang, McDermott & Cohen, 2008). Further, the benefit occurs with a range of different to-be-remembered materials in both between- and within-subject designs (Otgaar, Smeets & van Bergen, 2010; Savine, Scullin & Roediger, 2011). In line with Nairne et al.'s (2007) argument that human memory is tuned to process and remember survival-relevant information, Weinstein, Bugg, and Roediger (2008) observed that memory for words rated in the original grassland survival condition was superior to memory for words rated in a city survival scenario which may be less relevant for adaptive memory biases inherent in "'stone-age brains" (Nairne & Pandeirada, 2010).

Although the survival processing effect has proven to be a very robust memory phenomenon, it could be shown that the survival effect is markedly reduced or that it even vanishes when the scenarios or the task are changed to manipulate the degree to which the survival processing scenario stimulates effective encoding according to classical memory principles. For instance, Butler et al. (2009) reported a decreased memory advantage when incongruent word material had to be remembered that fitted poorly into the survival scenario. Whereas Burns, Burns, and Hwang (2011) found that the typical memory advantage is reduced in comparison to conditions that stimulate both relational and item-specific information, Klein, Robertson, and Delton (2011) argued that planning for the future is a necessary component of all scenarios leading to exceptionally good recall. Further, Otgaar and colleagues (2010) showed that survival processing does not only enhance correct recall, but also false memory intrusions.

Having examined whether the memory advantage is mediated by the richness with which the to-be-rated words are encoded, Kroneisen and Erdfelder (2011) claim that elaborate encoding might be a proximate mechanism underlying the survival processing effect. The idea that elaborate memory traces enhance retention is of course not entirely new. Kroneisen and Erdfelder refer to the levels of processing account (Craik & Lockhart, 1972) and the theoretical frameworks that have evolved from it (Craik & Tulving, 1975; Hunt & Smith, 1996; Watkins & Watkins, 1975) arguing that survival processing stimulates a particularly elaborate form of encoding. One of the key assumptions of the levels of processing account is that the probability of a successful recall depends on the "depth" with which the to-be-remembered information is encoded. Deep processing (in simplified terms, a greater degree of semantic analysis) is assumed to result in richer and more distinctive memory traces that make retrieval more probable.

It is long and well known that requiring participants to elaborate on material is one of the most effective manipulations to strengthen memory (Anderson, 1983; Anderson & Reder, 1979). For instance, single target words are better remembered when they are embedded in complex rather than simple sentences (Fisher & Craik, 1980). It has been argued that the memory advantage associated with "deeper processing" according to the levels of processing account is mostly due to the "number of elaborations subjects produce while studying the material" (Anderson & Reder, 1979, p. 385). For instance, according to the ACT model, elaboration at encoding might enhance retrieval by allowing the participants to generate additional concepts from which activation spreads to the target representations. Furthermore, participants might use inferential methods to reconstruct the target information from the elaborations that can still be retrieved at test (Anderson, 1983).

It is possible to assume that survival scenarios might stimulate more elaborate encoding, which in turn leads to better memory. Finding food in the grasslands, for instance, is naturally a more complex and creativity-demanding challenge than finding food in a city. Thus, when thinking about the relevance of items in an ancestral context, many different ideas and associations may readily come to mind. What is more, thinking about potential uses of items may be perceived as more important in a fitness-relevant than in a fitness-irrelevant context. Therefore, participants could be particularly motivated to generate many different survival ideas, which may then be used as retrieval cues at test to boost recall. Consistent with the richness-of-encoding hypothesis, Kroneisen and Erdfelder (2011) have demonstrated that the survival processing advantage diminishes when a short version of the survival scenario is used in which participants only focus on one fitness-relevant problem (i.e. lack of water) that may offer fewer opportunities to generate a rich set of ideas. Moreover, the survival processing advantage vanishes when participants are asked to write down only a single argument highlighting the relevance of the word with respect to either the survival or the moving scenario. The survival processing advantage also disappears when participants rate how easily they can imagine themselves using the described objects (Kroneisen, Erdfelder & Buchner, in press), a task that is accomplished by forming just one single image which is why this task is functionally equivalent to the one-argument-generation condition in Kroneisen and Erdfelder (2011). This leads to the conclusion that the survival processing advantage may be mediated by the richness and distinctiveness with which information is encoded.

The present experiments serve to test a straightforward prediction of the richness-of-encoding account of the survival processing advantage. If Kroneisen and Erdfelder's (2011) reasoning is correct and the survival processing advantage is due to a particularly large number of unique ideas that may serve as retrieval cues in the surprise memory test, then participants should spontaneously generate more ideas and potential uses for words in a grassland survival context than for words in fitness-irrelevant rating contexts.

In addition, we wanted to test whether richness of encoding is limited to scenarios in which participants assess the survival-relevance of words. Kroneisen and Erdfelder (2011) proposed two conflicting hypotheses about how survival processing might be associated with richness of encoding. First, survival processing might invite participants to think about a large number of different uses of the items. There are many ways in which an item may be used to enhance survival in the grassland. Objects fitting an ancestral environment such as plants and animals can be of help, but objects typically found in a modern environment (e.g., cell phones, golf clubs) could also be very useful. By contrast, many of the control scenarios may provide substantially fewer opportunities to think about an object's potential uses. There may be, for instance, fewer ways in which randomly sampled items can be used to locate and purchase a home and transport one's belongings to a foreign country. Thus, the survival processing paradigm may simply impose fewer restrictions on the possible use of items than most control scenarios. Second, it is conceivable that the survival processing paradigm enhances richness of encoding because participants are particularly motivated or "tuned" to think about ways that may increase their fitness and enhance the probability of survival, which would be consistent with an evolutionary explanation of the survival processing advantage. To differentiate between these two options, we constructed an afterlife scenario in which participants were to imagine themselves looking for friends and amusement in the eternity. We ensured in a norming study that the afterlife scenario was equally (or more) distinctive than the survival scenario. At the same time it is fitness-irrelevant and should not stimulate thinking about survival and reproduction.

