Evidence for a mnemonic benefit of animate-object interaction: Enhanced retention from animate contact

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By    Mindi Hope Cogdill

Entitled

Evidence for a Mnemonic Benefit of Animate-Object Interaction: Enhanced Retention From Animate Contact

For the degree of  Master of Science

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Head of the Departmental Graduate Program  Date
EVIDENCE FOR A MNEMONIC BENEFIT OF ANIMATE-OBJECT INTERACTION: ENHANCED RETENTION FROM ANIMATE CONTACT

A Thesis
Submitted to the Faculty
of
Purdue University
by
Mindi Hope Cogdill

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of
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ABSTRACT


The importance of animacy has been discovered in the perception literature, the neuroscience literature, and most recently in the memory literature. However, little is known about the extent to which we track the things that agents come into contact with in the environment, and its implications for human memory. Our memory system has been shaped by natural selection to assist in our ability to survive long enough to reproduce our genes. One of the major evolutionary influences on our survival would have been our ability to track, monitor, and predict the behavior of other agents because an agent can be a predator, potential food, potential mate (as described by the animate-monitoring hypothesis; New, Cosmides, & Tooby, 2007), and even a source for contamination as stated by the law of contagion (Rozin, Millman, & Nemeroff, 1986). Across three recall experiments, I examined if the human memory system was structured to prioritize objects that were touched by agents.

Experiment 1 tested the incidental memory for objects that were acted upon by agents and other inanimate objects. Participants read sentences that described living and nonliving things interacting with an object, and then were asked to imagine each
scene and make an imagery rating. Participants were significantly better at remembering objects that were associated with the agents relative to inanimates.

Experiment 2 investigated whether there would be mnemonic benefit for remembering the objects that were interacted with by an agent relative to a nonliving thing if participants were provided with the actors of the action (agent and inanimate) as a cue on a surprise recall test. Participants again created mental images and provided ratings. There was a significant improvement in memory for the target objects that were associated with a living thing compared to a nonliving thing.

Experiment 3 examined whether the memory benefit for objects that were touched by agents could be due to the more vivid mental images participants were creating for the agentic sentences as compared to the inanimate sentences. All the sentences were changed to have the exact same action that was performed by the living and nonliving actor. On a surprise cued-recall test where the participants were given the actor and verb as a cue, memory performance for the target objects was superior if that object was touched by an animate relative to an inanimate.

The consistent results across all three experiments support the idea that the human memory system is organized to track and remember the objects that living things interact with and physically touch. The mechanisms that allow for the mnemonic benefit are not yet understood, but it may be because there is an awareness (perhaps unconsciously) that living things are salient creatures in our environment that carry sickness, germs, and diseases. It is also possible that humans unknowingly track the objects that are owned or touched by agents because there is the common belief that characteristics of the agent get transferred to the object, which is referred to as the law
of contagion. Whether the reason for the enhanced memory is because both of these work in conjunction or context facilitates one over the other, the benefit is clear.
INTRODUCTION

A method to construct an understanding of how our memory system is designed to operate is to take a functional approach and “forward engineer” hypotheses as termed by Nairne (2015). Unquestionably, natural selection shaped our cognitive systems to enhance our ability to live long enough by noticing, avoiding, and/or escaping predators in order to reproduce our genes. This ability was no easy feat, and our understanding of the selection pressures that built our system is being advanced every day. However, we are still on the cusp of explaining the function and purpose of our memory system, and this requires generating hypotheses about selection pressures that may have been present in our ancestral past.

In order to examine this question, one must consider the specific problems in our environment that we needed to solve. Indeed, this is an empirical question and has been examined. Processing information for its survival relevance, contamination, and animacy has been shown to produce a memory advantage (see Nairne, 2015 for a review). A notable selection pressure would have been our ability to monitor and remember the behaviors of other living things, especially other humans. Humans and nonhuman animals (agents) would have been a categorical priority relative to nonliving things: humans for their potential to be a friend (e.g., an in-group member or a mating partner) or a foe (e.g., an out-group member, a cheater, a dangerous rival), and
nonhuman animals for their potential to be food (e.g., wild game), a shelter or tool
(e.g., animal hide, bone), or a survival threat (Nairne & Panderiada, 2010; Orians &
Heerwagen, 1992).

There is a need to clarify the use of the terms agent and animate. Though these
two concepts may be distinctly represented in the brain (Johnson, 2003; Lillard, Zeljo,
Currenton, & Kaugars, 2000; Lou, Kaufman, & Baillargeon, 2009; Mandler, 1992;
Okita & Schwartz, 2006), the neural distinction is the representation and perception of
self-initiated movement in combination with goal-orientated movement. The prior two
types of movement are classified as an agent in human studies. A description provided
by Gobbini et al. (2011) explains the difference, “Animate entities are living things that
can act as agents. Living things that are not sentient and do not act as agents are not
animate” (p. 1911). He later states that agents are entities that generate their own
movements in order to achieve goals. In this domain, animates refer to living beings
such as humans and nonhuman animals, and does not include living things such as
plants. For the purpose of this study, both terms will be used interchangeably, because
the materials used in the experiment are animals (both animate and agentic) and objects
(inanimate and not an agent).

Combining agentic selection pressures with the functionalist reasoning for
memory design, one can then hypothesize that memory would have been tuned for
agents in our environment (Cosmides & Tooby, 1992; Nairne, VanArsdall, Pandeirada,
Cogdill, & LeBreton, 2013). Agents would have been of critical importance in our
ancestral environment, and therefore, it would be reasonable to assume that our
memory system is biased to remember agents relative to nonliving things. Recently,
empirical evidence has been presented in support of this mnemonic advantage (Bonin, Gelin, & Bugaiska, 2014; Nairne et al, 2013; VanArsdall, Nairne, Pandeirada, & Blunt, 2013; VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). However, little is yet known about the extent to which our memory is tuned for the behavior of agents since this is a recent discovery in the literature. Additionally, limited work has focused on the theoretical framing to extend our predictions for mnemonic priorities in human memory.

An evolutionary approach in the cognition literature has gained insight to the relevance of animacy as a dimension that shaped our ancestral brains. From prioritizing agents in our visual attention, tracking their behavior with things they own or touch, and automatically imparting properties that were transferred onto those objects, these operations have undoubtedly shaped our cognitive architecture. Therefore, I suggest our ability to remember objects that came into physical contact with other agents would have been an adaptive trait that arguably developed from contagion avoidance (Rozin & Nemeroff, 2002).

In order to advance our knowledge for how our memory system is designed to monitor and remember things connected to agents, I propose to examine if there is a mnemonic component for the objects that are touched by agents relative to the objects that come into contact with each other. The ability to remember an artifact that an agent handled would have been adaptive for a few reasons. Preceding the identification of the objects, one must first identify the agent. Agents include human and nonhuman animals. It would be adaptive to assess that agents have intentions for their behavior based on internal goals. Our ability to attribute a mental state to other agents allowed
us to understand and predict their actions. This would have enabled us to avoid predators, catch prey, selectively mate, and attribute characteristics. Accordingly, the interactions between two agents or an agent and an object are relevant to the internal goals of the agent.

