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The role of perceived threat in the survival processing memory advantage

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Information that is processed in relation to survival tends to promote superior recall relative to other elaborate encoding manipulations (e.g., Nairne, Thompson, & Pandeirada, 2007). The current research examines whether perceived threat plays a role in the survival processing memory advantage. In the current experiment survival processing was manipulated such that participants were presented with an ancestral (grasslands) or modern (city) context, and either a low, medium, or high threat level. The results revealed a strong survival processing advantage, with the magnitude of the advantage related to level of perceived threat. The findings as a whole suggest that perceived threat contributes to the recall advantage.

Keywords: Memory; Evolution; Survival processing; Threat; Recall.

Within recent years considerable research has investigated the link between psychological entities and reproductive fitness (e.g., Buchner, Bell, Mehl, & Musch, 2009; Gangestad, Thornhill, & Garver-Apgar, 2005; Herlitz & Rehnman, 2008; New, Cosmides, & Tooby, 2007; Voyer, Postma, Brake, Imperato-McGinley, 2007). Within the field of human memory, a line of research spearheaded by Nairne and colleagues (e.g., Nairne, Pandeirada, & Thompson, 2008; Nairne et al., 2007;) has shown that encoding information in relation to an ancestral-like survival scenario produces superior rates of recall on a later memory test relative to other conditions known to promote high recall rates (e.g., pleasantness ratings). This is referred to as the *survival processing effect*.

The superior recall of stimuli encoded based on survival value has garnered much attention. Numerous experiments have found the survival processing effect to be quite robust for different stimuli (Nairne et al., 2008; Otgaar, Smeets, & van Bergen, 2010; Weinstein, Bugg, & Roediger, 2008; but see Savine, Scullin, & Roediger, 2011, for an exception), different age groups (Aslan & Bäuml, 2012; Otgaar & Smeets, 2010), and different experimental preparations (Nairne et al., 2007; Nairne, VanArsdall, Pandeirada, & Blunt, 2011). Additionally, multiple experiments have manipulated the survival and control scenarios that are presented to participants (e.g., Kang, McDermott, & Cohen, 2008; Weinstein et al., 2008). Largely, these experiments have tested alternative explanations to the survival processing hypothesis, which posits ancestral survival relevance as the critical factor behind the superior recall rates.

A fundamental question is whether the survival processing advantage requires participants to imagine a setting that specifically relates to the context of our hunter-gatherer ancestors. At this point the answer to this question is unclear. The results of some studies suggest that ancestral

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conditions are critical and others suggest they are not. For example, concerning the importance of ancestral-like conditions for producing the survival processing memory advantage, Kang et al. (2008) suggested that surviving in the grasslands might be a more emotionally arousing scenario than moving to a new city, and that this difference might explain the recall advantage. To test this, Kang et al. (2008) developed a bank heist script to use in the place of a moving to a new city script with the rationale that robbing a bank is likely as emotionally arousing as surviving in the grasslands. Despite this, participants recalled more words after grasslands-survival processing than bank heist processing. Thus Kang et al. (2008) suggests that arousal is not sufficient to account for the survival processing memory advantage.

Similar to Kang et al. (2008), Weinstein et al. (2008) manipulated the initial grassland-survival script by changing only the location and potential threat to represent modern components. Specifically, the word ''grasslands'' was replaced with ''city'' and ''predators'' was replaced with ''attackers''. Thus both conditions involved securing food, water, and protection, but in different contexts. Again, the words rated during the grassland-survival task were more likely to be recalled than words rated during the city-survival task (Weinstein et al., 2008).

Another set of experiments that support the conclusion that ancestral-like elements are critical for the survival processing advantage were designed to keep the imagined context and the imagined task similar, yet manipulate the goal of the task to involve survival or not (Nairne, Pandeirda, Gregory, & Van Arsdall, 2009). The encoding scenario involved imagining being in the wilderness (e.g., grasslands), and the imagined tasks were similar for both survival and control conditions. Specifically, some participants were asked to imagine gathering food for survival in a hunter-gatherer society, and others were asked to imagine gathering food for a scavenger hunt game. Similarly, in a separate experiment (Nairne et al., 2009, Expt 2), some participants were asked to imagine hunting and trapping animals for survival in a hunter-gatherer society while other participants were asked to imagine hunting and trapping animals for a modern context. Importantly, words rated in light of a hunter-gatherer context were remembered better than those rated in light of a contest/game (Nairne et al., 2009).

