Research Article

Adaptive Memory

Animacy Processing Produces Mnemonic Advantages

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Abstract. It is adaptive to remember animates, particularly animate agents, because they play an important role in survival and reproduction. Yet, surprisingly, the role of animacy in mnemonic processing has received little direct attention in the literature. In two experiments, participants were presented with pronounceable nonwords and properties characteristic of either living (animate) or nonliving (inanimate) things. The task was to rate the likelihood that each nonword-property pair represented a living thing or a nonliving object. In Experiment 1, a subsequent recognition memory test for the nonwords revealed a significant advantage for the nonwords paired with properties of living things. To generalize this finding, Experiment 2 replicated the animate advantage using free recall. These data demonstrate a new phenomenon in the memory literature – a possible mnemonic tuning for animacy – and add to growing data supporting adaptive memory theory.

Keywords: animacy, memory, evolution

The functionalist agenda in memory research asserts that our memory systems evolved to solve adaptive problems, particularly fitness-relevant problems in ancestral environments (Klein, Cosmides, Tooby, & Chance, 2002; Nairne, 2005; Sherry & Schacter, 1987). Given the constraints of natural selection, one can anticipate domain-specific memory "tunings" for information relevant to nature's criterion – the enhancement of reproductive fitness. Indeed, a growing body of evidence has revealed that memory tends to be enhanced when processing items along dimensions that correspond with ancestrally relevant "design problems" such as survival, hunting and gathering, and finding an appropriate mate (Nairne, Pandeirada, Gregory, & Van Arsdall, 2009; Nairne, Thompson, & Pandeirada, 2007; Smith, Jones, Feinberg, & Allan, 2012).

The current study focuses on people's ability to recognize and recall animate agents, an ability that is obviously critical for survival. The detection and perception of animacy has received considerable attention in some psychological circles. For example, Pratt, Radulescu, Guo, and Abrams (2010) recently outlined three main areas of research touching on the question of animacy as it relates to perception: prioritization of the visual processing of animate objects (New, Cosmides, & Tooby, 2007), extraction of information about animates from sparse input (Johansson, 1973), and capture of attention by motion onset, a typical characteristic of animates (Abrams & Christ, 2003). It has been known for some time that the perception of animacy and intentionality can be induced in objects as simple as geometric shapes if they are given the proper movements (Michotte, 1963; Scholl & Tremoulet, 2000). Some have even argued that human beings have evolved hyperactive agency detection systems to maximize the chances of detecting potential predators in their midst (H. C. Barrett, 2005; J. L. Barrett, 2004).

Developmentally, human beings learn the difference between living and nonliving (animate and inanimate) items from a very young age (e.g., Opfer & Gelman, 2011; Piaget, 1929). For example, children develop common cross-cultural rules for various categories of life and nonlife (though with some culture-specific differences; Hatano et al., 1993), rapidly learn the differences between living, sleeping, and dead things (Barrett & Behne, 2005), can distinguish surprisingly well between animals and objects at ages as young as four (Gelman, 1990), and have different expectations about animate and inanimate objects even in infancy (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Newman, Keil, Kuhlmeier, & Wynn, 2010). In addition, recent neuroimaging work suggests there may be distinct neural systems involved in agency and animacy detection (Gobbini et al., 2011).

It is therefore reasonable to hypothesize a priori that some aspects of animates – be it their attributes, locations, or indicators of their presence – are likely to be prioritized by memory as well as perceptual systems. Yet, surprisingly, the role of animacy in mnemonic processing has received little attention. There is an extensive literature on "action effects" in memory – for example, one typically sees enactment advantages in retention (e.g., Cohen, 1989; Nyberg & Nilsson, 1995). Motion and action are among the most important cues for detecting animate agents, so it is conceivable that animate processing systems are involved in such retention advantages.