Moreover, the physical contact between the agent and the object should be an important indicator for tracking ownership and property. Across cultures and in the lab, it has been observed that personal objects of agents are reported to contain an “essence” of the owner (see Rozin & Nemeroff, 2002, for a review). The essence transfer is a form of magical thinking called sympathetic magic. Specifically, it is called the law of psychological contamination (Frazer, 1895; Mauss, 1902). This implies that objects may be more than they appear because of the history of the artifact. In addition to psychological transfer of essence from agent to object, there is also the concept of contamination (or transfer of disease). Intrapersonal contact, which is primarily person (as opposed to a nonhuman animal) to object, then the object to another person is one typical way how illnesses spread. Sickly pathogens are also commonly spread from food that comes from living animals because meat tends to contain microbial bacteria that is not found in plants.

I am proposing a hypothesis based on a functional interpretation of our memory system: If our memory system is designed to solve specific problems directly related to fitness, then in addition to remembering the agents themselves, we should have also have a special tuning for the objects that are touched by agents. I argue the locus of the mnemonic advantage, if there is one, is rooted in the physical contact itself between the agent and the object. My hypothesis would predict a mnemonic advantage for the
objects physically touched by agents relative to objects that physically touch each other. I would not expect a mnemonic advantage for the interacting objects because objects do not have ownership of other objects, and they are less likely to be the source of microbial contamination.

The Animate-Monitoring Hypothesis

Numerous attention paradigms have been employed to study animacy, and the findings are consistent: humans are able to detect agents in the environment quickly and accurately. This attentional bias is called the animate-monitoring hypothesis (New, Cosmides, & Tooby, 2007). This hypothesis assumes that agents change their status in the environment quicker and more frequently than non-agents like plants, objects, and natural formations. Because agents have active minds and are mobile, the constant monitoring and updating of their status would be critically needed by our attention system. Therefore, we required a visual processing mechanism that worked automatically to attribute attentional resources to animates relative to inanimates. To test this hypothesis, New et al. (2007) gave participants a change-detection task and asked them to detect a single change between two natural scenes across many different categories: human, nonhuman animals, plants, objects, tools, and vehicles. Participants were only given 250 ms to view the initial scene. The initial scene was followed by a 250 ms mask then lastly another 250 ms for participants to view the paired (changed) scene and make the comparison judgment. The authors found that participants were able to detect the changes quicker and more reliably when those changes involved an agent (human or nonhuman animal) as compared to the other categories such as vehicles, even though people have more experience detecting vehicles in everyday life.
The remarkable speed of agent detection was later supported using a saccadic choice task. This paradigm was used to eliminate the possibility that participants were evaluating the changed scene for its global statistics, and not noticing the absence of the agent per se. However, it was revealed that agents were detected preceding the categorization of the scene (Crouzet, Joubert, Thorpe, & Fabre-Thorpe, 2012), suggesting that rapid animal detection might be due to a mechanism that selects specific features special to agents.

Further support for the animate-monitoring hypothesis has been found in inattentional blindness paradigms (Calvillo & Jackson, 2014; New & German, 2015), eye-tracking (Yang et al., 2012), visual searches (Jackson & Calvillo, 2013), and under high-perceptual load (Calvillo & Jackson, 2014; Jackson & Calvillo, 2013). During an inattentional blindness task, participants were actively engaged in attending to the visual scene, yet failed to notice when something had been added to the scene that did not typically belong considering the context. In a typical inattentional blindness task, the attention of the participant is directed elsewhere to complete a task, and they are not explicitly told something in the scene will change. The change-detection task, on the other hand, explicitly instructs participants in advance to seek out the change that had occurred between scenes. Calvillo and Jackson (2014) tested the susceptibility to inattentional blindness with animates or inanimates as the target of the change.

Participants were shown a circular area of white space on the screen with a centered fixation cross for 1 second. Next, an array of words (four for the low-cognitive load condition, six for high-cognitive load) appeared along the circumference of the viewing area for 1 second, then immediately followed by a mask. The critical manipulation
occurred on the last trial in a set of three trials. On the fourth screen, the fixation cross was replaced with a picture of an animate (e.g., horse, baby) or inanimate thing (e.g., scissors, hammer). Participants were instructed to write down the word in the array that represented a color. They were not informed of the change to the fixation cross in the center of the screen. At the end of the experiment, participants were asked if they noticed anything other than the words that was not present in the previous trials.

Consistent with the animate-monitoring hypothesis, participants were able to detect the change more frequently when the fixation cross changed to a living thing relative to an inanimate object.

Most recently, New and German (2015) tested inattentional blindness for an evolutionary-threatening stimulus (a spider) relative to a modern threatening stimulus (hypodermic needle) and a nonthreatening stimulus (housefly). Participants were instructed to judge the relative length of two lines that were presented in the center of the screen. On the fourth judgment trial, one of the three types of stimulus appeared in one of four quadrants along with the line segments. Immediately following this critical trial, participants were asked if they saw anything in addition to the cross on the screen. If they indicated they noticed the change, they were asked to identify the location and the stimulus. Before the last expected judgment trial, participants were informed to ignore the judgment task and only pay attention to the display. On this last trial, one of the three types of stimulus appeared on the screen. Participants were asked the same questions from the critical fourth trial. In two experiments with varying stimuli that included scrambled and abstract representations, New and German (2015) found that
participants were better able to detect and identify a spider (evolutionary threat) as compared to a hypodermic needle (modern threat) and a housefly (no threat).

By tracking the eye movements of participants when engaged in visualizing pictures of animates and inanimates, Yang et al. (2012) found that while equating valence, arousal, and other low-level visual features, animates were attended to for longer periods of time and visually preferred than inanimate objects. In a visual search task, Jackson and Calvillo (2013) found that participants processed and located animate things faster than inanimate things. Animates were least impacted by high perceptual load while inanimate detection was most slowed by perceptual load (Calvillo & Jackson, 2014; Jackson & Calvillo, 2013).

Gelman (1990) pointed out the importance of causal principles when processing information directly related to the animate and inanimate relationship. She reasoned that animates are causal forces for self-generated movement but inanimates are not. Only an outside or external force can cause the movement of an inanimate object. In contrast, the reason for animate movement is purposeful and in direct response to the environment. When an animate changes its status by changing its location, it is intrinsic movement, but when an inanimate changes its status, it is an extrinsic cause. Moreover, in five experiments, Cohn and Paczynksi (2003) found that the capacity to predict a future event was facilitated by an agent serving as the critical causal role in the event relative to an animate recipient of an action.

**Property Tracking of Agents**

There have been numerous studies evaluating how objects that were once owned or touched by other people change in estimated value. Most recently, Newman
and Bloom (2014) had participants make bids on particular objects that were advertised as for sale from celebrity auctions. The authors found that the estimated amount of money that one would pay to own the objects for sale were directly related to the amount of physical contact assumed and the remaining “essence” left in the object. This finding was consistent with previous work that showed the greater the amount of inferred physical contact, the more money participants would be willing to pay (Lee, Linkenauger, Bakdash, Joy-Gaba, & Profitt, 2011; Newman & Dahr, 2014; Newman, Diesendruck, & Bloom, 2011; Rozin, Nemeroff, Wane, & Sherrod, 1989).

Additionally, the amount of money willing to be paid decreased if the objects were to be sterilized first, but much less of a decrease if the objects were to be moved to a new location before being sold. As noted by Rozin et al. (1989), the history associated with an object directly affected the perceived value of that object. An interesting study by Newman, Diesendruck, and Bloom (2011) found that the concept of contagion was the primary influence that drove the willingness to pay for an object. They independently manipulated the market demand, the association, or the psychological contamination of an object to a celebrity (liked and disliked), and found the degree of physical contact directly affected the valuation of the object independent from the association or the market demand. The concept of an “essence” transfer was offered as an explanation for the increased estimated value of the object.