The experiments reviewed above suggest that the survival processing advantage specifically requires ancestral-like elements. However, there are several experiments that provide counter-evidence. These experiments show a survival processing memory advantage without elements directly tied to ancestral conditions. For example, Soderstrom and McCabe (2011) compared recall after participants read the standard survival script that included the imagined task of ''protecting yourself from predators'' to participants who read an altered script that included the imagined task of ''protecting yourself from zombies''. The term zombie was not described to the participants but the fictitious creatures are commonly known as reanimated dead humans that ravenously attack and ingest the flesh of living humans (Romero, Russo, Hardman, & Streiner, 1968; see also Boyle, Garland, & Macdonald, 2002). Similar to Weinstein et al. (2008), only two words, ''predators'' and ''grasslands'', were changed from the typical survival script (Nairne et al., 2007). Specifically, Soderstrom and McCabe (2011) tested four survival scenarios: grasslands-predators, city-attackers, grassland-zombies, and city-zombies. Relative to recall for words rated during a pleasantness task, words processed in each of these survival conditions were recalled more often. Most importantly, participants that rated words based on survival with ''zombies'' as the threat type had superior recall compared to participants that rated words based on survival with ''predators'' or ''attackers'' as the threat type (Soderstrom & McCabe, 2011). Additionally, recall rates were equal for grassland scripts and city scripts. The authors argue that these results provide evidence for the generality of the survival processing advantage beyond ancestral related aspects.

Along similar lines, a series of experiments by Kostic, McFarlan, and Cleary (2012) also provide evidence for the generality of the survival processing advantage. In these experiments an additional condition was included that described a survival scenario our hunter-gatherer ancestors could not have inhabited. For example, participants were asked to imagine surviving while lost at sea in a lifeboat. The key finding was that recall rates did not differ between a survival in the grasslands setting and a survival lost-at-sea setting. This finding was also replicated for different locations as well, such as a jungle context and an outer-space context (Kostic et al., 2012).

Numerous studies suggest that encoding aspects closely related to ancestral conditions do lead to higher rates of recall. However, what

aspect of the fictitious threat of zombies and other far-fetched survival scenarios lead to this mnemonic benefit? The current experiment tests the hypothesis that perceived threat is an underlying factor that ties these experimental findings together. Understanding how threatening participants perceive each scenario to be might allow us to predict the survival processing memory advantage. It may be the case that participants imagine surviving during a zombie apocalypse as more threatening than being stranded on the grasslands. This hypothesis is motivated by the way zombies are characterised in film and television: insatiable, tenacious, only attacking living humans, never sleeping, and harbouring a highly contagious and fatal disease (e.g., Boyle et al., 2002; Romero et al., 1968). On the other hand, dangerous predators can become satiated, can be deterred or frightened, attack many different animals, require sleep, and a single bite or scratch from one is rarely fatal. This potential difference in perceived threat might explain why Soderstrom and McCabe (2011) found higher recall rates for participants that rated words in relation to zombie survival over predator survival. Furthermore, imagining being stranded on the grasslands or being stranded on a lifeboat may be perceived as more threatening than being stranded in a foreign city, moving to a foreign city, or hunting for sport. Thus perceived threat may provide a unifying structure to understand the variability of recall rates within the survival processing literature.

The current experiment takes an initial step towards addressing the role of perceived threat in the survival processing advantage. In this study threat type (e.g., predators) was maintained across conditions, but qualifying sentences were added to the scripts to vary the perceived threat of the scenario. Specifically, the survival script instructions from previous work (Nairne et al., 2007; Weinstein et al., 2008) were altered by adding a sentence that qualifies the survival scenario as easy or difficult. It is assumed that an easy survival context is less threatening and a difficult survival context is more threatening. A third condition did not add a sentence to qualify the task difficulty and, thus, was identical to the instructions used in previous work (Weinstein et al., 2008). This allowed the comparison of three varying threat levels within a single experiment: low threat (easy survival), medium threat (typical instructions), and high threat (difficult survival).

