Mem Cogn
DOI 10.3758/s13421-014-0456-4

Source-constrained retrieval and survival processing

James S. Nairne · Josefa N. S. Pandeirada · Joshua E. VanArsdall · Janell R. Blunt

Abstract Three experiments investigated the mnemonic effects of source-constrained retrieval in the survival-processing paradigm. Participants were asked to make survival-based or control decisions (pleasantness or moving judgments) about items prior to a source identification test. The source test was followed by a surprise free recall test for all items processed during the experiment, including the new items (foils) presented during the source test. For the source test itself, when asked about the content of prior processing—did you make a survival or a pleasantness decision about this item?—no differences were found between the survival and control conditions. The final free recall data revealed a different pattern: When participants were asked to decide whether an item had been processed previously for survival, that item was subsequently recalled better than when the source query asked about pleasantness or relevance to a moving scenario. This mnemonic boost occurred across-the-board—for items processed during the initial rating phase and for the new items. These data extend the generality of source-constrained retrieval effects and have implications for understanding the proximate mechanisms that underlie the oft-replicated survival-processing advantage in recall and recognition.

Keywords Evolution · Memory · Source-constrained retrieval · Recall

A number of recent papers have reported that processing information for its survival relevance leads to particularly robust recall, as compared with traditional encoding procedures (Nairne, Thompson, & Pandeirada, 2007). In the typical experimental setup, participants are asked to imagine themselves stranded in the grasslands of a foreign land without survival materials. Over the next few months, they will need to find steady supplies of food and water and protect themselves from predators. The participants' task is to rate the relevance of words to this imagined survival scenario. The rating task is followed by a surprise retention test, usually free recall, and performance after survival processing is compared with a variety of control conditions. A few seconds of survival processing leads to better recall than forming a visual image of an item, relating the item to the self, engaging in prototypical deep processing, or processing the relevance of items to a variety of control scenarios (e.g., Kang, McDermott, & Cohen, 2008; Nairne, Pandeirada, & Thompson, 2008; Otgaar et al., 2011; Weinstein, Bugg, & Roediger, 2008). Survival processing even matches or betters the "gold standard" for improving free recall—combining individual-item and relational processing in the same list (Burns, Burns, & Hwang, 2011; Nairne & Pandeirada, 2008).

Although the survival-processing effect is an established and robust empirical phenomenon, at least when recall and recognition are used as the memory measures, its interpretation remains controversial. In their original paper, Nairne et al. (2007) offered a functional account rooted in evolutionary theory: Our capacity to remember evolved, subject to nature's criterion of fitness enhancement, and therefore our memory systems are sensibly "tuned" to the processing of fitness-relevant information. However, Nairne et al. (2007) left unspecified the proximate mechanisms that might lead to such a "tuning." A variety of accounts have subsequently been offered. For example, at least part of the survival-processing advantage typically seen in free recall may be accounted for by "congruity" between the survival task and the to-be-remembered target words (Butler, Kang, & Roediger, 2009; Nairne & Pandeirada, 2011). Moreover, traditional

J. S. Nairne (✉) · J. N. S. Pandeirada · J. E. VanArsdall · J. R. Blunt
Department of Psychological Sciences, Purdue University, 703 Third Street, West Lafayette, IN 47907-2081, USA
e-mail: nairne@psych.purdue.edu

J. N. S. Pandeirada
University of Aveiro, Aveiro, Portugal

Published online: 05 August 2014

explanatory mechanisms, such as “deep processing” or elaboration, may be sufficient to account for survival advantages in some cases. Kroneisen and Erdfelder (2011) showed that survival-processing advantages emerged only when the processing task afforded a sufficient amount of elaboration. For example, when the survival-encoding context was narrowed considerably, such as worrying only about finding potable water, no survival-processing advantage was detected. Assessing survival relevance also leads to the generation of more “ideas,” as compared with controls (Roer, Bell, & Buchner, 2013), suggesting a particularly rich form of encoding, and sometimes to higher rates of both true and false recollections (Howe, 2011; Howe & Derbish, 2010; Otgaar & Smeets, 2010).

Our present experiments were designed to address two important empirical questions. First, when asked about the content of prior processing, are people better able to identify information that has been processed for survival? If survival processing leads to a more elaborative memory trace or engages richer cognitive operations, one might anticipate better source identification performance after survival processing. Deep levels of processing typically lead to better internal source identification; that is, when people are asked to identify whether an item was processed at a deep or shallow level, they are more accurate at identifying the deeply encoded items (see Gallo, Meadow, Johnson, & Foster, 2008; Jacoby, Shimizu, Daniels, & Rhodes, 2005; Jacoby, Shimizu, Velanova, & Rhodes, 2005). Similar results are found when people are asked to decide whether a target word had been self-generated (e.g., from a word fragment) or merely read during study (e.g., Riefer, Chien, & Reimer, 2007). To the extent that survival processing induces deep or elaborative processing, we would therefore expect it to enhance source identification performance.

One might also reasonably argue that it would be adaptive from an evolutionary perspective to remember whether an environmental event had been processed in terms of its survival relevance. Earlier work from our laboratory has demonstrated that people show enhanced memory for the locations of items that have been processed for survival (Nairne, VanArsdall, Pandeirada, & Blunt, 2012), although the benefit depends on an orienting task that draws attention to location (see Bröder, Krüger, & Schütte, 2011). If survival processing produces a unique mark of nature’s criterion on encoded memories (see Nairne, 2010), participants should presumably be able to use this “mark” (or its absence) to solve the source identification problem. On the other hand, to the extent that emotional processing might be involved, source memory can sometimes be impaired (see Chiu, Dolcos, Gonsalves, & Cohen, 2013).

Second, our experiments were designed to examine the mnemonic consequences of source-constrained retrieval operations. When making judgments about prior occurrence, such as in a source identification test, people constrain their search to task-relevant encoding dimensions; these search processes, in turn, can affect later retention of the queried test items. Pertinent evidence comes from the “memory-for-foils” paradigm introduced by Jacoby et al. (2005a). After words had been processed with deep or shallow orienting instructions, recognition tests were given that required people to discriminate between new items (foils) and either the deep or the shallow targets. Under these conditions, people appear to constrain their memory search to the task-relevant encoding dimension; that is, people solve the recognition memory problem by probing both test items and foils for the presence or absence of deep features (when the target items are exclusively deeply processed items) or shallow features (when targets have been shallowly processed). The mnemonic consequences of the constrained search were revealed in a final “foil” recognition test that required people to discriminate the “old” foils from the original recognition tests from newly presented foils. Jacoby, Shimizu, Daniels, and Rhodes found a levels-of-processing effect for the foils: People were more likely to recognize the foils from the “deep” recognition test, presumably because they processed those items for meaning as a consequence of the source-constrained retrieval process (see also Alban & Kelley, 2012; Marsh et al., 2009).

The memory-for-foils paradigm indicates that people can exercise early cognitive control over the retrieval processes that govern recognition memory judgments (Jacoby et al. 2005a; see Halamish, Goldsmith, & Jacoby, 2012, for evidence of a similar constraining process during cued recall). It demonstrates as well that the operations engendered exclusively by retrieval can act as a memory modifier, enhancing later retention of retrieved items (e.g., Bjork, 1975). In the present case, we were interested in whether constraining retrieval to fitness-relevant features—the remnants of prior survival processing—would yield enhanced mnemonic benefits, relative to controls. More specifically, does asking people to decide whether an item has been processed previously for survival yield a more substantial mnemonic boost to that item than asking about other forms of deep processing? Such a demonstration would provide further support for source-constrained retrieval, using a novel processing mode, but also extend the study of fitness-relevant processing to a retrieval context. Some have argued that survival-processing advantages are an indirect consequence of relevance ratings, inducing differential “congruity” between survival and control conditions (e.g., Butler et al., 2009), so survival benefits in this retrieval context should help reduce the generality of such concerns.

