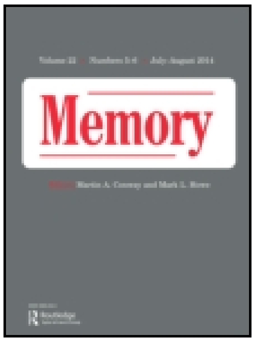

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Adaptive memory: Animacy effects persist in paired-associate learning

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Recent evidence suggests that animate stimuli are remembered better than matched inanimate stimuli. Two experiments tested whether this animacy effect persists in paired-associate learning of foreign words. Experiment 1 randomly paired Swahili words with matched animate and inanimate English words. Participants were told simply to learn the English "translations" for a later test. Replicating earlier findings using free recall, a strong animacy advantage was found in this cued-recall task. Concerned that the effect might be due to enhanced accessibility of the individual responses (e.g., animates represent a more accessible category), Experiment 2 selected animate and inanimate English words from two more constrained categories (four-legged animals and furniture). Once again, an advantage was found for pairs using animate targets. These results argue against organisational accounts of the animacy effect and potentially have implications for foreign language vocabulary learning.

Keywords: Animacy; Foreign language learning; Memory; Paired-associate learning.

Human memory, like the rest of the human form, evolved to solve adaptive problems. Consistent with nature's criterion—the enhancement of inclusive fitness—we can assume that memory evolved primarily to solve fitness-relevant problems, particularly those likely to have been important in ancestral environments (Klein, Cosmides, Tooby, & Chance, 2002; Nairne, 2005; Sherry & Schacter, 1987). Our laboratory has shown previously that domain-specific mnemonic "tunings" might exist for fitness-relevant problems such as gauging the survival-relevance of items (Nairne, Thompson, & Pandeirada, 2007), remembering potentially contaminated items (Nairne, 2014a, 2014b) and remembering living things in the environment (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013; VanArsdall, Nairne, Pandeirada, & Blunt, 2013; see also, Bonin, Gelin, & Bugaiska, 2014).

This latter finding—that animate concepts appear to be remembered better than inanimate concepts—represents a uniquely apt extension of the idea that memory systems are "tuned" to adaptive problems. Living beings such as animals

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and conspecifics (other humans) are among the most important stimuli in the environment: they represent potential predators, prey, mates, kin as well as partners for social interaction—among other possibilities. Substantial evidence already suggests that animacy is important perceptually: animals are prioritised in visual and attentional processing (New, Cosmides, & Tooby, 2007; Pratt, Radulescu, Guo, & Abrams, 2010), and information about biological animates can be extracted readily from sparse input (Johansson, 1973). Additionally, the distinction between what is animate and what is inanimate develops very early in life (Opfer & Gelman, 2011), is an important distinction in semantic knowledge (Caramazza & Mahon, 2003) and appears to be associated with specific brain structures (Caramazza & Shelton, 1998; Gobbini et al., 2011). A mnemonic advantage for animate concepts therefore seems appropriate to complement this suite of apparent tunings towards the detection of dynamic beings in the environment.

Previous research (Nairne et al., 2013; VanArsdall et al., 2013) has demonstrated that such a mnemonic advantage does exist for animate stimuli as well as for non-words processed as animate concepts. In Nairne et al. (2013), animate and inanimate English words were equated along a number of dimensions and participants were simply asked to memorise the presented words. Across repeated study-test trials using free recall as the retention measure, animate words were remembered best. In addition, using regression techniques applied to Rubin and Friendly's (1986) corpus of recall norms, we showed that an item's animacy status (living versus non-living) is an important predictor of recall. VanArsdall et al. (2013) showed that animacy effects can be induced for non-words as well; non-words thought of as representing animate concepts were both recognised and recalled significantly better than non-words that had been thought of as representing inanimate concepts. These demonstrations are important theoretically, supporting a functional/evolutionary account of remembering, but for procedural reasons as well. Animacy currently represents an uncontrolled word dimension in most cognitive research (see Nairne et al., 2013).

The present research explores the animacy effect in paired-associate learning, in a context similar to foreign language vocabulary learning. Paired-associate learning requires one to learn relationships between specific cues and target responses—in the current case, between Swahili words and animate or inanimate "translations". The Nairne et al. (2013) demonstration of animacy advantages for English words used free recall as the sole retention measure. Free recall affords certain retrieval strategies that are less useful in paired-associate learning. For example, one can employ category-based organisational strategies in free recall that are less viable in paired-associate learning. Extending the animacy advantage to paired-associate learning should ultimately help constrain theoretical interpretations of the effect.