One hypothesis drawn from previous work (e.g., Nairne et al., 2009) is that an ancestral survival context may be inherently more threatening than a modern one. To test this in the current experiment, survival context (ancestral vs modern) is manipulated in addition to manipulating perceived threat (low, medium, high). Additionally, a post-experiment survey was given with a question to assess how threatening participants viewed each survival scenario. This provided a means to check whether subjective reports of threat coincided with the experimental manipulation of perceived threat between conditions.

METHOD

Participants

A total of 288 undergraduate students from SUNY Binghamton participated in exchanged for partial credit towards a course requirement. They were tested individually.

Design

The experiment was conducted as a 2 (Rating Scenario: Survival, Pleasantness) $\times 2$ (Survival Location: City, Grassland) $\times 3$ (Survival Threat: Low, Medium, High) mixed design. Rating scenario was manipulated within participants and survival location and survival threat were manipulated between participants. The main dependent variable was the proportion of words recalled during a free recall test for all of the studied words. Results from a post-experiment survey that assessed perceived threat, arousal, imageability, familiarity, and interest in relation to the survival scenario were also collected for analysis.

Materials

Stimuli were 44 concrete nouns, 36 of which were used in a previous study (Weinstein et al., 2008) from which the words were selected randomly from a generated list. Eight additional words were used as primacy and recency buffers with four presented at the beginning of the experimental task and four at the end. The 44 words all ranged between 400 and 700 on the criterion of frequency, concreteness, imageability, and meaningfulness in the MRC Psycholinguistic Database (http://websites.psychology.uwa.edu.au/school/

MRCDatabase/uwa_mrc.htm). The remaining 36 words were randomly split into four lists of nine words. All participants studied the same four lists of nine words. The order of the lists, order of rating scenario, and assignment of word lists to rating scenario were counterbalanced across participants. The order of words within each list was randomised for each participant.

Procedure

The experiment was conducted on a computer using E-Prime experimental software (Psychology Software Tools). Participants were informed that they would be rating words based on various characteristics, but were not informed that their memory for the words would be tested later. They were then given instruction for rating words on the basis of a survival scenario or pleasantness task. The instructions for the rating tasks were adapted from previous survival processing experiments (Nairne et al., 2007; Weinstein et al., 2008). The grasslands-medium threat and city-medium threat survival scenarios were identical to those used by Nairne et al. (2007) and Weinstein et al. (2008). The low- and high-threat survival rating instructions included an additional sentence in an attempt to decrease or increase perceived threat. Because both survival location and survival threat were manipulated between participants, there were six unique survival rating scripts. Each participant was randomly assigned to one of the six survival rating scripts. All participants received the same pleasantness rating instructions. The rating task script from Nairne et al. (2007) and Weinstein et al. (2008), which we used as our medium threat condition, is presented below. For the low- and high-threat conditions, the script is presented again with the critical changes and additions italicised (these elements were not italicised in the actual scripts presented to participants).

> Grasslands survival (medium threat). ''In this task we would like you to imagine 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.''

> Grasslands survival (low/high threat). ''In this task we would like you to imagine 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/attackers. Importantly, we would like you to imagine that food and water are easy/difficult to obtain and that predators are easy/difficult to detect and avoid.* 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.''

There were three City-Survival conditions (Low, Medium, and High threat conditions). The scripts for these conditions were identical to the Grasslands conditions described above except that the word ''grassland'' was replaced with the word ''city'' and the word ''predators'' was replaced with ''attackers''.

> Pleasantness Condition. ''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 words may be pleasant others may not–it's up to you to decide.''

To encourage participants to read the rating instructions carefully, the scripts were presented slowly. Sentences were added incrementally with 10 seconds of viewing time for each before the next sentence appeared.

The different rating tasks were alternated with a blocked design such that there were two blocks of survival ratings and two blocks of pleasantness ratings. These rating blocks were intermixed with half of the participants starting with pleasantness (P) ratings and the other with survival (S) ratings (i.e., SPSP or PSPS). Not including the buffer trials at the beginning of the first block and at the end of the last block, each block contained nine words to be rated individually.