Before examining the number of ideas that are stimulated by the different types of rating scenarios, however, it must be ensured in a first step that the typical survival processing advantage is obtained with the material used in the present study. Therefore, in Experiment 1, we attempted to replicate the survival processing advantage under standard conditions.

Experiment 1

Method

Participants

A total of 218 students (160 women) at Heinrich-Heine-Universität Düsseldorf were paid for participating or received course credit (*N* = 73 in the survival and afterlife conditions, *N* = 72 in the moving condition). Their ages ranged from 18 to 55 years (*M* = 23).

Materials

Materials were taken from Experiments 1 and 2 of Nairne et al. (2007). The words to be rated for their relevance consisted of 30 typical members of 30 categories drawn from the updated Battig and Montague norms (Van Overschelde, Rawson & Dunlosky, 2004). All participants rated the usefulness of the same 30 words in one of three rating scenarios (survival, afterlife, moving). The descriptions for the scenarios were the following:

Survival. 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 will need to find steady supplies of food and water and protect yourself from predators. What could help you to achieve this goal? We are going to show you a list of 30 items. Please rate how useful these items are in your situation.

Afterlife. In this task, we would like you to imagine that you have died and find yourself as an eternal living being in heaven. In the near future, you will need to find new companions and come up with multiple interesting things to do, in order to prevent loneliness and boredom in the eternity. What could help you to achieve this goal? We are going to show you a list of 30 items. Please rate how useful these items are in your situation.

Moving. In this task, we would like you to imagine that you are planning to move to a new home in a foreign land. In the near future, you need to find a suitable new home and you have to transport your belongings. What could help you to achieve this goal? We are going to show you a list of 30 items. Please rate how useful these items are in your situation.

The distinctiveness of the rating scenarios was assessed in an independent norming study (*N* = 71). Replicating the results of Otgaar et al. (2011) the survival scenario (*M* = 5.8, *SD* = 2.0) was rated to be more distinctive than the moving scenario (M = 3.4, SD = 2.3). The afterlife scenario received the highest distinctiveness rating (M = 6.3, SD = 2.1), but at a statistical level the survival and afterlife scenario were equally distinctive, $t(70) = -1.78$, $p = .080$, $\eta^2 < .01$. Compared to the moving scenario, both the survival and the afterlife scenario were rated to be more distinctive ($t(70) = 7.78$, $p < .001$, $\eta^2 = .46$, and $t(70) = 8.54$, $p < .001$, $\eta^2 = .51$, respectively).

Except for the rating scenario, all aspects of the design were held constant across participants. All materials were presented in German.

Procedure

Participants were randomly assigned to one of three rating scenarios. The to-be-rated words were presented individually and in a random order in the center of the computer screen. Participants rated each word by clicking on a 5-point scale that ranged from completely useless (1) to very useful (5), which was displayed right below the word. Every word remained on the screen for 5 seconds. In case participants failed to generate a rating in that window they were cautioned to respond faster and the next word was presented. The to-be-rated words were separated by a blank 1-second inter-trial-interval.

After the last rating, participants completed eight trials of a distractor task in which they were required to serially recall a sequence of eight digits in silence. The distractor task lasted approximately 3 minutes and was identical to the task used in a recent working memory study (for a more detailed description, see Röer, Bell, Dentale & Buchner, 2011). Subsequently, the recall instructions appeared in which the participants were asked to write down all previously rated words they could recall, regardless of the order of their presentation. A maximum of 10 minutes was allowed to complete this task.

The experiment took approximately 25 min to complete, after which participants were offered an explanation as to the purpose of the experiment.

Design

A between-subjects design was used with rating scenario (survival, afterlife, moving) as the independent variable and free recall (i.e., the total number of correctly remembered words) as the dependent variable. Of primary interest is the comparison of recall performance between the survival condition and the survival-irrelevant control conditions. Given a sample size of $N = 218$, and $\alpha = .05$, an effect of size $f = 0.27$ could be detected with a probability of $1 - \beta = .95$.

The level of α was set to .05 for all analysis. Partial η^2 is reported as a measure of effect size. All power calculations reported in this article were conducted using G*Power (Faul, Erdfelder, Lang & Buchner, 2007).

Results

Rating. Participants provided ratings for 97% of the presented words within the 5-second window. The upper panel of Figure 1 illustrates the average rating provided as a function of the rating scenario. There was a main effect of rating scenario on the average rating score, $F(2,215) = 6.68$, $p = .002$, $\eta^2 = .06$, which is commonly observed (e.g. Kang et al., 2008; Nairne & Pandeirada, 2010; Nairne et al., 2007). Orthogonal contrasts revealed that the ratings in the survival and afterlife group did not differ significantly, $F(1,216) = 0.06$, $p = .488$, $\eta^2 < .01$, but both were significantly higher than those in the moving condition, $F(1,216) = 0.56$, $p < .001$, $\eta^2 < .01$.

