Survival Processing and the Stroop Task: Does the Survival Advantage Depend on Deeper Processing During Encoding?

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Abstract
This study was designed to investigate the impact of survival processing with a novel task for this paradigm: the Stroop color-naming task. As the literature is mixed with regard to task generalizability, with survival processing promoting better memory for words, but not better memory for faces or paired associates, these types of task investigations are important to a growing field of research. Using the Stroop task provides a unique contribution, as identifying items by color is an important evolutionary adaptation and not specific to humans as is the case with word recall. Our results indicate that survival processing, with its accompanying survival-relevance rating task, remains the best mnemonic strategy for word memory. However, our results also indicate that presenting the survival passage does not motivate better color-naming performance than color-naming alone. In addition, survival processing led to a larger amount of Stroop interference, though not significantly larger than the other conditions. Together, these findings suggest that considering one’s survival when performing memory and attention-based tasks does not enhance cognitive performance generally, although greater allocation of attentional resources to color-incongruent concrete objects could be considered adaptive. These findings support the notion that engaging in deeper processing via survival-relevance ratings may preserve these words across a variety of experimental manipulations.

Keywords
survival processing, Stroop task, free recall, levels of processing

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Introduction
The mnemonic benefit from processing words for their survival value, relative to other, well-known memory strategies, is known as the “survival advantage” (Nairne, Thompson, and Pandeirada, 2007). In their seminal work, Nairne, Thompson, and Pandeirada (2007) described findings from four related experiments. In each experiment, participants rated the relevance of a list of neutral, unrelated words to the following survival scenario:

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation. Some of the words may be relevant and others may not—it’s up to you to decide.

Then, participants received an unexpected memory test for the words that they had rated. Several deep-processing control conditions—moving relevance, pleasantness rating, and self-relevance—were pitted against the survival-relevance condition. Across all four experiments, Nairne et al. (2007) found that processing in terms of survival increased retention compared to these control conditions. The survival advantage was consistent across their experiments. These findings provide insight into the evolutionary history of the human memory system, as

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memory may be optimized to help us solve problems related to survival (Nairne et al., 2007; Nairne & Pandeirada, 2010). Moreover, it may be the case that considering ancestral priorities in particular may underlie the effect, relative to general survival situations (Weinstein, Bugg, & Roediger, 2008; but see Kostic, McFarlan, & Cleary, 2012).

Nairne, Pandeirada, and Thompson (2008) extended their previous findings by comparing the benefit of survival processing against other conditions that traditionally produce high retention. In Experiment 1, participants were assigned to the standard survival condition or one of several important control conditions: pleasantness, imagery, self-reference, generation, or intentional learning. Across all comparisons, survival processing promoted the best recall performance. These results were also upheld in an additional experiment that compared survival processing with another scenario: a vacation-processing condition. These findings have led Nairne et al. (2008) to argue that survival processing “is one of the best—if not the best—encoding procedures yet identified in human memory research” (p. 180).

Recently, researchers have begun to investigate the potential mechanisms underlying the survival advantage. For example, some have argued that survival processing is particularly effective for promoting better memory performance because it invokes self-referential processing (Klein, 2012, 2014) and planning (Klein, Robertson, & Delton, 2010). Burns and colleagues have also indicated that survival processing promotes both item-specific and relational processing, while control conditions often rely on just a single type of processing during encoding (Burns, Burns, & Hwang, 2011; Burns, Hart, Griffith, & Burns, 2013). Others have noted that survival processing leads to increased elaboration on the to-be-remembered words during the encoding task. According to Krones and Erdfelder (2011), this elaborative encoding during survival processing leads to a larger mnemonic benefit. Their modified survival passage—which described just a single survival problem in a need for water—did not promote better memory when compared with the typical control conditions. Similarly, Röer, Bell, and Buchner (2013) have observed that participants generate a significantly greater number of ideas for how the to-be-remembered words might be used in survival settings, relative to how they might be used in other settings. Together, these findings indicate that modifying the specific task used within the experiment can bring us closer to uncovering the precise mechanisms underlying the advantage.