Secondly, recent work by DeScioli, Rosa, and Gutches (2015) examined how memory was influenced by explicitly manipulating the association between an agent and an object. In three experiments, DeScioli et al. (2015) found that memory was enhanced for the object that was paired with an animate when the association was by
ownership, purposeful wanting, and thinking of the object relative to accidentally bumping into the object or the unrelated control. This study showed that intrinsic desires or ownership of an item lead to better memory for those items.

Gelman, Noles, and Stilwell (2014) tested memory for the association between a person and an object. They wanted to explore possession tracking with children and adults (as a control) for two relevant reasons. First, object tracking would allow one to monitor the history of the object. This would include information relevant for who or what has been in contact with it, and where it has been. This process would be directly related to the law of the contagion. Rozin and Nemeroff (1990) showed the strength of the perceptual influence of essence transfer when two things come into physical contact with each other. They showed that prior ownership of an object can have causal consequences, and people behave as if their interpretation of the object is the reality—as in a sweater previously worn by Hitler still carries an essence of evil. Secondly, children have shown the propensity to remember and mimic the actions performed by adults when they manipulate new objects. Gelman et al. (2014) theorized that if there was an attentional bias to track the actions of agents, in addition to a tendency to track the objects they possess, then children should show specialized attention and memory for objects owned by agents. By the end of two experiments, Gelman et al. (2014) discovered that children as well as adults showed a memory advantage for objects owned by agents (in this case, themselves) compared to learning the novel label of the objects (i.e., Sarn, Koba, and Manu) and preference (i.e., “Which one do you like best?”). The results of this study were an important contrast to previous work with toddlers that found children tend to devote their attention to the perceptual features of
objects relative to the object history. Therefore, Gelman et al. (2014) suggested that tracking the contact or ownership history of an object is a basic human disposition.

**Sympathetic Magic: The Law of Contagion**

Agents and the properties they carry play a critical role in shaping our mental architecture, and this impact can be detected by examining the behavioral role of magical thinking. Sympathetic magic was introduced by Sir James Frazer (1890/1922/1959) and Marcel Mauss (1902/1972) who described the details of ritualistic supernatural behavior across the cultures of the world. Two universal laws were characterized: the law of similarity and the law of psychological contamination, or the law of contagion as it is now referred. The law of similarity states that when two or more things physically resemble each other, they are interpreted as sharing basic properties. The law of contagion states that when two or more things come into physical contact with each other, there is a perception of permanent transmission or transference of properties between the items. Taken together, these two laws explain how people behave as if their interpretation of the physical world is the perceived reality (Rozin & Nemeroff, 2002).

The law of contagion dictates “once in contact, always in contact”, and typically describes a permanent transfer of an “essence” from one thing (the source) that is typically animate in nature to another thing (the target) that is typically inanimate in nature, but can be animate (Rozin & Nemeroff, 2002). Here, I will only focus on the importance of the law of contagion since it provides a complementary interpretation for why we would monitor, track, and remember objects that are touched by agents. Our ability to protect ourselves from potential contaminates, like unseen
pathogens or visible signs of polluted food, could have been modulated by disgust. Rozin and Nemeroff (2002) argued that what started out as a disgust domain to prevent our ancestors from ingesting contaminated food could have since been exapted to imbue physical and characteristic properties from physical contact. The operative behavior regarding the law of contagion has also shown to be asymmetrical in valence, repeatedly exhibiting stronger behavioral effects for negative attributes relative to positive ones (Nemeroff & Rozin, 1994; Nemeroff, Brinkman, & Woodward, 1994; Rozin & Royzman, 2001; Rozin, Markwith, & Nemeroff, 1992; Rozin, Millman, & Nemeroff, 1986).

In effect, the law of contagion plays two roles for the hypothesis presented in this study. First, the permanent nature of the property transmission from one object to another would have helped us track and therefore remember certain qualities of a given object. Second, the transfer of physical properties (like germs, diseases, etc.) along with characteristic properties (the “essence”) can only be done via actual physical contact. These two assumptions in conjunction would have facilitated our behavior and beliefs surrounding human and nonhuman interactions with other things (whether animate or inanimate).

**Memory for Animates**

There is now evidence for the direct mnemonic benefit of processing information for animates. A mnemonic preference for recalling animate words relative to inanimate words has been found for both incidental and intentional learning paradigms (Bonin, Gelin, & Bugaiska, 2014; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013; VanArsdall, Nairne, Pandeirada, & Blunt, 2013). Firstly, Nairne et
al. (2013) evaluated the recallability norms published by Rubin and Friendly (1986) for the previously uncoded dimension of animacy. Using a regression analysis, the authors found that if a word was animate, it was one of the highest predictors for subsequent recall. Secondly, to test memory for animate and inanimate words directly, items were selected and matched across 10 dimensions, and participants were asked to learn the words across three study trials. Overall, participants were able to recall more animate than inanimate words consistently across all three free recall trials.

Following this finding, VanArsdall et al. (2013) tested the hypothesis that animates should be better remembered than inanimates because of animate processing and not due to any prior knowledge or associations attributed to the items being learned. Ideally, this required participants to view nonwords. Across two experiments, participants rated each word for its degree of animacy represented by a short description provided with each word on the screen. For example: “FRAV has a round shape” (p.172). After a short delay, participants in the first experiment then performed an old-new recognition task, and participants in the second experiment performed a free recall task. Results revealed a consistent animacy advantage in recognition and recall as compared to inanimate words. The tendency to remember animates above and beyond inanimates has since been replicated by Bonin et al. (2014) with processing picture stimuli. Importantly in the fourth experiment, the authors showed the mnemonic benefit for animate words was not because of differences in the richness of encoding from the perceptual or semantic features. The question still remains what kind of spontaneous encoding occurs when processing animate words that would lead to enhanced retention.
Most recently, VanArsdall and et al. (2015) reported an animacy effect in a paired-associate learning paradigm. In two experiments, the memory benefit for animacy processing was tested using Swahili (foreign language) and English word pairs. An English word that was randomly paired with a Swahili word was represented as the fictional definition. Half of the English definitions were animate and the other half inanimate. Considering the potential difficulty of learning the English-Swahili word pairs, three learning trials were conducted in both experiments. As predicted, recall was consistently better for the animate “definitions” relative to the inanimate ones across all trials.

In a related set of studies using paired-associate learning, memory was investigated for animate and inanimate pairs of words in an interactive imagery task. Wilton and Mathieson (1996) had participants read animate pairs of words that were embedded in a sentence then later tested with a surprise recall test. The sentences presented either used action verbs or a conjunction that linked the two critical words to be remembered. In both studies, participants were asked to form a mental image of the sentence for 12 seconds. The sentences using action verbs to describe the interaction between two living things (e.g., “A gorilla threatening an ostrich”) produced better retention for the target word than the conjunction sentences (e.g., “The lizard and the whale”). In a follow-up study, Wilton (2006) used animal and object pairs but with an intentional learning design. The sentence syntax was similar to the sentences used in Wilton and Mathieson (1996)—the cue and target words were linked by an action verb or a conjunction. Participants were asked to create a mental image of the sentence read by the experimenter. A recognition test showed better accuracy for the action sentences
(e.g., “A chimpanzee sitting on an orange kettle”) compared to the non-interacting sentences (e.g., “A rabbit and a pink book”). Together, the Wilton and Mathieson (1996) and Wilton (2006) studies showed a memory benefit for the targets of a cue-target pair using interactive imagery. However, the retention benefit for living targets compared to nonliving targets was not examined. In contrast Popp and Serra (2015) recently argued that memory was actually impaired for learning pairs of words in which one word was an animate. Across two experiments in a standard paired-associate task, participants learned animate-animate, animate-object, object-animate, or object-object word pairs. Recall for the target word was worse in both experiments for the animate-animate word pairs (Experiment 1 and 3) compared to the object word pairs.