Recall. A response was only scored as correct when the recalled word was exactly identical to one of the previously presented words. The lower panel of Figure 1 illustrates the recall performance for each scenario. An ANOVA showed that rating scenario significantly affected recall, $F(2,215) = 4.26$, $p = .015$, $\eta^2 = .04$. Orthogonal contrasts were used to test more specific hypotheses. Replicating the survival processing memory advantage, processing words in a fitness-related context led to better recall than processing words in the other two scenarios combined, $F(1,216) = 1.46$, $p = .009$, $\eta^2 = .01$. Consistent with the assumption that thinking about the fitness-relevance of words enhances memory, recall in the afterlife condition did not differ significantly from recall in the commonly used moving control condition, $F(1,216) = 0.82$, $p = .205$, $\eta^2 < .01$.

Discussion

Experiment 1 replicates the typical survival processing memory advantage. It is noticeable that a recall advantage of the survival processing condition was obtained in comparison to the afterlife condition, although this scenario is very distinctive and, in principle, provides the opportunity to think about many ways how to use objects (although we do not know yet whether participants are motivated to do so). This finding supports the assumption that the recall advantage is restricted to scenarios in which participants are asked to think about the survival-relevance of items, and does not generalize to fitness-irrelevant scenarios with similar characteristics.

Given this pattern of results, it seems particularly interesting to test the hypothesis of Kroneisen and Erdfelder (2011) that richness of encoding represents a potential proximate mechanism underlying the survival processing memory advantage. If their approach is of any value, then participants should spontaneously generate more ideas when asked to evaluate the usefulness of items in a survival context than when being asked to do so in a fitness-irrelevant control context. If, by contrast, participants think as readily of a number of different aspects and possible applications for the items in the control contexts, this would challenge the qualification of richness of encoding as the key factor responsible for the survival processing memory advantage.

We expected significant inter-individual differences regarding the time spent for the main task and the number of words and ideas written down, which is why we decided to employ a within-subjects design to increase the statistical power to detect differences in the number of ideas between conditions. In addition, we were extremely vigilant about not giving examples for uses and arguments or hints what we expect as to content and number of words/ideas. Further the task was self-paced. Hence, it was entirely the participant's decision *what* to write and *how much*. Subsequent to the main task, participants completed a surprise memory test. According to the richness-of-encoding hypothesis, self-generated ideas may later act as retrieval cues during recall. Therefore, a replication of the survival processing advantage obtained in Experiment 1 is predicted. Further, recall of the words should depend on the number of ideas generated in response to the words in the encoding phase.

Experiment 2

Method

Participants

A total of 102 students (67 women) at Heinrich-Heine-Universität Düsseldorf were paid for participating or received course credit. Their ages ranged from 19 to 61 years (M = 26).

Materials

Again, stimulus materials from Nairne et al. (2007) were used, with the exception that participants were not shown all 30 words in one of the scenarios, but 10 words in each of them. The presentation order of the scenarios was balanced and the words were randomly assigned to the scenarios.

Procedure

Each word was printed on top of a single sheet of paper, on which participants wrote down everything that came to mind when thinking about the usefulness of the words in the presented scenario. No examples or time limits were given. In other words, participants decided for themselves what they considered relevant and when they proceeded to the next word.

After completing the main task participants validated the correctness of 32 simple mathematical equations (e.g., 13 + 11 = 24). Subsequent to this distractor task, which lasted for approximately 3 minutes, participants were asked to write down all previously presented words they could recall, regardless of the order of their presentation. A maximum of 10 minutes was allowed to complete this task.

The experiment took approximately 50 min to complete, after which participants were offered an explanation as to the purpose of the experiment.

Design

A within-subjects design was used with type of scenario (survival, afterlife, moving) as the independent variable and number of ideas as the dependent variable.

Of primary interest is the comparison between the number of ideas generated in the survival scenario and the fitness-irrelevant control scenarios (afterlife, moving). A significantly higher number of ideas generated in the fictional survival context as compared to the other two scenarios combined would support the richness-of-encoding hypothesis. In contrast, if the number of ideas generated is independent of the fitness-relevance, it has to be seriously questioned whether richness of encoding is a proximate mechanism responsible for the memory advantage.

Given a total sample size of N = 102, α = .05, and the assumption that the average population correlation between the levels of the repeated measures factor is ρ = .4, an effect of size f = 0.27 could be detected with a probability of 1 - β = .95.

Results

Main task. Two independent raters assessed the number of ideas that were generated in response to the words presented. An inter-rater correlation of r = 0.98 demonstrated the almost perfect inter-rater-agreement in the assessment of the ideas.

Consistent with the richness-of-encoding hypothesis, there was a main effect of scenario on the number of ideas, $F(2,100) = 10.01$, $p < .001$, $\eta^2 = .17$, which is illustrated in the upper panel of Figure 2. Orthogonal contrasts revealed that more ideas were generated in the survival scenario than in the control scenarios, $F(1,101) = 15.63$, $p < .001$, $\eta^2 = .13$. The number of ideas in the afterlife condition did not differ from the number of ideas in the moving condition, $F(1,101) = 1.83$, $p < .179$, $\eta^2 = .02$.

Recall. The lower panel of Figure 2 illustrates that the type of scenario significantly affected recall, $F(2,100) = 4.50$, $p = .013$, $\eta^2 = .08$. Replicating Experiment 1, orthogonal contrasts revealed a memory advantage for words processed in a survival-related context as compared to the control contexts, $F(1,101) = 8.01$, $p = .006$, $\eta^2 = .07$. Recall in the afterlife condition did not differ significantly from recall in the moving condition, $F(1,101) = 0.26$, $p = .614$, $\eta^2 < .01$.

