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Adaptive memory: Animacy, threat, and attention in free recall

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Abstract

Animate items are better remembered than inanimate items, suggesting that human memory systems evolved in a way to prioritize memory for animacy. The proximate mechanisms responsible for the animacy effect are not yet known, but several possibilities have been suggested in previous research, including attention capture, mortality salience, and mental arousal (Popp & Serra in *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*, 186-201, 2016). Perceived threat of items could be related to any of these three potential proximate mechanisms. Because the characteristic of animacy is sometimes confounded with the perceived threat of the animate items, and because threatening items are often more likely to capture attention (e.g., Blanchette in *The Quarterly Journal of Experimental Psychology, 59,* 1484–1504, 2006), a norming study was first conducted to aid in the creation of lists of threatening and non-threatening animate and inanimate items. Two experiments were then conducted to determine if the animacy effect persisted regardless of the threat level of the items. The first experiment demonstrated the typical animacy advantage as well as a memory advantage for threatening items. The second experiment replicated these results across three successive recall tests as well as in both full attention and divided attention conditions. The results are discussed with respect to the potential proximate mechanisms of attention capture, mortality salience, and mental arousal.

Keywords Animacy · Episodic memory · Attention · Survival advantage · Threat

Recent research in the field of memory has focused on the evolutionary underpinnings of our memory systems. Nairne, Thompson, and Pandeirada (2007) began an investigation into the survival processing effect showing that information processed with regard to one's survival is better remembered than information processed in other ways. Participants were presented with a list of words and asked to rate the relevance of each of the words to a grasslands survival scenario where they were to imagine they were stranded in the grasslands and would need to survive. When compared to control conditions of rating pleasantness of the items, rating personal relevance of the items, or rating the usefulness in a scenario where they were asked to imagine moving to a foreign land, the participants in the survival grasslands condition exhibited better memory for the items. In further explorations of the effect, myriad control conditions that typically lead to high levels of retention have been used, including the ones originally used by Nairne et al. (2007), such as rating the pleasantness or self-relevance of the information, as well as other conditions, such as rating the ability to form an image of the information and a generation task where participants had to unscramble the first two letters of the word before rating the pleasantness of the item (e.g., Nairne, Pandeirada, & Thompson, 2008). Most studies have found a retention advantage for the survival grasslands scenario when compared to conditions that are not related to survival (see Kazanas & Altarriba, 2015; Nairne, 2015, 2016; and Nairne, Pandeirada, & Fernandes, 2017 for reviews on the survival processing effect).

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The animacy effect

Due to the increased focus of exploring the evolutionary underpinnings of our memory system, researchers have begun exploring the effect that animacy has on retrieval of information, with animacy referring to the traits that distinguish living from non-living things (Popp & Serra, 2018). Other researchers define animates as living things that "are capable of independent movement and can suddenly change direction without warning" (Bonin, Gelin, Laroche, Méot, & Bugaiska, 2015, p. 371). The distinction between animate and inanimate items is fundamental (e.g., Opfer & Gelman, 2011) and demonstrated early in life (Rakison & Poulin-Doubis, 2001). There is evidence that humans have distinct regions of the brain devoted to the processing of animate and inanimate items (e.g., Caramazza & Shelton, 1998; Sha et al., 2015) and that visual and attentional processing prioritize animals over other stimuli (New, Cosmides, & Tooby, 2007). Recent evidence suggests that animate items are more likely than inanimate items to be detected in inattentional blindness tasks (Calvillo & Hawkins, 2016) and more likely to be reported in a serial visual presentation task (Guerrero & Calvillo, 2016). Although the importance of the animacy distinction in human cognition has been consistently shown, researchers have only relatively recently begun to focus on animacy in memory.

Animate items were better remembered than inanimate items in the first direct test of animacy and its effects on memory (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013). A list of 12 animate and 12 inanimate items was created and used as stimuli for a memory test. The items were matched on ten various characteristics that can affect memory (e.g., concreteness, familiarity, imagery). Participants were more likely to recall the animate items. It was also found that animacy was a strong predictor of recall when the recall rates data from Rubin and Friendly (1986), who examined recall rates of 925 nouns, were reanalyzed with animacy as a factor in a regression analysis (Nairne et al., 2013).

The animacy advantage was replicated using pronounceable nonwords that were paired with properties of animate or inanimate objects (VanArsdall, Nairne, Pandeirada, & Blunt, 2013). The animacy effect has been replicated across a variety of experiments, including with recognition memory (Bonin, Gelin, & Bugaiska, 2014), independent of encoding instructions (Gelin, Bugaiska, Méot, & Bonin, 2017; Leding, 2018), for picture stimuli (Bonin et al., 2014), and with children participants (Aslan & John, 2016; see Nairne, VanArsdall, & Cogdill, 2017 for a review).

Popp and Serra (2016) further explored the effect of animacy and created a normed list of animate and inanimate items where the two lists were equated on the characteristics of length, frequency, mental imagery, and concreteness. They found the animacy effect in free recall but found that cued recall was typically impaired when animate items were included in the pairs, except in a condition where Swahili words were paired with animate English words, similar to the results of VanArsdall, Nairne, Pandeirada, and Cogdill (2015). Because cued recall was impaired when animate items were in the pairs (except for the case of the Swahili-English pairings), Popp and Serra suggested that the animacy effect might exist when extra processing of individual items leads to increased memory, as in free recall, but might hinder memory performance when the attention given to animate items detracts attention from other information, as in cued recall tests where learning the association between items is necessary. Popp and Serra therefore stated that there could be a factor, such as attention capture, that is associated with animacy that is responsible for the relationship between animacy and memory. If animate items are more likely to capture the attention of participants, then the animate items might benefit from additional processing, which could then lead to greater memory, when compared to inanimate items. They also suggested that mortality salience, or thoughts of death and dying, related to some animate items (e.g., lion, wolf) might lead to stronger memory of those items compared to inanimate items, or that mental arousal associated with animate items might be a moderating factor associated with the animacy effect. Popp and Serra (2018) equated animate and inanimate word lists for mental arousal and found that animate items were still remembered better than inanimate items, suggesting that mental arousal might not be the factor leading to the animacy effect.

