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BRIEF REPORT

Remembering the place with the tiger: Survival processing can enhance source memory

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Abstract

Rating the relevance of words for survival in the grasslands of a foreign land often leads to a memory advantage. However, it is as yet unclear whether the survival processing effect generalizes to source memory. Here, we examined whether people have enhanced source memory for the survival context in which an item has been encountered. Participants were asked to make survival-based or moving-based decisions about items prior to a classical source memory test. A multinomial model was used to measure old–new discrimination, source memory, and guessing biases separately. We replicated the finding of a survival advantage in old–new recognition. Extending previous results, we also found a survival-processing advantage in source memory. These results are in line with the richness-of-encoding explanation of the survival processing advantage and with an adaptive perspective on memory.

Keywords Source memory · Recognition · Evolution · Survival processing effect

In the survival processing paradigm, participants are instructed to imagine being stranded in the grasslands of a foreign land, without any food or water, and in danger of predators. A list of items is presented, which participants are required to rate with respect to their relevance in this survival scenario. In a surprise retention test, words encoded in this scenario are recalled better than words encoded in control scenarios, such as imagining moving to a foreign country (Nairne, Thompson, & Pandeirada, 2007) or in other deep processing tasks such as rating the pleasantness of words (e.g., Nairne, Pandeirada, & Thompson, 2008; Nairne et al., 2007). This survival processing effect has proven to be very robust, and was replicated under different conditions many times, with different stimulus materials (Otgaar, Smeets, & van Bergen, 2010) and encoding tasks (Röer, Bell, & Buchner, 2013). This also includes a successful preregistered replication as part of the Open Science Collaboration project (Open Science Collaboration, 2015).

The survival processing effect has received much attention because it raises the question of whether our memory system has evolved to remember fitness-relevant information. According to the evolutionary account, the survival processing effect provides evidence that evolution has selectively tuned the human cognitive system to process and retain information that is fitness-relevant (see, for example, Nairne & Pandeirada, 2008, 2016; Nairne et al., 2007). The proximate mechanisms that underlie the effect are still under debate (for reviews, see Erdfelder & Kroneisen, 2014; Howe & Otgaar, 2013; Nairne & Pandeirada, 2016). One of the most promising domain-general class of explanations attributes the survival processing effect to elaborative and distinctive encoding (Erdfelder & Kroneisen, 2014; Howe & Otgaar, 2013). The richness-of-encoding hypothesis (Kroneisen & Erdfelder, 2011) implies that participants come up with a large number of highly distinctive and unique ideas of how an item can be used to increase one's chances of survival in the grasslands. This leads to distinct memory representations that are highly useful to retrieve the item later on. Consistent with this hypothesis, Röer et al. (2013) demonstrated that the survival scenario encourages participants to generate a large number of ideas about how to use the items, and the strength of the survival processing effect increases with the

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number of unique relevance arguments generated per item. Bell, Röer, and Buchner (2015) argued that participants do not only generate more ideas, they also generate more unique ideas, as evidenced by the fact that the ideas generated in response to the survival scenario were rated as being particularly creative. Interfering with the participants' ability to generate many and creative ideas in response to the survival scenario consequently reduces or abolishes the survival processing effect (Kroneisen & Erdfelder, 2011; Kroneisen, Erdfelder, & Buchner, 2013; Kroneisen, Rummel, & Erdfelder, 2014, 2016).