In an supplemental analysis we examined whether, within each scenario, the generating of more ideas was positively related to recall performance, as suggested in the richness-of-encoding hypothesis. Controlling for the overall number of ideas and the overall recall performance in all scenarios together, the partial correlation between the scenario-specific number of ideas and the scenario-specific recall rates was significant for the survival condition ($r = .27$, $p = .006$), the afterlife condition ($r = .25$, $p = .014$), and the moving condition ($r = .32$, $p = .001$).

Discussion

The results of the surprise memory test in Experiment 2 perfectly replicated those of Experiment 1. Words processed according to their relevance in a grassland survival scenario were remembered better than words processed in fitness-irrelevant control scenarios. Within the richness-of-encoding hypothesis of the survival processing advantage it is assumed that this memory advantage can be attributed to the particularly large number of uses that come to mind when participants rate words according to their fitness value and, indeed, the number of ideas generated for each word was higher in the survival condition than in the survival-irrelevant control conditions. Further, the more ideas were written down, the higher was the probability of successful recall. This, too, is in line with the richness-of-encoding hypothesis, according to which ideas that come to mind when rating the usefulness of items may later act as retrieval cues and thus boost recall.

However, there are experimental designs in which the typical survival processing memory advantage disappears or is at least markedly reduced. A good example for such a design is Experiment 2 of Butler at al. (2009) in which the authors asked participants to rate words according to their relevance in one of two different contexts. Both groups were shown the exact same words, half of which fitted well into the grassland survival scenario (e.g. fire, tent). The other half of the words was chosen to fit well into a newly constructed robbery scenario in which participants had to imagine that they are leading a bank heist (e.g. clerk, vault). In the surprise memory test there was an effect of congruency—in that recall was higher when the type of processing and the word material matched—but no survival processing advantage. Whereas the absence of the survival processing effect seems to depend on the materials used in the experiment, the congruency effect itself was replicated repeatedly (Butler et al., 2009; Nairne & Pandeirada, 2011).

Recall advantages for congruent stimulus materials are a well-established phenomenon in the memory literature. Schulman (1974) for example reported enhanced free and cued recall for keywords embedded in congruent queries (“Is SPINACH a vegetable?”) as compared with incongruent queries (“Is SPINACH an agency?”). Craik (2002) proposed that congruent information should result in richer and more elaborate encoding and, thus, in better retention. The reason for this is that congruent information can be better integrated in organized knowledge structures, which, at test, may provide a reconstructive framework for retrieval processes. Against this backdrop, it seems intriguing to examine whether the richness-of-encoding hypothesis (Kroneisen & Erdfelder, 2011) can also account for a pattern of results in which the survival processing effect disappears.

Experiment 3 serves to test whether richness of encoding may also explain another key finding in the survival processing paradigm, namely the enhanced recall of scenario-congruent over scenario-incongruent material. To examine congruency, we used the exact same materials as in Butler et al.'s (2009) original study. Participants were randomly assigned to either the survival or the robbery group in which the task was to generate ideas for both survival-relevant and robbery-relevant word material. Afterwards, following a short distractor task, participants were tested without prior notice on how many of the presented words they could recall. Experiment 3 served as a further critical test of the richness-of-encoding hypothesis. If Kroneisen and Erdfelder (2011) argued correctly and the richness with which the words are encoded is a proximate mechanism underlying the survival processing memory advantage, then participants should no longer generate more ideas in the survival condition when an experimental set-up is used in which the said advantage disappears. By contrast, a replication of the results from Butler et al. (2009) would be predicted. Regardless of the scenario's fitness-relevance more ideas should be spontaneously generated for congruent than for incongruent words. As in Experiment 2, recall of the words should depend on the number of ideas generated in the encoding phase.

Experiment 3

Method

Participants

A total of 100 students (71 women) at Heinrich-Heine-Universität Düsseldorf were paid for participating or received course credit. Their ages ranged from 18 to 38 years (M = 23).

Materials

The survival-relevant and robbery-relevant words (15 each) were taken from Butler et. al (2009). Whereas "clerk", "code", and "vault" are for example words from the robbery-relevant list, the survival-relevant list contained words such as "fire", "fruit", and "tent". We also used Butler et al.'s robbery scenario:

Robbery. In this task, we would like you to imagine that you are leading a heist of a well-guarded bank. Over the next few months, you'll need to find people to help you, make a plan, and gather any supplies you might need. What could help you to achieve this goal? We are going to show you a list of 30 items. Please rate how useful these items are in your situation.

Procedure

Participants were randomly assigned to either the survival or the robbery group and were shown all 30 words in a random order. Apart from that the procedure was identical with those in Experiment 2 with the exception that below the words there were nine rectangular boxes on every sheet of paper. The participants were instructed to write down different ideas in separate boxes. In other words, independent raters did not assess the number of ideas, but participants decided for themselves what they considered as separate ideas and what not.

The experiment took approximately 50 min to complete, after which participants were offered an explanation as to the purpose of the experiment.

Design

A mixed design was used with word type (survival-relevant, robbery-relevant) as within-subjects variable and type of scenario (survival, robbery) as between-subjects variable.

Of primary interest is the comparison between the number of ideas generated for congruent and incongruent words. A significantly higher number of ideas generated for words that fit well into the fictional context would support the richness-of-encoding hypothesis of the survival processing effect. If, by contrast, the number of ideas generated is independent of the word type, richness of encoding would not be able to account for congruency effects in the survival processing paradigm.