In addition, as noted, our experiments used a procedure similar to what occurs in foreign language vocabulary learning. It would be interesting to investigate whether it is easier to learn foreign language translations that refer to animate concepts. For example, it might be easier to learn the Portuguese word for cat (*gato*) than the word for pen (*caneta*). However, foreign words representing animate or inanimate concepts are apt to be confounded by numerous factors. For this reason, we decided simply to randomise foreign and English word pairs rather than directly test foreign language vocabulary acquisition. With this approach, we can more carefully control whether differences in the target concepts (such as animacy) produce differential learning. To reduce individual word distinctiveness that might arise from novel alphabets or accented characters, Swahili was chosen as the foreign language. Swahili does not use characters that are different from those found in English nor does the pronunciation of individual syllables differ significantly (Nelson & Dunlosky, 1994). An added benefit is that American English-speaking participants are more likely to be unfamiliar with Swahili, when contrasted with a language such as French or Spanish.

EXPERIMENT 1

In Experiment 1, all participants were asked to learn 24 Swahili-English word pairs for a later cued-recall test. The pairs were presented individually for 5 s; during this time, participants were asked to learn the English word that had been paired (randomly) with a Swahili word. Following this learning period, participants completed a short distractor task and then were tested on the pairs just presented. Importantly, half of the pairs had English targets that were animate and half of the pairs had English targets that were inanimate. These English words were previously matched on numerous dimensions by Nairne et al. (2013).

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Method

Participants and apparatus. Forty-six undergraduates (23 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. Twenty-four English words from Nairne et al. (2013) were used as targets in the initial encoding task, of which 12 were animate and 12 were inanimate. These word sets were chosen because they had been previously matched along a number of mnemonically relevant dimensions: Age of acquisition, category size and typicality, concreteness, familiarity, imagery, written frequency, meaningfulness, number of letters and relatedness (see Nairne et al., 2013, for details). In addition to the English words, 24 Swahili words were chosen from the Nelson and Dunlosky (1994) norms such that no more than three words began with the same letter; these words served as cues for the English "translation" targets. See Table 1 for these word lists. Four additional "buffer" words were chosen from both the English and Swahili pools. The experiment was a 2 × 3 repeated measures design with target word type (animate or inanimate) and study-test trial (1, 2 or 3) manipulated within-subject. Number of words recalled was the dependent variable.

TABLE 1
Swahili and English words used in each experiment

		Experiment 1		*Experiment 2*	
Swahili words		*Animate*	*Inanimate*	*Animate*	*Inanimate*
adui	nabii[a]	baby	doll	bear	bed
ambo	ndoo	bee	drum	cat	cabinet
baharia[a]	pombe	duck	hat	fox	chair
chura	punda	engineer	journal	mouse	couch
dafina	rembo	minister	kite	rabbit	desk
fahali	sahani	owl	purse	rat	dresser
godoro	tabibu	python	rake	sheep	lamp
kaburi[a]	tajiri	soldier	slipper	tiger	sofa
kasuku	wingu	spider	stove	turtle	stool
leso	yatima	trout	tent	wolf	table
malkia	ziwa	turtle	violin		
mshoni	zulia[a]	wolf	whistle		

Words in each category are presented here in alphabetical order.
[a]Swahili words that were not used in Experiment 2.

Procedure. Participants were presented with pairs of foreign and English words, one at a time, and were asked to remember the pairings for a later test that would require recall of the English word when given the foreign word. Again, the particular pairings were determined randomly for each participant; the Swahili words were not paired with their actual translations. As previously mentioned, half of the English target words were animate concepts and half were inanimate. The word pairs were presented in a random order, with the only constraint that an equal number of both word types (animate and inanimate) appeared in each half of the list. Each word pair appeared for 5 s, with a 250-ms intertrial interval. At the beginning and end of the list, two "buffer pairs" (one of each type) were added and not scored in recall. Apart from the randomization of both word pairings and list order, all aspects of the design, including timing, were held constant across participants.

Following the presentation of the final Swahili-English pair, participants were given a one-min distractor task in which they were asked to identify rapidly whether single digit numbers ranging from one to nine that appeared on the computer screen were even or odd. Participants had 2 s to respond to each digit and responded to even numbers by pressing the letter *E* on the keyboard; an odd number was indicated by pressing the letter *O*. After participants completed the distractor task, they were then asked to complete a cued-recall test in which only the Swahili cue words were presented (e.g., "malkia-______"). The order of presentation of the cues was randomly determined. In the blank space next to each cue, participants were prompted to remember the proper target English word and to enter it using the keyboard within 10 s. After participants completed this cued-recall task, they repeated the viewing, distractor and cued-recall procedures two more times with the same cue-target pairs in new random orders (for a total of three study-test trials).