In each of our experiments, participants were initially asked to process items with respect to a survival scenario or to one of two control conditions—pleasantness (Experiments 1 and 2) or the “moving” scenario (Experiment 3) employed originally by Nairne et al. (2007). Source identification tests then required people to identify the earlier form of processing (i.e., whether a survival or a control decision had been made about the item); both old and new items were presented on these tests. Lastly, in a surprise free recall test, people were asked to recall all of the items (old and new) from the source identification tests. Again, we were interested in whether source identification advantages would be found for survival items and whether survival queries during the source tests would enhance later free recall to a greater extent than control queries.

Experiment 1

Experiment 1 was divided into three phases. In phase 1, the encoding phase, participants were asked to rate 12 words for survival relevance and 12 words for pleasantness; the words were unrelated, and the rating decisions were intermixed within a single list.[1] In phase 2, the source identification test, the 24 *old* words were intermixed with 24 *new* words, and people were asked to decide whether each presented word had been processed previously for survival or pleasantness. Half of each word type—survival-rated, pleasantness-rated, and new words—were queried about survival ("Did you rate this word for survival?"), and half were queried about pleasantness ("Did you rate this word for pleasantness?"); decision and word group were again intermixed in the test list. In phase 3, the recall test, participants were given 10 min to recall all of the words that had appeared in the experiment.

Method

Participants and apparatus

Sixty participants were recruited from the Purdue community. Each received either a small monetary compensation or partial credit in an introductory psychology course. Everyone was tested in sessions lasting approximately 40 min. Up to 4 participants were tested in the same session. Stimuli were presented and controlled by personal computers.

Materials and design

Forty-eight words (plus six practice words) were selected from the MRC Psycholinguistic Database (e.g., Coltheart, 1981), with the following constraints: four to eight letters in length, Kučera–Francis written frequency between 7 and 10, and a relatively high familiarity and concreteness (between 500 and 700 on a 100-to-700 scale).

A within-subjects design was used. During phase 1, participants were instructed to make either a survival or a pleasantness rating about each of the 24 target words. Rating decisions were distributed evenly across the list, with the following constraints: No more than two ratings of a given type could occur consecutively, and the same number of survival and pleasantness decisions was required in each half of the list. Rating order was counterbalanced across participants to ensure that a survival and a pleasantness decision occurred the same number of times in each position of the list and for each word.

For the source identification test, the 24 *old* words and 24 *new* words were intermixed in one list, as was the source identification question ("Did you rate this word for SURVIVAL?" and "Did you rate this word for PLEASANTNESS?"). Half of the survival-rated words received a survival query (a correct *yes* response corresponds to a hit), as did half of the pleasantness-rated words (a *yes* response corresponds to an *old* false alarm) and half of the *new* words (a *yes* response corresponds to a *new* false alarm). Similarly, half of the pleasantness-rated words received a pleasantness query (a *yes* response corresponds to a hit), along with half of the survival-rated words (a *yes* response corresponds to an *old* false alarm) and half of the *new* words (a *yes* response corresponds to a *new* false alarm). Equal numbers of *old* and *new* words were presented in each half of the test list, along with an equal number of survival/pleasantness queries. All possible combinations were equally distributed in each half of the list. Query was also counterbalanced across participants, ensuring that each word was queried the same number of times about survival and pleasantness. Final free recall followed the source identification test.

Procedure

On arrival in the laboratory, people were randomly assigned to one of the counterbalancing versions. People were told that they would be rating words in one of two ways—for pleasantness or with respect to a survival situation. The specific instructions follow:

> In this task we are going to show you a list of words, and we would like you to rate each word in one of two ways. For some words, we would like you to provide a PLEASANTNESS rating; for other words, we would like you to rate their relevance to a SURVIVAL situation, as described below. Each word will be presented with a question that specifies the rating decision you'll have to make for that particular word.
> For the SURVIVAL situation, please imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water and

[1] Intermixing the two rating tasks (survival and pleasantness) might raise concerns about possible carryover effects. However, robust survival-processing advantages have been demonstrated repeatedly in designs in which survival and pleasantness ratings are intermixed in the same list (see, e.g., Nairne & Pandeirada, 2011, Experiment 1).

> protect yourself from predators. We would like you to rate how relevant the word would be for you in this survival situation. The scale of relevance ranges from one to five, with one (1) indicating totally irrelevant and five (5) signifying extremely relevant. Some of the words may be relevant and others may not—it's up to you to decide.
> For the other dimension, we would like you to rate the PLEASANTNESS of the word. The scale of pleasantness ranges from one to five, with one (1) indicating totally unpleasant, and five (5) signifying extremely pleasant. Some of the words may be pleasant and others may not—it's up to you to decide.

A short practice session of six items preceded the main rating session. Accompanying each word was a question specifying the required rating decision ("How relevant is this word to the SURVIVAL situation?" or "How PLEASANT is this word?"). The rating scale was presented along with the word. The target word was presented in the center of the screen (between the question and the rating scale). Participants produced their responses by entering the number of their choice, using the keyboard. Target words remained on the screen for the full 5 s; there was a short 250-ms intertrial interval.

After the last word was rated, participants engaged in a distractor task—solving Sudoku puzzles—that lasted 10 min. Phase 2 instructions then appeared. The specific instructions for the source identification test were as follows:

> In the next task, you will be presented with a set of words. For each word we will ask you to judge if during the initial task of the experiment you made a PLEASANTNESS or a SURVIVAL rating about that word. You will respond by clicking "Yes" or "No" on the screen using your mouse. Be careful: each word will appear for only five seconds so you'll need to make your decisions rather quickly.

People were given 5 s to complete each response. No further information was given about the nature of the test words; that is, participants were not told that the source test would contain a mixture of *old* and *new* words. The source test was followed by another short distractor task—solving a series of addition problems for approximately 2 min. Participants were then asked to recall all of the earlier presented words. The specific instructions follow:

> Now we would like to see if you can remember all the words you had to make decisions about throughout this experiment. These include the ones you rated in the initial part of the experiment and also all of the words presented during the Yes/No judgment task—this includes both the YES words and the NO words.

The final recall phase proceeded for 10 min, and participants were asked to draw a line on the recall sheet, under the last recalled word, after each min of recall. A clock was displayed on the computer monitor, and a "beep" sounded every minute signaling the participants to draw the line. Using this procedure allows one to construct cumulative recall curves, but they are not reported here.

Results and discussion

The level of statistical significance, unless otherwise noted, was set at $p < .05$ for all comparisons. During the initial rating task, less than one word, on average, was left unrated by each participant. Because of the small number of unrated trials, and to avoid item selection problems, we left the retention data described below unconditionalized.

During the initial rating task, the average relevance ratings for the survival-processing condition (2.68) and the pleasantness condition (2.74) did not differ statistically, $t(59) < 1$. However, participants took significantly longer to provide a survival rating than a pleasantness rating (survival = 3,067 ms; pleasantness = 2,763 ms), $t(59) = 6.20$, $p < .001$, $d = 0.75$.

