

The “How” of Animacy Effects in Episodic Memory

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Abstract. Animates are better remembered than inanimates. According to the adaptive view of human memory (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b), this observation results from the fact that animates are more important for survival than inanimates. This ultimate explanation of animacy effects has to be complemented by proximate explanations. Moreover, animacy currently represents an uncontrolled word characteristic in most cognitive research (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). In four studies, we therefore investigated the “how” of animacy effects. Study 1 revealed that words denoting animates were recalled better than those referring to inanimates in an intentional memory task. Study 2 revealed that adding a concurrent memory load when processing words for the animacy dimension did not impede the animacy effect on recall rates. Study 3A was an exact replication of Study 2 and Study 3B used a higher concurrent memory load. In these two follow-up studies, animacy effects on recall performance were again not altered by a concurrent memory load. Finally, Study 4 showed that using interactive imagery to encode animate and inanimate words did not alter the recall rate of animate words but did increase the recall of inanimate words. Taken together, the findings suggest that imagery processes contribute to these effects.

Keywords: adaptive memory, episodic memory, animacy

Imagine that, while walking in a forest, you suddenly come across a snake. You will probably remember this event better the next time you follow the same path than a special stone perceived along the same route. Also, if when alighting at the station in an unknown city, a heterosexual man sees a woman whom he finds very attractive, he will also remember this event better than a modern building he admired along the way. In these two fictitious examples, animate things are better remembered than inanimate things. In the first example, the ultimate goal of your behavior is to save your life, whereas in the second, the man’s goal might be to find a mate in order to transmit his genes. Although people are not usually aware of these (deep) ultimate goals, they are nevertheless expressed in individuals implementing a series of proximate mechanisms.

By animates, we mean living things that are capable of independent movement and can suddenly change direction without warning. Although the literature provides evidence showing that animates are better remembered than inanimates, the discovery that animacy is a potent mnemonic variable has only recently been reported (see below), but how exactly does this happen? The present article addresses this important issue.

In the present study, we endorse the view championed by Nairne and colleagues (Nairne, 2010; Nairne & Pandeirada, 2008, 2010a, 2010b) according to which our current memory functioning is the product of selective pressures that our distant ancestors faced in during the Pleistocene era, that is to say that the characteristics of episodic memory should “bear the imprints of the specific selection pressures that shaped their development” (Nairne & Pandeirada, 2010a, p. 977). According to this view, information related to survival issues is preferentially processed ahead of other types of information, with the result that the former is better remembered than the latter. This adaptive memory view is supported by two different, but related, lines of evidence: survival-processing effects and animacy effects.¹

In a series of experiments, Nairne and colleagues (e.g., Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007) have shown that when participants are instructed to rate a series of unrelated words for their relevance to an imagined grassland survival scenario, their long-term retention (as indexed, for instance, by performance in a subsequent surprise free-recall test) is enhanced in this survival situation compared to other deep encoding control conditions (e.g., scenarios such as

¹ In fact, there is a third line of evidence favoring the adaptive memory view which is related to contamination, but to date, there is less work on this issue than on both survival processing and animacy. Indeed, remembering whether an item or a person has been contaminated is clearly adaptive (and avoiding things or people potentially contaminated has long been a critical issue in our deep past). Nairne (2015) recently reported a study in which his research team found that, in a free-recall test, contaminated items (touched by a sick person) were better remembered than non-contaminated items (touched by a healthy person).

moving to a foreign country). This basic finding has been replicated in many studies using different participants and items (Bonin & Bugaiska, 2014; Schwartz, Howe, Togli, & Otgaar, 2013 for reviews). Although certain boundaries to the observation of the survival-processing advantage have been identified (e.g., Kroneisen & Erdfelder, 2011; Savine, Scullin, & Roediger, 2011; Tse & Altarriba, 2010), it is a robust phenomenon which has been interpreted as evidence in support of the adaptive view of memory. According to this view, human memory systems have been selectively tuned during our ancestral past to process and retain information that is relevant for fitness.

The animacy effect in memory corresponds to the observation that animate things (e.g., *a dog, a baby*) are better remembered than inanimate things (e.g., *a lamp, a mountain*). Although reports of this effect are more recent than those of the survival-processing effect, it also seems to be a robust effect. It has been found with nonwords associated with animate versus inanimate properties (VanArsdall, Nairne, Pandeirada, & Blunt, 2013), in word paired-associate learning (VanArsdall et al., 2015), with words (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013), and with picture stimuli (Bonin, Gelin, & Bugaiska, 2014). In the present study, we considered the question of animacy effects in episodic memory in order to shed light on the issue of how these effects arise. Thus far, the animacy effect in episodic memory has been accounted for by assuming that animates are more important in terms of fitness value than inanimates. In effect, animates can be predators, prey, or potential sexual mates. It must be stressed that such an explanation relates to the ultimate causes of this effect. However, the animacy effect is certainly underpinned by specific memory processes (i.e., proximate mechanisms) that have not as yet been identified. The aim of the present study was therefore to characterize and to identify the proximate mechanisms that give rise to animacy effects in long-term memory.