The question of whether animate stimuli per se are better remembered has not been addressed directly, however. One reason may lie partly in a major methodological

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concern: It is possible to conduct experiments directly comparing memory for animate and inanimate stimuli (e.g., animals versus object names), but item selection concerns loom large. One could attempt to equate the stimuli on numerous dimensions (e.g., word frequency, concreteness, meaningfulness, etc.), but one would still need to compare across stimulus events that potentially differ in a number of uncontrolled ways. Thus, demonstrating that people are more likely to remember animals than household objects might not be seen as particularly convincing by the community of memory researchers.

To solve this problem, in the present experiments we asked everyone to process and remember exactly the same stimuli – pronounceable nonwords – but manipulated whether those items were processed during study as animate or inanimate items. In order to impart animacy or not, we paired each nonword with a property that was characteristic of a living or a nonliving thing (e.g., "dislikes tomatoes," "dreams at night," "requires a key," and "assembled with screws"; see Appendix for a full list). People were asked to decide whether each nonword likely represented a living thing or an object, based on the paired property, and to remember the nonword for a later test. In Experiment 1, recognition memory for the nonwords was tested; in Experiment 2 we used free recall. We predicted that processing nonwords as animates would improve memory compared to an inanimate condition.

Experiment 1

In Experiment 1, all participants were asked to rate and subsequently recognize the same set of 60 nonwords. The nonwords (paired with a property) were presented individually for 5 s; participants were asked to decide how likely each nonword "name" corresponded to a living thing or an object (using a six-point scale). After finishing the 60 rating trials, participants completed a short distractor task and then their memory for the nonwords (without their corresponding properties) was tested using a recognition memory task containing 120 items (30 old "animate" nonwords, 30 old "inanimate" nonwords, and 60 new nonwords). Eighteen of the participants completed an additional imagery-rating task at the end of the experiment to determine whether there was a difference in the ease of creating a mental image between the animate and inanimate properties.

Method

Participants and Apparatus

Thirty-eight undergraduates (14 women) participated in exchange for partial credit in an introductory psychology course. Participants were tested in groups ranging from one to four in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers.

Materials and Design

Sixty pronounceable nonwords from the ARC nonword database (Rastle, Harrington, & Coltheart, 2002) were used in the initial rating task. Four additional nonwords were used in a practice phase, and a further 60 nonwords from the ARC database were used in the recognition portion of the experiment for a total of 124 nonwords. Nonwords used during encoding and recognition were counterbalanced across participants. Sixty properties (see Appendix) were used during the rating portion of the experiment; half were properties characteristic of animate objects and half of inanimate objects.

Properties were assigned randomly to the nonwords for each participant (such that half of the nonwords received animate and half inanimate properties). All of the nonword/property pairs were rated by the participants using the same scale. The rating task was followed by a 2 min distractor task – rapidly deciding whether single-digit numbers were even or odd – and then the recognition task occurred. The experiment used a simple within-subject design: All participants received both the animate and inanimate items for an initial rating, randomly intermixed throughout the session, followed by the same recognition test. Except for the word-property pairings, all aspects of the design, including timing, were held constant across participants.

Procedure

On arrival, all participants received the same instructions:

"In this task, please imagine that you are being shown a series of objects and living things that you have never seen before. They will have unusual names such as "BRUGUE," "FRAV," or "JOTE." Some of these names might be considered objects, whereas others might be considered living things. Each name will be shown with a property. The property will be listed directly under the word name. You will see each name and its property for 5 s. Your task is to try to remember the property that is associated with each name. For example, you might see the following:

FRAV has a round shape.

In this case, you would want to remember that this name (FRAV) has the given property (has a round shape). We will be giving you a memory test later in the session.

Additionally, we would like you to rate how likely this is to be the name of an object or living thing using a scale from one (1) to six (6). A rating of one (1) corresponds to "very likely to be an object" whereas a rating of (6) corresponds to "very likely to be a living thing." So, if you think that the fact that a FRAV has a round shape (in the previous example) makes it more like an object than a living thing, you might give it a rating of one, two, or three. If you think the opposite is true, you might give it rating of four, five, or six. Some of the names might seem more like objects while some may seem more like living things – it's up to you to decide."