**Introduction to the Experiments**

In three experiments, I aimed to explore if there was a memory benefit for the inanimate objects that were manipulated by agents. Empirical data has shown there is an attentional bias for agents relative to non-agents, that we attribute internal goals, track their actions, and have greater memory for them. In this study, tracking an agent would include anything that it touched so we could later remember whether to avoid it to prevent contamination, to preserve it because of the special characteristics it may contain, or to allow the prediction of the agent’s behavior.

Memory effects for animate and inanimate interactions have been previously done in the paired-associate learning paradigms with interactive imagery; however, to my knowledge no one has looked at recall of the target pair differentially between the living and nonliving actors (the one responsible for the action). On the other hand, there have been studies that found greater memory for objects that were labeled as
“owned” by an agent compared to a preference choice, a novel label (Gelman et al., 2014), bumped into by an agent, or described as unrelated to an agent (DeScioli et al., 2015).

Since the goal of this study was to investigate the memory influence from an interaction that occurred between two things, it would be important to ensure the participants envisioned the interaction in a similar manner for the animate and inanimate actors. It has been repeatedly established that asking participants to create a dynamic, interactive mental image enhances memory for those objects relative to a non-interactive or side-by-side spatial representation (Wilton & Mathieson, 1996; Wilton, 2006). Therefore, dynamic sentences were created for all three experiments, and participants were asked to imagine the scene stated on the screen. Experiment 1 was designed to test the memory effect for the target objects on a surprise free recall test. Experiment 2 tested whether the memory enhancement found in Experiment 1 would persist on a cued-recall test where participants were given the actor and action originally encoded. The second experiment was also designed to investigate the accuracy of actor-target pairs. Experiment 3 was intended to control for mental imagery between the sentences for living and nonliving actors. Participants completed a similar cued-recall test as done in Experiment 2.
EXPERIMENT 1

The first study examined whether memory for objects would be influenced by the source of interactivity: a living agent or a nonliving object interacting with an object. In the first experiment, participants were presented with sentences that described a living agent and a nonliving object acting on a target object (displayed as a line drawing). Participants were not informed of the upcoming memory test, but were instructed to create a mental image of the event described in each sentence and to give a mental imagery rating after each sentence.

I predicted that following a short delay, participants should have better recall performance for the objects that were interacted with by agents as compared to other inanimate objects. In the surprise recall task, they were prompted to try and recall as many of the pictures previously presented with the sentences. The pictures represented the object that was the recipient of the action in each sentence.

Method

Subjects and Design

Sixty-four undergraduates (34 females and 30 males) from Purdue University volunteered in exchange for partial credit in an introductory psychology course. Actor type (animate or inanimate) was manipulated as a within-subject variable. Vividness
ratings for mental imagery and proportion of objects correctly recalled were the dependent variables.

**Materials**

Sentences were created with careful consideration for the actor in each sentence. The actor of each sentence (animate and inanimate) was selected from the list of words compiled in a previous unpublished study by VanArsdall, Nairne, Pandeirada, and Cogdill (2014). List items were drawn from two tightly-constrained categories (as opposed to broader categories like “living things” or “objects”) from the Van Overschelde, Rawson, and Dunlosky (2004) category norms: ten four-legged animals (e.g., rabbit and turtle) and ten pieces of furniture (e.g., chair and lamp). These twenty words were equated as close as possible on eight dimensions including category typicality, number of letters, frequency, familiarity, concreteness, imageability, meaningfulness, and number of intralist related semantic associations. See Appendix Table 1 for the means and statistical comparisons. Ten sentences described a four-legged animal (animate) performing an action onto an object, and the other ten described a piece of furniture (inanimate) acting upon an object.

Twenty pictures of objects were chosen from the Snodgrass and Vanderwart (1980) picture norms to represent the object that would be the recipient of the action in each sentence. Pictures were selected that were not in the furniture category norms and had at least a 90% agreement rate for naming the picture (except for word, glasses, which had a 64% agreement rate due to the other name provided, eye-glasses). Appendix Figure 4 displays the full set of pictures.
Twenty sentences were created with ten animate and ten inanimate actors paired with an object. Each object was displayed as a picture on the screen. The actions of the actor were selected from action verbs that could apply to both animates and inanimates allowing for counterbalancing the actor-action-object relationship across animates and inanimates. A total of ten verbs and verb phrases were used: breaking, covering, holding up, landing on, pressing against, bending, scraping, knocking over, falling onto, and destroying. A few examples of the sentences are “The lamp is destroying the wax candle / The rat is destroying the wax candle; The stool is falling onto the antique vase / The rabbit is falling onto the antique vase”. A second list of sentences was created. The actor-object pair was counterbalanced to ensure that each object was presented with both an animate and an inanimate actor. The counterbalance was done by replacing the actor from an animate to an inanimate and vice-versa. This resulted in a pair of lists, List 1 and List 2, as displayed in Appendix Table 2. An additional presentation order (a second version) was created for each list to counter a list effect. For example, this meant that for List 1, each sentence was randomly chosen to a different position in the presentation order, but controlling for the placement to not include more than two sentences in a row for each condition. The presentation order was counterbalanced for condition. If List 1 began with an animate sentence, then the other version of the list began with an inanimate sentence and so forth for the rest of the list. A total of four lists were used (two versions of each list), but any participant only studied one list of 20 sentences. Practice sentences were created using a previously unselected word from each animate and inanimate category and an unused object.
**Procedure**

Participants were brought in the lab to a computer terminal alone or in groups of up to four people. The instructions were presented by computer, but the recall test was done with pencil and paper. The experimental session lasted no longer than 30 minutes.

At the beginning of the experiment, participants were instructed to perform the task according to the design adapted from McDaniel and Einstein (1986). Instructions asked the participants to focus on the mental imagery task during encoding.

In the first task, you will see a series of sentences presented one at a time on the computer screen. Below each sentence there will be a picture of an object. Reach each sentence and try to form a mental image of the event described by each sentence. The picture is to help you form your mental image of the event occurring in the sentence. Try to maintain the image for the entire time the sentence appears on the screen. Each sentence will appear for 7 seconds.

Animate and inanimate sentences were randomly intermixed within the session, but no more than two actors of the same type were presented consecutively. After the sentence and picture appeared on the screen for 7 seconds, the display changed to prompt participants to provide a rating for the vividness of their mental image on a scale from 1 (not a very clear image) to 5 (clear, vivid image). They were given 5 seconds to input their vividness rating. All participants completed a practice trial with two sentences to read and rate: one animate actor and one inanimate actor.
Following the encoding task, participants completed a math-based distractor for approximately two minutes. The final phase was the surprise free recall task. Participants were asked to freely recall as many of the pictures they previously viewed in the first phase of the experiment. They were told they would have five minutes to write down on a sheet of paper as many names of the pictures as they could remember, and may write them down in any order they wished. The computer displayed a countdown timer during the recall period. At the end of the experiment, they were asked to answer two demographic questions inquiring about their gender and native language.