It should be noted that in cognitive science in general, there are several sources of evidence that support the idea that animates receive priority in processing. In the domain of perception, it has been shown that animate stimuli (e.g., animals, human faces) capture visual attention more quickly and hold attention longer than inanimate stimuli (Abrams & Christ, 2003; Johansson, 1973; New, Cosmides, & Tooby, 2007; Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001; Pratt, Radulescu, Guo, & Abrams, 2010; Van Hooff, Crawford, & van Vugt, 2011). The distinction between animates and inanimates would be at the core of the building of conceptual representations in infancy (Opfer & Gelman, 2011) and in adults, animacy would be still a critical dimension in the organization of conceptual knowledge (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998). Also, in psycholinguistics, the animacy dimension affects the process of sentence comprehension (Clifton et al., 2003; Lowder, & Gordon, 2012). Finally, in neurosciences, several substrates of animate processing have been identified (e.g., Gobbini et al., 2011).

As far as the survival effect is concerned, certain researchers have claimed that, given that it can be accounted for by proximate mechanisms (e.g., self-encoding, richness of encoding), an evolutionary account of these effects has to be dismissed. However, as explained by Nairne (2013), this assumption may be due to a failure to distinguish between proximate and ultimate causes in the explanation of the survival-processing advantage. As Nairne says (2013), ultimate explanations are “statements about the function of a trait and ‘why’ it would have been selected by nature during an evolutionary process” while proximate explanations “focus on the mechanisms that produced the trait – that is, they are statements about “how” the trait works and the condition under which the trait is likely to be expressed.” (p. 309). It should be remembered that proximate and ultimate causes are complementary, not competing, levels of explanation and that both are necessary for a complete explanation of an effect (Buss, 2010).

In sum, the aim of the present study was to investigate proximate mechanisms that may underlie the animacy effect on episodic memory, namely what we have referred to as the “how” of animacy effects. Until now, only ultimate explanations of animacy effects have been considered while proximate explanations have only been alluded to. Although animacy is a variable that is rarely, if ever, controlled in cognitive research, it nevertheless happens to be an important mnemonic variable. By applying regression techniques to the Rubin and Friendly (1986) recall rates for five word lists comprising 157 animate words plus a random selection of 157 inanimate words, Nairne et al. (2013) found that the animacy variable was a strong predictor of recall (the two other most important predictors of recall rates were imagery and concreteness). As a result, even if one completely rejects the evolutionary framework, he/she should still be concerned with animacy effects and its proximate causes.

The first study was aimed at replicating and generalizing the original finding reported by Nairne et al. (2013) that animates are better remembered than inanimates in an explicit (intentional) learning task, while using a new (and different) set of words. Little such research on this memory effect has been conducted in the past and a replication is warranted and has even been strongly encouraged (Roediger III, 2012). We considered two candidate proximate mechanisms that have been claimed to underpin survival-processing effects and which have been assumed to be resource-dependent: elaboration and richness-of-encoding. Three other studies were therefore designed to test the hypothesis that animacy effects are sustained by resource-dependent mechanisms. In Studies 2-3A and 3B, we used a memory-load paradigm to test the hypothesis that animacy effects are due to the involvement of the process of elaboration. In Study 4, we tested the interactive imagery account of animacy effects by making use of interactive imagery. The precise rationale of Studies 2, 3, and 4 will be provided below in the introductions to each study.

Table 1. Statistical characteristics (mean, standard deviations, range, minimum-maximum, *t*-tests of the means) of the control variables for animate and inanimate stimuli