In line with the suggestion that attention might be related to the animacy effect, the effect has been found when participants participate in a deep processing task (i.e., rating the pleasantness of items), but also when participants engage in shallow processing of the stimuli (i.e., by determining whether the word includes the letter "e"; Leding, 2018). That the animacy effect persists through manipulations of processing suggests that these items are capturing attention even under conditions when the semantic meaning of the items is not the focus. Further, in a sample of young adults, a divided attention task reduced overall recall rates compared to a full attention condition, but did not diminish the typical survival processing effect (Stillman, Coane, Profaci, Howard, & Howard, 2014; although see Kroneisen, Rummel, & Erdfelder, 2014 and Nouchi, 2013 for evidence that a cognitive load disrupted the survival processing effect). Similarly, in three separate studies, Bonin et al. (2015) found that participants were more likely to remember animates than inanimates even when in a condition of a cognitive load. Participants were given a fixation point, presented with a series of five (or seven, in Study 3B) letters and numerals to remember, presented with a word that was to be categorized as animate or inanimate, and then asked to recall the letters and numerals. In a surprise free-recall task the participants recalled more of the animate than the inanimate words, under both the memory-load and the no memory-load conditions. Bonin et al. suggested that the mechanisms that are related to the animacy effect are relatively independent of cognitive resources and that animate items capture more attention than inanimate items or are processed in a way that requires fewer attentional resources than inanimate items. Further, using a modified Stroop task, participants took longer to process ink color for animate words when compared to inanimate words, suggesting that animates are capturing attention and prioritized in processing (Bugaiska, Grégoire, Camblats, Gelin, Méot, & Bonin, in press). These results, in addition to the results of Stillman et al. and Bonin et al., suggest that attention capture could be a proximate mechanism that contributes to both the animacy effect and the survival processing effect.

Animacy and threat

When considering attention capture as a possible proximate mechanism for the animacy effect, a possible confound in some studies examining cognitive processes and animacy is the perceived threat of the animate and inanimate items. That is, instead of the animacy status of the items leading to stronger memory, it could be that the perceived threat of items is the characteristic responsible for the effects, and that it just so happens that the animate items selected have a higher rate of perceived threat than the inanimate items. For example, in the original test of the animacy effect in memory, 12 animate and 12 inanimate items were used (Nairne et al., 2013). The items were equated for the two lists on ten different characteristics that could affect memory. However, examination of the lists shows that some of the animate items would likely be considered threatening by many individuals (i.e., bee, python, spider, wolf, from a list that also included baby, duck, engineer, minister, owl, soldier, trout, turtle), whereas the inanimate list does not include items that most people would consider threatening (i.e., doll, drum, hat, journal, kite, purse, rake, slipper, stove, tent, violin, whistle). Thus, a contributing factor to the animacy effect in this experiment could be due, at least in part, to the presence of threatening items in the animate list. Similarly, when examining the stimuli used by Popp and Serra (2016), it appears that there are more animate items than inanimate items that would be considered threatening by many individuals (pp. 200–201). As another example of animacy and threat being confounded, animate items were detected more quickly than inanimate items when snakes and spiders were used as the animate stimuli, and flowers and mushrooms were used as the inanimate stimuli (Öhman, Flykt, & Esteves, 2001). In this case, it is unclear whether the perceived threat of the animate items, the animacy of those items, or a combination of the two characteristics caused the difference in detection.

Other research has shown an advantage for detection of threatening items when the animacy of the items is equated. For example, Yorzinski, Penkunas, Platt, and Coss (2014) used eye-tracking technology and showed that participants more quickly locate targets when the targets are dangerous animals (e.g., lions or snakes) when non-dangerous animals were used as distractors compared to locating non-dangerous animals (e.g., impalas or lizards) when dangerous animals were used as distractors. They suggested that dangerous distractors capture and maintain the attention of participants when they are searching for the non-dangerous targets. Although the Yorzinski et al. (2014) study was not examining memory, the results indicate that threatening targets captured the attention of participants. Similarly, it was found that both ancient threats (e.g., snakes) and modern threats (e.g., guns) attracted attention and were detected more quickly than neutral stimuli (e.g., flowers and toasters), providing more evidence that threatening items are likely to capture attention (Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007). Furthermore, recent evidence suggests that evolutionary threatening images are more likely to engage activation in fear-processing areas of the brain, such as the amygdala, when compared to images of more modern threats (Dhum, Herwig, Opialla, Siegrist, & Brühl, 2017).

If people have adapted to be faster at detecting threatening stimuli than non-threatening stimuli, then perhaps memory for threatening information might be enhanced when compared to non-threatening information. For example, memory studies have shown improved recognition for threatening stimuli when compared to non-threatening stimuli, including an advantage for snakes over fish as well as an advantage of dangerous fish (e.g., sharks, deep sea fish, morays) compared to harmless snakes (Meyer, Bell, & Buchner, 2015). In the survival processing paradigm, the threat of a supernatural predator of a demon elicited levels of recall similar to that of the standard grasslands scenario (Kazanas & Altarriba, 2017), and the threat of a supernatural predator of zombies elicited higher levels of recall than the typical grasslands scenario (Soderstrom & McCabe, 2011). It was found that the strength of the survival processing advantage was related to the magnitude of the threat level of both an ancestral survival grasslands scenario and modern city survival scenario (Olds, Lanska, & Westerman, 2014). Threat in this study was manipulated by changing the wording of the scenarios to suggest that survival would be easy or difficult. Further, psychophysiological evidence of fear responses associated with heart rate were found for the survival scenario compared to the moving scenario, and analysis of items recalled indicated that the fear response was present for those items recalled, suggesting that perceived threat can enhance memory (Fiacconi, Dekraker, & Köhler, 2015).

Thus, there is evidence that threatening items or information processed with regard to higher levels of threat is better remembered (Fiacconi et al., 2015; Kazanas & Altarriba, 2017; Meyer et al., 2015; Olds et al., 2014; Soderstrom & McCabe, 2011). There is also evidence that threatening items are more likely to capture attention (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007; Yorzinski et al., 2014). Based on the suggestion made by Popp and Serra (2016) that perhaps the animacy advantage in memory is due to attention capture, it is necessary to independently manipulate threat and animacy to better understand how the animacy status and threat status of items relate to memory in the animacy effect. Further, because perceived threat could also be related to the other potential proximate mechanisms of mental arousal and mortality salience that were suggested by Popp and Serra, the ability to independently manipulate threat and animacy could aid future attempts to test potential proximate mechanisms of the animacy effect. That is, perhaps animate items that are threatening are more likely to be mentally arousing or encourage thoughts of mortality salience, which could then affect the rate at which they are remembered.

A norming study was conducted to create a list of animate and inanimate words that were considered threatening and non-threatening. The lists of the different word types were equated on word length, frequency, mental imagery, and concreteness, as was done by Popp and Serra (2016). Once the lists were created, an experiment was conducted to test recall rates for the various item types to determine if threat and animacy have independent effects on memory. It was predicted that recall rates would be higher for animate compared to inanimate items, consistent with the animacy effect literature, and that threatening items would be better remembered than non-threatening items.