**Results**

As predicted the proportion of recall for the target objects was higher for those that were in contact with an animate versus an inanimate, \( t(63) = 2.57, \ p = .01 \); Cohen’s \( d = .32 \), 95% CI [ .07, .57]. As shown in Figure 1, participants freely recalled more of the target objects acted upon by living agents (\( M = .40, SD = .17, SEM = .02 \)) than nonliving things (\( M = .34, SD = .16, SEM = .02 \)), even though the exact same action was performed in each case. The average number of intrusions was also evaluated. Two kinds of intrusions were possible: words that didn’t appear in the study sentences (extra-list intrusions) and words that were the actors in the sentences (e.g., rabbit, and stool). Overall, intrusions were few, but there were significantly fewer extra-list intrusions (\( M = 0.55, SD = 0.94 \)) than actor intrusions (\( M = 1.28, SD = 1.91 \)), \( t(63) = 3.64, p < .001 \). Interestingly, 67% of the actor intrusions were the previously presented pieces of furniture, whereas only 33% were the living animals previously presented.
Figure 1. Free recall performance for Experiment 1. Error bars represent 95% confidence intervals.
The ratings for mental imagery of the animate-actor sentences were more vivid than the inanimate-actor sentences, $t(63) = 5.83, p < .001$. An animal interacting with an object was rated as more vivid ($M = 3.52, SD = 0.74, SEM = 0.09$) than the furniture interacting with another object ($M = 3.00, SD = 0.62, SEM = 0.08$) even though, again, exactly the same target object and action verb were involved in each case (across participants).

**Discussion**

The first experiment supported my prediction that if a living agent interacted with an object, the memory for the object would be influenced. Specifically, incidental encoding of a living agent interacting with an object resulted in better memory for the object. The results of Experiment 1 complemented the findings from Gelman et al. (2014) and DeScioli et al. (2015). Memory was enhanced for the target objects without a reference to ownership between the actor and object. Moreover, the animate-monitoring hypothesis predicted this result. Though the effects via physical contact has been investigated in terms of estimated value, desire of ownership, affect, and willingness to consume or purchase, the effect of animate interaction on memory has also not been investigated until now. The law of contagion, as manipulated by physical contact in previous studies, would have also predicted this pattern of results because it would be important to trace the source of the contact for subsequent decision-making.

However, several interpretive problems remain. It would be reasonable to argue that the mnemonic benefit in recall could partly be due to the greater accessibility of the agent actors relative to the nonliving actors, which then facilitated the recall of the paired object. This argument would also be supported by the difference in vividness...
ratings between the living and nonliving sentences. According to previous work in the interactive imagery literature by Wilton and Mathieson (1996) and Wilton (2006), I would not necessarily expect an imagery rating difference between the living and nonliving sentences. The Wilton studies did not find significant imagery differences between animals that interacted with each other or animals that interacted with objects compared to non-interacting imagery. However, the interactive imagery ratings have not been looked at independently for living and nonliving actions. Therefore, Experiment 2 was designed to correct the concern of unmatched accessibility between the living and nonliving sentences.
EXPERIMENT 2

The purpose of the second experiment was to eliminate the possibility of differential access to the actors of the sentences during the recall task. In doing so, recall for Experiment 2 was a cued-recall test. The participants were given all the actors and actions of the sentences previously encoded and were asked to recall the object that had been acted upon by each given actor. This change made the recall task more similar to paired-associate learning. This was desirable because the contagion hypothesis assumes the participant remembers the source (the actor) of the physical interaction as well as the recipient (the object), and it is this relationship that increases or decreases the value of an object (Newman & Bloom, 2014). A cued-recall test required the participants to remember the original pairing of the actor and object.

Apart from the recall task, the rest of the experimental design was the same as Experiment 1. The sentences provided to the participants were the same as presented previously. Similarly, everyone was asked to rate the vividness of their mental images after each sentence.

First, I predicted a boost in recall performance for both conditions compared to the first experiment because of the change from a free to cued-recall test. Second, I predicted a replication of the results from Experiment 1. There should be better recall accuracy for objects that interacted with agents relative to inanimate objects.
Additionally, because the actors would be provided to the participants at test, I predicted fewer extra-list intrusions than the first experiment and near zero actor intrusions. No changes were made to the sentences or the rating task; therefore, I predicted the imagery ratings to be similar to the ones reported in Experiment 1.

**Method**

**Subjects and Design**

Sixty-four undergraduates (24 female and 40 male) from an introductory psychology course participated in exchange for course credit. None of the students from Experiment 1 were used for Experiment 2. A simple design was used with actor type (animate or inanimate) manipulated within-subjects. Imagery ratings and proportion of objects correctly recalled were collected.

**Materials**

All the sentences used for Experiment 1 were used for Experiment 2 in the same counterbalancing conditions using two primary lists (four study lists in total).

**Procedure**

The same encoding and distractor methods from Experiment 1 were used for Experiment 2. Each participant was provided with the same instructions and distractor task as the first experiment. Each participant read 20 sentences in total; half of the sentences described an animate interacting with an object, and the remaining half described an inanimate interacting with an object. All participants completed a practice trial with two untested sentences. Following each sentence, participants rated their mental imagery and then completed a math-based distractor task for approximately two minutes. The final task was the surprise cued-recall test. The recall paper had the
sentences previously presented but randomly re-ordered with a blank at the end of the sentence where the recipient object was presented (remember, this was also represented as a picture during the encoding phase). For example, an inanimate cue would be “The lamp is destroying the __________”, and the animate cue would be “The rat is breaking the __________”. All participants received the same recall sheet with the cues in the exact same order. They were given 5 minutes to complete as many sentences as possible. After the recall test, they were asked but not required to answer two demographic questions inquiring about gender and native language.

**Results**

Figure 2 shows the overall level of performance was higher than in Experiment 1. As predicted, the proportion of recalled objects was significantly greater if interacted with by an animate relative to an inanimate, $t(63) = 4.03, p < .001$; Cohen’s $d = .50$, 95% CI [.24, .76]. This meant participants correctly remembered more of the agent actor-object pairs ($M = .64$, $SD = .23$, $SEM = .03$) than the inanimate actor-object pairs ($M = .54$, $SD = .21$, $SEM = .03$). There were few extra-list intrusions ($M = 0.81$, $SD = 1.39$), which was expected considering they were presented with the partial sentences. The type of target intrusion was analyzed. These were target objects that were recalled, but paired with the wrong actor source. Target intrusions were examined as whether they were originally encoded as being in contact with an agent or an inanimate. Target intrusions were mostly those that were processed as interacting with an inanimate ($M = 1.18$, $SD = 0.90$), relative to an animate ($M = 0.57$, $SD = 0.73$), $t(43) = 3.55, p < .001$. This was an expected result from the recall data. Since participants recalled more of the target words for the animate actors correctly, this left more of the target words that was
Figure 2. Cued-recall performance for Experiment 2. Error bars represent 95% confidence intervals.
associated with the inanimate actors free to retrieve. Therefore, this particular analysis of the target intrusions does not offer much insight for the pattern of mistakes made by the participants.

The mental imagery ratings for the two kinds of sentences were statistically different. Participants reported clearer mental images for the sentences with an animate actor \((M = 3.66, SD = 0.70, SEM = 0.09)\) relative to an inanimate actor \((M = 3.05, SD = 0.70, SEM = 0.09)\), \(t(63) = 8.10, p < .0001\).

**Discussion**

This second experiment supported the results found in Experiment 1 depicting greater memory for the objects that were interacted with agents as compared to inanimates. Performance was better overall in this experiment, and that was most likely due to the change in recall procedure. Though the pattern of results were as predicted, it was surprising to get a medium-size effect in Experiment 2. The persistence of the effect was reassuring considering one of the reasons for the change was the concern about differential access to the actors in the sentences that could be retrieved and serve as a cue for the target object. Keeping this factor constant across participants and sentences did not eliminate the effect discovered in the first experiment.