	Animate				Inanimate				<i>t</i> -test
	Mean	<i>SD</i>	Range	Min-max	Mean	<i>SD</i>	Range	Min-max	
Number of letters*	6.14	1.81	7	3–10	6	1.77	6	4–10	.84
Bigram frequency (per million words)*	8,823.21	2,898.64	9,396	4,058–13,454	9358,14	3124,96	11,616	2,360–13,976	.65
Book frequency*	22.29	46.64	186.35	0.61–186.96	20.63	43.96	175.13	0.07–175.2	.93
Subtitle frequency*	31.94	61.30	188.2	0.21–188.2	17.38	39.27	154.07	0.06–154.13	.48
Age-of-acquisition (1–5)**	2.44	0.75	2.6	1.15–3.75	2.81	0.91	2.97	1.23–4.2	.26
Number of orthographic neighbors*	3.43	3.92	13.00	0–13	3.00	3.93	10.00	0–10	.78
Orthographic uniqueness point*	5.00	2.20	10.00	0–10	4.07	2.02	8.00	0–8	.27
Conceptual familiarity (1–5)**	2.39	0.79	2.83	1.07–3.90	2.74	0.84	3.34	1.63–4.97	.29
Imageability (1–5)***	4.28	0.38	1.28	3.64–4.92	4.05	0.51	1.56	3.24–4.8	.20
Image variability (1–5)**	2.77	0.72	2.45	1.85–4.3	2.51	0.61	2.22	1.85–4.07	.33
Concreteness (1–5)***	4.59	0.28	0.77	4.09–4.86	4.57	0.46	1.81	3.05–4.86	.93
Emotional valence (1–5)***	3.33	0.55	1.96	2.48–4.44	3.04	0.60	1.92	2.2–4.12	.21

Notes. *Values taken from Lexique (<http://www.lexique.org>; New, Pallier, Brysbaert, & Ferrand, 2004); **All the scales are 5-point scales. The values were obtained from Bonin, Peereman, et al. (2003) and from Alario and Ferrand (1999); ***All the scales are 5-point scales. The values were obtained from Bonin, Méot et al. (2003).

Study 1: Animacy Effects in an Intentional Learning Task

There have been relatively few studies of animacy effects and these effects have primarily been found in tasks where the animacy dimension was made explicit to the participants (e.g., Bonin et al., 2014, but see Nairne et al., 2013), which can be thought of as inducing a potential bias. Thus, although evidence for animacy effects in explicit memory tasks exists, it is relatively scarce. Additional evidence of animacy effects in tasks where the animacy dimension is not made explicit to the participants is therefore necessary. Our study differs from Nairne et al.'s (2013) in both the stimuli used and the procedural details (see Method below) and hence *is not an exact* replication. The observation of animacy effects in Study 1 will therefore extend the generality of the original finding.

Method

Participants

Thirty students (3 males, mean age 19.6 years) at the University of Bourgogne participated in the study. All participants received course credits for their participation. None were taking medication known to affect the central nervous system.

Stimuli

Twenty-eight nouns were selected from the Snodgrass and Vanderwart (1980) and Bonin, Peereman, Malardier, Méot, and Chalard (2003) databases. Each word referred to either an animate or an inanimate object. (The categorization of

the nouns into animates and inanimates was initially done by the authors of the paper. As a further check of the reliability of our classification, we asked five independent adults to classify the nouns used in Studies 1–3 and in Study 4 with a 3-point scale (1 = *clearly referring to an animate*, 2 = *ambiguous*, 3 = *clearly referring to an inanimate*). We found that the agreement between the five raters was perfect [Fleiss' $\kappa = 1$] and in full agreement with our classification.)

The words were divided into two sets of 14 items matched for the *surface variables* of number of letters and bigram frequency; the *lexical variables* of book and subtitle frequency, age-of-acquisition, number of orthographic neighbors, orthographic uniqueness point; and the *semantic variables* of conceptual familiarity, imageability, image variability, concreteness, and emotional valence. Overall, our stimuli were controlled on a set of 12 variables, six of which were also controlled for in Nairne et al.'s (2013) original study. The statistical characteristics of the words are provided in Table 1. We did not use the translated equivalents of Nairne et al.'s items (2013), indeed only three words (two animates and one inanimate) were common to the two studies.

Procedure

The participants were tested individually and were seated comfortably in a quiet room. They were informed that the experiment involved memory, but they were not given information about the different types of words (i.e., animates vs. inanimates) that would be presented. During the encoding phase, the words were presented on a Macintosh computer running the Psyscope v.1.2.5 software (Cohen, MacWhinney, Flatt, & Provost, 1993) at the rate of 3 s per word. The words were presented to each participant in a different random order. The participants were told to read the words carefully in order to remember them for a

test that would be administered later. The test phase was introduced following two interference tasks: the “X–O” letter-comparison task (Salthouse, Toth, Hancock, & Woodard, 1997) and the “plus-minus” task (from Jersild, 1927, and Spector & Biederman, 1976). These two interference tasks lasted for 5 min. After these two interference tasks, the participants were asked to recall in writing as many of the words they could remember from the learning phase during a period of 5 min.