Source identification

Mean data for the source identification test are shown in Fig. 1. The figure shows the mean proportion of *yes* responses for words queried at test for a survival or pleasantness decision. The left side of the figure shows the data for hits; these are correct responses for words processed initially for survival or pleasantness and then queried with a matching decision at test. The *old* false alarms represent cases in which people incorrectly responded *yes* to a word that had been seen during

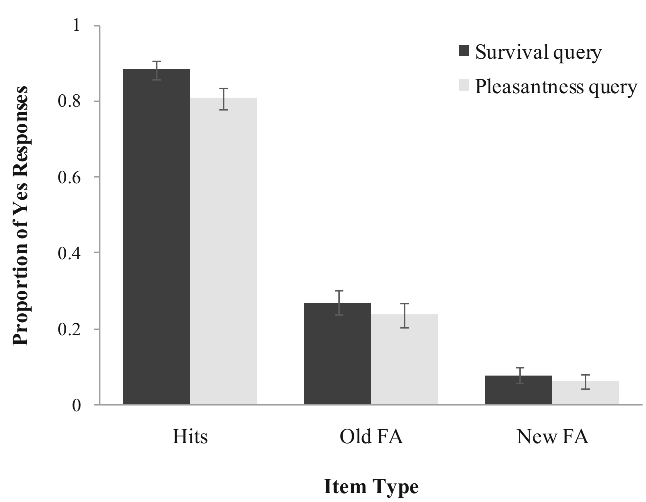

Fig. 1 Proportion of *yes* responses as a function of query and item type during the source identification test in Experiment 1. Error bars represent standard errors of the means

the initial rating phase of the experiment but was queried with a mismatching decision at test; for example, the participant incorrectly thought that a survival-rated word had been processed for pleasantness during the first phase. The *new* false alarms represent cases in which the participant incorrectly responded *yes* to a word that was not presented during the first phase of the experiment.

A repeated measures analysis of variance (ANOVA) on these data with source query (survival vs. pleasantness) and word type (*old* items with a matched decision, *old* items with a mismatched decision, and *new* items) as within-subjects variables revealed a main effect of query, $F(1, 59) = 7.89$, $MSE = .02$, $\eta^2_p = .118$, and word type, $F(2, 118) = 267.67$, $MSE = .074$, $\eta^2_p = .82$, but no reliable interaction, $F(2, 118) = 1.67$, $MSE = .02$, $\eta^2_p = .028$. Thus, people were more likely to respond *yes* to a survival query at test regardless of whether the item was old or new and, if old, whether the item had been rated initially for survival or pleasantness. People were able to perform the task successfully—that is, the hit rate was substantially higher than either the *old* or the *new* false alarm rate—but no survival-processing advantage was found in source identification. Signal detection analyses of the data led to the same conclusion: No significant difference in source identification was found between survival ($d' = 1.76$) and pleasantness ($d' = 1.67$) processing, using the *old* false alarms as the comparative base, $t(57) < 1$. However, there was a significant difference in criterion, *c*, with a greater bias toward responding *yes* for survival queries ($c = –.18$) than for pleasantness queries ($c = –.03$), $t(57) = –2.54$, $d = –0.40$.

Final free recall

Performance on the final free recall test, during which people were asked to recall all of the items from the source identification test, is shown in Fig. 2. Performance is plotted as a function of the query presented during the source test (survival or pleasantness) and word type (old or new). The left side of the figure shows proportion of correct recall for the *old* words (collapsed across the initial rating decision); performance for the *new* words is shown on the right. The full recall data, presented as a function of initial rating decision, are shown in the Appendix. A repeated measures ANOVA with source query and word type as within-subjects variables revealed a main effect of query: Words queried for survival were more likely to be recalled than words queried for pleasantness, $F(1, 59) = 4.39$, $MSE = .016$, $\eta^2_p = .069$. There was also a main effect of word type—more *old* words were recalled than *new* words, $F(1, 59) = 327.20$, $MSE = .022$, $\eta^2_p = .847$—but there was no reliable interaction between query and word type, $F < 1$.

To rule out any effect of query decision time on recall, we also analyzed response times during the source test. If people take longer to make decisions about survival queries than about pleasantness queries, perhaps because the survival decisions are more effortful, then one might be able to attribute the free recall differences to such a factor. Average response times are shown in Table 1 as a function of source query (survival vs. pleasantness) and whether the item was old (occurred during the initial rating phase) or new. An ANOVA on these data revealed a main effect of query, $F(1, 59) = 9.91$, $MSE = 49{,}463$, $\eta^2_p = .144$, indicating that participants actually took longer to respond to the pleasantness queries. There was also a main effect of word type, $F(1, 59) = 62.9$, $MSE = 193{,}890$, $\eta^2_p = .516$, with longer decision times for the *old* items than for the *new* items. The interaction between query and item type was not reliable, $F(1, 59) < 1$.

As was noted earlier, the final free recall test was designed to assess the mnemonic effects of source-constrained retrieval. Earlier work by Jacoby et al. (2005a) and others (Halamish et al., 2012; Marsh et al., 2009) has shown that source-constrained retrieval can have mnemonic effects on later recognition memory and the benefits obtained depend on the type of information processed during the source test. Searching for evidence of prior deep (semantic) processing enhances memory for encountered new word foils to a greater extent than does shallow (orthographic) processing. Does the act of assessing an item for the remnants of earlier survival processing produce a greater mnemonic boost than assessing for

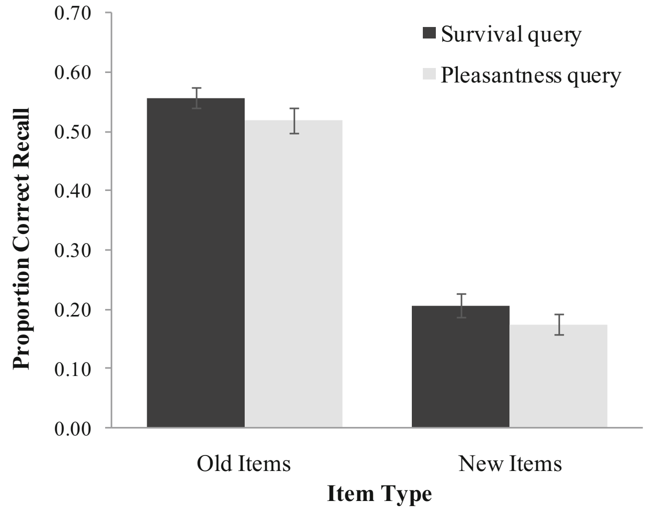

Fig. 2 Proportion of correct recall as a function of query and item type in Experiment 1. Error bars represent standard errors of the means

Table 1 Average response times (in milliseconds) and standard deviations (in parentheses) during the source identification test in Experiment 1 as a function of source query and word type

	Old Words	New Words
Survival	2,462 (360)	2,028 (452)
Pleasantness	2,569 (409)	2,101 (457)

pleasantness processing? The results of Experiment 1 provide evidence for a *survival effect* during final free recall, thereby extending earlier work on source-constrained retrieval to another domain (free recall) and to a new set of processing dimensions (survival vs. pleasantness processing). As we discuss later, these results may help constrain hypotheses about the possible proximate mechanisms that underlie survival-processing advantages.

Experiment 2

The purpose of Experiment 2 was to replicate Experiment 1 using a slightly different design, one that more closely mimics the criterial recollection task developed by Gallo et al. (2008). There were two major design changes from Experiment 1. First, during the initial rating phase of the experiment, some words were presented twice, and participants were required to rate those items for survival relevance on one trial and for pleasantness on the other. As Gallo et al. have argued, requiring both types of decision during initial encoding reduces the chances that people will focus exclusively on one type of processing to solve the source discrimination problem. For example, one might search for evidence of survival processing and, if absent, simply decide that the item must have been processed for pleasantness or that it is a new item. Presenting items twice solves this problem because the presence or absence of a particular feature type (e.g., encoded survival features) does not determine whether or not the other type of processing was engaged as well.