Given a total sample size of $N = 102$, $\alpha = .05$, and the assumption that the average population correlation between the levels of the repeated measures factor is $\rho = .4$, an effect of size $f = 0.24$ could be detected with a probability of $1 - \beta = .95$.

Results

Main task. Consistent with the richness-of-encoding hypothesis, the type of scenario variable had no effect on the number of ideas that were generated, $F(1,98) = 1.53$, $p = .223$, $\eta^2 = .02$. There was a significant main effect of word type, $F(1,98) = 8.21$, $p = .005$, $\eta^2 = .08$, in that participants wrote down more ideas for survival-relevant words than for robbery-relevant words. Importantly, word type interacted with type of scenario, $F(1,98) = 240.85$, $p < .001$, $\eta^2 = .71$,. Post-hoc analyses comparing the number of generated ideas as a function of word type revealed a survival processing advantage for survival-relevant words, $t(98) = 7.07$, $p < .001$, $\eta^2 = .34$, and a robbery processing advantage for robbery-relevant words, $t(98) = 4.16$, $p < .001$, $\eta^2 = .15$. This congruency effect is displayed in the upper panel of Figure 3.

Recall. The type of scenario did not affect the number of words that participants recalled correctly in the surprise memory test, $F(1,98) = 0.13$, $p = .910$, $\eta^2 < .01$. There was no main effect of word type either, $F(1,98) = 2.38$, $p = .126$, $\eta^2 = .02$, but importantly a significant interaction between both variables, $F(1,98) = 25.56$, $p < .001$, $\eta^2 = .21$. There was again a survival processing memory advantage for survival-relevant words, $t(98) = 2.91$, $p = .004$, $\eta^2 = .08$, and a robbery processing memory advantage for robbery-relevant words, $t(98) = 2.66$, $p = .009$, $\eta^2 = .07$. The congruency effect on recall is displayed in the lower panel of Figure 3.

Consistent with the supplemental analysis in Experiment 2, the generating of more ideas was positively related to recall performance within both scenarios. Controlling for the overall number of ideas and the overall recall performance in both scenarios together, the partial correlation between the scneario-specific number of ideas and the scenario-specific recall rates was significant for the survival condition ($r = .31$, $p = .002$) and the robbery condition ($r = .31$, $p = .002$).

Discussion

The data from the surprise memory test of Experiment 3 were completely consistent with those from Butler et al. (2009). Recall was highest when the scenario and the words to-be-processed were congruent, that is, participants in the survival group remembered survival-relevant words better than robbery-relevant words and vice versa, and the typical survival processing memory advantage disappeared.

Further, the pattern of the number of ideas generated in the main task was again practically identical to the recall performance pattern. There was a congruency effect, but no survival processing advantage. Participants wrote down more ideas for words that fitted well into the fictional context, while the context itself had no impact on the amount of ideas generated. Thus, the results obtained in previous studies examining congruency effects on memory in the survival paradigm is well reflected by the number of ideas generated in the present experiment.

General Discussion

The present results replicate key findings in the survival processing literature. First, the typical memory advantage for words processed in a survival-related context could be observed, even though an equally distinct (afterlife) scenario was employed as a control condition and independent of whether participants performed the standard rating task (Experiment 1) or wrote down ideas about the potential uses of the words in the scenarios (Experiment 2). Further, the congruency effect on recall (Butler et al., 2009; Nairne & Pandeirada, 2011) could be replicated one-to-one using the idea-generation task, too.

The main goal of the present study was to put the richness-of-encoding hypothesis of the survival processing advantage (Kroneisen & Erdfelder, 2011) to a critical test. More specifically, we began with examining if the assessment of words according to their fitness-relevance triggers the forming of a particularly large number of ideas that may act as retrieval cues (and thus boost recall). In line with this prediction, participants wrote down a larger number of ideas for words in the grassland survival context than for words in the fitness-irrelevant control conditions. In addition, the probability of successful recall in the surprise memory test increased as a function of the number of these self-generated potential retrieval cues. This pattern of results indicates that the number of ideas that come to mind when thinking about the usefulness of items may serve as a good predictor for future recall performance, most certainly a better one than for example the relevance ratings from Experiment 1 in which the same scenarios were used. At first glance, the task of writing down ones ideas about the uses of an item seems similar to rating its relevance. However, relevance ratings need not necessarily correlate with recall performance. For instance, a football probably has a low fitness value in a grassland survival context, but the mental image of playing football with a dangerous predator might still be a powerful retrieval cue that can be activated during recall. In fact, ideas that are absurd or unique at least in one dimension are known to "stick" particularly well—a phenomenon typically referred to as the von Restorff effect (von Restorff, 1933).

It seems plausible to assume that, similar to the survival condition, the afterlife condition provided the opportunity to generate many different ideas about how to use the items. The question then is why richness of encoding was only enhanced when the participants were asked to think about the usefulness of words in a survival context. From an evolutionary point of view one could argue that people may be particularly motivated or "tuned" to think creatively about various ways to increase their fitness, which leads to a particularly large set of potential retrieval cues in a survival processing condition, which then causes the survival processing advantage. In this case the memory advantage would not necessarily be due to a highly specific memory module specialized in the processing of survival-relevant material, but the survival processing advantage could still be linked to human evolution. From this perspective, the limited storage capacity of our memory systems—or to put it another way, the ability to forget—may even play a role, too. In a (fictional) life and death situation survival-relevant information should be perceived as particularly important. Forgetting "unimportant" information helps to increase the remaining memory traces' discriminability, which, in turn, enhances the probability of a successful recall at test.