Results of Study 1

Replicating the results of Nairne et al. (2013), the proportion of animate words correctly recalled ($m = .49$, $SD = 0.16$) was higher than that of inanimate words ($m = .37$, $SD = 0.14$), $t(29) = 3.81$, $p < .001$. The raw data can be found in the Electronic Supplementary Materials 1 (ESM 1). The analysis on the number of intrusions showed no significant difference between animate ($m = .33$, $SD = 0.80$) and inanimate words ($m = .43$, $SD = 0.93$), $t(29) = .55$, $p > .10$. For this and the following experiments, we used the same 3-point scale as described above in the Stimuli section on a new group of five independent raters in order to ensure that our classification of intrusive words into animates and inanimates was not biased. Across all studies, the agreement between the five raters was almost perfect (Fleiss’ $\kappa = .97$). However, there were three words (*pied [foot]*, *fleur [flower]*, *salamandre [salamander]*) for which the raters did not agree. For all studies, the analysis on the number of intrusions with these ambiguous words excluded revealed exactly the same results as those including them.

Discussion of Study 1

We found a reliable animacy effect in free-recall when participants were explicitly required to learn words. As mentioned above, this outcome replicates and extends previous findings obtained in a factorial experiment and a multiple regression analysis (Nairne et al., 2013). In effect, when they reanalyzed the Rubin and Friendly (1986) data and included animacy as a predictor variable in a multiple regression analysis, Nairne et al. (2013) found that animacy accounted for a large part of the variance in predicting recall. They further found a strong animacy effect in recall rates in a factorial experiment in which participants were asked to try to remember each presented word.

Study 2: Elaboration as a Proximate Mechanism for Animacy Effects

Survival-processing effects in long-term memory have been accounted for in terms of elaboration (Erdfelder & Kroneisen, 2013). According to this hypothesis, processing items for their survival value would require more elaborative effort than when the same items are processed

following other instructions related to control scenarios such as moving to a foreign land. In other words, more information would be added when processing items in survival than in non-survival encoding contexts, with the result that the retrieval cues for their recall would be more effective. Some researchers have shown that adding a cognitive load (e.g., a memory load; an auditory continuous choice reaction time task) eliminated survival effects (Kroneisen, Rummel, & Erdfelder, 2014; Nouchi, 2013, but see Stillman, Coane, Profaci, Howard, & Howard, 2014). Since elaboration is assumed to be a cognitive resource-demanding process, the observation that survival effects were no longer found following the addition of a secondary task has been interpreted as providing support for the hypothesis that these effects are underpinned by deliberative mechanisms such as elaboration (Nouchi, 2013). In the next experiment, we tested the hypothesis that elaboration could be one of the mechanisms responsible for animacy effects. It is possible that animates are better integrated in more complex frameworks than inanimates, for instance with multiple (episodic) contexts becoming more readily linked to the former than the latter. To give an illustration, when processing the animate word “zebra,” more episodic contexts may come to mind (e.g., a beautiful zebra that I saw in a zoo last year during my holidays; a zebra I recently saw while watching a TV documentary, or a picture of a zebra in a book my daughter read last month) than when processing the word “kettle” whose corresponding object can be remembered without the need for any specific details to be associated with it apart from the fact that the object is present in the kitchen. It is also possible to hypothesize that relational (or inter-item) processing is more efficient in the case of animates than inanimates because animates are easier to assign to different categories, such as “four-legged animals” or “people’s property” for example, than inanimates, which vary more across categories (this specific issue is addressed in the General Discussion). We used a secondary memory-load paradigm similar to that used by Nouchi (2013). As found for survival-processing effects, if animacy effects are underpinned by elaboration then, since elaboration is thought to be a resource-dependent mechanism, these effects should no longer be observed (or should be drastically reduced) when a secondary task is added.

Animate entities are capable of independent movement, are able to suddenly change course without direction, and can occasionally initiate violent actions that may result in injury, or even death. Thus, the failure to detect an animate item (e.g., *a snake*) can be detrimental to an individual’s fitness. Animates can also be friends, enemies, or potential mates who are therefore potentially of relevance for survival and reproduction. It is reasonable to hypothesize that animate items are processed by attentional processes that involve less attentional effort than inanimates. According to New et al.’s (2007) animate monitoring hypothesis, these processes are adaptively tuned in such a way that important features of the environment are captured quickly and automatically. Indeed, animacy is an important environmental dimension that seems to be processed very quickly (New et al., 2007). Thus, in our study, it is indeed possible that

animate words capture more quickly attention at the time of encoding. Therefore, the performance on the secondary task should be better when inanimate words are presented.