On each trial of the rating task, a word appeared in the centre of the screen, and participants were asked to rate it using a 5-point scale where 1 = *totally irrelevant* or *totally unpleasant* and 5 = *extremely relevant* or *extremely pleasant*. The rating scale was explained prior to the task

and was presented below each item as a reminder. Participants indicated their response by pressing the corresponding keyboard number. After participants finished rating words for each block of trials, they received instruction for the following rating task. Even though the third block of ratings had the same instructions as the first and the fourth block of ratings had the same instructions as the second, the instructions were still presented in the same sentence-by-sentence format each time.

After finishing all four blocks of ratings, participants performed a 2-minute filler task. The task presented country names one at a time and participants were asked to identify if the country belonged to the continent of Africa, Asia, or Europe. This task was timed such that each trial lasted 4 seconds and there were 30 trials. After the filler task participants were provided with a pen and blank sheet of lined paper and asked to recall as many words from the rating task as possible. Participants were given as much time as they liked to work on the memory task, but no participant exceeded ten minutes and most finished within approximately 5 minutes. After participants completed the memory test they were given a brief survey and asked to answer questions using a 5-point scale. The questions were designed to gauge participants' impression of the survival scenarios: how interesting it was, how easily they could generate imagery about it, how emotionally arousing it was, how threated they would feel if actually in the scenario, and how familiar they felt the scenario was.

RESULTS

The recall data are presented in Table 1. The survival advantage, which is the difference between the proportion of words recalled from the survival rating task and the proportion of words recalled from the pleasantness rating task, is shown in Figure 1 for each condition. To test for recall differences among the scenarios, a 2 (Rating Scenario: Survival, Pleasantness) $\times 2$ (Survival Location: Grassland, City) $\times 3$ (Survival Threat: Low, Medium, High) mixed ANOVA was conducted on the recall scores. Rating scenario was entered as a within-participants variable and survival location and survival threat were entered as between-participants variables. We found a significant Rating Scenario $\times$ Survival Threat interaction, $F(2, 282) = 3.48$, $MSE = .013$, $p = .032$, $\eta^2 = .024$. Performing simple effects analyses, our results revealed that words rated for survival relevance were recalled more often than words rated for pleasantness for all Survival Threat conditions ($ps < .001$). Specifically, as threat increased from low to high, the survival advantage (greater recall for survival rated words relative to pleasantness rated words) increased. Low threat yielded the smallest survival advantage (9%), followed by the medium threat condition (13%) and high threat yielded the largest survival advantage (15%). Similarly, a main effect of rating scenario was found, $F(1, 282) = 175.25$, $MSE = .013$, $p < .001$, $\eta^2 = .383$, indicating that the recall rates from the across all conditions were higher for words rated for survival relevance ($M = 36\%$, $SD = 14\%$) than words rated for pleasantness ($M = 23\%$, $SD = 13\%$). Thus the survival processing advantage was replicated.

TABLE 1
Proportion of words recalled for the current experiment as a function of between-participants condition

	Survival		*Pleasantness*	
Condition	*M*	*SD*	*M*	*SD*
Grasslands				
Low threat	.31	.12	.19	.13
Medium threat	.35	.15	.20	.14
High threat	.39	.13	.25	.15
City				
Low threat	.33	.16	.27	.12
Medium threat	.38	.13	.27	.12
High threat	.38	.15	.22	.12

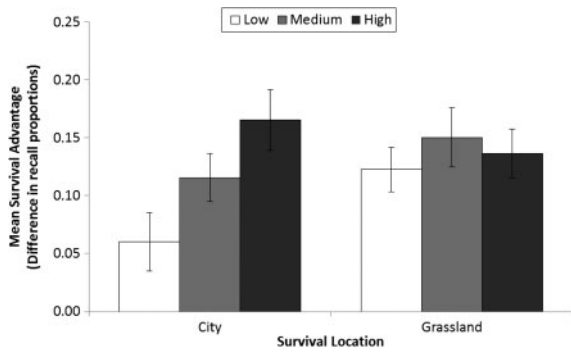

Figure 1. Mean survival advantage values, which represent the difference in proportion of words recalled from the survival rating task over the pleasantness rating task during free recall. Levels of survival threat are depicted by different contrast columns, with darker contrast representing higher threat. Standard errors are represented by error bars attached to each column.

