2022

Adaptive Memory: Richness of Encoding as a Possible Underlying Mechanism of The Threat Effect

Anthony Hall
n00695231@unf.edu

Adaptive Memory: Richness of Encoding as a Possible Underlying Mechanism of The Threat Effect

Anthony Hall

Department of Psychology

University of North Florida

Dedication and Acknowledgement

This work is dedicated to my daughter, Isabella Hall. May this work be a reminder that even if you struggle, you have the power to overcome anything. To my wife, Alexandra Hall, thank you for standing by my side and for all of your love. Finally, Dr. Juliana Leding, thank you for your guidance and oversight in this study.

Table of Contents

List of Tables

Abstract

In recent years, a growing body of research suggests that the human memory system has adapted to recall information that would have been vital to our ancestors' survival. One area of importance is animacy, where animate objects are better remembered than inanimate ones. From the study of animacy a new area of interest came about; perceived threat of stimuli. It was suggested that some of the stimuli used in previous research could be perceived as more threatening than others which could be a potential confound. This research lead to a potentially new phenomenon, the threat effect, which suggests that threatening stimuli are better remembered than nonthreatening stimuli. The current research attempts to examine richness of encoding as one possible underlying mechanism of this novel threat effect. In this study, participants were asked to generate ideas for each word of a word list and then later recall as many words as possible that the participants had generated ideas for. The results of this study provide further evidence of animacy and threat effects on recall. Threatening items generated more ideas than non-threatening items. The effects of this idea generation also mediated recall for threatening items, provides evidence for richness of encoding being one plausible underlying mechanism of the threat effect. This study did not replicate findings of past research that showed greater idea generation for animate items when compared to inanimate items. This study also failed to replicate the mediation found previously of idea generation on free recall of animate words.

Keywords: adaptive memory, threat, encoding

Adaptive Memory: Richness of Encoding as a Possible Underlying Mechanism of The Threat Effect

For nearly fifteen years it has been accepted that human memory systems have been adapted for fitness relevant information (Nairne et al., 2007). In their study, Nairne and colleagues had participants imagine themselves in a grasslands survival scenario. Participants then had to rate words for their relevance to the scenario. In a surprise recall test, items rated in this way were recalled more often than in a control condition that had participants imagine they were moving to a foreign country and would have to secure a place to live. Further, these words were also remembered better than in other processing conditions such as rating the words for pleasantness and self-relevance, which are known to offer a mnemonic advantage. This survival processing effect, as it has been coined, has been replicated many times (Otgaar & Smeets, 2010). The evidence suggests that this is, in fact, a robust effect. The work done in Nairne et al. (2007) led to an expanding body of research that focused on fitness relevant information that would have concerned our ancestors. This focus led researchers to examine the effect that animacy has on human memory systems.

Animacy was crucial to the survival of our ancestors. Animates represented predators, prey, and potential mates (Nairne et al., 2013). It has been shown that participants are able to locate and detect changes in images of animals better than in images of inanimate objects (New et al., 2007). In a study examining inattentional blindness, participants were given a cognitively demanding task and an unexpected image was shown. Over the course of two experiments, images of animate objects were detected more frequently than images of inanimate objects (Calvillo & Hawkins, 2016) . In a study examining attentional blink, which is when a secondary target cannot be identified when a target and secondary target are rapidly presented, animate

objects were identified better than other objects in two different short time frames (Guerrero & Calvillo, 2016). It has even been shown that the human brain has distinct areas for the processing of animate and inanimate items. In a case study of a patient with damage to the left posterior frontal and parietal lobes, the patient struggled to identify images of animals, but not images of inanimate objects (Caramazza & Shelton, 1998). Using functional magnetic resonance imaging, researchers were able to show that activity in the ventral vision cortex differed for highly animate objects and artifacts (Sha et al., 2015). In sum, these studies suggest that there are key areas within the human brain that are dedicated to the detection of animacy. Further, even under a heavy cognitive load the brain is still able to detect animacy.

Even though animacy has been studied in other areas of research for some time, it was only recently that animacy was studied in memory. Researchers explored the effects that animates and inanimates had on human memory (Nairne et al., 2013). In this study, participants studied a list of twenty-four words. Twelve of those words were words that represented animate objects and the other twelve words represented inanimate objects. These words were matched on characteristics known to affect memory such as concreteness, familiarity, and imagery. Once the words were studied, participants were given a surprise recall task. Results from this study showed that animate words were better remembered than inanimate words. This phenomenon became known as the animacy effect.