To examine whether evolutionary relevance per se fostered the generation of a rich set of ideas, we conducted Experiment 3 in which we used an experimental set-up from which we had reason to expect that the survival processing advantage would disappear. In fact, there was no survival advantage reflected in the number of ideas participants generated. Instead, the typical congruity effect was apparent in both the idea-generation task and the surprise memory test. The results clearly show that the richness-of-encoding hypothesis can account for another major phenomenon in the survival processing paradigm. The present data are perfectly consistent with the levels of processing framework (e.g., Moscovitch & Craik, 1976) as well, according to which congruent information is processed more elaborately than incongruent information. In other words, it should be easier to generate a rich set of ideas in those conditions in which the words fit well into the fictional context. Along these lines, the overall pattern of results provides a conceptual replication of Kroneisen and Erdfelder's (2011) Experiment 3 in which richness of encoding and evolutionary relevance were crossed, too. As in the present incongruent condition, the survival processing advantage vanished when there were fewer opportunities to engage in elaborate encoding.

The depth-of-processing approach has often been criticized for failing to provide a precise definition of the term "depth of processing" (Anderson, 1983), and it has been argued that most findings in the depth-of-processing framework can be understood in terms of elaborate processing (Anderson & Reder, 1979; Bradshaw & Anderson, 1982). In line with this argument, the richness-of-encoding explanation (Kroneisen & Erdfelder, 2011) also depends on a precise understanding of what is meant by the "richness of encoding" concept. In the present study, we focused on the question whether the most simple and direct measure of richness of encoding—that is the number of ideas stimulated by the words in each scenario—could explain the pattern of findings obtained in previous experiments. As it turned out, it was indeed possible to show that the number of ideas mirrored the findings of key studies in the survival processing literature (Butler et al., 2009; Nairne et al., 2007). What is more, the number of ideas was a good predictor of future memory performance in the present experiments. Thus, even a very simple operationalization produced results in line with the richness-of-encoding hypothesis.

The present study focused only on the richness-of-encoding explanation of the survival processing effect. However, there are also other promising approaches towards understanding the survival processing memory benefit. Burns et al. (2011), for instance, found the typical survival advantage compared to conditions that promoted only item-specific or relational processing, whereas the effect disappeared when control conditions were used that required both types of processing. Another mechanism that may contribute to the survival processing advantage is a planning component. Klein, Robertson and Delton (2011) compared a survival condition that required a considerable amount of planning to both a survival condition without planning and a survival-irrelevant planning condition. Having found a planning, but no survival processing effect, the authors argued that planning is a necessary component of the recall advantage. Soderstrom and McCabe (2011) demonstrated that emotional processing may even play a role, too. However, while it may be that the variables manipulated in these studies make unique contributions to the survival processing memory advantage, it may also turn out that many, if not most, of the variables affecting the survival processing memory advantage may be considered variants of the richness-of-encoding concept because the manipulations of these variables affect the number and perhaps the types of possible uses of objects invented by the participants (Erdfelder & Kroneisen, in press). In any case, it is already possible to conclude that the original grassland survival scenario may not be "special" by itself, but in its ability to induce a highly effective form of elaborate encoding. The present results provide further evidence that richness of encoding very likely is an important component thereof.

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Author Notes

Jan Philipp Röer, Raoul Bell, and Axel Buchner, Department of Experimental Psychology, Heinrich-Heine-Universität Düsseldorf, Germany. Correspondence concerning this article should be addressed to Jan Philipp Röer, Institut für Experimentelle Psychologie, Heinrich-Heine-Universität, D-40225 Düsseldorf, Germany. Electronic mail may be sent to jan.roeer@hhu.de.

Figure Captions

Figure 1: Mean rating (upper panel) and mean proportion of words recalled (lower panel) as a function of rating scenario (survival, afterlife, moving) for Experiment 1. The error bars depict the standard errors of the means.

Figure 2: Mean number of ideas generated (upper panel) and mean proportion of words recalled (lower panel) as a function of type of scenario (survival, afterlife, moving) for Experiment 2. The error bars depict the standard errors of the means.

Figure 3: Mean number of ideas generated (upper panel) and mean proportion of words recalled (lower panel) as a function of word type (survival-relevant, robbery-relevant) and type of scenario (survival, robbery). The error bars depict the standard errors of the means.