The second design change in Experiment 2 was that the type of query was blocked, rather than intermixed, during the source identification test. Participants received four blocks of 15 items during the source test (three survival-rated words, three pleasantness-rated words, three both-rated words, and six new words). People were queried about either pleasantness or survival in each block in an alternating fashion (i.e., SPSP or PSPS). The use of a blocked design, in which people make only one kind of decision during a block of trials, closely matches earlier experiments on source-constrained retrieval effects (e.g., Jacoby et al. 2005a). In addition, people were fully informed about the nature of the test list in Experiment 2; that is, they were told that for some words they had earlier made a pleasantness decision, for some words they had made a survival decision, and for some words they had made both a survival and a pleasantness decision and also that there would be new words.

Method

Participants and apparatus

Seventy-two Purdue undergraduates participated in exchange for partial credit in an introductory psychology course. Everyone was tested in sessions lasting approximately 40 min. Up to 4 participants were tested in the same session. Stimuli were presented and controlled by personal computers.

Materials and design

The 48 words from Experiment 1 were used again in Experiment 2. An additional set of 12 words was selected using the criteria described previously. A within-subjects design was employed: Participants were instructed to make either a survival or a pleasantness rating about each of 24 target words; for 12 additional words, participants provided a survival and a pleasantness rating on separate trials. Rating tasks were intermixed and distributed evenly across the list as described in Experiment 1. Also, for the words processed twice, half were processed for survival and half for pleasantness in each half of the list. The number of intervening items between the occurrences of the same item during the rating task ranged between 13 and 36, with an average of 24 intervening items. Task order was counterbalanced across participants.

Procedure

On arrival in the laboratory, people were randomly assigned to one of the counterbalancing versions. People were told that they would be rating words in two ways: either for pleasantness or with respect to a survival situation. The rating instructions were identical to those used in Experiment 1, with the following addition:

> For some words you will be asked to make only one rating decision (about either PLEASANTNESS OR SURVIVAL); for other words you will be asked to make both decisions (PLEASANTNESS AND SURVIVAL), but you will do so at different times.

In all other respects, the rating and 10-min distractor task followed the procedure outlined in Experiment 1. For the source task, 36 *old* words and 24 *new* words were divided into four blocks of 15 words. Each block contained 3 survival-rated words, 3 pleasantness-rated words, 3 both-rated words, and 6 new words. In a given block, participants were queried exclusively about either pleasantness or survival; query type varied in an alternating fashion across blocks (i.e., SPSP or PSPS). The question "Did you rate this word for SURVIVAL?" or "Did you rate this word for PLEASANTNESS?" was presented along with each individual word in a given type of block. The instructions for the survival blocks follow:

> In the next task, you will be presented with a set of words. For each word we would like you to judge if you made a SURVIVAL rating about that word in the first

part of the experiment. There will be four types of words presented to you: words that you made a pleasantness decision about, words you made a survival decision about, words for which you made both a survival and a pleasantness decision, and also new words. Your task is to click on the YES button if you remember making a survival decision about that word; otherwise click on the NO button.

It is important to remember that for some of the words you made two decisions—both a pleasantness decision and a survival decision. So, remembering that you made a pleasantness decision about a particular word is irrelevant in this task. You need to remember whether or not you made a survival decision about the word. You should click YES for any word you made a survival decision about, even if you also made a pleasantness decision about that word.

The instructions for the pleasantness blocks were exactly the same, except that the word *pleasantness* was substituted for *survival* (and vice versa when appropriate). The source task was followed by a distractor task lasting about 2 min. In this task, participants were asked to perform a series of addition operations. At the end of this period, participants were asked to recall all the earlier presented words—the ones presented during the processing task, as well as the ones presented in the source task. In all respects, including instructions, the free recall task resembled the one used in Experiment 1.

Results and discussion

During the initial rating task, less than one word, on average, was left unrated by each participant. Because of the small number of unrated trials and to avoid item selection problems, we left the retention data described below unconditionalized. In Experiment 2, average survival ratings (2.86) were significantly higher than average pleasantness ratings (2.68), $t(71) = 3.85$, $p < .001$, $d = 0.46$; as in Experiment 1, it also took people longer to rate the items for survival (2,932 ms) than for pleasantness (2,577 ms), $t(71) = 11.57$, $p < .001$, $d = 0.96$.

Source identification

Mean data for the source identification test are shown in Fig. 3. The figure shows the mean proportion of *yes* responses for words queried during the survival and pleasantness blocks. The first two sets of bars show correct responses (hits) for the items presented once or twice, respectively. The third and fourth sets show the false alarm data for *old* and *new* items, respectively. An overall repeated measures ANOVA with source query (survival vs. pleasantness) and word type (*old* items with a matched decision, "both" items, *old* items with a mismatched decision, and *new* items) as within-subjects variables revealed a main effect of word type, $F(3, 213) = 547.99$, $MSE = .045$, $\eta^2_p = .885$, but no significant effect of query, $F(1, 71) = 2.88$, $MSE = .023$, $\eta^2_p = .039$, or query × word type interaction, $F < 1$. Once again, replicating Experiment 1, the data fail to provide any evidence for a survival effect in source identification. Signal detection analyses confirmed this conclusion: No significant difference in source identification was found between survival ($d' = 1.68$) and pleasantness processing ($d' = 1.67$) using the *old* false alarms as the comparative base, $t(70) < 1$. We restricted our analysis here to the items presented only once, given that there was no defined false alarm rate for the items presented twice (any *yes* response for the "both" items was correct). As in Experiment 1, people were more likely to respond *yes* for items queried for survival, but the main effect of query did not reach conventional levels of significance in Experiment 2. Signal detection analyses showed a similar trend: There was a greater bias toward responding *yes* for survival queries ($c = -.16$) than for pleasantness queries ($c = -.06$), but the difference did not reach conventional levels of significance, $t(70) = -1.75$.

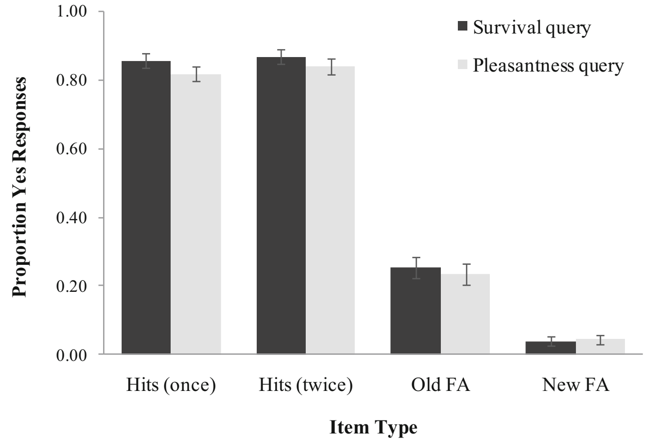

Fig. 3 Proportion of *yes* responses as a function of query and item type during the source identification test in Experiment 2. Error bars represent standard errors of the means

Final free recall

Figure 4 shows proportion correct recall for the various conditions as a function of query question (i.e., survival or pleasantness). The left side of the figure shows proportion of correct recall for *old* words presented once (collapsed across the initial rating decision), the middle shows proportion of correct recall for words processed twice, and the right side shows proportion of correct recall for the *new* words. An overall repeated measures ANOVA with query type (survival vs. pleasantness) and word type (once, twice, and new) as within-subjects variables revealed a reliable main effect for query, $F(1, 71) = 12.72$, $MSE = .016$, $\eta^2_p = .152$, and word type, $F(2, 142) = 310.83$, $MSE = .025$, $\eta^2_p = .814$, but also a reliable interaction, $F(2, 142) = 5.44$, $MSE = .022$, $\eta^2_p = .071$. For the *old* words processed once, query type failed to affect