Since this original study, the animacy effect has been replicated many times (e.g., Bonin et al., 2015; Leding, 2018; Nairne et al., 2017). In an effort to test the limits of the animacy effect, researchers paired made-up words with either animate properties or inanimate properties. Participants where then asked to freely recall as many of the words as they could (VanArsdall et al., 2013). Researchers found that made-up words that were paired with animate properties were

better recalled than the made-up words with inanimate properties. This study's findings would suggest that animacy is a key feature in human memory regardless of whether a word is known. In a similar study testing children and made-up words, children as young as four showed a memory advantage for made-up words with animate properties (Aslan & John, 2016). In this study children were given made-up words that were described with features of humans or animals (animate) or features of non-living things (inanimate). In a surprise recognition task, children from all age ranges that were examined better recognized the made-up words with animate properties than the made-up words with inanimate properties. In an experiment on judgements of learning (JoLs) it was found that animacy was a good cue of future recall (Li et al., 2016). In this study, participants studied a list of words, half of the words were animates and the other half were inanimates. The participants were then asked how likely they were to recall each word (JoLs). Overall, JoLs were higher for animate words than inanimate words. Further, in experiment three of this paper participants suggested that animacy would help others learn words as well.

Popp and Serra (2016) expanded on previous animacy research and created a normed list of animate and inanimate words. These words were matched on several key characteristics such as length, frequency, mental imagery, and concreteness. This work gave more evidence that animate words are better recalled than inanimate words in a free recall task. However, Popp and Serra did show that animacy tended to impair cued recall most of the time, except in the case of Swahili words paired with English words. Similar findings have been observed (VanArsdall et al., 2015). These findings led Popp and Serra to suggest that animates receive increased processing, which in turn would increase memory, such as in the case of free recall. However, they suggested that this increase could negatively affect memory when animate stimuli take

attention away from other stimuli, such as in the case of cued recall. Popp and Serra then discussed potential underlying mechanisms of the animacy effect which included mental arousal and attention capture. Researchers quickly started to look at these phenomena as possible underlying mechanisms of the animacy effect. When examining mental arousal, researchers found that the animacy effect persisted even when the words were controlled for their mental arousal (Meinhardt et al., 2018; Popp & Serra, 2018). This would suggest that mental arousal is not a candidate for the underlying mechanism of the animacy effect.

As for attention capture, recent research provides some evidence that connects the animacy effect and attention. Research has shown that the animacy effect can distract from a secondary task, such as remembering a string of random numbers and letters of varying lengths (Bonin et al., 2015). The animacy effect also seems to interfere with other paradigms as well, such as the Stroop task (Bugaiska et al., 2019). In this study, participants took longer to categorize the color of animate words when compared to inanimate words. The animacy effect persists through different levels of attention (Leding, 2019b). In this study participants were either in a full attention level where they would have to recall the words presented to them, or in a divided attention level. In this level, participants were told that they were going to take part in two tasks and that they should try to perform well on both tasks. The tasks participants were presented were, recognizing how many times they heard a number repeated three times in a random string of numbers and remembering words from a list presented. The results of this study suggest that animate words were better remembered in both the full attention and divided attention levels of this study.

A distinction between animate and inanimate images and the attention that they capture can be found in several different forms. Research examining joint attention showed that animacy

plays a key role in modulating attention (Lindemann et al., 2011). This study used images of grasping hands as animate stimuli and "U" shapes as inanimate stimuli. These stimuli were then used to cue participants to choose an item on screen whose color changed. The results of this study suggest that the animate stimuli had a notable effect on participants' performance in identifying the image whose color had changed, whereas the inanimate stimuli did not show the same effect. This relationship is not only seen when animate stimuli are added to a situation but can also be seen when an animate object is removed from a stimulus. In a study examining change detections, participants were quicker and more accurate recognizing that an object was revoked from an image when an animate object was removed from an image when compared to an inanimate object (Altman et al., 2016). This study gave further evidence that would suggest that animates distracted participants in this task when they were attempting to detect changes with inanimate targets. Although attention capture does seem like a plausible underlying mechanism for the effects of animacy, in the realm of human memory and animacy there was a potential issue with many of the stimuli used in the studies up to this point.

In 2019, it was suggested that there was a potential confound of perceived threat of the study items in several studies examining the animacy effect in memory (Leding, 2019b). The words within the word list, in the original study of the animacy effect (Nairne et al., 2013), were matched on several known factors that affect memory. For the animate words, these word lists contained the words bee, python, spider, wolf, baby, duck, engineer, minister, owl, soldier, trout, and turtle. For the inanimate words they contained the words doll, drum, hat, journal, kite, purse, rake, slipper, stove, tent, violin, and whistle. When examining the word list, it is clear that there were more animate words than inanimate words that could be perceived as threatening. Similarly the word list from Popp and Serra (2016) had more animate words than inanimate words that

could be perceived as threatening words. Several other studies have used these word lists as stimuli to test the animacy effect, and so there has been a persistent potential that threat may have been impacting results throughout the body of research. To study the animacy effect while controlling for threat, a word norming study was conducted (Leding, 2019b). The new word list consisted of 112 words that could be divided into four different categories (i.e., animate threatening, animate non-threatening, inanimate threatening, and inanimate non-threatening). In a surprise recall task, animate words were better recalled than inanimate words regardless of the level of threat of each word. Interestingly, threatening words were also recalled better than non-threatening words, independent of their animacy, suggesting that human memory systems have been tuned to detect threat as well as animacy. Other research showed that threatening items enhanced target recognition (Leding, 2020). In this experiment participants took part in a response signal delay (RSD) manipulation. This makes participants make a forced choice after a short or long delay. The results suggested that participants recognized threatening words more than non-threatening words, and the threatening words were better recognized in both the short and long delay levels.