Method

Participants

A group of 31 students (5 males, mean age 21.10 years) from the University of Bourgogne took part in the experiment in exchange for course credits. They were all native French speakers. Once again, none of the participants were taking medication known to affect the central nervous system.

Stimuli

The same word stimuli as in the previous study were used.

Procedure

The participants were tested individually seated comfortably in a quiet room. The animate-inanimate categorization task and the memory-load condition were within-participant factors. As in the Bonin et al. (2014) study, the participants were given a brief definition of what is meant by “animate” versus “inanimate” (e.g., an animate item can move autonomously whereas an inanimate item cannot) at the beginning of the experiment. They were further told that they would have to decide as quickly as possible whether a series of words referred to an animate or inanimate item.

The structure of an experimental trial is illustrated by Figure 1. A ready signal (+) was displayed in the middle of the screen for 500 ms. In the memory-load condition, a sequence comprising five letters and numbers (e.g., 1B8J7) was then presented for 5,000 ms. (The same sequence of letters and numbers never appeared twice.) The participants were asked to remember this sequence of items until *recall* appeared on the screen. In the no-load condition, exactly the same procedure was used except that instead of a sequence of numbers and letters, the participants saw the word WHITE presented on the screen and were told that they would have to recall this word later. Then, in both conditions, a word (animate vs. inanimate) was displayed in the middle of the screen and the participants had to indicate as quickly as possible whether it referred to an animate or an inanimate item by pressing a corresponding key. (The words were presented in a random order.) The word remained on the screen until the participant responded and the time taken to respond was recorded. After each decision, the word “recall” appeared on the screen and the participants had to say aloud the sequence of letters and numbers. They then pressed the space bar to go on to the next trial. The actual oral responses to each

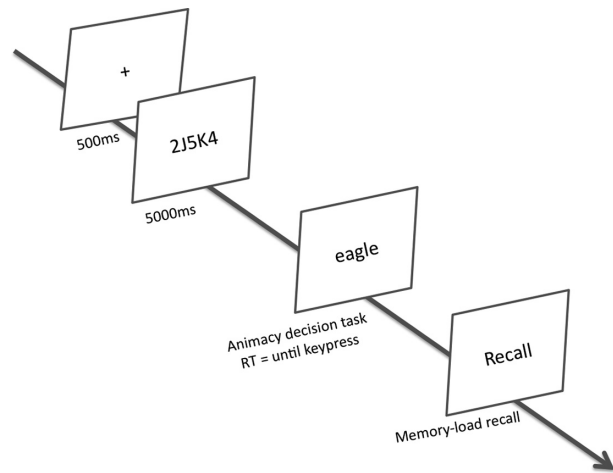


Figure 1. Structure of an experimental trial in Studies 2, 3A, and 3B.

series of trials in the memory-load condition were recorded online by the experimenter. At the end of each participant’s experimental session, the different “memory-load responses” were coded for accuracy.

The two memory-load conditions were blocked with the result that half of the participants began with the memory-load condition and the other half with the no-load memory condition. Moreover, for each type of word (animate and inanimate words), half (seven words) were accompanied by a memory load whereas the other half (seven words) were not.

After all the words had been categorized (with and without a memory load), the participants performed the same two interference tasks as used in the previous studies. Then, after 5 min had elapsed, they were given a surprise free-recall task.

Results of Study 2

Concerning performance on the secondary task, each entire sequence that was correctly recalled was coded one and otherwise zero. The results showed that the sequences comprising five letters and numbers were recalled less well when they were associated with animate words ($m = 4.87$, $SD = 1.65$) than inanimate words ($m = 5.61$, $SD = 1.23$), $t(30) = -2.07$, $p < .05$. With regard to categorization times² in the encoding task (see Table 2), neither the main effects nor the interaction was significant, all $F_s < 1$.

Figure 2 summarizes the results for the correct recall proportions for animates versus inanimates as a function of memory load in the current study and the two studies presented below. More words were recalled in the no-load condition than in the load condition, $F(1, 30) = 26.04$, $p < .001$, $\eta_p^2 = .46$. Also, as shown in Figure 2, more animate words than inanimate words were recalled, $F(1, 30) = 40.74$, $p < .001$, $\eta_p^2 = .58$. The interaction

² Given that mean RTs are sensitive to outliers, we also performed all the analyses involving categorization times using the medians. Across experiments, the results with the medians were very similar to those reported for the means.