Each to-be-rated nonword "name" appeared on the screen for 5 s, with its corresponding property presented directly below it. The rating scale was presented underneath the name/property pair with 1 on the left through 6 on the right; "very likely to be an object" was written below number 1 and "very likely to be a living thing" was written below number 6. During this 5 s presentation period, participants responded by pressing the key corresponding to their value of choice. All participants were cautioned to respond within the 5 s rating window. A short practice rating session preceded the actual rating session.

After rating the final item, instructions for the even-odd decision task appeared. In succession a single-digit number ranging from 1 to 9 was presented, and participants were asked to respond with the letter *E* on the keyboard if the number was even and the letter *O* if the number was odd. Participants had 2 s to respond to each digit; this task lasted for 2 min.

Instructions for the recognition memory test followed. Participants were told they would be seeing the names of objects and living things from earlier in the experiment in addition to the names of new objects and living things. Participants were then asked to judge whether or not they had seen the name during the first part of the experiment using a six-point scale ranging from 1 ("definitely did not see this name") to 6 ("definitely did see this name"). On each trial the nonword was presented without its corresponding property. Participants provided their recognition rating by pressing their value of choice on the keyboard; 5 s were given to respond to each item. Responses from 1 to 3 were categorized as "no" responses ("I did not see this name before") while responses from 4 to 6 were categorized as "yes" responses ("I did see this name before.")

Participants completing the imagery task did so after the recognition task. They were instructed to rate each of the properties (without their corresponding nonwords) for how easily they could create a mental image of the property. The scale ranged from 1 (very difficult) to 6 (very easy). As before, participants responded by entering their value of choice on the keyboard and were given 5 s to respond to each property.

Results and Discussion

The level of statistical significance, unless otherwise noted, was set at $p < .05$ for all comparisons. Average animacy and imagery ratings for the two types of properties are shown in Table 1. Not surprisingly, participants rated the nonwords paired with living properties significantly higher (and thus more like living things) than those with nonliving properties, $t(37) = 28.53, p < .001, d = 4.63$. The two types of properties did not differ, however, along the imagery dimension, $t(17) < 1$. This last result reduces the chances that imageability is a critical determinant of any retention differences between conditions – that is, it might be easier to form a visual image of an animate property which, in turn, could enhance retention of its associated nonword.

Table 1. Average animacy ratings (and *SD*s) for both experiments; imagery ratings (and *SD*s) for Experiment 1

	Rating	Living	Nonliving
Experiment 1	Animacy	5.44 (.46)	1.88 (.40)
	Imagery	3.92 (1.05)	3.97 (1.17)
Experiment 2	Animacy	5.54 (.43)	1.69 (.54)

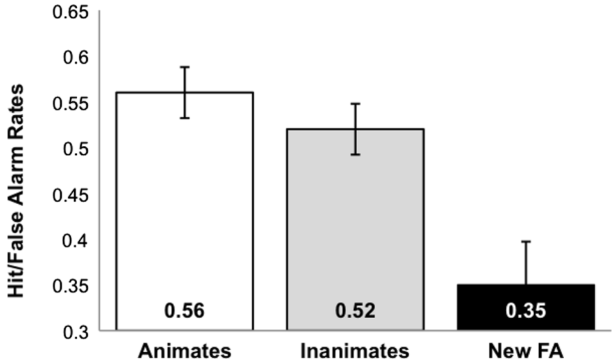

Figure 1. Average hit rates for the items associated with animate and inanimate properties and overall false alarm rate in Experiment 1. Error bars represent 95% confidence intervals.

Hit rates were defined as the proportion of old nonwords given a "yes" response (4 or greater on the rating scale) in a given condition; the false alarm rate was defined as the proportion of the new nonwords given a "yes" response. As predicted and shown in Figure 1, the recognition hit rate for nonwords associated with animate properties was greater than for nonwords associated with inanimate properties $t(37) = 1.96$, $p = .029$ (one-tailed), $d = .32$. In addition, hit rates for both types of nonwords were well above the false alarm rate. Because participants provided their own ratings for the nonword/property pairings, we could conditionalize recognition performance on the individual subjective judgments – that is, based on the participant's own judgment about whether a nonword represented an object or a living thing. Using this subjective criterion, the effect of animate processing on the hit rates remained significant, $t(37) = 2.28, p = .029, d = .37$.