Although the survival advantage was numerically larger for participants that rated words based on an ancestral-like survival context (grasslands) relative to participants that rated words based on a modern survival context (city), this difference was not statistically significant, $F(1, 282) = 1.45$, $MSE = .013$, $p = .230$, $\eta^2 = .005$. Additionally, the three-way interaction of survival advantage (survival recall compared to pleasantness recall), survival location, and survival threat was not significant, $F(2, 282) = 2.05$, $MSE = .013$, $p = .131$, $\eta^2 = .014$. This suggests that the pattern of an increasing survival advantage effect from low to high threat did not differ between grasslands and city survival locations.

Concerning the between-participants effects, which compared total recall proportions (survival and pleasantness recall combined), the analysis revealed a significant Survival Location × Survival Threat interaction, $F(2, 282) = 3.85$, $MSE = .024$, $p = .022$, $\eta^2 = .027$. Follow-up analyses revealed that participants that rated words in relation to survival within a city context had higher total recall than participants that rated words for survival in a grasslands context for the low- and medium-threat conditions (*p*s. < .05). There was no difference in total recall between the city and grasslands conditions for participants in the high-threat condition ($p = .332$). Similarly, a main effect of Survival Location was found for total recall proportions, $F(1, 282) = 5.12$, $MSE = .024$, $p = .024$, $\eta^2 = .018$, which showed that participants within the city condition had higher total recall overall. Lastly, the main effect of Survival Threat was not significant for total recall proportions, $F(2, 282) = 2.20$, $MSE = .024$, $p = .112$, $\eta^2 = .015$.

The purpose of this study was to determine whether the manipulation of survival threat, from low to high, would lead to a corresponding increase in the survival advantage. To test this directly a linear trend analysis was conducted on the difference in recall proportions between survival words and pleasantness words. The results from this analysis bolster those from the above ANOVA by showing a reliable positive linear trend, $F(2, 285) = 6.56$, $MSE = .026$, $p = .011$, $\eta^2 = .023$: the low-threat condition had the lowest survival advantage values, followed by the medium-threat condition, and the high-threat condition yielded the highest values. Upon inspection of the means, it appears that the effect of Survival Threat was driven predominantly by the city condition. This suspicion was confirmed by running a separate linear trend analysis on data collected from the city ($p < .05$) and grasslands ($p > .6$) conditions. Implications of this pattern are discussed later.

Looking only at the medium threat condition, a planned 2 (Rating Scenario: Survival, Pleasantness) × 2 (Survival Location: Grassland, City) mixed ANOVA was also conducted to match Weinstein et al. (2008). As stated earlier, these two conditions contained instructions identical to previous work that found superior recall for words rated for ancestral-like survival relevance over modern survival relevance (Weinstein et al., 2008). Although these results showed a slight numerical advantage for grasslands over city survival location, this difference was not reliable, $F(1, 94) = 1.12$, $MSE = .013$, $p = .292$, $\eta^2 = .012$.

As a manipulation check, data from the post-experiment survey were analysed. Two participants out of 288 did not complete survey ($N = 286$). Data from the questions concerning perceived threat and arousal are summarised in Figure 2. Separate 2 (Survival Location: Grassland, City) × 3 (Survival Threat: Low, Medium, High) between-participant ANOVAs were conducted; one for each question answered during the post-experiment survey as the dependent variable. For each ANOVA, none showed a significant interaction of Survival Location × Survival Threat or a main effect of Survival Location. Thus, across the dimensions of interest, $F(2, 280) = 2.07$, $MSE = .81$, $p = .151$, $\eta^2 = .007$, imagery, $F(2, 280) = .57$, $MSE = .99$, $p = .450$, $\eta^2 = .002$, arousal, $F(2, 280) = .03$, $MSE = 1.14$, $p = .863$,

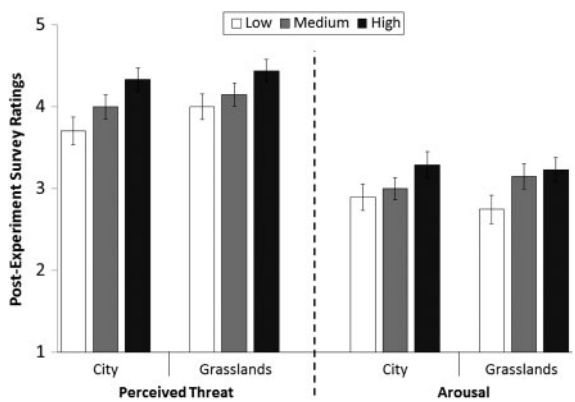

Figure 2. Mean participant survey ratings concerning the survival scenario scripts separated by individual survey question and between-participants condition. Levels of survival threat are depicted by different contrast columns, with darker contrast representing higher threat. Standard errors are represented by error bars attached to each column.