Results and discussion

Across all three study-test trials, a strong cued-recall advantage was present for the animate pairs, as shown in Figure 1. The number

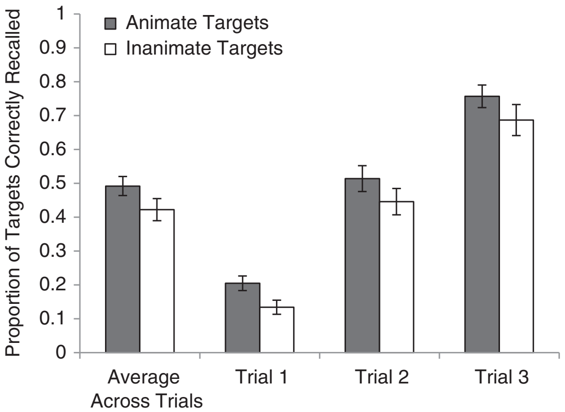

Figure 1. Results from Experiment 1: mean proportion of targets correctly recalled as a function of trial and word type. Data are shown averaged across the three cued-recall trials and separately for each trial. Error bars represent standard errors of the mean.

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of correctly remembered word pairs increased across trials as well. A 2 × 3 repeated measures ANOVA confirmed both a significant main effect of word type, $F(1, 45) = 18.82$, MSE = 0.018, $\eta_p^2 = 0.295$, and recall trial, $F(2, 90) = 262.16$, MSE = 0.027, $\eta_p^2 = 0.853$. The interaction was not significant, $F(2, 90) < 1$, indicating that the animacy advantage, although robust, remained constant across trials. It is difficult to interpret difference scores (e.g., animate versus inanimate) at different overall performance levels, but the fact that the animacy advantage did not increase over trials could be important theoretically. For example, one might attribute the animacy advantage to an initial boost in attentional processing for animate objects that diminishes with experience.

These results clearly demonstrate that the advantage for animate concepts first discussed by VanArsdall et al. (2013) and confirmed among real English words by Nairne et al. (2013) extends to paired-associate learning when the target is an animate concept. Still, the presence of an animacy advantage does not necessarily mean that it is easier to associate animates with other stimuli in the environment. Paired-associate learning can be mediated by stimulus or response accessibility rather than an association per se (see Crowder, 1976). It is possible that the animate responses were simply more available in memory which, in turn, enabled participants to choose from a larger pool of possible correct responses.

Some support for this idea is given in Table 2, which shows the average number of unique (non-repeated) incorrect responses that were either animate or inanimate. These data represent

TABLE 2
Average number of unique incorrect responses (and standard deviations) in both experiments

		Trial 1	*Trial 2*	*Trial 3*
Experiment 1	Animate	1.30 (1.28)	1.37 (1.69)	0.70 (1.09)
	Inanimate	0.78 (0.89)	0.87 (1.13)	0.63 (1.08)
Experiment 2	Animate	1.71 (1.26)	1.51 (1.27)	0.82 (1.19)
	Inanimate	2.11 (1.33)	1.60 (1.26)	1.31 (1.23)

cases in which an item from the list was incorrectly produced to a Swahili cue (repetitions of the same error were not counted). Overall, significantly more animate stimuli were produced as incorrect responses than inanimate stimuli, $F(1, 45) = 7.42$, $p < .01$, MSE = 1.221, $\eta_p^2 = 0.142$. This implies that animate responses may have simply been easier to produce—that is, more accessible as a pool of items—than inanimate responses. The number of unique incorrect responses declined over trials, $F(2, 90) = 5.63$, $p < .01$, MSE = 0.928, $\eta_p^2 = 0.111$ and no significant interaction between recall trial and word type was found, $F(2, 90) = 1.60$, $p > .20$, MSE = 0.955, $\eta_p^2 = 0.034$.

EXPERIMENT 2

As discussed, one interpretation of the animacy advantage in free recall is that animate concepts are simply more accessible overall than inanimate concepts. The superordinate category of "living things" is arguably more constrained than the superordinate category of "non-living things". Although we equated for category size in selecting the word pools—e.g., "type of reading material" and "thing that flies"— it is possible that animate concepts are still, on average, more accessible. In Experiment 2, we chose two new word lists that seemed less likely to suffer from accessibility differences: four-footed animals and household furniture. Both of these categories are tightly constrained and highly familiar. Experiment 2 sought to replicate the results of Experiment 1 using these new lists.