Table 2. Mean categorization times as a function of the different encoding conditions and type of words in Studies 2, 3, and 4. Standard deviations are provided in parentheses

	No cognitive load	Cognitive load
Study 2		
Inanimate words	1,374.29 (421.66)	1,411.09 (376.51)
Animate words	1,333.29 (346.36)	1,380.44 (363.43)
Study 3A		
Inanimate words	1,350.28 (348.81)	1,459.57 (453.75)
Animate words	1,277.95 (354.52)	1,402.11 (433.73)
Study 3B		
Inanimate words	1,282.62 (365.56)	1,547.72 (438.94)
Animate words	1,206.43 (294.74)	1,474.22 (489.32)
	Animacy task	Interactive imagery task
Study 4		
Inanimate words	1,198.84 (274.15)	3,256.78 (1327.90)
Animate words	1,078.32 (248.96)	3,266.74 (1299.18)

between Encoding condition and Type of words was not significant, $F < 1$.³ As far as the number of intrusions is concerned, there was a significant difference between animate and inanimate words, $t(30) = 2.06, p < .05$, with more intrusions being observed on inanimate words ($m = .64, SD = 1.11$) than on animate words ($m = .32, SD = 0.65$). (Even though the counterbalancing was not complete in this study, when the task completion order was introduced in the design, there was no main effect of this factor or interaction with it. Importantly, the results were exactly the same as those reported immediately above.) The raw data can be found online (see ESM 2).

Discussion of Study 2

The findings from Study 2 show that adding a memory load during the processing of animate and inanimate words did not impede animates from being memorized better than inanimates. In contrast, we found that animates were still remembered better than inanimates, even though the cognitive load manipulation was successful, as the generally deleterious effect on the overall level of recall compared to the no-load condition shows. It may be asked whether the decision to use an animacy-inanimacy categorization task at encoding had the effect of drawing attention more to animates than to inanimates. However, it is important to remember that, before the beginning of the categorization task, the participants were given a brief definition of what is meant by animate *and* inanimate. Animates were therefore not stressed more than inanimates. (Indeed, this was also the case in VanArsdall et al.'s (2013) study.) Moreover, it is important to stress that the animacy effect has been obtained in previous studies (e.g., VanArsdall et al., 2013), as well as in Study 1 which involved intentional learning and in which attention was not drawn to the animacy dimension.

³ We found the same pattern of results with the categorization times (z-transformed) and the scores obtained in the secondary task introduced as covariates in the analyses.

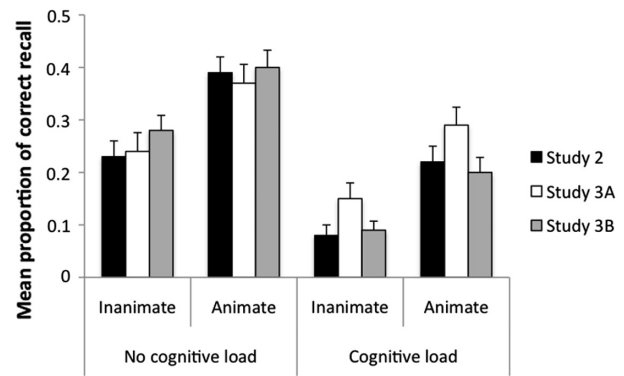


Figure 2. Mean proportions and standard errors of correct recall as a function of encoding condition (no cognitive load vs. cognitive load) and Animacy (animate vs. inanimate stimuli) in Study 2, Study 3A and 3B.

Elaboration has been assumed to be a cognitive resource-demanding process (Kroneisen et al., 2014) and has been considered to be a potential candidate mechanism underlying animacy effects. Given the pattern of results obtained in Study 2, elaboration does not therefore seem to be one of the mechanisms responsible for mediating animacy effects. However, as suggested by the findings concerning performance on the secondary task, there seems to be an attentional component in the animacy effect at the time of encoding: Animates capture more attention than inanimates. Given the importance of the findings of Study 2, before discussing them further, we wanted (1) to replicate this pattern of findings, and importantly, (2) to test whether they would persist with a greater memory load. In effect, it could be argued that the load manipulation used in Study 2 was not extreme enough. We think that we would be in a better position to argue that elaboration may not be involved in animacy effects in episodic memory if we could replicate the finding that animates are recalled better than inanimates in response to a more extreme load manipulation that further reduces the likelihood of effective elaboration. In Study 3, we therefore ran two follow-up experiments: Study 3A was an exact replication of Study 2 and Study 3B was the same as Studies 2 and 3A but with a greater load manipulation.

Study 3: Further Tests of Elaboration as a Proximate Mechanism for Animacy Effects

In the previous study, animacy effects were still reliable when a secondary task was added. This result (Study 2) suggests that the memory mechanisms giving rise to animacy effects are *relatively* independent of cognitive resources.