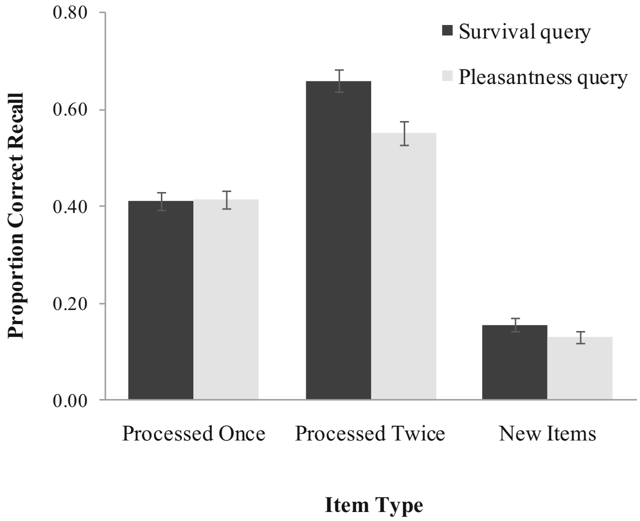

Fig. 4 Proportion of correct recall as a function of query and item type in Experiment 2. Error bars represent standard errors of the means

recall, $t(71) < 1$; for the words processed twice (both a survival and a pleasantness decision were required during the first phase of the experiment), the survival query significantly enhanced recall, as compared with the pleasantness query, $t(71) = 3.62$, $p < .001$, $d = 0.53$. The number of *new* words recalled after a survival query was also slightly higher than after a pleasantness query, but the difference was not statistically significant, $t(71) = 1.59$.

Once again, we also analyzed the response times from the source identification task to rule out any simple effort-based interpretation of the recall data. Table 2 shows the relevant data for the items processed once or twice and for the new items. A repeated measures ANOVA revealed a main effect of word type, $F(2, 142) = 71.94$, $MSE = 95{,}503.2$, $\eta^2_p = .50$. Participants were faster to respond to new items and slowest on the items rated once. Neither the main effect of query nor the interaction was reliable in the analysis, $F(1, 71) = 3.14$, $MSE = 111{,}093$, $\eta^2_p = .04$, and $F(2, 142) = 1.18$, $MSE = 42{,}469$, $\eta^2_p = .02$, respectively.

The results of Experiment 2 are generally consistent with those of Experiment 1 in demonstrating two findings. First, there was little indication that survival processing enhances identification of source, at least as compared with pleasantness processing, even though survival processing typically leads to significant benefits in free recall. To the extent that survival processing leads to a richer trace or more elaborate cognitive operations, we expected to find survival advantages on the source identification test. Second, both experiments showed that the source identification process itself has mnemonic effects, replicating the work of Jacoby et al. (2005a), although the present experiments used final free recall, rather than a final recognition test.

Table 2 Average response times (in milliseconds) and standard deviations (in parentheses) during the source identification test in Experiment 2 as a function of query and word type

	Processed Once	Processed Twice	New Words
Survival	2,119 (330)	1,941 (337)	1,709 (341)
Pleasantness	2,218 (363)	1,968 (459)	1,753 (348)

Experiment 3

Our first two experiments compared survival processing with a control condition in which participants rated items for pleasantness. Pleasantness processing has often been used as a control in survival-processing experiments; it represents a quintessential form of "deep processing," one that leads to significant improvements in long-term recall and recognition (e.g., Packman & Battig, 1978). As a result, survival advantages relative to a pleasantness control demonstrate the power of survival processing as a mnemonic encoding technique (Nairne et al., 2008). At the same time, processing an item for pleasantness is typically conceptualized as a form of individual-item processing, as opposed to relational or whole-list processing, and encoding techniques that focus on item qualities may transfer especially well to source identification tests. In Experiment 3, we used another common control for survival processing—a scenario involving moving to a foreign land. Unlike rating an item for survival, the moving scenario does not involve fitness-relevant processing, but it presumably invokes more schematic processing than does pleasantness (see Nairne et al., 2007, for relevant evidence). Except for blocking the survival and control (moving) conditions during the initial rating task, the design of Experiment 3 matched the one used in Experiment 2.

Method

Participants and apparatus

Sixty-four Purdue undergraduate students participated in exchange for partial credit in an introductory psychology course. Everyone was tested in sessions lasting approximately 40 min. Up to 4 participants were tested in the same session. Stimuli were presented and controlled by personal computers.

Materials and design

The 60 words from Experiment 2 were used again in this experiment. A within-subjects design was employed: Participants were instructed to make either a survival or a moving rating about each of the 24 target words. For 12 additional words, participants provided both a survival and a moving rating (in separate blocks). Rating tasks were blocked in sets of 12 words (6 words to be processed once and 6 words to be processed in both encoding conditions); blocks alternated in a SMSM or MSMS fashion to ensure that a survival and a moving decision occurred the same number of times in each position of the list and for each item. Words were randomly distributed within each block, with the constraint that no more than 2 words of the same type (processed once or twice) would be presented consecutively.

Procedure

On arrival in the laboratory, people were randomly assigned to one of the counterbalancing conditions. People were then told that they would be rating words in two ways. The specific instructions for each block (for either the survival or the moving rating task) appeared at the beginning of the block. Specific instructions follow:

> *Survival instructions:* "In this task, please imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water and protect yourself from predators. We would like you to rate how relevant the word would be for you in this survival situation."
> *Moving instructions:* "In this task, please imagine that you are planning to move to a new home in a foreign land. Over the next few months, you'll need to purchase a new house and find help transporting your belongings. Please rate how relevant each of these words might be for you in this moving situation."

A short practice session of three items preceded the first two blocks to familiarize participants with each scenario. In all other respects, the procedure matched the one used in Experiment 2. After the rating phase, there was a 10-min distractor task (Sudoku puzzles) followed by the source identification test. The source test was identical to the one used in Experiment 2, except that *moving* queries were substituted for pleasantness queries. Following the source test, there was a 2-min distractor task, and then the instructions for the final free recall test appeared. Again, the procedure matched the one used in Experiment 2.

Results and discussion

During the initial rating task, less than one word, on average, was left unrated in each condition. Because of the small number of unrated trials and to avoid item selection problems, we left the retention data described below unconditionalized. As in Experiment 2, the survival ratings exceeded the control ratings (survival = 2.7, moving = 2.2), $t(63) = 7.66$, $p < .001$, $d = 1.05$; however, no differences were found in response times between the survival and moving conditions (survival = 2,047, moving = 2,040), $t(63) < 1$.