Method

Participants and apparatus. Fifty-five undergraduates (25 women) participated in exchange for partial credit in an introductory psychology

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course. Testing conditions were the same as in Experiment 1.

Materials and design. Twenty English words were chosen as targets in the initial encoding task, half of which were animate. These word sets were selected using a method similar to Nairne et al. (2013), with the added restriction that all of the words of a given type (animate or inanimate) had to belong to a specific category from the Van Overschelde, Rawson, and Dunlosky (2004) category norms. The sets were matched for category typicality, concreteness, number of letters, familiarity, imagery, Kučera-Francis written frequency, meaningfulness and relatedness (as measured by latent semantic analysis). The two categories chosen were "a four-footed animal" for animate words and "an article of furniture" for inanimate words; see Table 3 for average values and standard deviations for these attributes. Notably, the category size of four-footed animals is somewhat larger than that of furniture (28 members compared to 21 members), suggesting that the furniture category is perhaps *more* constrained (and thus affording a greater degree of accessibility to its constituent words) than the four-footed animal category.

Of the Swahili words, 4 of the 24 used in Experiment 1 were discarded in Experiment 2 (words marked with a superscript "a" in Table 1 were not used in this experiment). Four additional "buffer" words were chosen that matched the categories for the English words, while the same Swahili buffer words were used. Other than these changes to the words, the design of Experiment 2 was identical to that of Experiment 1.

Results and discussion

As in Experiment 1, cued-recall was significantly higher for animate words than for inanimate words across all three trials (see Figure 2). Once again a 2 × 3 repeated measures ANOVA revealed main effects of word type, $F(1, 54) = 24.26$, MSE = 0.037, $\eta^2_p = 0.310$ and recall trial, $F(2, 108) = 342.67$, MSE = 0.023, $\eta^2_p = 0.864$; the interaction was not significant, $F(2, 108) < 1$. In addition to replicating the animacy advantage in correct recall, Table 2 shows that we effectively eliminated any accessibility advantage for the animate targets, as measured by the proportions of incorrect responses that were generated. In fact, inanimate words made up the bulk of unique incorrect responses supplied by participants, $F(1, 54) = 7.89$, $p < .01$, MSE = 1.120, $\eta^2_p = 0.127$. As in the previous experiment, the number of errors significantly decreased across test trials, $F(2, 108) = 13.19$, $p < .01$, MSE = 1.503, $\eta^2_p = 0.196$ and the interaction was not reliable, $F(2, 108) = 1.07$, $p > .300$, MSE = 1.132, $\eta^2_p = 0.019$.

These results replicate the animacy advantage in cued-recall, with a new set of stimuli, and suggest that it is probably not the cohesiveness of the animate category per se that leads to a mnemonic advantage; if anything, the "furniture" category was more cohesive and accessible than the "four-footed animals" category in Experiment 2. Thus, the animacy advantage remains strong in cued-recall regardless of whether people are more (Experiment 1) or less (Experiment 2) likely to output animate stimuli as incorrect responses.

TABLE 3
Average values of various dimensions for the animate and inanimate list of items used in Experiment 2

Dimension	*Animate*	*Inanimate*	*df*	t *value*
Category size	21	28	n/a	n/a
Category typicality	0.259 (0.274)	0.436 (0.291)	18	1.401
Concreteness	616 (17.8)	600 (23.2)	18	−1.786
Familiarity	527 (24.1)	563 (50.1)	12.95	2.053
Imagery	599 (18.4)	577 (33.1)	18	−1.778
Kučera-Francis written frequency	16.4 (15.6)	51.8 (64.9)	10.04	1.676
Meaningfulness[a]	442 (22.9)	445 (53.6)	17	0.183
Number of letters	4.4 (1.17)	4.9 (1.29)	18	0.908
Relatedness	0.311 (0.098)	0.335 (0.114)	18	0.517

Standard deviations are given in parentheses. Values for category size and category typicality were taken from the Van Overschelde et al. (2004) category norms. Values for concreteness, familiarity, imagery, Kučera-Francis written frequency, meaningfulness (Colorado norms) and number of letters were obtained from the MRC Psycholinguistic Database (Coltheart, 1981). The relatedness dimension was assessed using latent semantic analysis (Landauer et al., 1998).

[a]A meaningfulness value was not available for the word "cabinet"; degrees of freedom for this test were therefore 17.