Although survival processing effects on recall and recognition have been robustly obtained, it is less clear whether the survival processing effect generalizes to source memory. In line with the source-monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993), the term "source" is used here to refer "to a variety of characteristics that, collectively, specify the conditions under which a memory is acquired (e.g., the spatial, temporal, and social context of the event)" (p. 3). Nairne, VanArsdall, Pandeirada, and Blunt (2012) required participants to rate pictures of food or animals according to how easy they were to collect or to capture in a survival or a contest scenario. The items were either "near" to the participant's position, or "far" away. In a later source memory test, a survival-processing source memory advantage was obtained: The location of the items was better remembered when the items were encoded in the survival scenario than when they were encoded in the control scenario. By contrast, Bröder, Krüger, and Schütte (2011) did not find enhanced location memory for words or pictures after survival processing. In their experiments, participants had to rate the relevance of different items (words or pictures) according to a survival or a control scenario. The items could appear in one of 16 possible positions on the screen that were randomly determined, and not linked to survival value. In a later source memory test, no source memory advantage for the location of the survival items was obtained. The elaborative-encoding account is largely compatible with this pattern of findings because Bröder et al.'s survival scenario does not encourage the elaboration of the location of the words on the screen; if anything, it may rather distract from the processing of this task-irrelevant feature of the words. In the paradigm of Nairne et al., location is a property that determines the survival-relevance of the items (in conjunction with other properties). Therefore, this information is elaborated at encoding (processed in relation to other properties of the items), which may contribute to the occurrence of the survival processing effect.

While location is not necessarily a relevant source dimension in the original survival-processing paradigm, the survival scenario in which the item was encoded can be expected to be well remembered. Surprisingly, Nairne, Pandeirada, VanArsdall, and Blunt (2015) found that participants remembered equally well whether an item was encoded in a survival or in a control scenario. According to the elaborative-encoding account, the unique relevance arguments generated in the survival scenario (e.g., using a fork to defend oneself from predators) should not only enable participants to determine that the item has been presented during the encoding phase, it should also allow them to specifically attribute the item to the survival scenario. This leads to the prediction that people should remember particularly well that an item was encoded in a survival rather than in a moving context. The finding that there is no such source memory advantage for items processed in a survival scenario is surprising under an evolutionary perspective as well: what evolutionary benefit is the memory advantage supposed to have when people are able to remember the item, but fail to remember its survival context?

However, there are several reasons why further evidence is necessary before firm conclusions should be drawn about this issue. First, Nairne et al. (2015) did not use a standard survival processing task because survival ratings and control ratings were intermixed and not blocked. Evidence that a survival processing effect can be obtained with mixed lists is only limited (Nairne & Pandeirada, 2011), and effect sizes may be smaller due to switch costs and carryover effects. Furthermore, switching between survival and control ratings may prevent participants becoming completely immersed with the survival scenario. The paradigm of Nairne et al. (2015) also differed from a standard source memory task in a number of ways. In Experiment 1, source attributions were made under time pressure. In Experiments 2 and 3, source attributions were made in a blocked design. Participants were only required to respond "yes" or "no" in response to a single source-attribution question, which also means that the data does not provide enough degrees of freedom to disentangle item recognition, source memory, and guessing with standard measurement models (see Discussion below). Note that the test also included items that were encoded twice: once in the survival scenario and once in the control scenario. This is because the experiments of Nairne et al. (2015) were not designed to examine source memory for the encoding context. Instead, they served to test whether thinking about the survival context in a source memory test leads to a testing effect in a subsequent recall test. While the experiments were well designed to answer this innovative research question, it remains an open question whether a survival processing source memory advantage exists. To answer this question, it is necessary to combine the classical survival-processing paradigm with a standard source monitoring test.

Measuring source memory

A good measure of source memory should be sensitive to differences in source memory without being sensitive to differences in the ability to remember the items themselves (Murnane & Bayen, 1996). It is also important not to confound source memory with guessing (Bayen, Murnane, & Erdfelder, 1996; Murnane & Bayen, 1996). A solution to this problem is to analyze the data by using stochastic models that serve to disentangle these cognitive processes. A well-established multinomial source-monitoring model was developed by Bayen et al. (1996). An advantage of this model is that validation studies have established that its source memory parameters remain unaffected by differences in old–new recognition and guessing manipulations (Bayen & Kuhlmann, 2011; Bayen et al., 1996). Schütz and Bröder (2011) demonstrated that this model is at least as good as an alternative model based on signal detection theory (see also Klauer & Kellen, 2010). Moreover, hypotheses about source memory can be directly tested by restricting the source memory parameters, and by examining how well the resulting model fits the data.