Source identification

Mean data for the source identification test are shown in Fig. 5, presented in the format used for Experiment 2. The figure shows the mean proportion of *yes* responses for words queried during the survival and moving blocks. An overall repeated measures ANOVA with source query (survival vs. moving) and word type (*old* items with a matched decision, "both" items, *old* items with a mismatched decision, and *new* items) as within-subjects variables revealed a main effect of query, $F(1, 63) = 36.79$, $MSE = .025$, $\eta^2_p = .369$, and word type, $F(3, 189) = 275.61$, $MSE = .064$, $\eta^2_p = .814$; the interaction was significant as well, $F(3, 189) = 6.52$, $MSE = .02$, $\eta^2_p = .094$. Separate paired *t*-tests revealed significant survival advantages in the hit rate data for items presented either once, $t(63) = 5.77$, $d = 0.55$, or twice, $t(63) = 4.10$, $d = 0.43$; there was also a significant survival advantage for the *old* false alarms, $t(63) = 2.80$, $d = 0.43$, but not for the *new* false alarms, $t(63) < 1$. Signal detection analyses confirmed these results, using the once-presented items: No significant difference in source identification was found between survival ($d' = 1.46$) and moving ($d' = 1.39$) processing, using the *old* false alarms as the comparative base, $t(59) < 1$. However, there was a significantly greater bias toward responding *yes* for survival queries ($c = -.35$) than for moving queries ($c = -.05$), $t(59) = -4.62$, $p < .01$, $d = -0.66$.

Final free recall

Figure 6 shows proportion correct recall for the various conditions as a function of query question (i.e., survival or

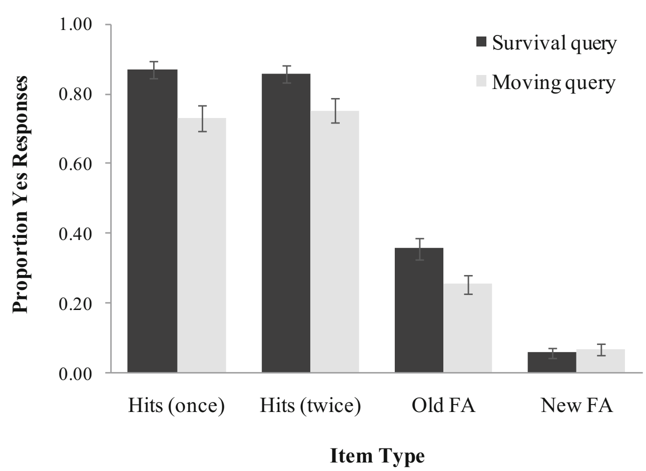

Fig. 5 Proportion of *yes* responses as a function of query and item type during the source identification test in Experiment 3. Error bars represent standard errors of the means

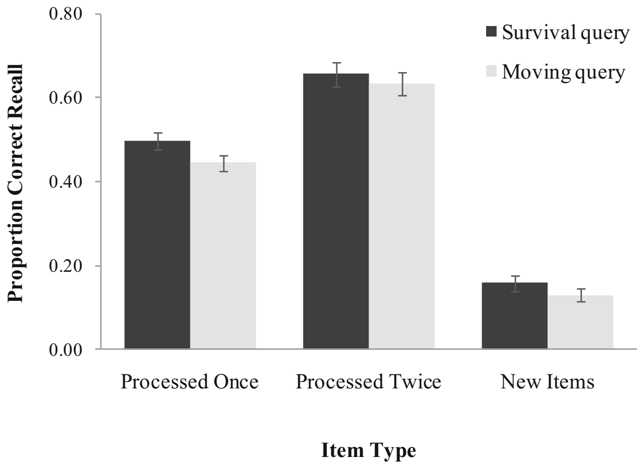

Fig. 6 Proportion of correct recall as a function of query and item type in Experiment 3. Error bars represent standard errors of the means

moving). A repeated measures ANOVA with query type (survival vs. moving) and word type (once, twice, and new) as within-subjects variables revealed a reliable main effect for query, $F(1, 63) = 5.13$, $MSE = .021$, $\eta^2_p = .075$, and word type, $F(2, 126) = 324.28$, $MSE = .026$, $\eta^2_p = .837$, but no significant interaction, $F < 1$. Items presented twice were recalled better than items presented once, *old* items were recalled better than *new* items, and there was a consistent recall advantage when items were queried for survival during the source identification test. As in the previous two experiments, an analysis of the response times during the source identification task failed to explain the survival advantages seen during final free recall. The relevant data are shown in Table 3; a repeated measures ANOVA revealed significant main effects of query, $F(1, 63) = 10.4$, $MSE = 129{,}296$, $\eta^2_p = .14$, and word type, $F(2, 126) = 42.17$, $MSE = 111{,}573$, $\eta^2_p = .40$, as well as a reliable interaction, $F(2, 126) = 3.21$, $MSE = 61{,}213$, $\eta^2_p = .05$. Longer recognition decision times were found for moving queries than for survival queries.

The overall recall pattern matches the one found in the previous two experiments; constraining the search process during retrieval to survival "features" has a greater long-term mnemonic effect than constraining retrieval to features based on a non-fitness-relevant encoding task. Experiment 3 shows that this pattern holds when using a schematic control (moving) extending the generality of the result.

Table 3 Average response times (in milliseconds) and standard deviations (in parenthesis) during the source identification test in Experiment 3 as a function of query and word type

	Processed Once	Processed Twice	New Words
Survival	2,081 (376)	1,721 (323)	1,749 (315)
Moving	2,178 (357)	1,926 (403)	1,802 (380)

General discussion

The present experiments addressed two relevant empirical questions. First, when asked about the content of prior processing, are people better able to identify information that has been processed for survival? If survival processing simply leads to a more elaborative memory trace or engages richer cognitive operations, we would anticipate better source identification performance after survival processing. Across all three experiments, people failed to show an enhanced ability to identify items that had been processed previously for survival; that is, there was no "survival effect" in memory for processing source. There was an increased tendency for participants to respond *yes* to previously processed items when the source query was survival based—that is, did you process this item for survival?—but the increase occurred for both hits (survival items) and false alarms (control items). This interesting pattern, which did not occur consistently for new items in the source test, suggests that people adopt a more liberal criterion for a survival-based decision when an item is recognized as familiar.[2]

Previous work using similar experimental designs has found better source discrimination performance for deep (semantic), as compared with shallow (letter checking), encodings (Gallo et al., 2008). Not only are hit rates for deeply processed items higher, but deep processing leads to fewer false alarms in source identification as well. For example, when queried for deep processing—did you make a pleasantness judgment about this item?—people are less likely to respond *yes* to both new (lure) items and to items that had previously received shallow processing. Our experiments produced a quite different pattern: Survival queries led to higher hit rates and higher false alarm rates, as compared with the control query conditions. This suggests that people did not (or were unable to) use a distinctiveness heuristic, based on characteristics of survival encodings, as a way to control performance in the source identification test. Importantly, the use of a survival query led to consistent and statistically significant effects across the three experiments, but not to improved source identification performance.

Our source identification results also contrast with data obtained comparing two "deep" processing modes: autobiographical elaboration and semantic processing. McDonough and Gallo (2008) asked participants either to generate a relevant autobiographical experience to a presented trait word or simply rate the word as positive or negative. Source identification tests followed in which people were asked to decide

[2] There has been some controversy in the literature regarding whether people can change response criteria when items of differing strength are mixed in the same list. People do seem to change their criteria under some circumstances (see Rotello & Macmillan, 2007). As an added check, we calculated discriminability and response bias using nonparametric measures in each of the reported experiments and obtained the same results.

whether they had previously generated an autobiographical memory for a word or produced a valence rating. Generating an autobiographical experience is thought to recruit multiple cognitive operations, establishing a rich and elaborate memory trace, so McDonough and Gallo reasoned that people should be able to employ a distinctiveness heuristic, based on the elaboration, to reduce false recollections. Indeed, matching the pattern found for deep processing (Gallo et al., 2008), there were fewer false alarms to old (previously studied) lures on the autobiographical test than on the valence test. To the extent that survival processing produces robust recall because of increased elaboration relative to control conditions, a similar pattern should have been found in the present experiments. Instead, false alarms to studied lures increased when items were queried for survival, a pattern that is inconsistent with a simple elaboration hypothesis.