To begin an exploration into the potential role of attention capture in the animacy effect, an additional experiment was conducted to test whether the animacy effect occurs without the use of resource-demanding processes. Half of the participants studied the words under full attention and half under divided attention. Popp and Serra (2016) found that memory performance in a cued recall task was impaired when animate items were included in the word pairs, and suggested that animacy might capture the attention of participants, which would lead to the typical animacy effect that has been found in the literature. Further, Bonin et al. (2015) found that the animacy effect persisted through a memory load exercise and suggested that there might be an attentional component related to the animacy effect such that animate items capture more attention than inanimate items. Thus, if animate items are likely to capture attention, then the animacy effect should persist through a divided attention task when participants are not able to use all of their attentional resources to study the word lists, and this should occur for both threatening and non-threatening animate items. Similar to the results of studies showing that threatening items are likely to capture attention (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007; Yorzinski et al., 2014), it should also be the case that threatening items, independent of their animacy status, are better remembered even when they are studied during a divided attention task. After studying the words for an intentional memory test under full or divided attention, the participants completed three successive recall tests to test whether recall rates for all item types would demonstrate a hypermnesia effect, where recall increases over successive recall attempts (Erdelyi & Becker, 1974; Roediger & Payne, 1985). Nairne et al. (2013) found that the animacy effect persisted through three successive study and testing phases. The inclusion of the three successive recall tests in the present study was to replicate the finding that the animacy effect occurred after the first recall test, as in Nairne et al., and continued to persist across repeated testing using different materials and a modified method. Further, it was included to determine whether any particular item type would have a stronger hypermnesia effect, as prior studies have shown that the effect can be stronger for different types of words. For example, Roediger and Payne (1985) found a hypermnesia effect for both low- and high-imagery words, but the effect was stronger for the high-imagery words. Although imagery of the items included in the present studies was equated, and imagery has been shown to not support animacy effects in memory (Gelin, Bugaiska, Méot, Vinter, & Bonin, in press), it is still possible that there are other characteristics of items that could lead to a stronger hypermnesia effect, thereby causing increased recall across recall tests for some item types compared to the others. Thus, similar to the first experiment, in the second experiment, the main effects of animacy and threat were predicted. In line with related evidence from Bonin et al. (2015) and Stillman et al. (2014), it was predicted that these results would persist through a divided attention task, although overall recall rates were expected to be lower in the divided attention condition.

Norming study

Method

Participants Participants were 191 students from the University of North Florida. The participants were recruited through an online experiment sign-up system and were told that they should only participate if English was their first language. Participants received partial course credit for participation. An additional 11 participants began the program but their data were not included because they either did not complete the majority of the questions, completed none of the questions, or did not say "Yes" on the consent form indicating that their data could be used.

Materials To create the threatening and non-threatening lists of animate and inanimate items, a large list of animate and inanimate objects was compiled. The list included 100 animate nouns that were all animals, as was done by Popp and Serra (2016). The list also included 116 inanimate nouns. Many of these items came from the lists created by Popp and Serra but others were added. These 216 items were divided into two lists with an equal number of animate and inanimate objects in each one. For each word there were three questions. The first question was "How easy is it to form an image of the word XXX?" with a seven-point response scale where 1 was Extremely difficult and 7 was Extremely easy. The second question was "How abstract or concrete is the word XXX?" with a seven-point response scale where 1 was Extremely Abstract and 7 was Extremely Concrete. The third question was "How threatening is the word XXX?" with a seven-point response scale where 1 was Extremely Nonthreatening and 7 was Extremely Threatening. A Qualtrics program presented these questions for one of the two lists of 108 items. The three questions for each word were presented together in the order listed above.

Procedure The participants signed up for the study and were directed to the Qualtrics survey. Participants completed an informed consent and then rated each of the words on the three dimensions. When participants finished answering the questions they were thanked and the session ended.

Results

In addition to the ratings of how easy it is to form an image of the object, the concreteness of the object, and the threat-level of the object, the length of the words and the frequency of each word in the Google Internet search engine database as of August 2017 were included. This method of obtaining the frequency information for the words was selected because it was the same measure used by Popp and Serra (2016), and the present norming study was created to replicate, as closely as possible, the method used by Popp and Serra when creating their stimuli lists. Four different word lists were constructed: threatening animate, non-threatening animate, threatening inanimate, and non-threatening inanimate. To create these lists, the 100 animate items and the 116 inanimate items were separately sorted by the mean threat rating of the words and then the most and least threatening animate and inanimate items were grouped together. Care was taken to create word lists for the four item types that were equivalent in the other characteristics of imageability, concreteness, word length, and frequency, while keeping the mean threat rating of the threatening and non-threatening items significantly different. This was accomplished by removing items from the lists until there was an equal number of items in each of the four word types while maintaining equivalence in the means of the four characteristics. That is, some words that were rated as very threatening or very non-threatening were not included in the final lists because their inclusion would have led to significant differences in the other characteristics (e.g., frequency). This process resulted in 28 items in each of the four lists. A 2(Animacy: Animate, Inanimate) × 2(Threat: Threatening, Nonthreatening) between-subjects ANOVA was conducted on the threat ratings to ensure a significant difference in the threatening and non-threatening lists. As predicted, there was a significant main effect of Threat, $F(1, 108) = 894.91$, $MSE = .28$, $p < .001$, with threatening words ($M = 5.17$, $SD = .64$) having a higher threat rating than non-threatening words ($M = 2.19$, $SD = .38$). The main effect of Animacy and the interaction were not significant (both p's > .15). To ensure equivalence in the categories of imageability, concreteness, word length, and frequency, 2(Animacy: Animate, Inanimate) × 2(Threat: Threatening, Nonthreatening) between-subjects ANOVAs were conducted on each of these ratings (see Online Supplementary Information for means and standard deviations). In all of the ANOVAs the main effects of Threat and Animacy and the interaction were not significant (all p's > .11). Thus, the lists were equivalent in all of the characteristics, with the exception of the threat level of the threatening and non-threatening items.

Experiment 1

Method

Participants Participants were 40 students (34 indicated that their current gender identify was female, five indicated that their current gender identity was male, one indicated that their current gender identity was non-binary trans-identity; mean age 21.15 years, $SD = 6.34$). The participants were recruited through an online experiment sign-up system and were told that they should only participate if English was their first language. One student indicated that English was not their first language and the data from that participant were still included.[1] The participants received partial course credit for participation.

Materials The four lists of different word types (i.e., animate threatening, animate non-threatening, inanimate threatening, inanimate non-threatening) that were created in the norming study were used. Four different presentation orders were created with the 112 words presented in a different random order in each of the lists. Each participant studied one of these four presentation orders. The lists were created in Direct RT (Jarvis, Version 2014.1.114) and the words were presented at a rate of one word every 2 s. Words were presented in light blue font in the center of the screen on a black background.

Procedure Participants completed the study individually or in groups of up to four people. Participants sat at computers that were separated by dividers. After signing the consent form, participants were told that they would be viewing a list of words and that they should attend to the words because their memory for the words would later be tested. They viewed one of the four different presentation orders of the 112 words on the computer screen and then completed a 2-min distractor task where they wrote down as many of the states in the USA as they could. After the distractor task, the participants were given 5 min to write down as many words from the list as they could remember. After 4 min had passed, the participants were told that they had 1 min remaining and that they should continue trying to remember words. Participants then completed a short demographic questionnaire that asked their age, whether English was their native language, and their current gender identity. Participants were then thanked and debriefed.

[1] When the data were analyzed with this participant excluded, the significant effects and pattern of results remained the same.