Animacy also affected response times in the rating task: Participants rated nonwords paired with animate properties faster than those paired with inanimate properties, $t(37) = -7.12$, $p < .001$, $d = -1.18$. Thus, even though participants took significantly less time initially processing the animate items, an animacy advantage was found in recognition memory. One might argue that quick animacy decisions afforded more time to study the animate nonwords given that participants were explicitly told to remember the property that was paired with each of the nonword names. To assess the relationship more formally, we correlated the recognition hit rates with the rating response times for the both the animate ($r = 0.20$) and inanimate ($r = 0.27$) items. Note that both of the correlations were positive: Longer initial decision times were associated with higher subsequent hit rates (although neither correlation was statistically significant). The study time hypothesis predicts a negative correlation between rating response time and hit

Table 2. Response times in ms (and *SD*s) for the rating task in both experiments and for the recognition task in Experiment 1

	Task	Animate	Inanimate
Experiment 1	Rating	2648 (563)	3020 (496)
	Recognition (hits only)	1903 (466)	1826 (457)
Experiment 2	Rating	4369 (1333)	4867 (1423)

rate – faster response times should have led to better recognition performance – which was not the pattern obtained. For the recognition task itself, correct responses were marginally slower for nonwords previously processed as animates, $t(37) = 1.96$; $p = .058$, $d = .32$. Means (and *SD*s) for the response time data are presented in Table 2.

Overall, these data confirm our main prediction that recognition memory should be enhanced when items are processed as animates. Participants were able to recognize nonwords associated with animate properties better than nonwords associated with inanimate properties. Importantly, everyone was asked to process and recognize the same set of nonwords, so it is not possible to attribute the "animacy effect" obtained here to an item selection artifact. Rather, as predicted, the data suggest that our memory systems may be tuned to process and remember animates.

Experiment 2

Experiment 2 was designed to replicate the memory advantage for animate processing using a different memory measure. Similar stimuli were used (nonwords) and the rating task was identical to the task described in Experiment 1, but instead of a recognition memory test, participants were asked simply to recall the nonwords (without the corresponding properties).

Method

Participants and Apparatus

Thirty-two people (16 women) participated in exchange for partial credit in an introductory psychology course or were compensated $10. Participants were tested in groups ranging from one to four in sessions lasting approximately 30 min. Stimuli were presented and controlled by personal computers, and participants entered their responses using the keyboard.

Materials and Design

Sixteen pronounceable nonwords from the ARC nonword database (Rastle et al., 2002) were chosen and adapted to be four letters in length and distinct from each other (e.g., GUTE, LAIL, YOUN, etc.). Four additional four-letter nonwords were used during a practice rating phase for a total of 20 four-letter nonwords.

Sixteen properties were chosen from those used in Experiment 1, with preference for those that had previously received mean animacy ratings at the extremes of the scale – that is, properties that were most characteristic of objects and living things. Eight from each category were chosen (see Appendix). The properties were also chosen such that each set of eight had equivalent mean imagery ratings. We once again used a within-subject design; half of the nonwords were paired with living properties and half with nonliving properties. All participants rated the nonwords in the same random order, only the assignment of properties to nonwords changed. Experiment 2 was counterbalanced such that each nonword was paired with one living property and one nonliving property, guaranteeing its participation as both a living thing and a nonliving object across participants. Except for the property pairings, all aspects of the design, including timing, were held constant across participants.

Procedure

Participants received the same instructions for the rating task as in Experiment 1, with slight adjustments reflecting the fact that all nonwords were four letters in length. During the rating task, each to-be-rated nonword "name" appeared on the screen for 10 s with its associated property directly underneath. Processing time was increased in Experiment 2 because free recall is traditionally a more difficult task than recognition. Participants were given the entire 10 s to study the name/property pair and decide their rating. As in Experiment 1, a rating of 1 represented "very likely to be an object" whereas 6 represented "very likely to be a living thing." All participants were cautioned to respond within the 10 s rating window. A short practice rating session preceded the actual rating session.