Figure 1

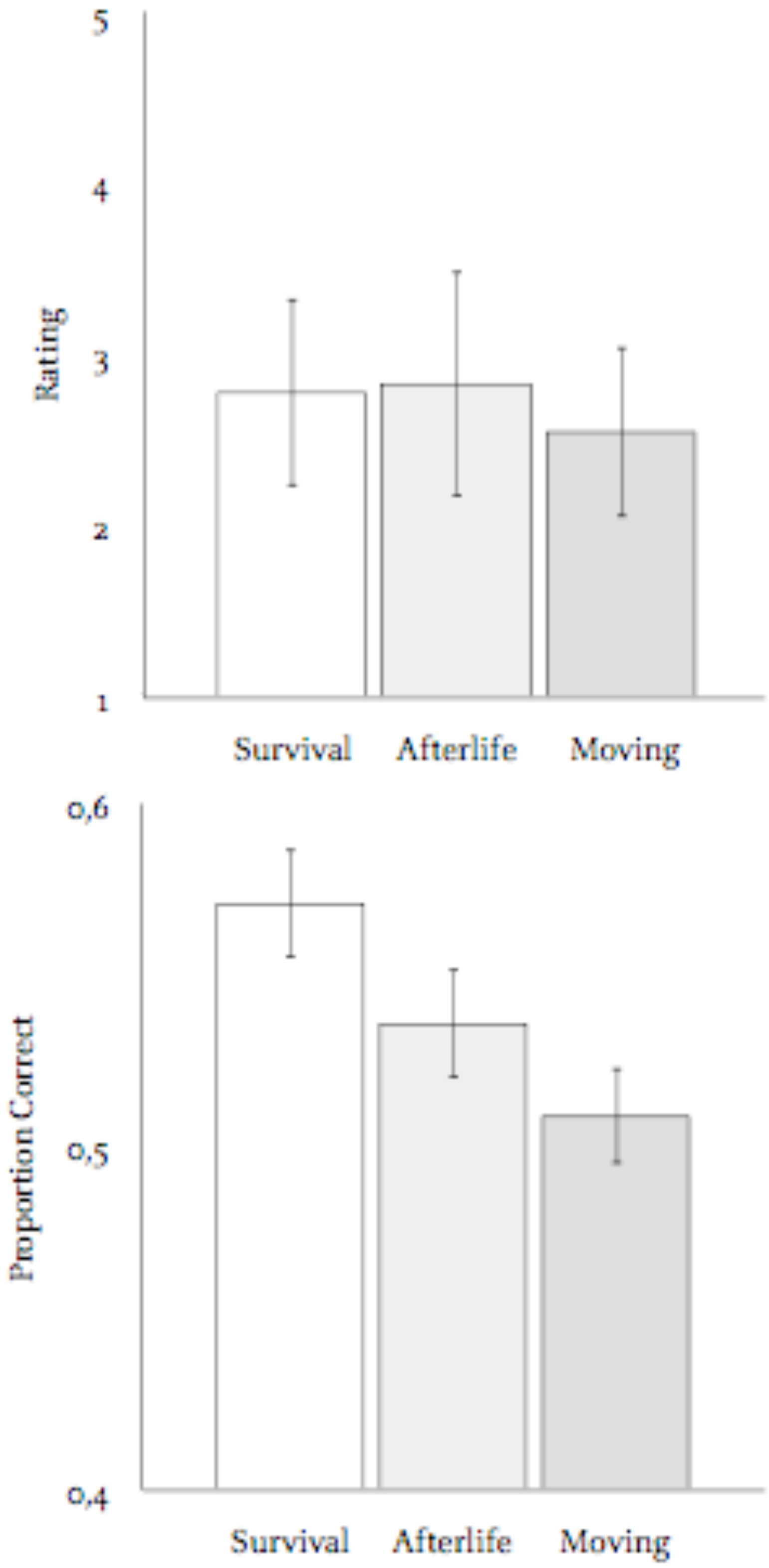

5
4
3
2
1
Rating
Survival
Afterlife
Moving
0,6
0,5
0,4
Proportion Correct
Survival
Afterlife
Moving