Results

The purpose of the experiment was to test whether threat and animacy affected recall rates. A 2(Animacy: Animate Words, Inanimate Words) × 2(Threat: Threatening Words, Nonthreatening words) repeated-measures ANOVA was conducted on proportion of recall. See Table 1 for means and standard deviations. There was a significant effect of Animacy, $F(1, 39) = 19.92$, $MSE = .01$, $p < .001$, $\eta_p^2 = .338$, with participants recalling more animate words than inanimate words, replicating the animacy effect found in prior literature. There was also a significant effect of Threat, $F(1, 39) = 31.08$, $MSE = .01$, $p < .001$, $\eta_p^2 = .444$, with participants recalling more threatening items than non-threatening items. The Animacy × Threat interaction was not significant, $F(1, 39) = 1.42$, $MSE = .01$, $p > .05$. The mean intrusion rate was 2.98 ($SD = 4.85$) with a range of intrusion responses from 0 ($n = 14$) to 25 ($n = 1$).

Examination of the means in Table 1 shows that proportion of recall was relatively low, especially when compared to other studies on the animacy effect (e.g., Nairne et al., 2013; Popp & Serra, 2016). The lower performance is likely due, in part, to the larger number of items studied by participants (i.e., 28 words in each of four categories, for a total of 112 words in the present study, whereas participants in Nairne et al. studied 24 words total), the presentation rate of the items in the present study (i.e., 2 s per word instead of 5 s per word that has been used in other studies such as Nairne et al. and Popp and Serra), and because participants studied all of the words before the recall test occurred. The mean proportions in the present study are more similar to the fourth experiment of Bonin et al. (2015), where there were 28 words in each of two categories. Thus, the present study had a larger study list with items being presented for a shorter amount of time than in previous examinations of the animacy effect, and the recall test occurred after all of the study words had been presented. Under these more difficult test conditions the animacy effect was replicated, providing strong evidence for the robustness of this effect.

Experiment 2

The results of the first experiment were in the predicted direction, with animate items and threatening items being remembered at higher rates than inanimate and non-threatening items. The purpose of the second experiment was to replicate the results of better recall for animate and threatening items and to determine whether the animacy effect would persist through a divided attention task where participants were instructed to monitor a string of digits and keep track of how many times they heard three consecutive odd digits. Furthermore, three successive recall tests were completed to see if the animacy effect persisted across the three recall attempts, similar to what was found in Nairne et al. (2013) using repeated study and test sessions, and to explore whether different item types were more likely to exhibit the hypermnesia effect.

Table 1 Correct recall proportions for Experiment 1

	Threatening	Non-threatening
Animate	.22 (.13)	.16 (.08)
Inanimate	.18 (.12)	.09 (.08)

Standard deviations are presented in parentheses

Method

Participants Participants were 94 students (80 indicated that their current gender identity was female and 14 male; mean age 20.68 years, $SD = 4.56$) from the University of North Florida. The participants were recruited through an online experiment sign-up system and were told that they should only participate if English was their first language. Two students indicated that English was not their first language and the data from those participants were still included.[2] Data from an additional two participants were not included because the participants did not follow the directions of the distractor task and the memory tests. Data from 45 participants in the full attention condition and 49 participants in the divided attention condition were analyzed. The participants received partial course credit for participation.

Materials The word lists were the same as those used in Experiment 1 where the words were presented in light blue font on a black background at a rate of one word every 2 s.

The divided attention task consisted of a digital recording of a randomly presented string of digits read aloud at a rate of one digit per second. The recording was created so that ten digits were presented to participants and then the word "Begin" was stated so that participants would know when to advance the DirectRT presentation to begin the presentation of the word list. The presentation of the digits then continued throughout the time that participants viewed the word lists. Participants were to monitor for strings of three odd digits presented consecutively and mentally keep track of how many times that occurred (Craik & Byrd, 1982; Jacoby, 1991; Mulligan & Hirshman, 1997). At the end of the presentation of the words, the participants wrote down how many times they had heard three consecutive odd digits in the recording.

Procedure The procedure for the second experiment was the same as the first with two exceptions. The first difference was that the participants in the divided attention condition were

[2] When the data were analyzed with these two participants excluded, the significant effects and pattern of results remained the same.

told that they would be participating in two tasks and that they should try to perform equally well on both of the tasks. The participants first received instructions about the digit monitoring task. They were instructed to listen to the recording and keep track of how many times they heard three odd digits in a row so that they could report the number of times it occurred at the end of the task. The participants were then given the same instructions about viewing the list of words as the participants in the full attention condition. After the presentation of the word lists, the participants in the divided attention condition recorded the number of times they heard three odd digits in a row. The second difference was that after viewing the study words and completing the distractor task, all participants completed three successive 5-min recall tests. On the second and third recall tests the participants were asked to write down the words that they had written during the previous recall attempt(s) and any other words they could remember.

Results

The purpose of this experiment was to replicate the effects of animacy and threat from the first experiment, to test whether the animacy effect persisted through a divided attention condition, to test whether the animacy effect persisted across three successive recall tests, and to explore whether the hypermnesia effect was stronger for different word types. A 2(Animacy: Animate Words, Inanimate Words) × 2(Threat: Threatening Words, Nonthreatening words) × 2(Attention: Full Attention, Divided Attention) × 3(Test: Test 1, Test 2, Test 3) mixed-factors ANOVA was conducted on proportion of recall. Animacy, Threat, and Test were within-subjects variables and Attention was a between-subjects variable. See Table 2 for means and standard deviations. As discussed in the results of Experiment 1, the mean proportions recalled were lower than in some previous examinations of the animacy effect (e.g., Nairne et al., 2013). This was likely due to the length of the study list, the presentation rate of the study items, and that recall occurred for the first time after the entire study list had been presented. Data from all participants in the divided attention condition were included in the analyses, regardless of their performance on the divided attention task.[3]

There was a significant main effect of Test, $F(2, 184) = 4.93$, $MSE = .001$, $p = .008$, $\eta_p^2 = .051$. *Post hoc* tests using the Bonferroni correction indicated that recall rates were significantly higher in Test 3 ($M = .13$, $SEM = .01$) than Test 2 ($M = .118$, $SEM = .01$), but not significantly different than Test 1 ($M = .119$, $SEM = .01$). Test 1 and Test 2 were not significantly different from each other. The main effects of Animacy and Threat were also significant, $F(1, 92) = 99.89$, $MSE = .01$, $p < .001$, $\eta_p^2 = .521$ and $F(1, 92) = 30.58$, $MSE = .01$, $p < .001$, $\eta_p^2 = .249$, respectively, with higher recall rates for animate items than inanimate items and higher recall rates for threatening items than non-threatening items. The main effect of Attention was also significant, $F(1, 92) = 47.28$, $MSE = .04$, $p < .001$, $\eta_p^2 = .339$, with recall rates being higher in the full attention condition compared to the divided attention condition. The Animacy × Attention interaction was significant, $F(1, 92) = 9.36$, $MSE = .01$, $p = .003$, $\eta_p^2 = .092$ and the Test × Threat by Attention interaction was also significant, $F(2, 184) = 4.76$, $MSE = .001$, $p = .010$, $\eta_p^2 = .049$. None of the other interactions were statistically significant (all F's < 2.34), although there was a marginally significant interaction between Threat and Attention, $F(1, 92) = 3.70$, $MSE = .01$, $p = .057$, $\eta_p^2 = .039$. To further examine the significant interactions separate 2(Animacy: Animate Words, Inanimate Words) × 2(Threat: Threatening Words, Nonthreatening words) × 3(Test: Test 1, Test 2, Test 3) mixed-factors ANOVA were conducted on recall rates in the divided attention condition and the full attention condition.