The fewer errors that were made during the recall task for the animate relative to the inanimate condition was not surprising considering participants accurately recalled more target objects that were paired with agents. Taking this into account, it left more target objects that were paired with inanimates freely available for the participant to retrieve. This would explain the larger proportion of target errors for objects that were processed as interacting with a nonliving thing.
The persistent difference in mental imagery between the conditions was troubling, however. Across both experiments, there were rather large differences in the clarity ratings between the living and nonliving sentences, meaning the sentences that depicted a living thing were a more vivid mental picture. This was a problem because it could be argued that if the participants found it easier to access clear, vivid mental images during the recall task than less vivid ones, this could explain the pattern of results in the recall data for both experiments.

Lastly, participants provided feedback at the end of the experiment that described any difficulties, if any, while creating the mental images. One comment that was reported 48% of the time was that if the actor and object were largely different in scale, they experienced difficulty imagining the event described (e.g., “The actions seemed out of order”, “The actions didn’t make sense because the larger one was doing something to the smaller one”). The other comment reported by 42% of the participants was that it was difficult to create a mental image if the actor and object didn’t normally appear together in everyday life. Experiment 3 was designed to try and correct as many scale differences as possible between the actor and object. Lastly, Experiment 3 was designed to use the same action verb for all the living and nonliving actors because a large proportion of participants reported difficulty creating a mental image for some of the actions used in the sentences.
EXPERIMENT 3

According to the law of contagion, physical contact between the actor and the object is the driving factor for perceived change in the physical properties of the object (Nemeroff & Rozin, 1994; Newman & Bloom, 2014; Rozin, Millman, & Nemeroff, 1986). To ensure the interactions between the actor and object are physical, the verbs in Experiment 3 were all changed to “touching”. This action verb was chosen because it implied direct physical contact, and importantly it should be reasonably simple to imagine for both living and nonliving actors.

A second change to the stimuli was made because of the feedback from participants. Some reported it was difficult to create a mental image for the sentences if there was a difference in physical size between the actor and object. This discrepancy was corrected by replacing pictures of objects that are small in nature to ones that are larger and more similar to the sizes of the actors.

The predictions for Experiment 3 were the same as in the second experiment.

Method

Subject and Design

Participants were part of an introduction to psychology course at Purdue University. Sixty-four people (37 female, 27 male) volunteered in exchange for partial course credit. Anyone who participated in the previous experiments was not eligible to
participate in Experiment 3. Actor type (animate or inanimate) was manipulated within-subjects.

**Materials**

There were two changes to the sentences used from the previous experiments. First, all of the action verbs were changed to “touching”, which could be applied to living and nonliving things. Second, “sofa” was replaced with “shelf” to reduce the intralist similarity in the inanimate condition caused by “couch” and “sofa”. The replacement made the intralist relationship more equal to the animate word list. A new statistical comparison was made between the animate and inanimate items because of the word change. There was only one marginal difference between the four-legged animals category and the furniture category items among the eight dimensions. The animal category contained words that were marginally more concrete ($p = .05$), but the two categories did not differ in imageability values. (See Appendix Table 3 for the means and statistical comparisons). As in the previous experiments, two study lists were created that counterbalanced each object to be paired with both an animate and an inanimate actor. Each list was then reordered to counterbalance list effects. Four study lists were used in this experiment. The two primary lists are displayed in Appendix Table 4.

The third change to the stimuli was to the pictures (objects that were the recipients of the action). Approximately half of the pictures were changed to be more equivalent in physical size to the actors as an attempt to equalize the mental imagery ratings. The picture stimuli used in Experiment 3 are presented in Appendix Figure 5.
**Procedure**

The procedure used in Experiment 2 was used for Experiment 3. Participants were given a cued-recall test in which the beginning of each sentence served as the cue.

**Results**

As predicted the results replicated the pattern from Experiment 2. Figure 3 shows that recall performance for target objects was better for those touched by agents relative to inanimate things, $t(63) = 4.77, p < .0001$; Cohen’s $d = .60$, 95% CI [.33, .86]. The average recall of targets for the agent-actor sentences was $.47 (SD = .27, SEM = .03)$, and $.35 (SD = .26, SEM = .03)$ for the inanimate-actor sentences, respectively. There were extremely few extra-list intrusions ($M = 0.28, SD = 0.78$). However, there was approximately the same number of target intrusions in this experiment as compared to Experiment 2. Again, there were fewer errors made for the target objects that were touched by an agent ($M = 0.63, SD = 0.85$) as compared to those touched by an inanimate ($M = 1.04, SD = 0.80$), $t(50) = 2.44, p = .02$, but this was not surprising considering the proportion of recall was greater for the animate-targets.

The mental imagery ratings were more similar between conditions than the previous experiments. Participants reported almost numerically equal mental image clarity, however, the difference approached significance, $t(63) = 2.06, p = .04$. The average vividness rating for the animates that touched an object was $3.58 (SD = 0.81, SEM = 0.10)$, and a slightly lower average for the inanimates that touched an object ($M = 3.40, SD = 0.77, SEM = 0.10$).
Figure 3. Cued-recall performance for Experiment 3. Error bars represent 95% confidence intervals.
Discussion

Incidental memory for objects that were touched by animates versus inanimates was measured with a cued-recall test. Similar to the pattern of results in Experiment 2, memory was enhanced for objects that came into physical contact with animates relative to inanimates. Additionally, as desired, the difference in imagery ratings was more equivalent, though the animate sentences were rated as significantly more vivid than the inanimate sentences.

Overall, recall performance was lower in this experiment compared to Experiment 2. This most likely was because all the actions provided were the same, whereas in the previous experiments, ten unique action verbs were used. The use of varying actions could allow for participants to more easily discriminate among actors, however, all verbs were used equally across animate and inanimate sentences for each participant.

The significant difference between the mental imagery ratings was not ideal. However, if the ability of the participant to retrieve the target object for each actor was primarily due to the vividness of the mental image, then I would have expected the recall results to closely mimic the imagery ratings. This was not the finding. The memory effect in recall persisted despite the drastic reduction in rating differences. It is also worth noting that by changing the action verb in this experiment, it raised the vividness ratings for the inanimate sentences to the average level of the animate sentences (for both previous experiments).
GENERAL DISCUSSION

The purpose of this study was to investigate if there was a memory effect for objects that were touched by living things. Specifically, if an object was touched by a living thing, would that object be better remembered than if it were touched by a nonliving thing? Three experiments were designed to test this question. Whether memory was tested in a free-recall task (Experiment 1) or in cued recall (Experiment 2 and 3), there was a consistent mnemonic benefit for objects touched by animates relative to inanimates. Importantly, in all three experiments, participants were not expecting the recall test. Taken together, these three experiments support the idea that our memory systems may be “tuned” for attributing priority to objects that come into physical contact with an agent.

I discussed two primary reasons one might expect a memory advantage for objects that were in physical contact with an agent relative to a nonliving thing. First, there has been strong evidence suggesting that our cognitive systems are especially sensitive to animate agents. It is possible that memory is enhanced for agents and anything they touch simply because processing a scene involving a living thing is enough to enhance memory, not necessarily because of the physical contact involved. On the other hand, there are good reasons to suspect that physical contact might be important. The law of contagion, one of the two laws of sympathetic magic, suggests
that when two objects come into physical contact, a transfer of “essence” occurs. Agent-to-object transfer is the most common type of transfer belief recorded in practice in Western and Eastern cultures (Frazer, 1959; Rozin & Fallon, 1987). There is a strong behavioral response to the interpretation of a transferred “essence” from the agent via ownership or by physical contact. Experiment 3 was specifically designed to make the physical contact between the actor (living or nonliving) and the object clear to the participants. All the objects were explicitly touched by a living and nonliving thing, and the results replicated the previous experiments. In conclusion, whether the mnemonic benefit was from agency, the physical contact, or the combination of both has yet to be distinguished.