Although the effect of threatening words and human memory has only recently been examined, threat has been shown to play a significant role within the human brain on several occasions. A study exploring images of animals provided evidence that suggested that threatening animals are better recognized than non-threatening ones (Meyer et al., 2015). Within the survival processing paradigm, researchers showed that the survival processing effect was enhanced when the level of perceived threat was increased (Olds et al., 2014). This study used three different levels of threat (low, medium, and high) in different survival scenarios (grasslands and city). Participants recalled more items as the threat level increased in both scenarios. In a

scenario that included a zombie predator, participants were more likely to recall words than when they rated words for their pleasantness (Bonin et al., 2019). In similar fashion, when zombies were added as a predator in the survival processing paradigm, recall rates were higher than in the standard survival scenario (Soderstrom & McCabe, 2011). Other supernatural threats, such as demons, have shown similar recall rates as the original grasslands scenario (Kazanas & Altarriba, 2017). These findings seem to suggest that the threat effect is rather robust.

Consistent with the attention capture hypothesis, one study that tracked the eye movements of participants found that threatening animals were detected more quickly than non-threatening animals when each type of animal was used as a distractor for the other (Yorzinski et al., 2014). In fact, participants were found to become distracted by threatening animals while searching for non-threatening stimuli. Similar to the animacy effect, threat may capture attention. It is possible that the rich features and attributes of threatening objects may cause these items to capture attention in a similar way as animate items. It is then plausible to suggest that a potential underlying mechanism for the threat effect could be richness of encoding.

In discussing underlying mechanisms, it has been suggested that it is possible that, in most cases, animate objects possess more rich features than inanimate objects (Nairne et al., 2017). For this reason, Nairne suggests that these rich features may play a key role in facilitating the encoding process and would be integral in the retrieval process of animate objects. These rich characteristics may lead to a deeper and richer encoding when compared to inanimate objects. This richness of encoding concept is based on the idea that memory performance is improved when many distinct associations to other items are encoded with the target item. This is because these other items can act as retrieval cues for the target item at recall (Moscovitch & Craik, 1976).

Evidence for the richness of encoding account of memory advantages can be seen in the study of the survival processing phenomena. One such study showed evidence that considering items for their survival relevance allowed for participants to come up with a significantly more ideas when compared to considering items for other use cases. These ideas in turn allow for multiple retrieval cues (Kroneisen & Erdfelder, 2011). Further, when the original survival scenario was altered, from focusing on many survival issues such as predators and finding food and water, to now only focused on finding water; the results showed that the survival processing effect was reduced or eliminated (experiment 1&2). In experiment 3, participants were asked to generate either multiple arguments for usefulness of a word or a single argument for the usefulness of a word in regard to the survival scenario. Results showed that when in the single argument level of the study, participants' free recall scores were diminished when compared to participants in the multi-argument level. Another study showed that thinking about the function of items in the survival processing paradigm allowed participants greater recall when compared with the traditional survival processing advantage (Bell et al., 2015). In a direct test of the richness of encoding account, researchers had participants write down as many ideas as they could think of for words within the survival processing paradigm (Röer et al., 2013). Their hypothesis was that words in the survival group would generate more ideas than those in the control group. The results of this study showed that participants did in fact generate more ideas in the survival group when compared to the control group.

Because rich and elaborative encoding not only encodes the target but several cues to go along with it, it can be seen as cognitively demanding. Evidence for the demands of richness of encoding is seen when a concurrent cognitive load is presented during encoding (Kroneisen et al., 2014, 2016). In these studies, researchers had participants take part in dual process tasks. The

dual process task was to take part in rating words in the survival processing paradigm and listening to tones from a computer and either keep track of how many tones were heard or manually respond to the tones. The results suggest that when the secondary task was simple such as keeping track of one tone, the survival processing effect persisted. When the secondary task became more demanding than keep track of just one tone, the survival processing effect was diminished or eliminated.

Similar to the survival processing effect, a direct test of the richness of encoding mechanism was used with the animacy effect (Meinhardt et al., 2020). Participants were asked to generate as many ideas as they could for each of twenty-four words. Twelve of these words were animate (e.g., bee, baby, frog), and twelve of these words were inanimate (e.g., violin, sled, and dresser). This study found that participants generated more ideas for animate words than inanimate words and that words that generated more ideas were better remembered in a free recall test. These results suggest that, at least in part, richness of encoding is an underlying mechanism of the animacy effect.