After rating the final item, instructions for the distractor task appeared as in Experiment 1. In this experiment, however, the task only lasted for 1 min. Participants were then asked to recall the names from the rating task, in any order, and not to write down the properties associated with the names. Participants were given 4 min to complete the task.

Results and Discussion

As expected, the nonwords associated with living properties were rated significantly higher than those associated with nonliving properties $t(31) = 25.42$, $p < .001$, $d = 4.50$ (see Table 1). As in Experiment 1, participants also rated the nonwords paired with living properties significantly faster than those paired with nonliving properties, $t(31) = -3.03$, $p = .005$, $d = -.54$ (see Table 2). The correlation between rating response time and proportion correct free recall was essentially zero for both the living ($r = -0.077$) and the nonliving ($r = 0.001$) items.

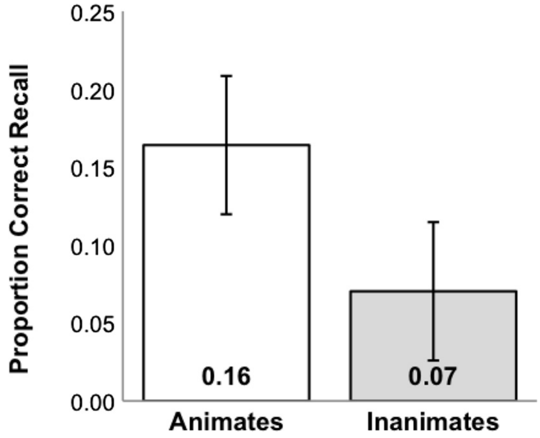

Figure 2. Proportion correct recall for the items associated with animate and inanimate properties in Experiment 2. Error bars represent 95% confidence intervals.

The free recall data are shown in Figure 2. Performance levels were relatively low, but there was a highly significant recall advantage for the nonwords paired with living properties, $t(31) = 3.05$, $p = .005$, $d = .61$. As in Experiment 1, conditionalizing the recall data on the participants' subjective responses during the rating phase produced similar results: there was a highly significant recall advantage for nonwords classified as animates $t(31) = 3.07$, $p = .004$, $d = .60$.

General Discussion

The ability to detect and remember animates in the natural world is critical for survival. Considerable empirical attention has been directed at understanding the processes that underlie the detection and perception of animacy (e.g., Pratt et al., 2010; Scholl & Tremoulet, 2000), but virtually no attention has been given to the role of animacy in remembering. Part of the reason, as suggested earlier, may have been methodological, but memory researchers rarely consider functional questions when constructing theory (Klein et al., 2002; Nairne, 2005, 2010). The idea that our memory systems might be "tuned" or "prepared" to retain information about animates follows sensibly from an adaptive or evolutionary perspective, but not easily from one assuming that cognitive processes are domain-general.

In the current experiments, memory was enhanced when nonword "names" were associated with animate properties. Importantly, everyone was asked to process and remember exactly the same nonword stimuli in these experiments, thus effectively eliminating item selection concerns; what mattered was whether a particular stimulus was processed as a living (animate) item or not. The animate advantage held when item memory was tested using a standard recognition task or with free recall. Moreover, it does not appear that the animate advantage can be easily explained by appealing to less interesting dimensions, such as processing depth or effort. As noted, in both experiments people were faster to rate the nonwords paired with animate properties, suggesting ease of processing, but showed a clear mnemonic advantage in both recognition and recall. One could assume that animate properties lead to "deeper" forms of processing, although deeper forms of processing typically require more processing time (Craik & Tulving, 1975), but such reasoning is clearly post hoc. In addition, the imagery ratings were matched between the animate and inanimate properties, suggesting that both kinds of properties afforded the same potential for elaboration.