However, results are mixed regarding the use of additional tasks to test the survival advantage. For example, researchers have found that survival processing can promote better compound remote association task performance (Garner & Howe, 2013), location memory (Nairne, Van Arsdall, Pandeirada, & Blunt, 2012), and picture recall (Otgaar, Sneets, & van Bergen, 2010) than control conditions. On the other hand, survival processing does not appear to benefit face memory (Savine, Scullin, & Roediger, 2011), implicit task performance (McBride, Thomas, & Zimmerman, 2013; Tse & Altarriba, 2010), paired-associate learning (Schwartz & Brothers, 2014; unless they are animate paired-associates, VanArsdall, Nairne, Pandeirada, & Cogdill, 2015), or spatial N-back performance (Altarriba & Kazanas, 2014). Thus, an interesting area of inquiry for this area of research is determining the precise conditions when survival processing does and does not enhance cognitive performance (Kazanas & Altarriba, 2015). As the majority of studies conducted within this area of research have used rating tasks designed to promote word memory, we believe it is important to investigate whether survival processing can improve performance on other tasks as well.

One task that has not been used within this area of research is the Stroop (1935) color-naming task. In this task, words are printed in color, and participants respond to each word by naming the color. When color words (e.g., red and blue) are used, congruent trials (e.g., red printed in red) are easier to process than incongruent trials (e.g., red printed in blue). Stroop had commented that this interference from the color manipulation was the result of color naming disrupting normal reading. An interesting set of follow-up experiments conducted by Besner, Stolz, and Boutilier (1997) manipulated the amount of color interference used in their Stroop tasks: Words were either printed fully in color or only a single letter within each word was presented in color. This latter condition significantly reduced the amount of interference in color naming, as less attention was given to the entire word.

Why would the Stroop color-naming task provide a unique contribution to this area of research? Very few studies have examined the role of survival processing on evolutionarily-relevant tasks (but see Savine et al., 2011 for a failure to replicate the survival advantage with faces). Studies from related paradigms, such as the emotion literature, indicate that processing threatening stimuli can have a facilitative effect on color-naming performance. For example, Shibasaki, Isomura, and Masataka (2014) determined that both adults and children were able to detect the color of snakes faster than the color of flowers. These findings indicate that negative emotion, and perhaps fear in particular, can have a motivating effect on cognitive processing.

Detecting color and identifying items by color are also rooted in evolutionary theory (for recent reviews, see e.g., Jacobs, 2009; Lucas et al., 2003; Melin et al., 2012; Sumner & Mollon, 2003). For example, Bompas, Kendall, and Sumner (2013) have determined that normal trichromats (organisms with three types of color receptors on their retina, including humans) detect fruit better than those with color deficiencies, with the largest differences in detection performance at long distances. Other selection pressures may have included a need to detect predators, young leaves, or social signals related to reproduction (Kawamura et al., 2012; Melin et al., 2012; Pessoa et al., 2014; Surridge, Osorio, & Mundy, 2003). Several of these hypotheses have also been assessed using animal models, including macaque (Horwitz, 2015) and capuchin (Melin et al., 2014) monkeys. These hypothetic accounts for the evolution of color vision lend themselves to the survival-processing paradigm in that they are the goals outlined within the survival passage itself.
The Current Study

The current study was motivated by a set of related goals. First, we were interested in the impact of manipulating levels of processing within the survival-processing paradigm. While researchers have begun to investigate the role of deeper processing within the survival passage relative to control conditions (e.g., Kroneisen & Erdfelder, 2011; Röer, Bell, & Buchner, 2013), the current study aims to compare depth of processing within the encoding tasks themselves. By using the Stroop task specifically, we can investigate a second but related line of research. As human color vision is strongly believed to be evolutionarily adaptive in nature (e.g., Bompas, Kendall, & Sumner, 2013), using the Stroop task will allow us to determine whether survival processing can boost color-naming performance. Additionally, we are able to determine whether a congruency between the survival passage and the adaptive nature of the color-naming task can promote better memory performance. Finally, by using multiple variants of the Stroop task, we can directly test whether differences in color-naming performance reported by Besner et al. (1997) replicate within this paradigm.