An adaptation of the model for the present experiment is illustrated in Fig. 1. The most relevant parameters in the present context are parameter D, representing the probability of recognizing an item as old, and parameter d, representing the conditional probability of remembering the (survival or moving) scenario in which the item has been encoded. To obtain an identifiable model, we followed the procedure described by Bell, Mieth, and Buchner (2015) to incorporate the assumption $D_{\text{New}} = (D_{\text{Source A}} + D_{\text{Source B}})/2$ into the model, which corresponds to the usual assumption of two high threshold models that the detection of new items is equal to that of old items. This model has zero degrees of freedom, which means that there are as many free parameters as there are independent data categories to fit. MultiTree (Moshagen, 2010) was used to obtain the parameter estimates and to perform the goodness-of-fit tests. Only restrictions on top of the base model can be tested statistically. As a goodness-of-fit

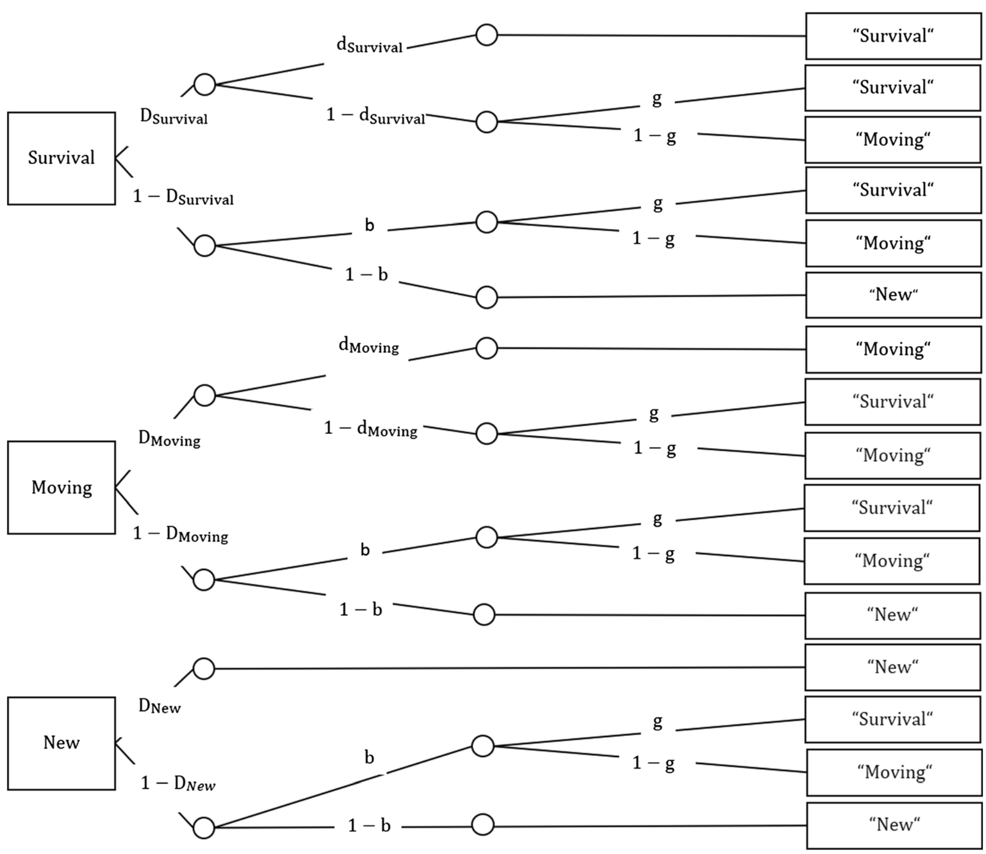

Fig. 1 Bayen et al.'s (1996) source memory. Rectangles on left represent items shown in a specific scenario during the encoding phase (word shown in the context of a survival scenario vs. moving scenario or new words). Letters along links represent the probabilities with which certain cognitive states occur (D: probability of correctly identifying a word as old or new; d: conditional probability of remembering the scenario in which a specific word occurred given that the word is correctly recognized as old [source memory]; b: probability of guessing that a nonrecognized word is old; g: probability of guessing that a nonrecognized word that was guessed to be old was shown in the context of the survival scenario). Rectangles on right represent answers of the participants ("survival," "moving," or "new"). First tree in figure represents test items associated with the survival context during the encoding phase. Parameter D_{Survival} represents the probability of recognizing the item as old. Parameter d_{Survival} represents the conditional probability of also remembering that the item has been encoded in the survival scenario, which leads to a correct classification of this item as a "survival" item. If the source of a recognized item is not known (with probability $1 - d_{\text{Survival}}$), it may be guessed (correctly) that the item was encoded in the survival scenario with probability g, or, (incorrectly) that the item was encoded in the moving scenario with the complementary probability $1 - g$. If the item is not correctly recognized as "old" with probability $1 - D_{Survival}$, participants may still guess, with probability b, that the item is old, in which case they have to guess, with probability g, that the item was encoded in the survival scenario or, with probability $1 - g$, that the item was encoded in the moving scenario. Finally, if an item is not recognized as "old" nor guessed to be "old," the item is (falsely) classified as "new" with the probability $1 - b$