In the divided attention condition there was a significant main effect of Test, $F(2, 96) = 5.57$, $MSE = .001$, $p = .005$, $\eta_p^2 = .104$. *Post hoc* analyses using the Bonferroni correction indicated that recall rates were significantly higher in Test 3 ($M = .083$, $SEM = .01$) than in Test 2 ($M = .078$, $SEM = .01$) but that there was no difference between Test 1 ($M = .075$, $SEM = .01$) and either of the other tests. The main effect of animacy was significant, $F(1, 48) = 35.95$, $MSE = .01$, $p < .001$, $\eta_p^2 = .428$ with recall being higher for animate items than inanimate items. The main effect of threat was also significant, $F(1, 48) = 10.40$, $MSE = .01$, $p = .002$, $\eta_p^2 = .178$, with recall rates being higher for threatening items than non-threatening items. The Test × Animacy interaction was significant, $F(2, 96) = 3.91$, $MSE = .001$, $p = .023$, $\eta_p^2 = .075$,

Table 2 Correct recall proportions and intrusion rates for full and divided attention conditions in Experiment 2

	Test 1	Test 2	Test 3
Full attention			
Animate threatening	.22 (.12)	.21 (.12)	.22 (.12)
Animate non-threatening	.18 (.09)	.18 (.10)	.20 (.12)
Inanimate threatening	.16 (.10)	.15 (.10)	.16 (.11)
Inanimate non-threatening	.09 (.06)	.09 (.07)	.10 (.07)
Intrusions	2.98 (5.36)	5.71 (12.90)	6.89 (13.64)
Divided attention			
Animate threatening	.10 (.07)	.11 (.08)	.12 (.09)
Animate non-threatening	.08 (.06)	.09 (.07)	.09 (.07)
Inanimate threatening	.06 (.07)	.07 (.06)	.07 (.06)
Inanimate non-threatening	.05 (.05)	.05 (.05)	.05 (.04)
Intrusions	3.10 (3.45)	6.88 (9.26)	8.80 (13.56)

Standard deviations are presented in parentheses

[3] There was a range of performance on the divided attention task. Two participants did not report the number of times they heard three odd digits in a row and two participants reported very high values. Data analyses conducted with the data from these participants removed revealed the same pattern of significant main effects and interactions as the data analyses including all of the participants.

whereas the other interactions were not significant (all *F*'s < 2.17). The significant interaction was further explored by conducting one-way repeated measures ANOVAs for each of the four item types across the three tests. The ANOVA conducted on animate threatening items was significant, $F(2, 96) = 7.25$, $MSE = .001$, $p = .001$, $\eta_p^2 = .131$. *Post hoc* tests using the Bonferroni correction indicated that the recall rates in Test 3 ($M = .13$, $SEM = .01$) were significantly higher than in Test 2 ($M = .11$, $SEM = .01$) and Test 1 ($M = .10$, $SEM = .01$) with no significant difference between Test 2 and Test 1. Thus, in the divided attention condition the recall rates for the animate threatening items increased from the first to the third recall test. The ANOVAs conducted on the other item types were not significant, indicating that the significant Test × Animacy interaction in the divided attention condition was driven by the hypermnesia effect for the animate threatening items. Thus, in the divided attention condition, the main effects of Test, Animacy, and Threat were all in the predicted directions but further exploration indicated that the hypermnesia effect was driven by the increase in recall rates for the animate threatening items only, with no parallel hypermnesia effect for the other three item types.

In the full attention condition the main effect of Test was not significant. The main effects of Animacy and Threat were significant, $F(1, 44) = 61.50$, $MSE = .01$, $p < .001$, $\eta_p^2 = .583$ and $F(1, 44) = 19.33$, $MSE = .02$, $p < .001$, $\eta_p^2 = .305$, respectively, with recall rates being higher for animate items than inanimate items and recall rates being higher for threatening items compared with non-threatening items. The interactions were not statistically significant, (all *F*'s < 2.81). For the participants in the full attention condition, the animate items and threatening items were better remembered across all three tests, with no effects of repeated testing. These results, when combined with those of the participants in the divided attention condition, suggest that the effects of animate items and threatening items being remembered at higher rates are not due to a resource-demanding process, and thus these items could possibly be capturing attention, leading to better memory.

The recall rate of intrusions was analyzed with a 3(Test: Test 1, Test 2, Test 3) × 2(Attention: Full Attention, Divided Attention) mixed-factors ANOVA. There was a significant main effect of Test, $F(2, 184) = 17.12$, $MSE = 32.93$, $p < .001$, $\eta_p^2 = .157$. *Post hoc* tests using the Bonferroni correction indicated that the intrusion rates significantly increased from Test 1 ($M = 3.04$, $SEM = .46$) to Test 2 ($M = 6.29$, $SEM = 1.15$) to Test 3 ($M = 7.84$, $SEM = 1.40$; all *t*'s > 3.03). The main effect of Attention and the interaction were not significant (both *F*'s < 1).

General discussion

The animacy effect for memory has been well established (e.g., Nairne et al., 2013; Gelin et al., 2017; Popp & Serra 2016, 2018); animate items are better remembered than inanimate items across a variety of experimental manipulations and materials (see Nairne et al., 2017 for a review). As suggested by several researchers, including Bonin et al. (2014), Gelin et al. (in press), Popp and Serra (2016), and VanArsdall et al. (2013), it is likely that animacy is not directly exerting an effect on memory, but that there are proximate mechanisms responsible for the animacy effect. Popp and Serra (2016) suggested mental arousal, attention capture, and mortality salience as possible proximate mechanisms responsible for the animacy effect based on their findings that cued recall was typically impaired when animate items were included in the paired associates learning task. They suggested that the animacy status of the items might be capturing participants' attention, leading to less attention being available for the second item of the pair as well as for the relationship between the items. Further, Bonin et al. (2015) found that the animacy effect persisted through a task where participants experienced a cognitive load, suggesting that the animate status of items might be capturing attention of the participants, leading to stronger memory. They suggested that animate items might be prioritized during processing due to their stronger fitness value, when compared to inanimate items, and that the mechanisms that are responsible for the animacy effect might not be resource demanding. In line with this is recent evidence from a modified Stroop task showing that participants took longer identifying the ink color of animate items compared to inanimate items, suggesting that the animate items were prioritized in processing (Bugaiska et al., in press).