Method

Participants

Participants in this experiment (N = 130) were University at Albany undergraduate students. Each participant gave their informed consent and received either course credit or extra credit for a psychology course. Participants indicated that they had normal or corrected to normal vision and were tested for normal color vision with the Ishihara (1993) Test Chart Book for Color Deficiency.

Experimental Conditions

Participants were randomly assigned to one of the five conditions (N = 26 for each of the five conditions) and received instructions specific to their condition: survival with relevance ratings, survival with word-color naming, survival with letter-color naming, pleasantness ratings, or baseline word-color naming. Participants in three of the conditions read the survival scenario (Nairne et al., 2007). One condition resembled the standard survival scenario, with all words presented in black in a survival-relevance word rating task:

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to name each color that the word is presented in. Identifying items by color may be useful to survival.

In the second condition, the letter-color naming condition (Besner, Stolz, & Boutilier, 1997), one letter within each word, was presented in a color. The remaining letters were presented in black. Instructions for this condition read:

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and a single letter in each word will be colored. We would like you to name the color of that single-letter. Identifying items by color may be useful to survival.

Pleasantness rating instructions, with all words presented in black, read:

In this task, we are going to show you a list of words, and we would like you to rate the pleasantness of each word. Some of the words may be pleasant and others may not—it’s up to you to decide.

One final condition was used as a baseline for the two Stroop conditions. In this condition, participants performed a simple word-color-naming task (without reading the survival passage), in order to determine the effectiveness of color processing in encoding a word for later retrieval. In this condition, entire words were presented in color. Their instructions read:

We are going to show you a list of words, and we would like you to name each color that the word is presented in.

Materials

All participants rated or named the color of the same set of 32 words, presented in the same order (selected from Nairne et al., 2007, Experiments 1 and 2). Five additional words (all concrete nouns, selected from Nairne et al., 2007, Experiment 3) were used to allow the participants to practice the task, but their responses to these words were not retained for analyses.
Procedure

Participants were run individually, within the Cognition and Language Laboratory. Each word was presented for 5 s, during which participants performed either the rating or naming task, via keypress. The experimenter assisted with practice trials, only. After the rating or color-naming experimental trials, all participants performed 2 min of forward digit span (set to a length of seven digits), followed by an unexpected free recall task. Each participant was given a maximum of 10 min to recall as many words as they could, in any order.

After the recall task, participants in the three survival conditions answered the following questions (from Nairne & Pan-deirada, 2010): (1) How interesting was the scenario? (2) How easy was it for you to create an “image” of the scenario in your mind? (3) How emotionally arousing was the scenario? (4) How familiar are you with the situation described? Two additional questions were included in the questionnaire (from Otgaar et al., 2011; Sandry, Trafimow, Marks, & Rice, 2013): (5) How distinctive, or unusual, was the scenario? (6) How rich in detail would you rate the scenario?

After answering these questions, participants completed a brief demographic questionnaire, which included questions related to age, gender, education, and native language. Each participant received a debriefing form and was granted credit for their participation.

Results

First, participants in all five conditions were matched on age, level of education, and native language (all ps > .05). In addition, there were no significant differences in survival relevance, pleasantness, or color naming (whether naming was according to word or letter color) response times (RTs; all ps > .05). RTs in these conditions (M = 1667 ms) were significantly slower than RTs in the baseline word-color naming condition (M = 1370 ms; p < .05). Finally, survival-relevance and pleasantness ratings did not interact with recall performance (all ps > .05), which is common in this area of research (see Kazanas & Altarriba, 2015). This is an important indicator that a word’s a priori survival relevance or pleasantness does not increase its memorability during the recall task.