However, given the strong theoretical implications of this finding, we designed the following two studies. Study 3A was an exact replication of Study 2 whereas Study 3B was an extension of Studies 2 and 3A since the procedure was the same, except for the fact that the difficulty of the secondary task was increased. In effect, the use of a memory load comprising five letters and numbers as in Clarys' study (Clarys, Isingrini, & Haerty, 2000) could have been insufficient to reliably alter participants' short-term memory capacity and cognitive resources. Thus, in Study 3B, the number of items that participants had to retain was increased to seven. Because it has been assumed that elaboration requires cognitive resources (Kroneisen et al., 2014), the observation of reliable animacy effects in both Study 3A and Study 3B under memory-load conditions would reinforce the hypothesis that elaboration might not be involved in the emergence of animacy effects in memory.

Study 3A: Exact Replication of Study 2

Method

Participants

Twenty-eight students from the University of Bourgogne took part in the experiment (7 males, mean age 19.36 years). As in the previous study, they were given course credits for their participation. They were all native French speakers and none were taking medication known to affect the central nervous system.

Stimuli

The same word stimuli as in the previous study were used.

Procedure

The procedure was strictly the same as that used in Study 2.

Results of Study 3A

Performance on the secondary task was coded in the same way as in Experiment 2. The number of sequences correctly recalled did not vary significantly between animates ($m = 5.54$, $SD = 1.35$) and inanimates ($m = 5.68$, $SD = 1.16$), $t(27) = -.72$, $p > .10$.

As far as categorization times are concerned (see Table 2), neither the main effect of Encoding condition nor the interaction between Encoding condition and Type of words was significant, $F(1, 27) = 3.15$, $p > .05$ and $F < 1$. In contrast, the main effect of Type of words was significant, with animate words being categorized faster than inanimate words, $F(1, 27) = 4.81$, $p < .05$, $\eta_p^2 = .15$.

Turning to free-recall, as illustrated by Figure 2, more words were recalled in the no-load condition than in the

load condition, $F(1, 27) = 4.86$, $p < .05$, $\eta_p^2 = .15$. Also, more animate than inanimate words were recalled, $F(1, 27) = 22.07$, $p < .001$, $\eta_p^2 = .45$. The interaction between Encoding condition and Type of words was not reliable, $F < 1$.³

Finally, the number of intrusions was not significantly different between animate ($m = .32$, $SD = 0.61$) and inanimate words ($m = .61$, $SD = 0.87$), $t(27) = -1.77$, $p > .05$. The raw data can be found online (see ESM 3).

Study 3B: Extension of Study 2 With a Higher Memory Load

Method

Participants

Thirty-two students (4 males, mean age 19.81 years) from the University of Bourgogne took part in the experiment. As in the previous experiments, they were given course credits for their participation. They were all also native French speakers and none were taking medication known to affect the central nervous system.

Stimuli

The same word stimuli as in the previous experiments were used.

Procedure

The procedure was the same as in Study 2 except for the memory load used. Here, a sequence comprising seven letters and numbers (e.g., 5K4L9I8) was presented to participants in the memory-load condition.

Results of Study 3B

Performance in the secondary task was coded in the same way as in Studies 2 and 3A. As in Study 3A, the results (i.e., correct performance) for the secondary task showed no significant difference between animate ($m = 2.00$, $SD = 1.59$) and inanimate words ($m = 1.78$, $SD = 1.54$), $t(31) = .73$, $p > .10$. Regarding the time taken to perform the encoding task (Table 2), the main effects of Encoding condition and Type of words were significant. Animate words were categorized faster than inanimate words, $F(1, 31) = 8.29$, $p < .01$, $\eta_p^2 = .21$, and the participants were faster in the no-load condition than in the load condition, $F(1, 31) = 26.52$, $p < .001$, $\eta_p^2 = .46$. The interaction between Encoding condition and Type of words was not significant, $F < 1$.

The free-recall scores are presented in Figure 2. More words were significantly recalled in the no-load condition than in the load condition, $F(1, 31) = 59.13$, $p < .001$,

$\eta_p^2 = .59$. Also, there was an effect of Type of words, with more animates being recalled than inanimates, $F(1, 31) = 21.94$, $p < .001$, $\eta_p^2 = .51$. The interaction between Encoding condition and Type of words was not significant, $F < 1$.³

The number of intrusions was significantly smaller for animate ($m = .25$, $SD = 0.44$) than inanimate words ($m = .65$, $SD = 0.82$), $t(31) = -3.22$, $p < .01$. The raw data can be found online (see ESM 4).