The present studies focused on the characteristic of perceived threat of the to-be-remembered items. Threat was chosen as a variable of interest due to its relation to attention capture in the literature on attention (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007; Yorzinski et al., 2014). That is, previous studies have found that items that are perceived to be threatening are more likely to capture the attention of participants. If attention capture is responsible for the animacy effect, as suggested by Popp and Serra (2016), then it could be that the animacy status of items is capturing attention, leading to increased processing of those items and increased memory. However, because previous studies have not controlled for the perceived threat of the animate items, it could be that the threatening status of many of the animate items is capturing attention, leading to what looks like an "animacy effect" in memory that is really a "threat effect" in memory. By creating a list of normed words that included threatening and non-threatening animate and inanimate items, the potential of animacy being confounded with threat was removed. In the present experiments animate items were more likely to be recalled than inanimate items. There was also a significant effect of threat, where threatening items were remembered more often than non-threatening items, regardless of the animacy status of the item. There was no significant interaction in either study, suggesting that the effects of animacy and threat are additive but do not interact with each other in a way that would suggest that the threat status of animate items is responsible for the animacy effect. The significant effects of animacy and threat persisted across both experiments, and in the second experiment the effects persisted across the three successive recall tests.

Additionally, the significant effects of both animacy and threat persisted through a divided attention task, suggesting that the effects do not require resource-demanding processing. This could mean that the proximate mechanism of attention capture is an important component of the animacy effect and that the characteristic of threat is not responsible for causing the animacy effect in memory. That is, the effect of increased memory for threatening items persisted through the divided attention task, as would be predicted by previous studies examining threat and attention (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007; Yorzinski et al., 2014). However, independent of threat status, the animacy effect also persisted through the divided attention condition, suggesting that the animacy effect is pervasive enough, regardless of the perceived threat of the items, to occur even when participants are not able to focus all of their cognitive resources on the items. The present results extend those of Bonin et al. (2015) by replicating the animacy effect through a condition where participants' attentional resources were not solely focused on the presented words, while also providing evidence that the effect of threat also persisted through the divided attention task. Although overall recall rates were lower in the divided attention task compared to the full attention task, higher recall for animate items and threatening items persisted, suggesting that these items are remembered in the absence of resource-demanding processes. These results are similar to those found by Stillman et al. (2014) with the survival-processing effect, where young adults continued to experience the survival-processing advantage through a divided attention condition, although overall memory rates were lower than for the participants in the full attention condition (see also Kroneisen et al., 2014 and Nouchi, 2013 who found reduced performance or participants under a cognitive load with a reduction in the survival-processing effect).

Further, in the present studies the only item type that exhibited a significant hypermnesia effect was the threatening animate items in the divided attention condition. Roediger and Payne (1985) found that there was a stronger increase in recall across successive tests for higher-imagery words compared to lower-imagery words. The different word lists used in the present studies were equated for imagery, so it is unlikely that imagery is responsible for this increase in the threatening animate items in the divided attention condition. Additionally, there was no hypermnesia effect in the full attention condition, further suggesting that imagery was not responsible for that effect. Instead, it could be that in the divided attention condition, the threatening animate items were the items that were most likely to capture attention, which led to greater memory improvement for those items over the three successive recall tests. In the full attention condition, the lack of a hypermnesia effect for any of the item types could be explained by the participants having such strong memory for the animate items and threatening items that there was little room for improvement across the successive recall tests.

In addition to the potential proximate mechanism of attention capture potentially being responsible for the animacy effect, Popp and Serra (2016) mentioned mortality salience and mental arousal as other possibilities. Although the present studies did not directly test either of these proximate mechanisms, the variable of perceived threat could potentially be related to both mental arousal and mortality salience. For example, Popp and Serra suggested that encountering specific animate items could trigger thoughts of predation or hunting, which could then trigger thoughts of death or dying, or mortality salience. The relation between memory and mortality salience, or "dying to remember," was originated by Hart and Burns (2012) and replicated by Bugaiska, Mermillod, and Bonin (2015), where it was found that thoughts of one's own death led to increased memory for items encoded after the thought induction. Burns, Hart, and Kramer (2014) and Bugaiska et al. (2015) further found similar or higher levels of retention in various "death processing" scenarios when compared to the traditional survival processing scenario, suggesting that thoughts of mortality salience increase memory. In the present studies, mortality salience was neither directly manipulated nor assessed in the participants. However, the independent manipulation of the animacy status and threat status of the items allows an initial exploration of the idea that mortality salience could be responsible for the animacy effect, as threatening items might be more likely to elicit thoughts of death in individuals. The results suggest that, while mortality salience might magnify the animacy effect, it alone is likely not responsible for the animacy effect, because an animacy effect persisted for the non-threatening items. Further research could directly test the relationship between perceived threat and mortality salience in the animacy effect, perhaps by initially collecting normative data regarding the extent to which the threatening and non-threatening items are likely to elicit thoughts of death.

Regarding the potential proximate mechanism of mental arousal, it could be that items that are perceived as threatening are more likely to elicit higher mental arousal in participants. For example, Fiacconi et al. (2015) examined the role of perceived threat in the survival-processing paradigm and found that the survival scenario was rated higher in perceived arousal. Further, psychophysiological measurements at encoding revealed patterns of heart rate deceleration suggesting a fear response that was associated with the survival scenario, and a significantly higher recall rate for those words, suggesting that the arousal and perceived threat of the words associated with the survival scenario enhanced memory for those items. However, when examining mental arousal and the animacy effect, the effect persisted for animate words that had been equated on arousal with inanimate words, suggesting that mental arousal might not be responsible for the animacy effect (Popp & Serra, 2018). The present studies did not directly or indirectly measure mental arousal of the threatening and non-threatening lists, but future studies could further explore the role of perceived threat and mental arousal in the animacy effect.

Methodological issues

The word lists created for the present study were constructed in a way to independently manipulate threat of an item and the animacy of the item. The norming study was conducted to collect information regarding perceived threat, imagery, and concreteness of the items and lists of stimuli for the four word types were then equated on the same variables used by Popp and Serra (2016): imagery, concreteness, word frequency, and length. Care was taken to create word lists for the different item types that were equated on these characteristics that can affect memory, while also balancing the need to have a large set of stimuli available for each of the item types for use in the experiments. Further, there was a significant difference in perceived threat for the items composing the "threatening" lists and for the items composing the "non-threatening" lists. Although care was taken to equate the lists on various attributes that are related to memory, there are, of course, several attributes that could have been included that were not. For example, Popp and Serra (2018) suggest that the valence (i.e., pleasantness) of the items on their word lists could have affected memory rates.[4] Furthermore, the suggestion has been made in the past that lists of animate items are more likely to include subcategories (e.g., mammals, cats, farm animals) that could contribute to the increased memory performance for animate items. Many of the items that were included in the norming study for potential inclusion in the word lists came from the stimuli from Popp and Serra (2016), and care was taken to include a wide variety of types of animals as well as a wide variety of inanimate objects, including multiple inanimate objects from the same categories (e.g., clothing and accessories, musical instruments, furniture). Further, it was found that a categorical recall strategy could not be used to explain the animacy effect (VanArsdall et al., 2015), suggesting that if subcategories exist in the lists they are not completely responsible for the animacy effect.