Another possibility is that the nonwords processed for animacy were remembered well because animate things are especially likely to capture attention. As reviewed earlier, there is evidence that animate objects are given priority in visual processing – in fact, animacy detection systems may be hyperactive – so the locus of the retention benefits could be in attentional processing rather than in any special mnemonic "tunings." Of course, the to-be-remembered stimuli were not actually animate or inanimate items. The tested stimuli were nonwords that acquired their animate status only after the participant had attended to and processed their associated properties. One could also argue that animate properties are naturally more accessible in memory, so associating the nonwords with accessible properties (i.e., acting as retrieval cues) produced enhanced retention. These are simply speculations at this point, but each is consistent with the idea that animacy may have some special status in cognitive processing (Gobbini et al., 2011; Wheatley, Milleville, & Martin, 2007).

It is also worth noting that we used animate properties that corresponded uniquely to a "human" category – that is, the decision to mark an item as a "living thing" was always based on some kind of human action (e.g., "watches action movies"). Human actions may be especially memorable, because of their self-relevance and social implications, so it is possible that our results will not generalize to other kinds of animate agents (e.g., nonhuman animals) or plants. The human category is presumably more homogeneous and sharply defined as well, especially compared to the more broadly-defined "inanimate" category, which could have supported retrieval of the associated nonwords (albeit only indirectly through the recall of the associated properties). Whether the effect presented here is restricted to human agents or can be generalized to other animate objects should be addressed in follow-up empirical research.

Our results also fit well with a recent study by Camilleri, Kuhlmeier, and Chu (2010), which examined the role of intentionality in helping and hindering behavior. In this experiment participants were presented with colored triangles that acted in various ways in video recordings. Some of the triangles "helped" a red ball up a slope, whereas others hindered its progress. The key manipulation in the study was whether the action of the triangle could be construed as intentional or unintentional. Altering the intentionality dimension was done by manipulating the movements of the triangle so that it was seen as moving on its own accord or moving due to outside influences, such as accidentally falling from a height. Interestingly, participants were able to perform significantly better on a recognition task for the colors of triangles performing "intentional" behaviors compared to ones performing "unintentional" behaviors – regardless of whether those behaviors helped or hindered.

To our knowledge, the current experiments are the first to show that processing information along an animate dimension can lead to enhanced retention compared to an inanimate control, not only in recognition but also in free recall. This novel finding is important because it suggests that our cognitive systems are possibly prepared or "tuned" to detect as well as remember animate things. As noted throughout, the animacy hypothesis follows naturally from an adaptive, or functional, perspective on human cognition. More generally, the crux of the functionalist agenda is the recognition that our cognitive systems are purposive; that is, we developed the capacity to perceive and remember because those capacities help us solve critical adaptive problems – in the present case, recognizing and remembering animates.

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Appendix

Properties Used in Both Experiments (Alphabetical)

	Animate properties	Inanimate properties
Experiment 1	believes in God	adjustable in size
	celebrates its birthday	assembled with screws
	cheats at cards	built in Spain
	composes music	can be folded up
	cries when upset	comes in a box
	dislikes tomatoes	costs a lot of money
	dreams at night	decorated with jewels
	enjoys cooking	dissolves when wet
	has a best friend	easily rebuilt if broken
	has a busy schedule	filled with wires
	has a short temper	gives off light
	has low self-esteem	has a hollow center
	hates playing chess	has a smooth surface
	is a photographer	has multiple configurations
	laughs when tickled	has several compartments
	likes to be in control	has sharp edges
	listens to pop music	has transparent parts
	loves to travel	highly flammable
	makes to-do lists	made of wood
	multi-tasks well	needs batteries
	prays daily	reflects light
	reads emotions well	requires a key
	reads romance novels	rolls along the ground
	sings opera	rubs off on clothes
	speaks French	runs on gasoline
	tries to save money	sewn together
	wants to be a doctor	shatters if dropped
	was recently married	sinks in water
	watches action movies	thin as paper
	works at a store	used as a tool
Experiment 2	believes in God	built in Spain
	dreams at night	dissolves when wet
	is a photographer	filled with wires
	listens to pop music	made of wood
	reads romance novels	needs batteries
	wants to be a doctor	requires a key
	was recently married	runs on gasoline
	watches action movies	shatters if dropped