To summarize, the body of research would suggest that threatening items have a robust effect on the human memory system. The work done in Leding (2019) does offer the potential underlying mechanism of attention capture. However, other research may point to an equally plausible mechanism, as the richness of encoding hypothesis has at least, in part, been suggested to account for both survival processing and the animacy effect in a more direct test. It is possible that richness of encoding may be a core mechanism in adaptive memory. As such, this theory should be explored in all areas that fall under the umbrella of adaptive memory for a better understanding of the field as a whole. Thus. It seems only fitting that richness of encoding would be studied as an underlying mechanism of the threat effect in human memory.

The present study seeks to provide further evidence for both the animacy effect and the threat effect in human memory. Like Meinhardt et al. (2020), this study will use an idea generation task to directly examine the hypothesis that richness of encoding is an underlying mechanism of the threat memory advantage in human memory. Participants will be asked to generate as many ideas as they can for each item of a word list that includes threatening and nonthreatening animate and inanimate items. After a distractor task, participants will be given a free recall test. It is hypothesized that participants will generate more ideas for threatening items than non-threatening items. Further, it is hypothesized that participants will generate more ideas for animate items than inanimate items. It is also hypothesized that threatening items will be better remembered than non-threatening items. Similarly, it is hypothesized that animates will be better remembered than inanimates. Another hypothesis, which is in line with the richness of encoding theory, is that idea generation will mediate recall for both animate and threatening words. Of the four categories of words, it is hypothesized that animate threatening words will have the most ideas generated by participants and will have the highest levels of recall.

Method

Participants

Participants were 99 undergraduate students from the University of North Florida. (87 indicated their current gender identity as female, 10 indicated their current gender identity as male, and 2 indicated their current gender identity as non-binary trans; mean age 22.60 years *SD* = 5.62; 74.75% reported being white/Caucasian, 15.15% reported being black/African American, 4% reported being Asian/Asian American, 2% reported being Hispanic) Students signed up to be a part of the research on the university's SONA system. Participants did receive credit through the SONA system for one of their psychology courses. Based on the power analysis done in

Meinhardt et al. (2020), a population of 86 would have the power to detect effect sizes of .36 with an $\alpha = .05$. As such the current study should have more than enough power to detect a similar finding to those reported in the Meinhardt et al. (2020) paper.

Materials

There were two wordlists. Each consisted of a total of twenty-eight words, with seven words from each of four categories (threatening animate, non-threatening animate, threatening inanimate, and non-threatening inanimate; Leding, 2019b). The words were selected by taking words with the highest and lowest threat scores from the norming study, while attempting to keep imagery and concreteness equivalent between all of the word types. A total of fifty-six words were selected. A one-way analysis of variance (ANOVA) was conducted on the four different word types to test imagery scores. There was no significant difference between the word types, F (3, 52) = .45, p = .720, suggesting that the word types were matched on imagery. A one-way ANOVA was conducted on the four different word types comparing their concreteness scores. There were no significant differences in concreteness scores for any of the word types, F (3, 52) = 1.21, p = .316, suggesting that the word types were also matched on concreteness. An independent t-test determined the threatening words and non-threatening words differed on threat scores. Results suggest that the twenty-eight threatening words (M = 5.27, SD = .55) and the twenty-eight non-threatening words (M = 2.01, SD = .39) differed significantly from one another, t (54) = -25.59, p < .001. After analysis, each of the four categories of words were separated into two lists, with the first seven words of each category forming the first list of words and the second set of seven words forming list two. The lists of words can be found in Table 1 and Table 2.

This study was completed online using the Qualtrics system. This study began with an instruction page that read, “Please take a few seconds to make sure you are comfortable and away from distractions. It is important to note that this study cannot be completed on a mobile device. This study should take about an hour and should be completed in one sitting. If you exit the survey, you will not be able to return. When you are ready please click the arrow to continue to the next page.” This prompt was followed by a consent form. The next page provided directions for the idea generation task, it read, “On the following pages you will find a single word at the top of the page. Please type any ideas that come to mind when you think of this word. You can take as much time as you need for each word. When you cannot think of any other ideas please continue on to the next page and repeat the process for each new word”. The next twenty-eight pages consisted of one of the twenty-eight words from list one or list two presented in a random order and a free response box. This idea generation prompt was like that found in Experiment 2 of Meinhardt et al. (2020). This portion of the test was not timed, and no examples were given to the participant. Following the idea generation portion of the survey, there was an instruction page for the distractor task. The prompt there read, “On the next page please type all of the states that you can think of that are in the United States of America. You will have two minutes to complete this task. The survey will automatically progress to the next part of the study when the two minutes have passed. Please keep trying during the entire two minutes.”.

When two minutes elapsed, the survey automatically progressed to the next instruction page for the surprise free recall task. The prompt read, “For the next task we would like you to try to remember as many of the words that you generated ideas for and type them into the space provided below. The words can be typed in any order. You will have four minutes to complete

this task. The survey will automatically progress to the next part of the study when the four minutes have passed. Please keep trying to remember the words during the entire four minutes". The next page was an empty response box for participants to recall as many words as they could. After four minutes had elapsed, the survey automatically switched to a demographics questionnaire with a prompt that read, "Please provide some personal information if you are comfortable doing so". The demographics that were collected were current gender identity, age, if English was the participant's native language, and the race and ethnicity of the participants.". On the final page participants were thanked by a prompt that read, "Thank you for participating in this study on human memory".