[4] To explore this suggestion, the valence ratings for the words in the present study list were obtained from the normative data in Warriner, Kuperman, and Brysbaert (2013). For the words that were available in the normative data, the valence ratings were analyzed with a 2(Animacy: Animate, Inanimate) × 2(Threat: Threatening, Nonthreatening) between-subjects ANOVA. There was a significant effect of threat, $F(1, 97) = 64.88$, $MSE = .81$, $p < .001$, $\eta_p^2 = .401$. The non-threatening items had higher mean valence rating ($M = 5.94$, $SD = 0.78$) than the threatening items ($M = 4.50$, $SD = 1.01$). The main effect of animacy and the interaction were not significant (both F's < 2.24). This examination of valence suggests that valence is not responsible for the animacy effect. Further research could explore the relationship between threat and valence. The author would like to thank an anonymous reviewer for suggesting this analysis.

Conclusion

The present studies add to the growing body of research showing enhanced memory for animate items compared to inanimate items by independently manipulating the threat level of the items. Threat has been shown to capture the attention of participants (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007; Yorzinski et al., 2014), thus ruling out the possible contribution of threat to the animacy effect is a necessary step for understanding the possibility of attention capture as a proximate mechanism for the animacy effect. The main effect of animacy persisted regardless of the threat level of the items, suggesting that the animacy effect is robust and not due to potential confounds of animacy with threat. The present studies add to the growing body of research examining the potential proximate mechanisms for the animacy effect (e.g., Bonin et al., 2015; Gelin et al., in press; Popp & Serra, 2016). As Popp and Serra (2016) noted, it is unlikely that animacy exerts a direct influence on memory, but that other factors are related to the animacy effect. Future studies should continue to examine attention capture as a potential proximate mechanism for the animacy effect, as the main effects of animacy and of threat that persisted through manipulations of attention show that the effects occur in the absence of resource-demanding processes, suggesting that attention capture could be related to the effect of animacy on memory. These results are similar to those of Bonin et al. (2015), who suggested that the mechanisms responsible for the animacy effect are perhaps not resource demanding. Further, the other potential proximate mechanisms for the animacy effect suggested by Popp and Serra (2016), including mortality salience and mental arousal, could be related to perceived threat. Although Popp and Serra (2018) found evidence that did not support mental arousal as a proximate mechanism for the animacy effect, they suggested that the way in which they characterized words as being mentally arousing could have affected the results. Thus, the independent manipulation of animacy and threat in the current set of materials could be used to further explore the role of attention capture and other potential proximate mechanisms in the animacy effect.

References

Aslan, A., & John, T. (2016). The development of adaptive memory: Young children show enhanced retention of animacy-related information. *Journal of Experimental Child Psychology*, *152,* 343-350. https://doi.org/10.1016/j.jecp.2016.07.007

Blanchette, I. (2006). Snakes, spiders, guns, and syringes: How specific are evolutionary constraints on the detection of threatening stimuli?. *The Quarterly Journal of Experimental Psychology*, *59*, 1484-1504. https://doi.org/10.1080/02724980543000204

Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition*, *42*, 370-382. https://doi.org/10.3758/s13421-013-0368-8

Bonin, P., Gelin, M., Laroche, B., Méot, A., & Bugaiska, A. (2015). The 'how' of animacy effects in episodic memory. *Experimental Psychology*, *62*, 371-384. https://doi.org/10.1027/1618-3169/a000308

Bugaiska, A., Grégoire, L., Camblats, A., Gelin, M., Méot, A., & Bonin, P. (in press). Animacy and attentional processes: Evidence from the Stroop task. *Quarterly Journal of Experimental Psychology*. https://doi.org/10.1177/1747021818771514

Bugaiska, A., Mermillod, M., & Bonin, P. (2015). Does the thought of death contribute to the memory benefit of encoding with a survival scenario?. *Memory, 23*, 213-232. https://doi.org/10.1080/09658211.2014.881881

Burns, D.J., Hart, J., & Kramer, M.E. (2014). Dying scenarios improve recall as much as survival scenarios. *Memory*, *22*, 51-64. https://doi.org/10.1080/09658211.2013.795973

Calvillo, D.P., & Hawkins, W.C. (2016). Animate objects are detected more frequently than inanimate objects in inattentional blindness tasks independently of threat. *Journal of General Psychology*, *143*, 101-115. https://doi.org/10.1080/00221309.2016.1163249

Caramazza, A., & Shelton, J.R. (1998). Domain-specific knowledge systems in the brain: The animate–inanimate distinction. *Journal of Cognitive Neuroscience*, *10*, 1-34. https://doi.org/10.1162/089892998563752

Craik, F.I.M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F.I.M. Craik & S.E. Trehub (Eds.), *Aging and cognitive processes* ((pp. 191 – 211). New York, NY: Plenum Press.

Dhum, M., Herwig, U., Opialla, S., Siegrist, M., & Brühl, A. B. (2017). Evolutionary and modern image content differentially influence the processing of emotional pictures. *Frontiers in Human Neuroscience*, *11,* 1-11. https://doi.org/10.3389/fnhum.2017.00415

Erdelyi, M.H., & Becker, J. (1974). Hypermnesia for pictures: Incremental memory for pictures but not words in multiple recall trials. *Cognitive Psychology*, *6*, 159-171. https://doi.org/10.1016/0010-0285(74)90008-5

Fiacconi, C.M., Dekraker, J., & Köhler, S. (2015). Psychophysiological evidence for the role of emotion in adaptive memory. *Journal of Experimental Psychology: General, 144,* 925-933. https://doi.org/10.1037/xge0000097

Fox, E., Griggs, L., & Mouchlianitis, E. (2007). The detection of fear-relevant stimuli: Are guns noticed as quickly as snakes?. *Emotion*, *7*, 691-696. https://doi.org/10.1037/1528-3542.7.4.691

Gelin, M., Bugaiska, A., Méot, A., & Bonin, P. (2017). Are animacy effects in episodic memory independent of encoding instructions?. *Memory*, *25*, 2-18. https://doi.org/10.1080/09658211.2015.1117643

Gelin, M., Bugaiska, A., Méot, A., Vinter, A., & Bonin, P. (in press). Animacy effects in episodic memory: Do imagery processes really play a role? *Memory* doi.org/10.1080/09658211.2018.1498108

Guerrero, G., & Calvillo, D.P. (2016). Animacy increases second target reporting in a rapid serial visual presentation task. *Psychonomic Bulletin & Review*, *23*, 1832-1838. https://doi.org/10.3758/s13423-016-1040-7

Hart, J., & Burns, D.J. (2012). Nothing concentrates the mind: Thoughts of death improve recall. *Psychonomic Bulletin & Review*, *19*, 264-269. https://doi.org/10.3758/s13423-011-0211-9

Jacoby, L.L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513-541. https://doi.org/10.1016/0749-596X(91)90025-F

Jarvis, B.G. (2014). DirectRT (Version 2014.1.114) [Computer Software]. New York, NY: Empirisoft Corporation.