Figure 2

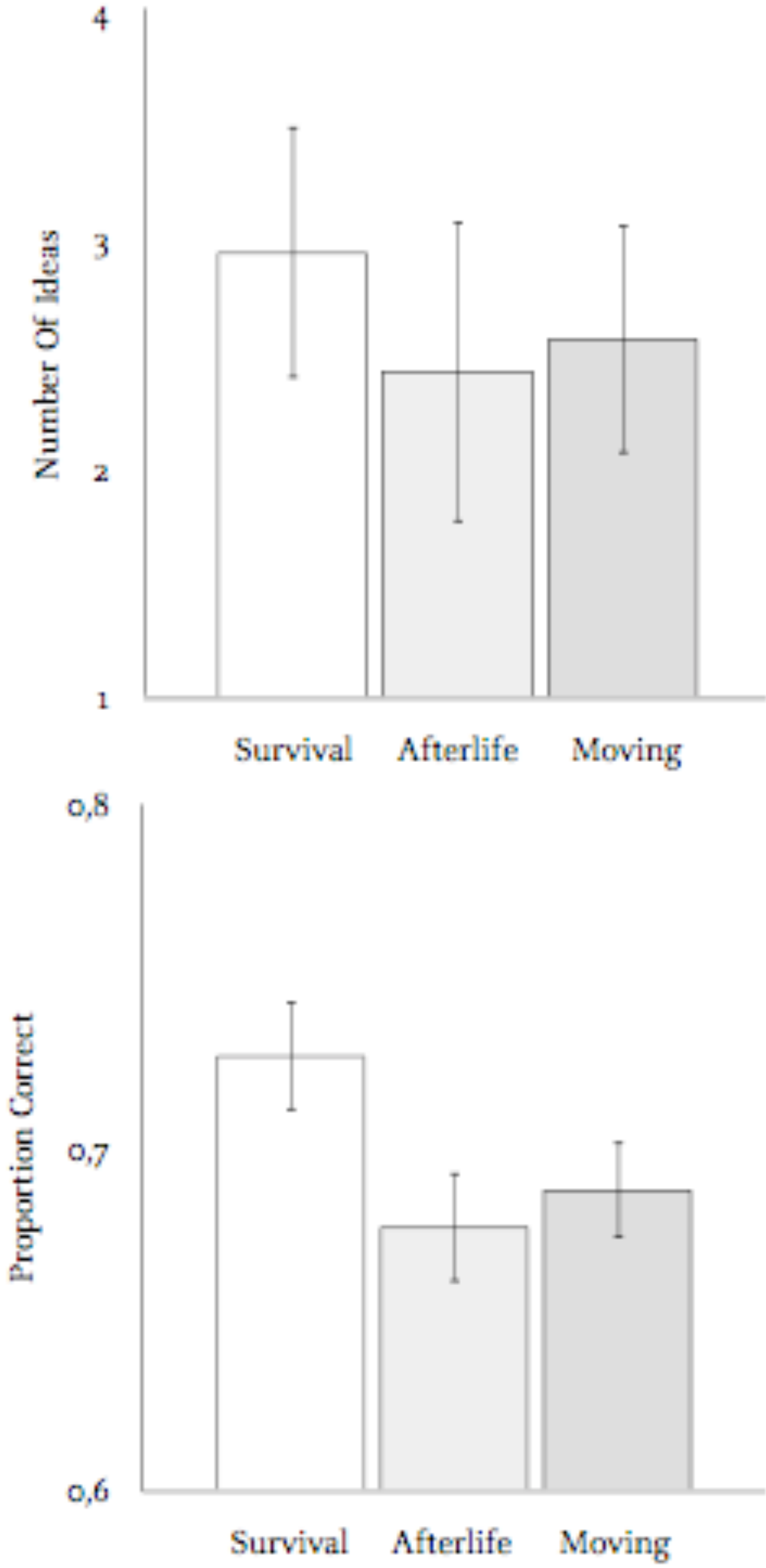
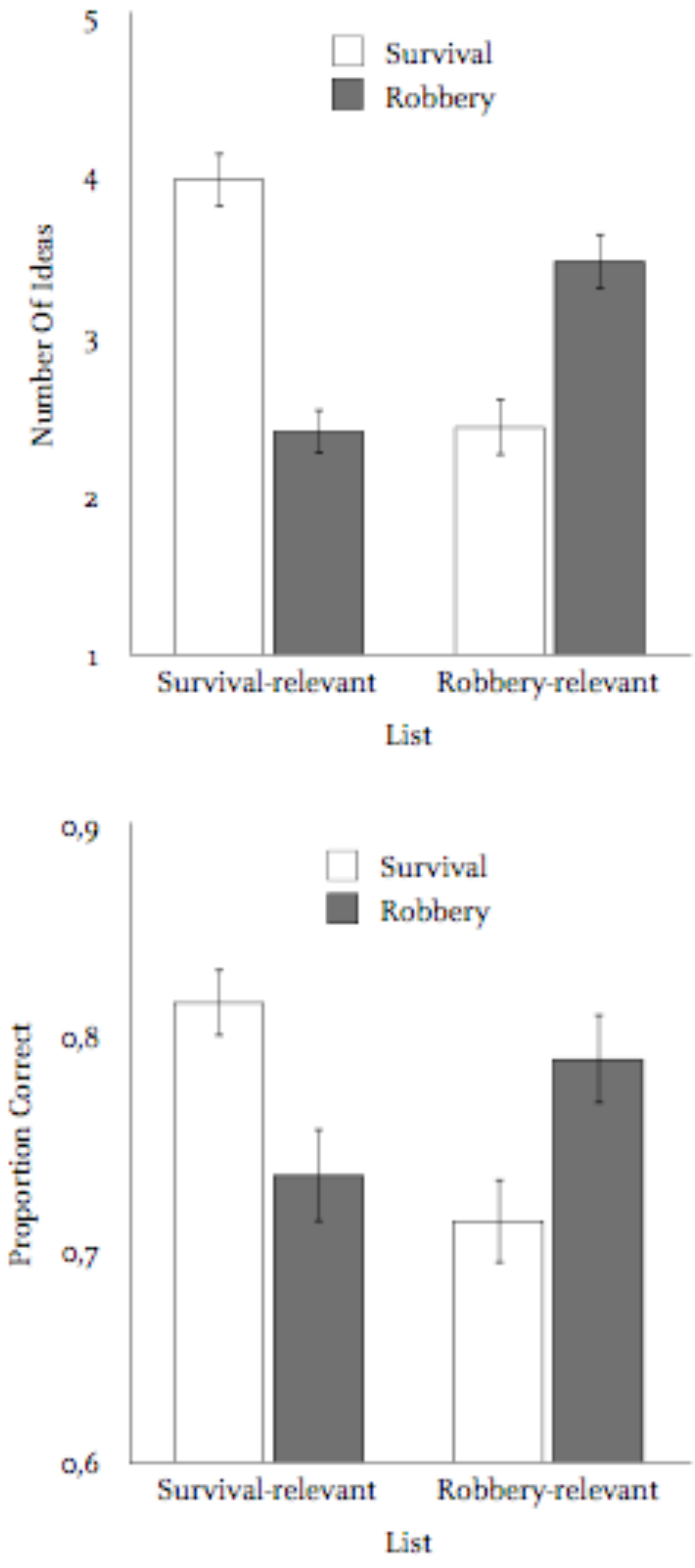

4
3
2
1
Number Of Ideas
Survival
Afterlife
Moving
0,8
0,7
0,6
Proportion Correct
Survival
Afterlife
Moving

Figure 3


5
4
3
2
1
Number Of Ideas
Survival
Robbery
Survival-relevant
Robbery-relevant
List
0,9
0,8
0,7
0,6
Proportion Correct
Survival
Robbery
Survival-relevant
Robbery-relevant
List