$\eta^2 < .001$, threat, $F(2, 280) = 2.24$, $MSE = 1.07$, $p = .136$, $\eta^2 = .008$, and familiarity, $F(2, 280) = .83$, $MSE = 1.25$, $p = .365$, $\eta^2 = .003$, participants in the grasslands condition did not reliably differ from the city survival location condition. The purpose of the script variations was to manipulate the perceived threat of the scenarios. Analysis of the survey data revealed that subjective reports of threat increased in conjunction with threat condition, $F(2, 280) = 6.43$, $MSE = 1.07$, $p = .002$, $\eta^2 = .044$. We also found that reported levels of arousal differed in conjunction with threat condition as well, $F(2, 280) = 4.08$, $MSE = 1.14$, $p = .030$, $\eta^2 = .023$. Specifically, as threat condition increased, subjective reports of arousal and threat both increased as well. This parallels the pattern produced by the survival advantage in recall. The other three questions (interest, imagery, familiarity) did not differ across the levels of threat (all p values $> .2$).

GENERAL DISCUSSION

The current experiment suggests that perceived threat is a factor contributing to the survival processing effect. Indeed, as the survival scenario increases in threat from low to high, the recall advantage for survival processed words over control words increased as well. As expected, subjective reports of threat also increased as threat increased across conditions.

Despite using scenario scripts that contained wordings similar to the original survival processing script (Nairne et al., 2007), an advantage for words processed in relation to an ancestral context (grasslands, predators) over words processed in relation to a modern context (city, attackers) was not found. This cannot be explained as due to the slight alteration of script wording because a separate analysis that compared the two conditions with identical survival script wordings as previous work (Weinstein et al., 2008, Expt 2) also did not find this difference. Further, the current study had approximately the same number of participants in each between-participants condition as previous work that did find an advantage for ancestral-like elements (Weinstein et al., 2008). Indeed, using the effect size from Weinstein et al. (2008), the current experiment had ample power to detect this difference ($\sim .92$). One aspect that might reconcile the failure to replicate this previous finding is that Weinstein et al. (2008, Expt 2) manipulated scenario perspective; in their study, participants were presented with a scenario in which they were asked to imagine either themselves to be in (first-person perspective) or a friend (third-person perspective). From their results, the third-person conditions produced a numerically larger survival processing advantage than the first-person conditions (Weinstein et al., 2008). Thus, since the current experiment only had scenarios with the first-person perspective wordings, the survival processing effect may be relatively smaller.

An inspection of the survival advantage values (the proportion of survival condition recall minus pleasantness condition recall) reveals an interesting pattern for further speculation. The four groups within the low-threat and medium-threat conditions show an easily interpretable pattern: the survival advantage values increase from low to medium and are slightly higher for the grassland conditions over city conditions. However, after including the two high-threat conditions, the picture becomes less clear. For the city location condition the survival advantage continues to increase from low threat to high threat. The addition of the high-threat grasslands condition does not follow the same pattern. Instead, the survival advantage decreases slightly from medium threat to high.

The distinction between a clear effect from low to medium threat and to a more ambiguous effect from medium to high threat is consistent with the notion of threat as an underlying factor of the survival processing effect. If perceived threat is truly an important component of this phenomenon, then it is likely to have a larger effect when diminished from the baseline condition (medium threat) than when enhanced. This is because the medium-threat condition uses a script that has been shown to produce a survival processing advantage in previous work (e.g., Weinstein et al., 2008). In other words, the medium-threat condition may engender a sufficient amount of imagined threat. Thus we speculate that increasing the imagined threat may provide a smaller effect on recall than diminishing it. It is also important to note that, within the high-threat condition, participants presented with the city survival scenario had numerically higher (and statistically equivalent) recall advantage scores compared to participants presented with the grasslands survival scenario. It is worth reiterating that this is speculation; however, it might be the case that if perceived threat is high enough then the effect of survival context (ancestral vs modern)

might not have an effect. Thus perceived threat may indeed be a general mechanism behind the survival processing advantage.