It is important to note as well that our results join others in demonstrating some limitations (or boundary conditions) of survival processing. Survival-processing advantages fail to extend to the processing of faces (Savine, Scullin, & Roediger, 2011) or story content (Seamon et al., 2012), may have little or no effect on judgments of learning (Palmore, Garcia, Bacon, Johnson, & Keleman, 2012), and do not appear on some implicit tests of retention (Tse & Altaribba, 2010). More pertinent, Bröder et al. (2011) recently failed to find any survival-processing advantages in a source memory test that required people to remember the position that rated words appeared on a computer screen. Recent work from our laboratory has shown that survival processing can lead to enhanced location memory, but only when the encoding task specifically orients the participant to location information (Nairne et al., 2012). As Bröder et al. suggested, from an adaptive perspective, we would anticipate survival processing to improve memory for source. Remembering that an item was previously processed in a survival context certainly seems important, more so than remembering that it was previously processed for pleasantness or with respect to a moving scenario.

The second question that motivated the present experiments focused on the mnemonic effects of source-constrained retrieval operations. When asked to decide about the content of prior processing—for example, was this item previously processed for survival?—people typically constrain retrieval to task-relevant dimensions; in other words, people search for information in the test item that is consistent with the test query (e.g., remnants of survival processing). Constraining retrieval in this way has long-term mnemonic consequences for evaluated items. For example, retrieval queries that ask about deep or semantic features lead to better long-term recognition of evaluated lures (items that were newly presented during the recognition test) than do queries about shallow features (Jacoby et al. 2005a; Marsh et al., 2009). We were interested in whether constraining retrieval to the evaluation of prior survival processing would produce a larger mnemonic boost on later recall than would constraining retrieval to control dimensions (pleasantness or moving).

The final free recall data revealed a consistent pattern: When participants were asked to decide whether an item had been processed previously for survival, that item was subsequently recalled better than when the source query asked about pleasantness or relevance to a moving scenario. Figure 7 shows the final free recall data collapsed across the experiments for each type of item: items processed once or twice during the initial rating task and the new items. The new items are of particular interest because they were not processed during the initial rating phase of the experiments—they occurred only during the source identification test—so differential recall performance for these items can be attributed uniquely to the consequences of the source-constrained retrieval process. A survival advantage was obtained for these items, $t(195) = 2.62$, $p < .01$, $d = 0.22$. A survival advantage was also found for the items processed twice, $t(135) = 3.0$, $p < .01$, $d = 0.32$. Here again, these items left the initial rating stage in an equivalent mnemonic state: Each item had been processed once for survival and once for pleasantness or moving. Differences in final free recall can therefore be attributed uniquely to the processing that occurred during the source task itself. These data support earlier work on source-constrained retrieval (e.g., Jacoby et al. 2005a) but generalize the conclusions beyond the recognition-based "memory for foils" paradigm to free recall and to a new processing domain—survival processing (see also Danckert, MacLeod, & Fernandes, 2011).

We believe the present experiments have implications for understanding the proximate mechanisms that may underlie survival processing; at least, they help constrain

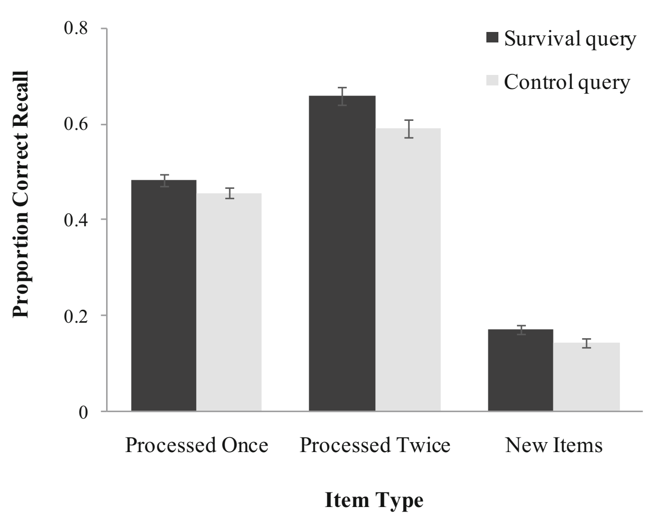

Fig. 7 Proportion of correct recall collapsed across all experiments as a function of query and item type. Error bars represent standard errors of the means

what those mechanisms might be. In the present case, unlike previous research using manipulations of processing depth, our experiments dissociate memory for internal source from the mnemonic effects of the source judgment task. We did not detect an enhanced ability to identify items that had been processed previously for survival, but the process of survival-based retrieval itself led to enhanced retention. The first finding suggests that elaboration, perhaps through the engagement of enriched cognitive operations, may not completely explain the survival advantage frequently found in recall. The second finding shows that the benefits of survival processing extend beyond those studied previously in simple relevance-ratings contexts. Some have argued that relevance ratings promote enhanced congruity, or "fit," between items and survival scenarios (e.g., Butler et al., 2009); thus, demonstrating survival advantages in the absence of relevance ratings—that is, as a consequence of a source decision—lowers the chances that congruity can completely explain survival-processing effects (see also Nairne & Pandeirada, 2011).

At the same time, the null effect of survival processing on source identification seems inconsistent with a functional/evolutionary account as well. If survival processing produces a unique mark of nature's criterion on encoded memories (see Nairne, 2010), then why were participants unable to use the presence or absence of this "mark" to solve the source identification problem? Of course, null effects are difficult to interpret; one could always claim that the current manipulations were not robust enough for differences to be detected on our source identification tests. But source identification performance overall was well above chance levels, and the final free recall data indicate that our experiments were sensitive enough to detect query-based differences in retention. For whatever reason, people were clearly unable to use the memory records of items processed for survival to gain a selective advantage in the source identification task.

In the past, we have suggested that survival processing may be "special;" that is, organisms may have evolved special systems for processing fitness-relevant information. It is extremely difficult to make a definitive case for evolved cognitive adaptations, but the present data, along with relevant data from other laboratories, do indicate that the mnemonic effects of survival processing may be somewhat unique, relative to other standard forms of processing (see Burns et al., 2011; Nairne, 2010). For example, survival processing is not easily categorized as simply another form of deep processing (see also Savine et al., 2011). Unfortunately, at present, memory researchers have a relatively sparse theoretical "tool kit" from which to draw explanatory mechanisms. Elaboration, and its companion "distinctiveness," remain viable theoretical accounts for many mnemonic phenomena and may explain some aspects of survival processing, but are unlikely to provide a complete account of survival-processing effects (see Nairne, 2010). Of course, such a conclusion is certain to remain controversial as we await the outcome of further research.

Acknowledgments This research was supported by a grant from the National Science Foundation (BCS-0843165). Josefa N. S. Pandeirada was, in part, supported by the Portuguese Foundation for Science and Technology Fellowships SFRH/BPD/21534/2005 and SFRH/BPD/81438/2011.