Next, a one-way analysis of variance (ANOVA) was conducted to detect any differences in the proportion of correct recall among the five conditions. This ANOVA was significant, F(4, 125) = 129.213, p < .01. Planned contrasts revealed that recall in the survival with relevance-rating condition was significantly greater than recall in the pleasantness condition (M = .283; p < .01). These two conditions led to significantly greater recall than the three color-naming conditions (all ps < .01). Recall across the survival with word-color naming (M = .082), baseline word-color naming (M = .055), and survival with letter-color naming (M = .049) conditions did not differ (all ps > .05). Means and standard deviations (SDs) for recall in these five conditions are included in Table 1, and Figure 1 includes means and 95% confidence intervals.

A series of one-way ANOVAs and planned contrasts were conducted to detect any differences in each of the scenario ratings among the three survival conditions. Two of these ANOVAs were significant. The rating for how “interesting the scenario was” was significant, F(2, 75) = 3.413, p < .05, with planned contrasts revealing that participants found the survival with relevance-rating and survival with letter-color naming conditions as equally interesting and more interesting than the survival with word-color naming condition. The rating for “imageability” was also significant, F(2, 75) = 9.119, p < .001, with the survival with relevance-rating condition being the most imageable and survival with letter-color and word-color naming conditions being equally imageable. The ratings for “emotional arousal,” “familiarity,” “distinctiveness,” and “richness” did not differ among the three survival conditions (i.e., participants found these conditions to be equally arousing, familiar, distinctive, and rich in detail).

Means and SDs for each rating by condition comparison are included in Table 2. Overall, results from the scenario ratings reflect those of the recall task: Each of these ratings is believed to measure a dimension of encoding that enhances memory and retrieval. Thus, it is reasonable for higher ratings on these dimensions to correspond with better recall. While participants consistently rated the survival with relevance-rating condition higher than the other conditions on many of these dimensions, differences across conditions were only significant for the “interesting” and “imageable” dimensions, with the “imageable” ratings matching recall performance. Perhaps the concrete nature of the relevance-rating task is an important contributor to its effect on memory.

Approximately half of our participants recalled words that were not included on either the practice or the experimental trials. Intrusions were analyzed in two ways. First, we analyzed the total number of intrusions according to condition, using a one-way ANOVA. This ANOVA was significant, F(4, 73) = 3.728, p < .01. Participants in the survival with word-color naming condition recalled the highest number of intrusions (M = 4.18), which was significantly greater than the number reported by participants in the pleasantness condition, who recalled the fewest intrusions (M = 1.42; p = .01). We then grouped our intrusions into a number of categories: survival-related (e.g., knife), semantically related to words from the lists (e.g., rock, as stone was one of the practice words), phonologically related to words from the lists (e.g., can, as pan was one of the experimental words), orthographically related to words from the lists (e.g., pen, as pan was one of the experimental words), colors (e.g., blue), color related (e.g., fire hydrant), and other (e.g., believe). When analyzing the intrusion categories according to condition, two of the interactions were significant: the survival-related category, F(4, 75) = 4.215, p < .01, and the color-related category, F(4, 75) = 3.153, p < .05. In the survival-related category, participants in the survival with word-color naming condition made more intrusions (M = 2.17) than the baseline color-naming condition (M = .64) and
presented in blue) words across the three color-naming conditions. Next, we compared word-color naming (e.g., emerald) to the survival with letter-color naming (e.g., mel, and Erdfehr (2013) found that increasing load with an additional task reduced word recall and eliminated the survival advantage. Similarly, when comparing recall performance in the current study across the color-naming conditions, differences in recall performance were minimal. In addition, as was the case with Kroenesen et al. (2013), recall performance was significantly impaired, with participants in our three color-naming conditions recalling less than 10% of the word list (near floor performance). Particularly, poor recall, with little variation across these conditions, indicates that the survival advantage may rely on additional processing, relative to less effortful control conditions.