measure, the log-likelihood ratio statistic, G^2, was used, which is asymptotically χ^2 distributed (Hu & Batchelder, 1994).

We expected to replicate the survival processing effect on old-new recognition ($D_{\text{Survival}} > D_{\text{Moving}}$). The main question was whether source memory would be better for words processed in a survival scenario relative to those processed in a moving scenario ($d_{\text{Survival}} > d_{\text{Moving}}$), as predicted by the elaborative-encoding account.

Method

Participants

Forty students (five male) at University of Koblenz-Landau participated for course credit or monetary compensation. Their age ranged from 18 to 28 years ($M = 22.03$, $SD = 2.61$).

Materials

We sampled 160 target words from 10 different categories (animals, clothes, fruits, furniture, musical instruments, professions, sports, tools, vegetables, and vehicles) from the database of Schröder, Gemballa, Ruppin, and Wartenburger (2012). The full set of words is available in the Online Supplementary Material. To absorb primacy and recency effects, four buffer words were added, two at the beginning and two at the end of the list. Eighty words were presented at study (40 in the survival and 40 in the moving scenario), and the remaining 80 words were used as distractors in the source memory test. The words were randomly assigned to four sets of 20 words, their presentation as target or distractor was counterbalanced across participants. All words, except the buffer words, were presented in a random order. The survival and moving descriptions were identical to those used by Kroneisen and Erdfelder (2011).

Procedure

Participants first read the scenario description (i.e., either the survival or the moving scenario, counterbalanced across participants), and rated the relevance of 40 items with respect to this scenario. Then, the other scenario (i.e., the moving or the survival scenario, counterbalanced across participants) was presented, and 40 other items were rated. All words were rated on a 5-point scale, with 1 indicating that the word was *completely irrelevant* and 5 indicating that the word was *extremely relevant* to the scenario. Each word stayed on screen for 5 seconds, after which the next word was shown. After completing the rating task and a short break of 20 seconds, the instructions of the surprise source memory test were presented. The 80 old words were intermixed with 80 new words. For each word, participants were asked whether or not they had rated it during the encoding phase. If the word was classified as old, it was asked whether the word was known from the survival or moving scenario. After a response option had been selected, the next word was shown. The experiment lasted approximately 30 minutes.