THEORETICAL IMPLICATIONS

How does the current set of findings, which suggest that perceived threat modulates the survival processing effect, fit with and qualify the rest of the survival processing literature? To address this it is important first to fully appreciate the boundary conditions and qualifications of the survival advantage suggested from other research. First, the survival processing advantage does not manifest for all types of information, such as faces (Savine et al., 2011) or specific details (Otgaar et al., 2010). Second, the advantage can be explained by proximate memory mechanisms such as amount of elaboration (Kroneisen & Erdfelder, 2011) or, similarly, as a concert of item-specific and relational processing (Burns, Hwang, & Burns, 2011). Lastly, the survival processing advantage can be found when participants are asked to imagine non-ancestrally relevant locations (Kostic et al., 2012) or non-ancestrally relevant threats (Soderstrom & McCabe, 2011). Taken together, the survival processing advantage does support the idea that the human memory system is functionally designed but, importantly, this functional design is not as rigidly specific as originally presumed by some evolutionary psychologists (e.g., Tooby & Cosmides, 1990).

Evidence that the survival processing advantage shows generality to non-hunter-gatherer ancestral settings and that it is likely driven by more general memory processes, converges with theoretical challenges to the adaptationist approach (e.g., Bolhuis, Brown, Richardson, & Laland, 2011). The adaptationist approach suggests that the human cognitive system contains multiple encapsulated solutions to specific problems derived from ancestral contexts (e.g., Tooby & Cosmides, 1990). Indeed, Bolhuis and colleagues (2011) suggest that research from adjacent scientific fields (e.g., genetics, neuropsychology, gene-culture coevolution, developmental psychology) provide strong evidence that evolutionary psychology should be more open to domain-general mechanisms. Thus a survival processing system is not likely independent in a massively modular sense (e.g., Fodor, 1983). A current working hypothesis is that, instead of rigid stimulus specificity (i.e., the survival advantage occurs only for grassland settings and specific predators), the survival processing advantage might occur when certain behaviours are imagined. For example, the survival advantage might occur when participants think of situations that engender a response against potential bodily harm. That is, there might be implicit differences between dealing with threats in a modern context compared with an ancestral-like context. For example, dealing with threatening situations in a modern context might involve behaviours such as calling the police, running for shelter, or asking a community centre for food and water. Whereas dealing with threats in settings such as grasslands, jungle, lifeboat lost at sea, or zombie apocalypse might involve behaviours that are more similar to behaviours of our hunter-gatherer ancestors. The reliable effect of perceived threat in explaining the survival processing advantage fits nicely with this hypothesis. Indeed, threat is a general factor that is evolutionarily relevant to both ancestral and modern humans. It is likely the case that ancestral-like contexts readily invoke feelings of threatened survival, yet other modern, fictional, or far-fetched contexts may do the same as well.

One potential explanation to be explored further is the role of arousal. As stated earlier, this was first addressed by Kang et al. (2008) by replacing the typical control condition script, which asked participants to imagine moving to a new home in a foreign city, with the more exciting and arousing scenario of a bank heist. Their results suggested that arousal cannot explain the survival processing advantage since recall for words presented during the grassland-survival task was higher than words presented during the bank heist rating task. Related to this, Soderstom and McCabe (2010) found that participants rated the zombie conditions (city and grassland) as more arousing than the predator conditions. This pattern matched the recall results; more words were recalled for the zombie conditions than the predator conditions. Furthermore, from the current experiment we found that ratings of arousal increased as the level of threat increased between conditions, and this pattern matches both recall rates and the subjective reports of perceived threat. In an attempt to better understand the survival processing advantage, disentangling the two factors of arousal and perceived threat may be difficult. However, further analysis of the current data set provides preliminary evidence which suggests that the threat of imminent bodily

harm or sickness may be the factor that best explains the survival processing advantage.[1]

Recently some research has shown that negative valence and mortality salience cannot account for the survival processing memory advantage (Bell, Röer, & Buchner, 2013). These findings qualify the notion of perceived threat and survival as distinct from mortality salience. That is, we speculate that the mnemonic advantage engendered from survival processing might require participants to consider behaviours associated with avoiding bodily harm or sickness for self-preservation. In other words, death alone without a struggle for survival might not be sufficient to produce the memory advantage. This hypothesis is in line with the distinction between survival and mortality salience suggested by Klein (2012).