Kazanas, S.A., & Altarriba, J. (2015). The survival advantage: Underlying mechanisms and extant limitations. *Evolutionary Psychology*, *13*, 360-396.

Kazanas, S.A., & Altarriba, J. (2017). Did our ancestors fear the unknown? The role of predation in the survival advantage. *Evolutionary Behavioral Sciences, 11,* 83-91. https://doi.org/10.1037/ebs0000074

Kroneisen, M., Rummel, J., & Erdfelder, E. (2014). Working memory load eliminates the survival processing effect. *Memory*, *22*, 92-102. https://doi.org/10.1080/09658211.2013.815217

Leding, J. K. (2018). The animacy advantage in memory: Manipulations of levels of processing and survival processing. *The American Journal of Psychology, 131, 273-281.*

Meyer, M.M., Bell, R., & Buchner, A. (2015). Remembering the snake in the grass: Threat enhances recognition but not source memory. *Emotion*, *15*, 721-730. https://doi.org/10.1037/emo0000065

Mulligan, N.W., & Hirshman, E. (1997). Measuring the bases of recognition memory: An investigation of the process-dissociation framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 280-304. https://doi.org/10.1037/0278-7393.23.2.280

Nairne J.S. (2015). Adaptive memory: Novel findings acquired through forward engineering. In Lindsay, D.S., Kelley, C.M., Yonelinas, A.P., & Roediger, H.L. (Eds.). *Remembering: Attributions, processes, and control in human memory.* New York: Psychology Press.

Nairne, J.S. (2016). Adaptive memory: Fitness-relevant "tunings" help drive learning and remembering. In C.D. Geary, & B.D. Berch (Eds.), *Evolutionary perspectives on child development and education* (pp. 251-269). Springer International.

Nairne, J.S., Pandeirada, J.N.S., & Fernandes N.L. (2017) Adaptive memory. In J. H. Byrne (Ed.) *Learning and memory: A comprehensive reference* (2nd edition, J. Wixted, Ed.). Oxford: Academic Press.

Nairne, J.S., Pandeirada, J.N.S., & Thompson, S.R. (2008). Adaptive memory: The comparative value of survival processing. *Psychological Science, 19,* 176-180. https://doi.org/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. https://doi.org/10.1037/0278-7393.33.2.263

Nairne, J.S., VanArsdall, J.E., & Cogdill, M. (2017). Remembering the living: Episodic memory is tuned to animacy. *Current Directions in Psychological Science*, *26*, 22-27. https://doi.org/10.1177/0963721416667711

Nairne, J.S., VanArsdall, J.E., Pandeirada, J.N.S., Cogdill, M., & LeBreton, J.M. (2013). Adaptive memory: The mnemonic value of animacy. *Psychological Science, 24,* 2099-2105.

New, J., Cosmides, L., & Tooby, J. (2007). Category specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences, 104,* 16598–16603. https://doi.org/10.1073/pnas.0703913104

Nouchi, R. (2013). Can the memory enhancement of the survival judgment task be explained by the elaboration hypothesis?: Evidence from a memory load paradigm. *Japanese Psychological Research*, *55*, 58-71. https://doi.org/10.1111/j.1468-5884.2012.00531.x

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*, 466-478. https://doi.org/10.1037/0096-3445.130.3.466

Olds, J.M., Lanska, M., & Westerman, D.L. (2014). The role of perceived threat in the survival processing memory advantage. *Memory, 22*, 26-35. https://doi.org/10.1080/09658211.2013.806554

Opfer, J.E., & Gelman, S.A. (2011). Development of the animate-inanimate distinction. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of childhood cognitive development* (2nd ed., pp. 213-238). Oxford, England: Wiley-Blackwell.

Popp, E.Y., & Serra, M.J. (2016). Adaptive memory: Animacy enhances free recall but impairs cued recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*, 186-201. https://doi.org/10.1037/xlm0000174

Popp, E.Y., & Serra, M.J. (2018). The animacy advantage for free recall performance is not attributable to greater mental arousal. *Memory, 26,* 89-95. https://doi.org/10.1080/09658211.2017.1326507

Rakison, D.H., & Poulin-Doubis, D. (2001). The developmental origin of the animate-inanimate distinction. *Psychological Bulletin, 127,* 209-228. https://doi.org/10.1037/0033-2909.127.2.209

Roediger, H.L., & Payne, D.G. (1985). Recall criterion does not affect recall level or hypermnesia: A puzzle for generate/recognize theories. *Memory & Cognition*, *13*, 1-7. https://doi.org/10.3758/BF03198437

Rubin, D.C., & Friendly, M. (1986). Predicting which words get recalled: Measures of free recall, availability, goodness, emotionality, and pronunciability for 925 nouns. *Memory & Cognition*, *14*, 79-94. https://doi.org/10.3758/BF03209231

Sha, L., Haxby, J.V., Abdi, H., Guntupalli, J.S., Oosterhof, N.N., Halchenko, Y.O., & Connolly, A.C. (2015). The animacy continuum in the human ventral vision pathway. *Journal of Cognitive Neuroscience*, *27*, 665-678. https://doi.org/10.1162/jocn_a_00733

Soderstrom, N.C., & McCabe, D.P. (2011). Are survival processing memory advantages based on ancestral priorities?. *Psychonomic Bulletin & Review, 18*, 564-569. https://doi.org/10.3758/s13423-011-0060-6

Stillman, C.M., Coane, J.H., Profaci, C.P., Howard, J.J., & Howard, D.V. (2014). The effects of healthy aging on the mnemonic benefit of survival processing. *Memory & Cognition*, *42*, 175-185. https://doi.org/10.3758/s13421-013-0353-2

VanArsdall, J.E., Nairne, J.S., Pandeirada, J.N.S., & Blunt, J.R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology, 60,* 172-178. https://doi.org/10.1027/1618-3169/a000186

VanArsdall, J.E., Nairne, J.S., Pandeirada, J.S., & Cogdill, M. (2015). Adaptive memory: Animacy effects persist in paired-associate learning. *Memory, 23*, 657-663. https://doi.org/10.1080/09658211.2014.916304

Warriner, A. B., Kuperman, V., & Brysbaert, M. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behavior Research Methods*, *45*, 1191-1207. https://doi.org/10.3758/s13428-012-0314-x

Yorzinski, J.L., Penkunas, M.J., Platt, M.L., & Coss, R.G. (2014). Dangerous animals capture and maintain attention in humans. *Evolutionary Psychology*, *12*, 534-548. https://doi.org/10.1177/147470491401200304