Results also indicate that survival processing did not motivate better color-naming performance, relative to the baseline color-naming condition. When comparing word color-naming accuracy, participants who read the survival passage actually performed numerically worse than those who had not read the survival passage. Similarly, participants who read the survival passage before engaging in the color-naming task experienced a larger amount of interference than participants who had not read the survival passage. As differences in the magnitude of color-naming interference were not significant (a failure to replicate effects reported by Besner et al., 1997), our interpretations of these findings are cautious. While sample size may account for some portion of null effects, the reduction in Stroop processing, relative to less effortful control conditions.

Findings from the current study are numerous and provide a significant contribution to this area of research. First, we have replicated the survival advantage in memory, when comparing the effects of survival-relevance ratings against pleasantness ratings and new color-naming conditions. Importantly, this advantage was not due to any significant difference in RTs or ratings during encoding. However, results from the scenario ratings indicate that the survival advantage may be due, in part, to relevance rating being a more imageable task. There was some evidence that survival-relevance rating may be a more interesting task as well. In other words, the encoding portion of the task is likely to be the most critical portion of the task, overall.

Findings from the color-naming conditions were novel to this paradigm. First, recall performance in these conditions was significantly worse than the survival-relevance and pleasantness rating conditions. Encouraging participants to consider a survival situation while color naming impaired later recall performance. Importantly, there is a precedent for this pattern of evidence that survival-relevance rating may be a more imageable task. There was some ratings during encoding. However, results from the scenario ratings are cautious. While sample size may account for some portion of null effects, the reduction in Stroop performance, relative to less effortful control conditions.

| Rating         | Survival + Relevance Rating | Survival + Word-Color Naming | Survival + Letter-Color Naming |
|----------------|-----------------------------|------------------------------|--------------------------------|
| Interesting    | 3.92 (0.744)                | 3.42 (0.578)                 | 3.62 (0.752)                   |
| Imageability    | 4.35 (0.892)                | 3.15 (1.190)                 | 3.42 (1.065)                   |
| Emotional       | 2.58 (1.206)                | 2.19 (0.895)                 | 2.46 (1.029)                   |
| Arousal         | 2.39 (1.299)                | 1.85 (0.834)                 | 2.19 (0.895)                   |
| Familiarity     | 3.23 (0.951)                | 3.27 (0.962)                 | 3.00 (0.849)                   |
| Distinctiveness | 3.31 (0.970)                | 3.38 (0.983)                 | 3.04 (0.916)                   |
| Richness        | 3.31 (0.970)                | 3.38 (0.983)                 | 3.04 (0.916)                   |

Table 1. Proportion of Correct Recall: Means and SDs.

Table 2. Survival scenario ratings: Means and SDs.
interference has been demonstrated with conditions having as few as 16 participants (Besner, 2001). Thus, our findings may be the result of a sizable difference in design, given the additional survival scenario presented to two of the three color-naming conditions.

With respect to both survival-processing and color-naming interference, it is possible that the incongruent items (e.g., a green *orange* or blue *broccoli*) were more difficult to conceptualize, as they violated the laws of nature as well as our participants’ expectations from previous experiences with oranges and broccoli. Thus, these participants may have been particularly preoccupied by these items, with greater interference indicating poorer performance. Importantly, processing this discrepancy between an object’s typical color and its color during the task did not increase recall performance (nor did it significantly slow RTs).