While perceived bodily threat and survival may appear as synonymous, a subtle yet important distinction is that perceived threat is easily described along a continuum, while survival is more readily described as binary. Thus the main theoretical contribution of the current work is the addition of ''perceived threat to survival'' as an important factor to tie together the divergent findings within the survival processing literature. Indeed, grassland scenarios similar to those of our hunter-gatherer ancestors might be special in that participants readily consider directly avoiding the threat of bodily harm or sickness. Likewise, in modern scenarios such as a bank heist, these thoughts might be less frequent because modern scenarios bolster survival via niche constructions such as law enforcement, medicine, supermarkets, etc. Thus removing modern aspects such as these from a survival scenario should increase the perceived threat and produce a survival processing effect.

As it stands currently, it appears there are two distinct factors driving the survival processing phenomenon: perceived threat and elaboration. Increasing either of these two factors can produce recall rates comparable to those produced by the initial survival processing scenario (Nairne et al., 2007). However, it is also possible that the manipulation of perceived threat in the current experiment might have generally influenced amount of elaboration in addition to perceived threat. That is, the additional sentence that qualified the imagined survival scenario as easy or difficult might have encouraged participants to devote more or less effort to encoding the words during the rating task. This is an important distinction to address in further research, yet additional analyses of the current data do not suggest that participants in the higher-threat conditions exerted more effort than those in the other threat conditions.[2]

By directly manipulating perceived threat within the survival processing memory paradigm we have provided evidence which suggests that perceived threat is an important factor behind the memory advantage. However, to better understand this memory phenomenon, further research could directly test the importance of perceived

[1] Two separate mixed-factor ANCOVAs were run to investigate how much variability of the survival processing advantage could be attributed to perceived threat and arousal. These analyses were similar to the 2 (Rating Scenario: survival, pleasantness) $\times 2$ (Survival Location: city, grasslands) $\times$ 3 (Survival Threat: low, medium, high) ANOVA fully reported previously, except that survey scores concerning perceived threat and arousal were entered as covariates independently for each analysis. A main effect of Rating Scenario was still found for both ANCOVAs ($ps < .05$), yet relative to the survival advantage effect size of the previously reported ANOVA ($\eta^2 = .382$), the ANCOVA with perceived threat as a covariate accounted for more variability ($\eta^2 = .023$) compared to the ANCOVA with arousal as a covariate ($\eta^2 = .082$). Additionally, the Rating Scenario $\times$ Survival Threat interaction was still found for the ANCOVA with arousal entered as a covariate ($p < .05$), but not when perceived threat was entered as a covariate ($p > .05$). We thank an anonymous reviewer for suggesting this analysis.

[2] We thank an anonymous reviewer for this insight and for recommending the following analysis: To address the notion of task effort during the survival relevance rating task we performed an analysis of ratings and reaction time data. If cue demand varied in conjunction with perceived threat condition, we would expect ratings and/or reaction times to increase linearly from low to high threat. Due to a programming error we only had data for 63 participants (approximately 20 for each perceived threat condition). We performed separate ANOVAs on both mean ratings and median reaction times for the different levels of perceived threat. Not only did neither ratings, $F(2, 62) = 1.36$, $p = .266$, $\eta^2 = .045$, nor reaction times, $F(2, 62) = 0.20$, $p = .819$, $\eta^2 = .007$, reliably differ across threat conditions, but the numerical pattern for both did not show a linear pattern as predicted. Mean ratings for low-, medium-, and high-threat conditions were 2.9, 2.7, and 2.8, respectively with an average standard error of .06. Mean reaction times for low-, medium-, and high-threat conditions were 2.9, 2.8, and 3.0 seconds, respectively, with an average standard error of .15 seconds. Although these results are far from definitive they provide preliminary evidence against the notion that the amount of effort during encoding (at least as indexed by encoding time) depended on the perceived threat manipulation.

threat in light of alternative explanations such as general arousal or elaboration.

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