Design and Procedure

The experiment was a 2 (Threat) x 2 (Animacy) within-subjects design. Although two lists were used, there was no expected differences between the lists. As such, both lists were considered to be a single variable. As this was an online study, participants were able to sign into the study wherever they chose. Participants were not able to use mobile devices for this study. Once signed into the study, participants were presented with a consent form. Following consent, participants took part in the idea-generation task.

After the idea-generation portion of the experiment, participants took part in a distractor task that had them type all the states they could think of. This portion of the task lasted for two minutes. Following the distractor task, participants then took part in the surprise free recall task. After four minutes, participants were then asked to complete a demographic questionnaire. The final page of the survey thanked the participants.

Results

Recall

When examining the data for recall a 2(Animacy: Animate, Inanimate) by 2(Threat: Threatening, Non-threatening) repeated measures ANOVA was conducted on the number of target words recalled. Means and standard deviations can be found in Table 3[1]. There was a significant main effect of animacy $F(1,98) = 46.72$, $MSE = 1.40$, $p < .001$, with animate words being better recalled than inanimate words. There was also a significant main effect of threat $F(1,98) = 60.68$, $MSE = 1.25$, $p < .001$, with threatening words being better recalled than non-threatening words. This was also expected and adds further evidence for the threat effect on memory. These findings replicate previous research and provide further evidence for both the animacy and threat effects in human memory.

There was also a significant interaction between animacy and threat $F(1,98) = 6.70$, $MSE = .91$, $p = .011$, and examined by comparing recall for threatening and non-threatening items for the animate and inanimate conditions separately. For the animate items, there was no significant difference between the threatening and non-threatening items, $t(98) = 1.433$, $p = .155$. For the inanimate items, there was a significant effect between threatening and non-threatening items, $t(98) = 4.800$, $p < .001$, with inanimate non-threatening items recalled at a significantly lower rate than inanimate threatening items.

Idea Generation

When examining the data for idea generation, a 2(Animacy: Animate, Inanimate) by 2(Threat: Threatening, Non-threatening) repeated measures ANOVA was conducted on the

[1] Recall rates of this study are lower than those found in other recall studies. There was a total of 29 participants that did not recall any of the study words in the recall task. Instead these participants recalled ideas they had generated for the study words.

number of ideas participants spontaneously generated. Means and standard deviations for can be found in Table 4. A significant main effect was found for threat $F(1,98) = 21,09$ $MSE = 48.58$, $p < .001$, suggesting that threatening items generated more ideas than non-threatening items. The main effect of animacy and the interaction of animacy and threat were not significant, both p's > .11. Failing to find a significant main effect of animacy on idea generation was unexpected as it was predicted that animate words would generate more ideas when compared to inanimate words, replicating previous findings. Not finding a significant interaction was unexpected as it was predicted that the additive properties that have been speculated previously would persist within the idea generation task.

The Relationship between Idea Generation and Recall

To examine the relationship between ideas generated and number of words recalled by participants, a Pearsons correlation was conducted. A weak but significant positive correlation was observed $r(97) = .29$, $p = .001$. This suggests that as the number of ideas increased so did the number of words that were recalled.

Using the SPSS macro MEMORE V. 2.1 (Montoya & Hayes, 2017), a mediating analysis was conducted on recall rates using the bootstrapping method with 10,000 samples. Correctly recalled threatening and non-threatening words were used as dependent variables (Y-variables), while ideas generated for threatening and non-threatening words were used as mediating variables (M-variables). 95% confidence intervals (CI) are reported. The total effect model of this analysis suggests a significant positive effect of threat on recall $b = .92$, $p < .001$, *CI* (.473, 1.366). The direct effect model was also significant and positive $b = .66$, $p = .011$, *CI* (.155, 1.162). The indirect effect of threat through idea generation was significant as well $b = .26$, *CI*

(.010, .509). In sum this mediation analysis offers evidence that threat has an effect on recall and that that effect is mediated by idea generation,

Using the SPSS macro MEMORE V. 2.1, a mediating analysis was conducted on recall rates using the bootstrapping method with 10,000 samples. Correctly recalled animate and inanimate words were used as dependent variables (Y-variables), while ideas generated for animate and inanimate words were used as mediating variables (M-variables). 95% confidence intervals (CI) are reported. The total effect model of this analysis suggests a significant positive effect of animacy on recall $b = 1.63$, $p < .001$, *CI* (1.154, 2.098). The direct effect model was also significant and positive $b = 1.69$, $p < .001$, *CI* (1.201, 2.164). The indirect effect was not significant $b = -.061$, *CI* (-.190, .026). These results suggest that although animacy played a significant role in recall, idea generation did not play a mediating role within this population.