The findings of this study are in contrast to the findings of a recent paired-associate learning study using animate and inanimate pairs. In two experiments using animate and object pairs, Popp and Serra (2015) found that the animate-animate pairs produced the worst performance (Experiment 1 and 3). Their first study had participants study animal-animal and object-object pairs then gave them a cued-recall test with the left stimulus word as the cue. Recall accuracy was higher for the object-object pairs compared to the animal-animal pairs. Their third study had participants study animal-animal, animal-object, object-animal, and object-object pairs. Again, object-object performance was significantly better compared to the other three conditions. It is reasonable to consider that in the Popp and Serra (2015) study, participants were learning the pairs without any context or use of interactive imagery that were provided in this study. This could be a reason for the difference in recall, especially considering the same categorical word pairings were used by Wilton and

Results from the current study also support the work done by Wilton and Mathieson (1996) and Wilton (2006) using interactive imagery. Wilton and Mathieson (1996) used animal-animal pairs in an incidental paired-associate learning design manipulating interactive imagery. They found in two experiments that recognition of the target was better for the interactive imagery compared to the control. Wilton (2006) replicated his results in a cued-recall test using animal-object pairs. Across three experiments, recall of the target objects was highest when the processing involved the use of interactive imagery between the animal and object. The results from these two studies, in combination with the current study provide support that the interaction between a living and nonliving thing facilitates the memory advantage.

There was a concern regarding the mental image rating difference discovered in all three experiments. In previous interactive imagery studies that implemented imagery ratings and used living and nonliving stimuli (as either the stimulus, response, or both), no rating differences were reported (Wilton, 2006; Wilton & Mathieson, 1996; Winograd & Lynn, 1979). However, there are important differences. First, one study mixed animate and inanimate pairs for a collapsed rating value (Winograd & Lynn, 1979). Wilton (2006) used all animate-inanimate pairs, and Wilton and Mathieson (1996) used all animate-animate pairs. Therefore, imagery ratings have not been separated between animate-object and inanimate-object pairs.

One could argue that the difference in mental image clarity could have contributed to the mnemonic benefit for the sentences that had the most vivid image.
This could have been the case for Experiment 1 and 2. However, the rating differences for Experiment 3 were numerically closer compared to the previous experiments. The ratings for the inanimate sentences also increased to the average ratings for the animate sentences. This would suggest that making the sentences more similar in structure (same action verb or less dynamic verb) allowed the inanimate actions to be easier to mentally imagine. Finally, since the recall advantage between the two conditions did not decrease relative to each other when the imagery ratings nearly equalized, this would suggest the vividness of the mental images was not the locus of the recall effect.

A second limitation in this study was the unintended inferential differences between animate and inanimate actors that performed an action. In other words, when a participant read “The wolf is touching the football”, it was likely that the mental image included the wolf using a limb or limbs to do the action. For the inanimate sentences like “The dresser is breaking the plastic drum”, the mental image created would not include a limb executing the action since a piece of furniture does not have limbs. Therefore, the actions depicted in the sentences for all three experiments were not controlled for this factor. This was a limitation recognized after Experiment 2. However, it was not clear after the first two experiments if the physical contact between the actor and the object was processed by the participant. Therefore, it was decided that Experiment 3 should first make the physical contact salient to the participants to determine if the memory effect would reproduce. Whether or not the locus of the memory advantage is due to the physical contact or not has yet to be determined.
Lastly, another limitation to the present study was the normality of the interactions. Because of the nature of the stimuli chosen for the actors in the sentences (animals and furniture), it was impossible to choose objects that both categories of words would ordinarily interact. The objects that animals touch are typically not the same objects that pieces of furniture touch. Therefore, it was possible that the interactions between the animals and objects were more distinctive in nature than the interactions between the furniture pieces and other objects. It was also possible that this distinction was independent of the ability for the participants to create a clear, mental image. All three experiments were conducted with animacy manipulated as a within-subjects variable. This would mean that if distinctiveness were somehow responsible for the memory advantage, it would only be detected in a between-subjects manipulation because distinctiveness effects are eliminated when the participants can no longer make relative judgments between items. I would predict that if the recall advantage was mostly because of distinctiveness, there would be no recall difference between objects touched by animates and inanimates. This would be an important consideration for a follow-up study.

The three experiments in this study provided some insight for broader learning implications, specifically for educational purposes. Well-established methods for enhanced learning of words include retrieval practice, producing a mental image, processing it for survival, and processing it for animacy. Though the results of this study are yet unclear for identifying the locus of the mnemonic effect, it is clear a retention benefit is produced when participants process stimuli for its specific association to a living thing. There is potential to enhance learning for students by
instructing them to imagine a living thing (e.g., their friend, sibling, pet, or themselves) interacting with the stimulus that is to-be-learned. For example, when students in elementary school are trying to learn new words, this strategy has the potential to encapsulate their active imaginations while enhancing their learning for the words. This learning strategy would also be applicable to adults when learning a new language. For instance, VanArsdall et al. (2015) demonstrated better memory for the (fabricated) English translation of Swahili words when the Swahili word was processed as representative of a living thing. The results from VanArsdall et al. (2015) and the current study suggest learning of educational material can be strengthened if students generated associations of the material to living things.

In conclusion, the purpose of this study was to further our understanding of the memory architecture. A functionalist theory for memory design would predict selective retention for information relevant to enhancing fitness. The selection pressures for perceptually identifying and attending to living agents relative to other objects and moving objects in the environment has been repeatedly demonstrated. Only recently has the animacy dimension been investigated for the effect it has on memory. I proposed there would be an adaptive value for remembering the objects that were in contact with a living agent relative to another inanimate object. Whether the object retained a special “essence” from the living agent that touched it, whether the object was a source for contamination, or whether the object was better remembered because it was associated with a living agent could all be adaptive reasons for enhanced retention of the target object.
LIST OF REFERENCES
LIST OF REFERENCES


APPENDICES
Appendix A

Table 1

Statistical Comparison Between Properties for Four-Footed Animals and Furniture Categories for Experiments 1 and 2