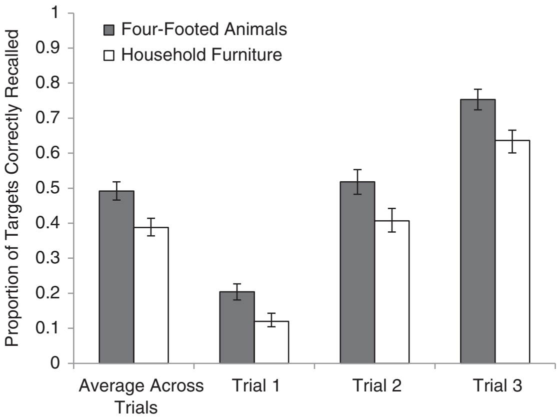

Figure 2. Results from Experiment 2: mean proportion of targets correctly recalled as a function of trial and word type. Data are shown averaged across the three cued-recall trials and separately for each trial. Error bars represent standard errors of the mean.

GENERAL DISCUSSION

The analysis of ancestral selection pressures can be an effective source for hypotheses about the function and design of human memory systems (Nairne, 2014a, 2014b). The question of interest in these two experiments was whether the mnemonic advantage for animate concepts observed in free recall and recognition (Bonin et al., 2014; Nairne et al., 2013; VanArsdall et al., 2013)— a phenomenon discovered and motivated by evolutionary functional analysis—persists in paired-associate learning. The results were clear: not only are animate concepts well-remembered by themselves, but they also appear to be more easily associated to other stimuli.

Yet is the locus of the cued-recall advantage truly in associative learning? Paired-associate learning models discuss three important components in paired-associate tasks: stimulus (cue) discrimination, response (target) learning and associative linkage or "hook-up" between cue and target (Crowder, 1976). By selecting a set of Swahili words and randomly pairing them with animate and inanimate words, stimulus discrimination was equated in the present studies—the Swahili words were equally discriminable between the two word types of interest because they were assigned randomly to those word types. As for the other two dimensions of stimulus-response learning, either animate responses are simply learned better, or something about an animate response helps to cement the stimulus-response link.

If animate responses are simply more accessible, then the proportion of responses as a whole would be biased in the direction of animates, both correct and incorrect. The results from Experiment 1 followed this pattern: animate words were accurately paired with their Swahili counterparts more often than inanimate words, and the majority of incorrect responses were animate as well. Experiment 2 tried to equate accessibility by using more tightly constrained categories. A strong animacy advantage once again emerged in cued-recall, but in this case, more inanimate than animate stimuli were output as incorrect responses. As a result, these data suggest that the locus of the animacy advantage is in the association itself. Animate concepts are simply easier to associate with matched stimulus terms. Our data do not rule out a role for response availability in animacy effects—in fact, animate stimuli, on average, probably are more available in memory—but the data do indicate that animacy can enhance specific stimulus-response associations as well.

At the same time, the proximate mechanisms that produce animate advantages remain to be determined. The distinction between animate and inanimate stimuli is foundational, appearing early in development, and animate events are often given priorities in attentional and perceptual processing. Such attentional or perceptual priorities could underlie the mnemonic advantages seen here. It is also possible that animate stimuli are simply richer, in terms of numbers of features or dimension that are relevant to retention (e.g., Hargreaves, Pexman, Johnson, & Zdrazilova, 2012). However, the current stimuli were carefully matched along a number of mnemonically relevant dimensions, and prior work by Bonin et al. (2014) suggests animacy advantages in recall and recognition may not be due to the richness of the sensory and/or perceptual experience evoked by the stimuli. One might also argue that animate stimuli are more distinctive—that is, less easily confused with one another—which, in turn, makes it easier to form unique associations with given stimuli. However, in the present experiments the pools of animate and inanimate words were matched for relatedness using latent semantic analysis (Landauer, Foltz, & Laham, 1998). In other words, on average, the measured similarities among the items in the animate and inanimate pools were not significantly different. The discovery of animate advantages in retention remains relatively recent, so considerable work remains to be done.

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Still, the current results are important for at least two main reasons. First, they extend the generality of the animacy advantage in retention to a new task—paired-associate learning. As noted throughout, previous demonstrations of animacy advantages, particularly in free recall, have been subject to interpretations based on retrieval strategies (e.g., organisational processing) that are less easily applied to cued-recall. Second, the current results strongly reinforce the conclusion that animacy is an important dimension to be controlled in cognitive research, particularly memory experiments. At the moment, researchers are careful to control for known mnemonic dimensions (e.g., concreteness, word frequency), but animacy has potentially been confounded in prior research.

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