Discussion

The present study was able to provide evidence for the animacy effect. As predicted, animate items were better remembered than inanimate items. Likewise, evidence was found that supports the threat effect on memory. When compared to non-threatening items, threatening items were better remembered. The evidence also reinforces the hypothesis that animate threatening items will have the greatest levels of recall, this suggests an additive property when animacy and threat are combined. The present study had hypothesized that animate threatening words would have the most ideas generated out of all the levels within the study. The evidence shows that this was not the case and in fact that inanimate threatening items had the most ideas generated for them. Although the correlation found a weak but significant positive relationship between idea generation and recall, in the case of animacy, idea generation did not mediate the

recall. The evidence did suggest that idea generation did mediate recall for threatening items, supporting that hypothesis.

The present study offers evidence to two different phenomena. The first being the animacy effect on memory (Nairne et al., 2013), and the novel threat effect (Leding, 2019b), as well as a possible underlying mechanism for the threat effect, richness of encoding. These effects describe a positive effect on memory based on an item representing an animate object when compared to an inanimate item, or a threatening item compared to a non-threatening item respectively. The animacy effect has been well documented over the last decade with a variety of materials and tasks (Leding, 2019b; Nairne et al., 2013; Popp & Serra, 2016). It had been hypothesized that animacy did not directly affect memory on its own, but that some proximate mechanism was responsible for the animacy effect (Popp & Serra, 2016).

One possible mechanism for the animacy effect was richness of encoding (Meinhardt, 2020). Using the same methods as Meinhardt and colleagues, the present study attempted to reaffirm this theory, however, the present study was unable to provide evidence to support the richness of encoding account for the animacy effect. It is possible that the present study differs from the work done by Meinhardt and colleagues because the confidence level used for the mediation analysis in the current study was different than that used by Meinhardt and colleagues. Whereas Meinhardt and colleagues used a confidence level of 90%, the present study used a 95% confidence level. This makes it possible that the mediating effect of idea generation on animate recall that Meinhardt and colleagues found was a false positive.

The present study was not without its own shortcomings. There were participants who failed to recall any study words and instead during the recall task wrote down some of the ideas they generated. This goes beyond typical intrusion rates and represents either a failure of the

participant to follow directions or a failure of the study to be clear with its directions.The present study also was presented online, where the work done by Meinhardt and his colleagues was done in person. However, this difference does not seem like a likely confound as previous research has shown that other forms of memory tasks done online follow similar patterns of results as the same tasks done in person (Leding. 2019a).

The work done in Leding (2019b) did not just provide evidence for a possible mechanism for the influence of animacy on recall, but also provided evidence for a novel threat effect on human memory as well as evidence that suggests that attention capture could be a possible underlying mechanism of the threat effect as well. Using a selection of materials from Leding (2019b) that had been matched on concreteness and imagery, the present study was able to provide further evidence of the threat effect in human memory. Further, the present study provided evidence of richness of encoding being a possible underlying mechanism of the threat effect. Future research could explore the relationship of attention capture and richness of encoding. Further research should also explore multiple mediations or moderation of the threat effect with a model that has both attention capture and richness of encoding.

The present study strengthens the body of previous research of the animacy effect. It also provides evidence that supports the theory of the threat effect. Further, the present study offers evidence of an underlying mechanism for the threat effect. Although, the present study did not find evidence of richness of encoding being a potential underlying mechanism of the animacy effect, taken together with evidence from past research, richness of encoding should be considered as a key mechanism of adaptive memory. The findings of this study offer further understanding of the human memory system and some of its key features.

References

Altman, M. N., Khislavsky, A. L., Coverdale, M. E., & Gilger, J. W. (2016). Adaptive attention: How preference for animacy impacts change detection. *Evolution and Human Behavior*, *37*(4), 303–314. https://doi.org/10.1016/j.evolhumbehav.2016.01.006

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

Bell, R., Röer, J. P., & Buchner, A. (2015). Adaptive memory: Thinking about function. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(4), 1038–1048. https://doi.org/10.1037/xlm0000066

Bonin, P., Gelin, M., Laroche, B., Méot, A., & Bugaiska, A. (2015). The "How" of Animacy Effects in Episodic Memory. *Experimental Psychology*, *62*(6), 371–384. https://doi.org/10.1027/1618-3169/a000308

Bonin, P., Thiebaut, G., Prokop, P., & Méot, A. (2019). "In your head, zombie": Zombies, predation and memory. *Journal of Cognitive Psychology*, *31*(7), 635–650. https://doi.org/10.1080/20445911.2019.1664557

Bugaiska, A., Grégoire, L., Camblats, A.-M., Gelin, M., Méot, A., & Bonin, P. (2019). Animacy and attentional processes: Evidence from the Stroop task. *Quarterly Journal of Experimental Psychology*, *72*(4), 882–889. https://doi.org/10.1177/1747021818771514

Calvillo, D. P., & Hawkins, W. C. (2016). Animate Objects are Detected More Frequently than Inanimate Objects in Inattentional Blindness Tasks Independently of Threat. *The Journal of General Psychology*, *143*(2), 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), 1–34. https://doi.org/10.1162/089892998563752