Design

The within-subject independent variable was *type of scenario* (survival vs. moving). Relevance ratings, old–new recognition and source memory were the dependent variables. Given a sample size of $N = 40$, 160 responses in the source memory test, and $\alpha = .05$, the power to detect a difference between the source memory parameters with a small effect size of $w = 0.10$ was > .99. The power calculation was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007).

Results

Old–new recognition

Confirming the survival processing effect on old–new recognition, P_r (hit rate minus false-alarm rate) was higher for words rated in the survival scenario ($M = .82$, $SEM = .018$) than for those rated in the moving scenario ($M = .77$, $SEM = .015$), $F(1, 39) = 23.11$, $p < .001$, $\eta_p^2 = .15$.

Model-based analysis of old–new recognition and source memory

First, we tested whether the old–new recognition parameter D was higher for words encoded in a survival situation than for words encoded in a moving situation. The null hypothesis of no difference can be implemented by imposing the restrictions $D_{\text{Survival}} = D_{\text{Moving}}$ on the base model. An incompatibility of this assumption with the data should lead to a significant increase in model misfit caused by this restriction as expressed in the goodness-of-fit statistic ΔG^2. As can be seen in Fig. 2 (upper panel), words encoded in the survival scenario were better recognized than words encoded in the moving scenario, $\Delta G^2(1) = 18.08$, $p < .001$. The estimates of the source memory parameter d are also shown in Fig. 2 (lower panel). A survival advantage was detected: source memory for the survival scenario was better than source memory for the moving scenario, $\Delta G^2(1) = 9.98$, $p = .002$ (i.e., the restriction $d_{\text{Survival}} = d_{\text{Moving}}$ was incompatible with the data). Guessing parameter g corresponded to .41, which means that participants had a tendency to guess that an item whose source was not remembered was encoded in the moving scenario, $\Delta G^2(1) = 7.27$, $p = .007$, which could be due to a compensatory guessing strategy (Küppers & Bayen, 2014).

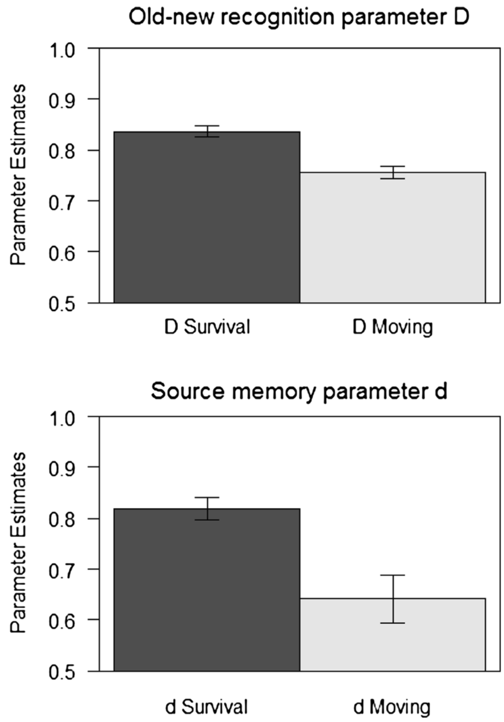

Fig. 2 The old–new recognition parameter *D* and source memory parameter *d* as a function of type of scenario (survival vs. moving). Error bars represent the standard error of the means

Relevance ratings

Although relevance ratings were generally low ($M = 2.53$, $SEM = 0.08$ in the survival condition, and $M = 1.83$, $SEM = 0.08$ in the moving condition), survival relevance was perceived as higher than moving relevance, $F(1, 39) = 57.49$, $p < .001$, $\eta_p^2 = .60$, which is typical for the survival-processing literature (e.g., Nairne & Pandeirada, 2008; Röer et al., 2013).[1]