However, can poorer performance in a color-naming task be considered adaptive? Perhaps coming across an unusual fruit or vegetable requires additional inspection, to ensure it is safe to ingest, as our general pattern of interference data from the color-naming task would indicate. In other words, it may be the case that being in a survival setting puts us “on high alert” to find good nutrients. Likewise, our intrusion analyses indicate that participants who read the survival passage recalled more survival-relevant intrusions than those who had not read the survival passage. We surmise that these false memories are a strong indicator that survival processing encourages spreading activation from the related words to other words that would be useful in survival situations (e.g., a *knife*). These findings have been observed in similar memory studies, such as those within the Deese-Roediger-McDermott (DRM) paradigm, with both adults and children (Howe & Derbish, 2010; Otgaar & Smeets, 2010). There are many examples of similar “errors” within the memory literature, and several of them have similar adaptive value. For example, a child’s tendency to imitate or defer to an adult’s opinion or memory provides them with unique advantages. For one, source-monitoring errors provide a valuable memory boost: A young child observes an adult perform a task yet falsely attributes the action to themselves, leading to increased elaboration and better memory (see Sellers & Bjorklund, 2014, for a review).

Sellers and Bjorklund (2014) have hypothesized that negative emotions, such as those related to fearing the consequences of a survival situation, may be driving these effects. Thus, these seemingly negative consequences of survival processing may actually have adaptive value when conceptualized within both memory and evolutionary theories. Together, they indicate that survival processing provides a large number of benefits, which can only be studied when exploring new tasks and experimental manipulations.

**Implications and Future Directions**

Although these results are not the most straightforward examples of a survival advantage, we believe that they greatly extend the original conception of the advantage (Nairne et al., 2007). In fact, it may be the case that survival processing has far-reaching implications for understanding behavior, such as color-naming performance described in the current study. Thus, this area of literature would greatly benefit from additional studies investigating the generalizability of the survival advantage to new tasks and experimental procedures, particularly those with adaptive value, such as the unconventional intrusion findings reported in the current study. The number of experiments designed to study the limits of the advantage are greatly outnumbered by the number of experiments designed to replicate the advantage with different control conditions, participant populations, or modified passages (for a review, see Kazanas & Altarriba, 2015). Thus, we encourage greater exploration of how the advantage fares with tasks that tap into cognitive domains other than episodic memory (e.g., attention, working memory, etc.). Additional research might also explore real-world applications or more realistic situations for adult-age populations (e.g., the first day of school at a new university, starting a new job, etc.). Perhaps future work would benefit from additional control conditions, such as these familiar situations, to compare memory following survival and nonsurvival processing. A limitation of our study lies in our lack of a situation-based control condition, although we did include a pleasantness rating task.

We also encourage additional research investigating the relationship between considering one’s survival needs and identifying items by color. For example, how would results from a study using picture stimuli (e.g., having participants name the color of a red *apple* versus a blue *apple*) compare with our results using words? If participants are concerned about a food shortage, would an unusually colored piece of fruit draw more attentional resources? In addition, would some colors capture more attention and increase memorability for those objects? Would participants categorize objects by color and recall them together? How might animacy play a role in this paradigm? For example, children as young as 4 years old detect snakes in visual search tasks faster when the snakes are presented in color, rather than gray scale (Hayakawa, Kawai, & Masataka, 2011). Findings from studies conducted with adult participants are equally relevant: Color naming is significantly faster when snakes are presented—a threatening stimulus—relative to flowers (Shibasaki, Isomura, & Masataka, 2014). Finally, we encourage additional investigations related to those conducted by Besner et al. (1997). Our interference data resemble their pattern of data, encouraging additional research regarding this phenomenon. We recommend that researchers assess whether the reduction in Stroop interference reported by Besner et al. (1997) replicates when participants are simultaneously completing other tasks, as we attempted here, using survival processing. These are just a few potential research questions to continue this interesting area of inquiry.

**Conclusion**

Our overall findings indicate that engaging in survival processing increases memory for a set of unrelated words. In addition,
this task led participants to spend more time on words that were presented in incongruent colors, relative to participants who were not thinking about the survival scenario. These results support a survival advantage specifically guided by ancestral priorities: Our ancestors would have benefited from turning their attention toward objects that violated their expectations, especially if they were in danger or needed to quickly gather survival materials. Additionally, having carefully classified and analyzed participants’ intrusions—a measure often associated with false memory—we believe that survival processing may also promote spreading activation from one survival item to an entire set of related items. Together, these findings replicate the survival advantage and extend its generalizability to a new task with adaptive value.