Appendix

Table 4 Average proportion of correct recall in Experiment 1 as a function of encoding rating task and type of query

		Type of Query		
		Survival	Pleasantness	Average
Encoding Rating Task	Survival	.56	.51	.54
	Pleasantness	.56	.53	.54
New words		.21	.18	.19

Table 5 Average proportion of correct recall in Experiment 2 as a function of encoding rating task and type of query

		Type of Query		
		Survival	Pleasantness	Average
Encoding Rating Task	Survival	.43	.42	.43
	Pleasantness	.39	.40	.40
	Both conditions	.66	.55	.61
	New words	.16	.13	.14

Table 6 Average proportion of correct recall in Experiment 3 as a function of encoding rating task and type of query

		Type of Query		
		Survival	Moving	Average
Encoding Rating Task	Survival	.53	.43	.48
	Moving	.47	.46	.46
	Both conditions	.66	.63	.65
	New words	.16	.13	.14

References

Alban, M. W., & Kelley, C. M. (2012). Variations in constrained retrieval. *Memory & Cognition, 40,* 681–692. doi:10.3758/s13421

Bjork, R. A. (1975). Retrieval as a memory modifier: An interpretation of negative recency and related phenomena. In R. L. Solso (Ed.), *Information processing and cognition: The Loyola symposium* (pp. 123–144). Erlbaum: Hillsdale.

Burns, D. J., Burns, S. A., & Hwang, A. J. (2011). Adaptive memory: Determining the proximate mechanisms responsible for the memorial advantages of survival processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 206–218. doi:10.1037/a0021325

Bröder, A., Krüger, N., & Schütte, S. (2011). The survival processing memory effect should generalise to source memory, but it doesn't. *Psychology, 2,* 896–901. doi:10.4236/psych.2011.29135

Butler, A. C., Kang, S. H. K., & Roediger, H. L. (2009). Congruity effects between materials and processing tasks in the survival processing paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35,* 1477–1486. doi:10.1037/a0017024

Chiu, Y.-C., Dolcos, F., Gonsalves, B. D., & Cohen, N. J. (2013). On opposing effects of emotion on contextual or relational memory. *Frontiers in Psychology, 4,* 1–4. doi:10.3389/fpsyg.2013.00103

Coltheart, M. (1981). The MRC psychlinguistic database. *Quarterly Journal of Experimental Psychology, 33A,* 497–505. doi:10.1080/14640748108400805

Danckert, S. L., MacLeod, C. M., & Fernandes, M. A. (2011). Source-constrained retrieal influences the encoding of new information. *Memory & Cognition, 39,* 1374–1386.

Gallo, D. A., Meadow, N. G., Johnson, E. L., & Foster, K. Y. (2008). Deep levels of processing elicit a distinctiveness heuristic: Evidence from the criterial recollection task. *Journal of Memory and Language, 58,* 1095–1111. doi:10.1016/j.jml.2007.12.001

Halamish, V., Goldsmith, M., & Jacoby, L. L. (2012). Source-constrained recall: Front-end and back-end control of retrieval quality. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 1–15. doi:10.1037/a0025053

Howe, M. L. (2011). The adaptive nature of memory and its illusions. *Current Directions in Psychological Science, 20,* 312–315. doi:10.1177/0963721411416571

Howe, M. L., & Derbish, M. H. (2010). On the susceptibility of adaptive memory to false memory illusions. *Cognition, 115,* 252–267. doi:10.1016/j.cognition.2009.12.016

Jacoby, L. L., Shimizu, Y., Daniels, K. A., & Rhodes, M. G. (2005a). Modes of cognitive control in recognition and source memory: Depth of retrieval. *Psychonomic Bulletin & Review, 12,* 852–857. doi:10.3758/BF03196776

Jacoby, L. L., Shimizu, Y., Velanova, K., & Rhodes, M. G. (2005b). Age differences in depth of retrieval: Memory for foils. *Journal of Memory and Language, 52,* 493–504. doi:10.1016/j.jml.2005.01.007

Kang, S. H. K., McDermott, K. B., & Cohen, S. M. (2008). The mnemonic advantage of processing fitness-relevant information. *Memory & Cognition, 36,* 1151–1156. doi:10.3758/MC.36.6.1151

Kroneisen, M., & Erdfelder, E. (2011). On the plasticity of the survival processing effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 1553–1562. doi:10.1037/a0024493

Marsh, R. L., Meeks, J. T., Cook, G. I., Clark-Foos, A., Hicks, J. L., & Brewer, G. A. (2009). Retrieval constraints on the front end create differences in recollection on a subsequent test. *Journal of Memory and Language, 61,* 470–479. doi:10.1016/j.jml.2009.06.005

McDonough, I. M., & Gallo, D. A. (2008). Autobiographical elaboration reduces memory distortion: Cognitive operations and the distinctiveness heuristic. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1430–1445. doi:10.1037/a0013013

Nairne, J. S. (2010). Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 53, pp. 1-32). Burlington: Academic Press. doi:10.1016/S0079-7421(10)53001-9

Nairne, J. S., & Pandeirada, J. N. S. (2008). Adaptive memory: Is survival processing special? *Journal of Memory and Language, 59,* 377–385. doi:10.1016/j.jml.2008.06.001

Nairne, J. S., & Pandeirada, J. N. S. (2011). Congruity effects in the survival processing paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 539–549. doi:10.1037/a0021960

Nairne, J. S., Pandeirada, J. N. S., & Thompson, S. R. (2008). Adaptive memory: The comparative value of survival processing. *Psychological Science, 19,* 176–180. doi:10.1111/j.1467-9280.2008.02064.x

Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33,* 263–273. doi:10.1037/0278-7393.33.2.263

Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., & Blunt, J. R. (2012). Adaptive memory: Enhanced location memory after survival processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 495–501. doi:10.1037/a0025728

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. doi:10.1037/a0019402

Otgaar, H., Smeets, T., Merckelbach, H., Jelicic, M., Verschure, B., Galliot, A.-M., & van Riel, L. (2011). Adaptive memory: Stereotype activation is not enough. *Memory & Cognition, 39,* 1033–1041. doi:10.3758/s13421-011-0091-2

Packman, J. L., & Battig, W. F. (1978). Effects of different kinds of semantic processing on memory for words. *Memory & Cognition, 6,* 502–508. doi:10.3758/BF03198238

Palmore, C. C., Garcia, A. D., Bacon, L. P., Johnson, C. A., & Kelemen, W. L. (2012). Congruity influences memory and judgments of learning during survival processing. *Psychonomic Bulletin & Review, 19,* 119–125. doi:10.3758/s13423-011-0186-6

Riefer, D. M., Chien, Y., & Reimer, J. F. (2007). Positive and negative generation effects in source monitoring. *Quarterly Journal of Experimental Psychology, 60,* 1389–1405. doi:10.1080/17470210601025646

Roer, J. P., Bell, R., & Buchner, A. (2013). Is the survival-processing memory advantage due to richness of encoding? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 1294–1302. doi:10.1037/a0031214

Rotello, C. M., & Macmillan, N. A. (2007). Response bias in recognition memory. In A. S. Benjamin & B. H. Ross (Eds.), *The psychology of learning and motivation (Vol. 48)*. San Diego, CA: Academic Press.

Savine, A. C., Scullin, M. K., & Roediger, H. L. (2011). Survival processing of faces. *Memory & Cognition, 30,* 1359–1373. doi:10.3758/s13421-011-0121-0

Seamon, J. G., Bohn, J. M., Coddington, I. E., Ebling, M. C., Grund, E. M., Haring, C. T., …, Siddique, A. H. (2012). Can survival processing enhance story memory? Testing the generalizability of the adaptive memory framework. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 38*, 1045-1056. doi:10.1037/a0027090

Tse, C.-H., & Altarriba, J. (2010). Does survival processing enhance implicit memory? *Memory & Cognition, 38,* 1110–1121. doi:10.3758/MC.38.8.1110

Weinstein, Y., Bugg, J. M., & Roediger, H. L. (2008). Can the survival recall advantage be explained by the basic memory processes? *Memory & Cognition, 36,* 913–919. doi:10.3758/MC.36.5.913