Guerrero, G., & Calvillo, D. P. (2016). Animacy increases second target reporting in a rapid serial visual presentation task. *Psychonomic Bulletin & Review*, *23*(6), 1832–1838. https://doi.org/10.3758/s13423-016-1040-7

Kazanas, S. A., & Altarriba, J. (2017). Did our ancestors fear the unknown? The role of predation in the survival advantage. *Evolutionary Behavioral Sciences*, *11*(1), 83–91. https://doi.org/10.1037/ebs0000074

Kroneisen, M., & Erdfelder, E. (2011). On the plasticity of the survival processing effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(6), 1553–1562. https://doi.org/10.1037/a0024493

Kroneisen, M., Rummel, J., & Erdfelder, E. (2014). Working memory load eliminates the survival processing effect. *Memory*, *22*(1), 92–102. https://doi.org/10.1080/09658211.2013.815217

Kroneisen, M., Rummel, J., & Erdfelder, E. (2016). What kind of processing is survival processing? Effects of different types of dual-task load on the survival processing effect. *Memory & Cognition*, *44*(8), 1228–1243. https://doi.org/10.3758/s13421-016-0634-7

Leding, J. K. (2018). The Animacy Advantage in Memory: Manipulations of Levels of Processing and Survival Processing. *The American Journal of Psychology*, *131*(3), 273–281. JSTOR. https://doi.org/10.5406/amerjpsyc.131.3.0273

Leding, J. K. (2019a). Intentional memory and online data collection: A test of the effects of animacy and threat on episodic memory. *Journal of Cognitive Psychology*, *31*(1), 4–15. https://doi.org/10.1080/20445911.2018.1564756

Leding, J. K. (2019b). Adaptive memory: Animacy, threat, and attention in free recall. *Memory & Cognition*, *47*(3), 383–394. https://doi.org/10.3758/s13421-018-0873-x

Leding, J. K. (2020). Animacy and threat in recognition memory. *Memory & Cognition*, *48*(5), 788–799. https://doi.org/10.3758/s13421-020-01017-5

Li, P., Jia, X., Li, X., & Li, W. (2016). The effect of animacy on metamemory. *Memory & Cognition*, *44*(5), 696–705. https://doi.org/10/ggfjvf

Lindemann, O., Nuku, P., Rueschemeyer, S.-A., & Bekkering, H. (2011). Grasping the other's attention: The role of animacy in action cueing of joint attention. *Vision Research*, *51*(8), 940–944. https://doi.org/10.1016/j.visres.2010.12.009

Meinhardt, M. J., Bell, R., Buchner, A., & Röer, J. P. (2018). Adaptive memory: Is the animacy effect on memory due to emotional arousal? *Psychonomic Bulletin & Review*, *25*(4), 1399–1404. https://doi.org/10.3758/s13423-018-1485-y

Meinhardt, M. J., Bell, R., Buchner, A., & Röer, J. P. (2020). Adaptive memory: Is the animacy effect on memory due to richness of encoding? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(3), 416–426. https://doi.org/10.1037/xlm0000733

Meyer, M. M., Bell, R., & Buchner, A. (2015). Remembering the snake in the grass: Threat enhances recognition but not source memory. *Emotion*, *15*(6), 721–730. https://doi.org/10.1037/emo0000065

Montoya, A. K., & Hayes, A. F. (2017). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6–27. https://doi.org/10.1037/met0000086

Moscovitch, M., & Craik, F. I. M. (1976). Depth of processing, retrieval cues, and uniqueness of encoding as factors in recall. *Journal of Verbal Learning and Verbal Behavior*, *15*(4), 447–458. https://doi.org/10.1016/S0022-5371(76)90040-2

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*(2), 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*(1), 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*(10), 2099–2105. https://doi.org/10.1177/0956797613480803

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*(42), 16598–16603. https://doi.org/10.1073/pnas.0703913104

Olds, J. M., Lanska, M., & Westerman, D. L. (2014). The role of perceived threat in the survival processing memory advantage. *Memory*, *22*(1), 26–35. https://doi.org/10.1080/09658211.2013.806554

Otgaar, H., & Smeets, T. (2010). Adaptive memory: Survival processing increases both true and false memory in adults and children. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(4), 1010–1016. https://doi.org/10.1037/a0019402

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*. 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*(1), 89–95. https://doi.org/10.1080/09658211.2017.1326507

Röer, J. P., Bell, R., & Buchner, A. (2013). Is the survival-processing memory advantage due to richness of encoding? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(4), 1294–1302. https://doi.org/10.1037/a0031214

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*(4), 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*(3), 564–569. https://doi.org/10.3758/s13423-011-0060-6

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology*, *60*(3), 172–178. https://doi.org/10.1027/1618-3169/a000186