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References
Altarriba, J., & Kazanas, S. A. (2014). Survival processing and attentional processing. In B. Schwartz, M. Howe, M. Toglia, & H. Otgaar (Eds.), What is adaptive about adaptive memory? (pp. 123–138). New York, NY: Oxford University Press.
Besner, D. (2001). The myth of ballistic processing: Evidence from Stroop’s paradigm. Psychonomic Bulletin & Review, 8, 324–330.
Besner, D., Stolz, J. A., & Boutilier, C. (1997). The Stroop effect and the myth of automaticity. Psychonomic Bulletin & Review, 4, 221–225.
Bompas, A., Kendall, G., & Sumner, P. (2013). Spotting fruit versus picking fruit as the selective advantage of human colour vision. i-Perception, 4, 84–94.
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.
Burns, D. J., Hart, J., Griffith, S. E., & Burns, A. D. (2013). Adaptive memory: The survival scenario enhances item-specific processing relative to a moving scenario. Memory, 21, 695–706.
Garner, S. R., & Howe, M. L. (2013). False memories from survival processing make better primes for problem-solving. Memory, 22, 9–18.
Hayakawa, S., Kawaii, N., & Masataka, N. (2011). The influence of color on snake detection in visual search in human children. Scientific Reports, 1, 80.
Horwitz, G. D. (2015). What studies of macaque monkeys have told us about human color vision. Neuroscience, 296, 110–115.
Howe, M. L., & Derbish, M. H. (2010). On the susceptibility of adaptive memory to false memory illusions. Cognition, 115, 252–267.
Ishihara, S. (1993). Ishihara’s tests for colour-blindness. Tokyo, Japan: Kanehara & Co.
Jacobs, G. H. (2009). Evolution of colour vision in mammals. Philosophical Transactions of The Royal Society, 364, 2957–2967.
Kawamura, S., Hiramatsu, C., Melin, A. D., Schaffner, C. M., Aureli, F., & Fedigan, L. M. (2012). Polymorphic color vision in primates: Evolutionary considerations. In H. Hirai, H. Inai, & Y. Go (Eds.), Post genome biology of primates (pp. 93–120). Tokyo, Japan: Springer Science+Business Media.
Kazanas, S. A., & Altarriba, J. (2015). The survival advantage: Underlying mechanisms and extant limitations. Evolutionary Psychology, 13, 360–396.
Klein, S. B. (2012). A role for self-referential processing in tasks requiring participants to imagine survival on the savannah. Journal of Experimental Psychology: Learning, Memory, and Cognition, 38, 1234–1242.
Klein, S. B. (2014). Evolution, memory, and the role of self-referent recall in planning for the future. In B. Schwartz, M. Howe, M. Toglia, & H. Otgaar (Eds.), What is adaptive about adaptive memory? (pp. 11–34). New York, NY: Oxford University Press.
Klein, S. B., Robertson, T. E., & Delton, A. W. (2010). Facing the future: Memory as an evolved system for planning future acts. Memory & Cognition, 38, 13–22.
Kostic, B., McFarlan, C. C., & Cleary, A. M. (2012). Extensions of the survival advantage in memory: Examining the role of ancestral context and implied social isolation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 28, 1091–1098.
Kroneisen, M., & Erdfelder, E. (2011). On the plasticity of the survival processing effect. Journal of Experimental Psychology: Learning, Memory, and Cognition, 37, 1553–1562.
Kroneisen, M., Rummel, J., & Erdfelder, E. (2013). Working memory load eliminates the survival processing effect. Memory, 22, 92–102.
Lucas, P. W., Dominy, N. J., Riba-Hernandez, P., Stoner, K. E., Yamashita, N., Calderon, E. L., … Darvell, B. W. (2003). Evolution and function of routine trichromatic vision in primates. Evolution, 57, 2636–2643.
McBride, D. M., Thomas, B. J., & Zimmerman, C. (2013). A test of the survival processing advantage in implicit and explicit memory tests. Memory & Cognition, 41, 862–871.
Melin, A. D., Hiramatsu, C., Fedigan, L. M., Schaffner, C. M., Aureli, F., & Kawamura, S. (2012). Polymorphism and adaptation of primate colour vision. In P. Pontarotti (Ed.), Evolutionary biology: Mechanisms and trends (pp. 225–241). Berlin, Germany: Springer.
Melin, A. D., Hiramatsu, C., Parr, N. A., Matsushita, Y., Kawamura, S., & Fedigan, L. M. (2014). The behavioral ecology of color vision: Considering fruit conspicuity, detection distance, and dietary importance. International Journal of Primatology, 35, 258–287.
Naima, J. S., & Pandeirada, J. N. S. (2010). Adaptive memory: Ancestral priorities and the mnemonic value of survival processing. Cognitive Psychology, 61, 1–22.
Naima, J. S., Pandeirada, J. N. S., & Thompson, S. R. (2008). Adaptive memory: The comparative value of survival processing. Psychological Science, 19, 176–180.
Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33, 263–273.