[1] We also tested if there was a relationship between the relevance rating and source memory performance. To test this question, we needed to adjust the rating data for an analysis with an MPT model. Because MPT models are made for categorical data, we divided the ratings in low (ratings 1–3) and high (ratings 4, 5) ratings. Then, we adjusted our model (1) to test if item and source memory differed between low and high ratings for the survival and moving scenario separately, and (2) to test whether item and source memory differed between the survival and the moving scenario for the low and for the high ratings separately. Item memory did not differ between low and high ratings for the moving scenario, $\Delta G^2(1) = 0.38$, $p = .537$, but they did differ for the survival scenario, $\Delta G^2(1) = 7.75$, $p = .005$. For the survival scenario, higher ratings led to higher item memory. However, for both rating types there was still a difference between the moving and the survival scenario, low ratings: $\Delta G^2(1) = 7.14$, $p = .008$; and high ratings: $\Delta G^2(1) = 6.22$, $p = .01$. Overall, survival ratings led to better item-memory. Source memory between low and high ratings did differ for the moving scenario, $\Delta G^2(1) = 17.22$, $p < .001$, and for the survival scenario, $\Delta G^2(1) = 12.07$, $p < .001$, higher ratings led to higher source memory. For the low rating types, there was still a difference between the moving and the survival scenario, low ratings: $\Delta G^2(1) = 7.95$, $p = .005$, survival ratings led to better source memory. For high ratings, no difference in source memory between survival and moving could be found, $\Delta G^2(1) = 0.26$, $p = .61$.

Discussion

The present study tests whether the survival processing effect generalizes to source memory. Not only did we replicate the finding of a survival processing effect on old–new recognition, we also observed that source memory was enhanced for items processed in a survival scenario relative to items processed in the standard moving control scenario. When looking at the influence of the relevance ratings on old–new recognition, we found an effect for the survival condition but not for the moving condition. However, for both, low and high ratings, a difference between survival and moving could be detected. For source memory, relevance ratings had an effect on both, the survival and the moving condition. Interestingly, a difference in source memory between the survival and the moving condition could be seen for the low but not for the high relevance ratings. However, these results have to be interpreted with caution because the ratings (high vs. low) were not evenly distributed.

From an evolutionary perspective on survival processing, our results are anticipated (Nairne et al., 2015). According to the adaptive-memory framework, context is of key importance for determining the survival value of an item:

> Item meaning is often context dependent. Thus, the survival value of an item depends very much on the context in which that item is encountered. For example, a pencil is not inherently related to survival, although it might be in a context in which it could be used as a weapon or as a device for writing a note that secured freedom or food. (Nairne et al., 2007, p. 270)

According to Nairne and Pandeirada (2016), "the mnemonic effects of survival processing are best viewed within the context of a more general survival optimization system, crafted by natural selection because it helped organisms prepare for and react to recurring and novel threats" (p. 504). However, if the survival value of an item (e.g., a pencil) is largely determined by its context (e.g., its use as a weapon or writing tool), then it is unclear how better memory for this item could help to prepare the individual to deal with environmental challenges if the survival context of the item is lost at retrieval. To illustrate, in an ancestral environment, it is insufficient to simply recognize a wild berry as having been seen before (item memory), it is vital to remember whether it is edible or poisonous (source memory). In other words, the integration of information into survival-relevant contexts seems to be crucial for survival, and it seems therefore of utmost importance to give source memory more weight in the discussion on adaptive memory (see Buchner, Bell, Mehl, & Musch, 2009, for similar arguments). Here, we have argued that a survival advantage would be of little value if the items were successfully remembered, but without the context that signifies their survival value. If the survival processing effect reflects the footprints of ancestral selection pressures (Nairne & Pandeirada, 2016), it is to be expected that people do not only remember the items that were evaluated for their survival relevance, but also the survival context in which these items were encoded, because their context, rather than their content, determines the survival-relevance of the items (relative to the control items). Therefore, it is to be expected from an adaptive-memory framework that contexts with a high survival value can be better retrieved than those with a low survival value. This hypothesis was confirmed by the present results.