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Category Typicality</th>
<th>Number of Letters</th>
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<th>Concreteness</th>
<th>Imageability</th>
<th>Meaningfulness</th>
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<td>M</td>
<td>SEM</td>
<td>M</td>
<td>SEM</td>
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<td>df</td>
<td>Sig. (2-tailed)</td>
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</tr>
<tr>
<td>Frequencya</td>
<td>16.4 (15.6)</td>
<td>4.94</td>
<td>51.8 (64.9)</td>
<td>20.5</td>
<td>-1.68</td>
<td>18</td>
<td>.11</td>
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<tr>
<td>Familiarity</td>
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<td>7.62</td>
<td>563 (50.1)</td>
<td>15.8</td>
<td>-2.05</td>
<td>18</td>
<td>.06</td>
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<tr>
<td>Concreteness</td>
<td>616 (17.8)</td>
<td>5.64</td>
<td>600 (23.2)</td>
<td>7.32</td>
<td>1.79</td>
<td>18</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Imageability</td>
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<td>5.81</td>
<td>577 (33.1)</td>
<td>10.5</td>
<td>1.78</td>
<td>18</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Meaningfulness</td>
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<td>7.23</td>
<td>445 (53.6)</td>
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<td>-0.18</td>
<td>17</td>
<td>.86</td>
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<td>Relatedness</td>
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<td>.031</td>
<td>.335 (.114)</td>
<td>.036</td>
<td>-0.52</td>
<td>18</td>
<td>.61</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sofa is pressing against the leather shoe</td>
<td>The sofa is covering the toy football</td>
</tr>
<tr>
<td>The rat is breaking the lead pencil</td>
<td>The rat is destroying the wax candle</td>
</tr>
<tr>
<td>The sheep is covering the toy football</td>
<td>The sheep is knocking over the aluminum ladder</td>
</tr>
<tr>
<td>The bed is scraping the reading glasses</td>
<td>The bed is pressing against the inflated ball</td>
</tr>
<tr>
<td>The wolf is holding up the cotton sock</td>
<td>The wolf is bending the steel nail</td>
</tr>
<tr>
<td>The dresser is breaking the plastic drum</td>
<td>The dresser is falling onto the smoking pipe</td>
</tr>
<tr>
<td>The couch is covering the small clock</td>
<td>The couch is landing on the shiny whistle</td>
</tr>
<tr>
<td>The rabbit is landing on the shiny whistle</td>
<td>The rabbit is falling onto the antique vase</td>
</tr>
<tr>
<td>The cabinet is bending the steel nail</td>
<td>The cabinet is scraping the dinner fork</td>
</tr>
<tr>
<td>The fox is pressing against the inflated ball</td>
<td>The fox is covering the small clock</td>
</tr>
<tr>
<td>The stool is falling onto the antique vase</td>
<td>The stool is breaking the lead pencil</td>
</tr>
<tr>
<td>The lamp is destroying the wax candle</td>
<td>The lamp is holding up the outside flag</td>
</tr>
<tr>
<td>The tiger is bending the metal bell</td>
<td>The tiger is holding up the wooden broom</td>
</tr>
<tr>
<td>The mouse is scraping the dinner fork</td>
<td>The mouse is landing on the empty bottle</td>
</tr>
<tr>
<td>The chair is knocking over the aluminum ladder</td>
<td>The chair is destroying the cotton sock</td>
</tr>
<tr>
<td>The turtle is knocking over the food bowl</td>
<td>The turtle is pressing against the leather shoe</td>
</tr>
<tr>
<td>The desk is landing on the empty bottle</td>
<td>The desk is bending the metal bell</td>
</tr>
<tr>
<td>The cat is falling onto the smoking pipe</td>
<td>The cat is breaking the plastic drum</td>
</tr>
<tr>
<td>The table is holding up the wooden broom</td>
<td>The table is knocking over the food bowl</td>
</tr>
<tr>
<td>The bear is destroying the outside flag</td>
<td>The bear is scraping the reading glasses</td>
</tr>
</tbody>
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Table 3
Statistical Comparison Between Properties for Four-Footed Animals and Furniture Categories for Experiment 3

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Animate</th>
<th>Inanimate</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category Typicality</td>
<td>.259 (.274)</td>
<td>.409 (.315)</td>
<td>-1.14</td>
<td>18</td>
<td>.27</td>
</tr>
<tr>
<td>Number of Letters</td>
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<td>5.00 (1.25)</td>
<td>-1.11</td>
<td>18</td>
<td>.28</td>
</tr>
<tr>
<td>Frequencya</td>
<td>16.4 (15.6)</td>
<td>52.4 (64.5)</td>
<td>-1.72</td>
<td>18</td>
<td>.10</td>
</tr>
<tr>
<td>Familiarity</td>
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<td>561 (50.4)</td>
<td>-1.94</td>
<td>18</td>
<td>.07</td>
</tr>
<tr>
<td>Concreteness</td>
<td>616 (17.8)</td>
<td>596 (22.0)</td>
<td>2.17</td>
<td>17</td>
<td>.05</td>
</tr>
<tr>
<td>Imageability</td>
<td>599 (18.4)</td>
<td>575 (32.4)</td>
<td>2.03</td>
<td>18</td>
<td>.06</td>
</tr>
<tr>
<td>Meaningfulness</td>
<td>442 (22.9)</td>
<td>439 (53.7)</td>
<td>0.15</td>
<td>16</td>
<td>.88</td>
</tr>
<tr>
<td>Relatedness</td>
<td>.311 (.098)</td>
<td>.293 (.094)</td>
<td>0.40</td>
<td>18</td>
<td>.69</td>
</tr>
</tbody>
</table>

Table 4

*Animate and Inanimate Sentences Used for Experiment 3*

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cat is touching the telephone</td>
<td>The cat is touching the barrel</td>
</tr>
<tr>
<td>The dresser is touching the vase</td>
<td>The dresser is touching the umbrella</td>
</tr>
<tr>
<td>The couch is touching the bicycle</td>
<td>The couch is touching the clock</td>
</tr>
<tr>
<td>The mouse is touching the sled</td>
<td>The mouse is touching the guitar</td>
</tr>
<tr>
<td>The lamp is touching the bottle</td>
<td>The lamp is touching the basket</td>
</tr>
<tr>
<td>The wolf is touching the football</td>
<td>The wolf is touching the bicycle</td>
</tr>
<tr>
<td>The rabbit is touching the shoe</td>
<td>The rabbit is touching the box</td>
</tr>
<tr>
<td>The stool is touching the guitar</td>
<td>The stool is touching the telephone</td>
</tr>
<tr>
<td>The fox is touching the basket</td>
<td>The fox is touching the broom</td>
</tr>
<tr>
<td>The bed is touching the suitcase</td>
<td>The bed is touching is the piano</td>
</tr>
<tr>
<td>The sheep is touching the umbrella</td>
<td>The sheep is touching the bottle</td>
</tr>
<tr>
<td>The turtle is touching the wagon</td>
<td>The turtle is touching the vase</td>
</tr>
<tr>
<td>The table is touching the ladder</td>
<td>The table is touching the wagon</td>
</tr>
<tr>
<td>The cabinet is touching the barrel</td>
<td>The cabinet is touching the sled</td>
</tr>
<tr>
<td>The rat is touching the clock</td>
<td>The rat is touching the suitcase</td>
</tr>
<tr>
<td>The chair is touching the broom</td>
<td>The chair is touching the shoe</td>
</tr>
<tr>
<td>The bear is touching the television</td>
<td>The bear is touching the ladder</td>
</tr>
<tr>
<td>The desk is touching the box</td>
<td>The desk is touching the football</td>
</tr>
<tr>
<td>The tiger is touching the piano</td>
<td>The tiger is touching the flag</td>
</tr>
<tr>
<td>The shelf is touching the flag</td>
<td>The shelf is touching the television</td>
</tr>
</tbody>
</table>
Appendix B

Figure 4. Picture drawings selected from Snodgrass & Vanderwart (1980). Names of pictures from left to right: ball, bell, bottle, bowl, broom, candle, clock, drum, flag, football, fork, glasses, ladder, nail, pencil, pipe, shoe, sock, vase, whistle.
Figure 5. Picture drawings selected from Snodgrass & Vanderwart (1980). Names of pictures from left to right: barrel, basket, bicycle, bottle, box, broom, clock, flag, football, guitar, ladder, piano, shoe, sled, suitcase, telephone, television, umbrella, wagon, vase.