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

Yorzinski, J. L., Penkunas, M. J., Platt, M. L., & Coss, R. G. (2014). Dangerous Animals Capture and Maintain Attention in Humans. *Evolutionary Psychology*, *12*(3), 147470491401200320. https://doi.org/10.1177/147470491401200304

Table 1

List 1 of The Word Stimuli

Animate Threatening				Animate Non-threatening			
Word	Threat	Imagery	Concreteness	Word	Threat	Imagery	Concreteness
Cheetah	5.46	6.62	6.15	Beaver	1.24	6.34	5.94
Bear	5.47	6.77	6.33	Butterfly	1.85	6.82	6.20
Bull	5.48	6.58	6.21	Frog	2.29	6.76	6.28
Hyena	5.56	6.02	6.08	Grasshopper	1.82	6.56	5.88
Scorpion	6.04	6.52	6.18	Hedgehog	1.89	6.33	6.15
Shark	5.99	6.72	6.40	Otter	1.91	6.47	5.91
Tiger	5.45	6.70	6.21	Panda	1.59	6.81	6.33
Means	5.64	6.56	6.22	Means	1.80	6.58	6.10
(SD)	(.26)	(.25)	(.11)	(SD)	(.32)	(.21)	(.19)

Inanimate threatening				Inanimate Non-threatening			
Word	Threat	Imagery	Concreteness	Word	Threat	Imagery	Concreteness
Cannon	5.11	6.41	5.84	Bicycle	1.93	6.69	6.16
Dynamite	6.08	6.10	5.63	Diploma	1.97	6.47	5.77
Gun	6.02	6.67	6.29	Doorknob	1.73	6.69	6.28
Knife	5.38	6.78	6.14	Drum	2.32	6.65	5.87
Needle	4.57	6.73	6.15	Faucet	1.70	6.60	6.20
Scissors	4.27	6.77	6.15	Towel	1.63	6.64	6.05
Handcuffs	4.97	6.74	6.27	Violin	2.18	6.71	5.85
Means	5.20	6.60	6.07	Means	1.92	6.64	6.03
(SD)	(.68)	(.25)	(.24)	(SD)	(.26)	(.08)	(.20)

Notes. This table shows the first set of twenty-eight words used in this study and the mean scores for threat, imagery, and concreteness. These scores were obtained from the norming study completed in Leding (2019b).

Table 2

List 2 of The Word Stimuli

Animate Threatening				Animate Non-threatening			
Word	Threat	Imagery	Concreteness	Word	Threat	Imagery	Concreteness
Coyote	5.32	6.18	5.93	Antelope	2.98	5.53	5.72
Eel	4.82	6.44	6.14	Armadillo	2.68	6.46	6.36
Gorilla	4.94	6.74	6.26	Caterpillar	1.85	6.62	6.09
Jellyfish	5.12	6.78	6.15	Clownfish	1.93	6.49	5.95
Leopard	5.45	6.48	5.91	Ferret	2.69	5.92	5.97
Lion	5.55	6.74	6.38	Giraffe	2.49	6.76	6.05
Tarantula	5.62	6.56	6.01	Hamster	1.82	6.79	6.36
Means	5.26	6.56	6.11	Means	2.35	6.37	6.07
(SD)	(.31)	(.22)	(.17)	(SD)	(.47)	(.47)	(.23)

Inanimate threatening				Inanimate Non-threatening			
Word	Threat	Imagery	Concreteness	Word	Threat	Imagery	Concreteness
Rifle	5.69	6.55	6.14	Mitten	1.73	6.62	6.16
Scalpel	5.12	5.99	6.00	Helmet	1.87	6.70	6.25
Fire	5.35	6.66	5.58	Flute	1.75	6.53	6.24
Arrow	4.66	6.67	6.01	Dresser	1.73	6.58	6.00
Hammer	4.14	6.76	6.32	Barrel	2.55	6.44	5.78
Motorcycle	4.10	6.76	6.16	Broom	1.93	6.84	6.34
Lava	5.71	6.47	5.70	Accordion	2.13	5.92	5.98
Means	4.97	6.55	5.99	Means	1.96	6.52	6.11
(SD)	(.68)	(.27)	(.26)	(SD)	(.30)	(.20)	(.20)

Notes. This table shows the second set of twenty-eight words used in this study and the mean scores for threat, imagery, and concreteness. These scores were obtained from the norming study completed in Leding (2019b).

Table 3

Means and Standard Deviations of Recalled Words

	Animate	Inanimate
Threatening	2.49 (2.35)	1.93 (2.07)
Nonthreatening	2.28 (2.16)	1.22 (1.48)

Notes. This table shows the mean number of recalled words for each of the four word-types used in this study. Standard deviations are shown in parentheses.

Table 4

Means and Standard Deviations of Ideas Generated

	Animate	Inanimate
Threatening	29.27 (24.89)	31.30 (29.75)
Nonthreatening	27.00 (22.58)	27.14 (23.30)

Notes. This table shows the mean number of ideas generated for each of the four word types used in this study. Standard deviations are shown in parentheses.