As discussed in the Introduction, it is debatable whether the survival processing effect is to be attributed to specialized "survival modules" or whether it is consistent with domain-general memory mechanisms. One candidate mechanism for explaining the source memory advantage is the congruity between the material and the processing task. Although congruity has been shown to have beneficial effects on free recall (Butler, Kang, & Roediger, 2009), it is unlikely the only candidate for explaining the source memory advantage observed here. Congruity has beneficial effects on source monitoring (Bell, Mieth, et al., 2015; Kuhlmann, Vaterrodt, & Bayen, 2012; Küppers & Bayen, 2014), but these are entirely due to source *guessing*, while source *memory* is often enhanced for incongruent material. For instance, when presenting congruent and incongruent objects (e.g., "toothbrush" or "oven") in either a kitchen or bathroom context, participants have a strong tendency toward guessing that the objects (e.g., "toothbrush") were encountered in a congruent context (e.g., "bathroom"), but source memory (adjusted for guessing) is either unaffected by congruence or even better for the *in*congruent items (Küppers & Bayen, 2014). The present survival processing effect is qualitatively different from these congruity effects because its beneficial effects on source monitoring are due to source *memory* rather than reconstructive *guessing*.

However, the present and previous results can be easily integrated into the elaborative-encoding view outlined in the Introduction. According to a variant of the elaborative-encoding view (Bell et al., 2015; Erdfelder & Kroneisen, 2014; Kroneisen & Erdfelder, 2011; Röer et al., 2013), the survival processing scenario leads participants to generate highly specific and unique ideas of how to use items (e.g., a fork) for survival (e.g., to defend oneself from predators). These unique ideas (e.g., stabbing a tiger with a fork) may later act as highly distinctive retrieval cues that could help to determine that the item was indeed encountered in the encoding phase and not in any other context. This hypothesis obviously implies that people should not only be better in determining that an item has been seen before, they should also be able to remember that the item has been encountered in the survival context and not in the control context. The present results confirm this prediction. In line with the idea that the survival-processing effect is caused by a combination of item-specific and relational encoding (Burns, Burns, & Hwang, 2011), the elaboration of unique features of the items relevant to the survival scenario (e.g., "Is the object sharp enough to be used as a weapon against predators?") could strengthen both item memory as well as the association between the item and the survival scenario. Furthermore, relational processing (e.g., thinking about the survival value of an item, relative to other items) may strengthen the episodic integration of these items into the common theme of survival in the grasslands. The effective combination of both encoding types (e.g. item-specific and relational encoding) could lead to the survival advantage in source memory. It has also been argued that self-reference may play a role in the explanation of the survival processing effect (Klein, 2012) because thinking about one's own survival clearly is a self-referential task. However, the moving control scenario (thinking about moving to another city) is self-referential as well, and there are studies showing that changing the perspective from first person to third person in the survival processing task does not influence the classical survival processing effect (Kang, McDermott, & Cohen, 2008 Weinstein, Bugg, & Roediger, 2008), suggesting that self-reference may contribute, but is not solely responsible for, the survival processing memory advantage.

The elaborative-encoding view advocated here could also help to integrate previous findings on source memory. For instance, in the study of Bröder et al. (2011), participants rated the relevance of items according to their relevance in a standard survival processing scenario. The words were placed at different positions at the screen, but location was entirely irrelevant to the rating task. Therefore, participants were not encouraged to elaborate the context information. In the study of Nairne et al. (2015), in contrast, the rating task required participants to integrate the item information with the context information to determine the survival value of an item. It therefore seems possible to conclude that survival processing may benefit source memory if the orienting task requires participants to elaborate the items in relation to the source dimension that is assessed at retrieval. In essence, then, it seems possible to conclude that the effects of survival processing on source monitoring are consistent with the elaborative-encoding account, as well as with a functional view on memory.

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