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.

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.

Otgaar, H., Smeets, T., Merckelbach, H., Jelicic, M., Verschuere, B., Galliot, A.-M., & van Riel, L. (2011). Adaptive memory: Stereotype activation is not enough. *Memory & Cognition*, 39, 1033–1041.

Otgaar, H., Smeets, T., & van Bergen, S. (2010). Picturing survival memories: Enhanced memory after fitness-relevant processing occurs for verbal and visual stimuli. *Memory & Cognition*, 38, 23–28.

Pessoa, D. M. A., Maia, R., de Albuquerque Ajuz, R. C., De Moraes, P. Z. P. M. R., Spyrides, M. H. C., & Pessoa, V. F. (2014). The adaptive value of primate color vision for predator detection. *American Journal of Primatology*, 76, 721–729.

Röer, 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.

Sandry, J., Trafimow, D., Marks, M. J., & Rice, S. (2013). Adaptive memory: Evaluating alternative forms of fitness-relevant processing in the survival processing paradigm. *PloS One*, 8, e60868.

Savine, A. C., Scullin, M. K., & Roediger, H. L., III. (2011). Survival processing of faces. *Memory & Cognition*, 39, 1359–1373.

Schwartz, B. L., & Brothers, B. R. (2014). Survival processing does not improve paired-associate learning. In B. L. Schwartz, M. L. Howe, M. P. Toglia, & H. Otgaar (Eds.), *What is adaptive about adaptive memory?* (pp. 159–181). New York, NY: Oxford University Press.

Sellers II, P. D., & Bjorklund, D. F. (2014). The development of adaptive memory. In B. L. Schwartz, M. L. Howe, M. P. Toglia, & H. Otgaar (Eds.), *What is adaptive about adaptive memory?* (pp. 284–307). New York, NY: Oxford University Press.

Shibasaki, M., Isomura, T., & Masataka, N. (2014). Viewing images of snakes accelerates making judgments of their colour in humans: Red snake effect as an instance of ‘emotional Stroop facilitation’. *Royal Society Open Science*, 1, 140066.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643–662.

Sumner, P., & Mollon, J. D. (2003). Did primate trichromacy evolve for frugivory or folivory? In J. D. Mollon, J. Pokorny, & K. Kno blauch (Eds.), *Normal and defective color vision* (pp. 21–30). New York, NY: Oxford University Press.

Surridge, A. K., Osorio, D., & Mundy, N. I. (2003). Evolution and selection of trichromatic vision in primates. *TRENDS in Ecology and Evolution*, 18, 198–205.

Tse, C.-S., & Altarriba, J. (2010). Does survival processing enhance implicit memory? *Memory & Cognition*, 38, 1110–1121.

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Cogdill, M. (2015). Adaptive memory: Animacy effects persist in paired-associate learning. *Memory*, 23, 657–663.

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