Discussion of Study 3

In Study 2, animacy effects were still reliable when a secondary task was added. This finding suggests that the memory mechanisms giving rise to animacy effects are *relatively* independent of cognitive resources. However, we wanted to gather more empirical data in order to substantiate our claim. Therefore, two additional studies were performed. Study 3A was an exact replication of Study 2 and Study 3B was an extension of Studies 2 and 3A in which the difficulty of the secondary task was increased. The findings on recall rates from both Studies 3A and 3B are clear-cut. More animate words than inanimate words were recalled in the exact replication of Study 2. More importantly, exactly the same finding was observed in Study 3B when the concurrent memory load was increased. It is important to stress that the increase in the memory load in Study 3B was successful as revealed by the secondary-task performance. In effect, the number of correctly reported sequences of letters and digits (computed over animates and inanimates) dropped to 1.89 out of 7 (which is the maximum possible number of correct responses), whereas it was 5.24 and 5.61 in Studies 2 and 3A respectively. There was therefore no indication of any modulation of animacy effects due to increased memory load in the encoding task. Contrary to the finding of Study 2 concerning performance on the secondary task, where it was observed that animates yielded a lower score than inanimates (suggesting that attention may have contributed to animacy effects), Studies 3A and 3B did not reveal any significant modulation of the secondary-task performance at the level of the animacy dimension. A direct comparison of the secondary-task performance across Studies 2, 3A, and 3B revealed a main effect of the memory-load factor, $F(2, 88) = 95.89$, $p < .001$, $\eta_p^2 = .69$, with the impact of the memory load used in Study 3B being stronger than in Studies 3A and 2, $t(88) = 13.83$, $p < .001$, and no significant difference was observed between these latter two studies, $t(88) = 1.19$, $p > .10$ (Note that, concerning the latter comparison, it would have been somewhat surprising to find a significant difference given that the memory load used in Studies 2 and 3A was exactly the same). The main effect of animacy was not significant, $F(1, 88) = 1.18$, *ns*. The interaction between “animacy” and “memory load” was nearly significant, $F(2, 88) = 2.96$, $p = .056$, $\eta_p^2 = .06$. A close examination of this interaction confirmed that only in Study 2 was the secondary-task performance higher when it is accompanied by inanimate words than by an animate words. The findings concerning the secondary-task performance as a function of animacy are therefore

inconsistent across Experiments 2, 3A, and 3B. Given that the difference was in the same direction in Experiment 3B and in Experiment 2, even though it was not significant in Experiment 3B, we conducted a power analysis on the data of this latter experiment. This analysis revealed that the observed power was weak (.11 if the size of the observed difference is considered to be the true one). However, this analysis also revealed that about 330 participants would be required to obtain a power of .80 (one-tailed test).

If we now consider the categorization times, in line with Bonin et al.’s (2014) findings, animate words were categorized faster than inanimate words across studies even though the difference was not significant in Study 2. This trend is also consistent with findings in the literature showing that animates are detected faster than inanimates (New et al., 2007). Given that animates were recalled better than inanimates in spite of the fact that the participants self-exposed animates less time than inanimates, the above finding cannot therefore be attributable to animates taking more time to process than inanimates.

Taken as a whole, the findings from Studies 2 and 3 strongly suggest that the memory mechanisms giving rise to animacy effects are *relatively* independent of cognitive resources. However, this should not be taken to mean that evolved mechanisms, in general, are automatic. In effect, as claimed by Barrett, Frederick, Haselton, and Kurzban (2006), the use of cognitive load in experiments should not be taken as a litmus test for evolved mechanisms because “automaticity” is not a mandatory component of evolutionary accounts. We will return to this issue in the General Discussion.

Study 4: Richness of Encoding and Interactive Imagery as a Proximate Mechanism for Animacy Effects

Kroneisen et al. (2014) have claimed that the survival-processing advantage in memory is due to the fact that it involves a powerful set of domain-general encoding processes, that is, elaboration and distinctive processing, which are not present at such level in control conditions. Both elaboration and distinctive processes are assumed to be resource-dependent. In one study, Kroneisen, Erdfelder, and Buchner (2013) tested the hypothesis that survival-processing effects in memory are due to the richness of encoding. According to this hypothesis, in a survival context, the survival-relevance rating task leads participants to implicitly think about different possible uses of objects. As a result, more distinctive and unique memory representations of the items are produced during encoding in the survival scenario than in the other deep encoding control scenarios used. These memory traces provide a large number of potential retrieval cues at the time of memory tests. In line with the richness-of-encoding account of the survival-processing advantage, Kroneisen et al. (2013) found that the survival-processing effect vanished when an interactive imagery task was used compared to a classical

relevance-rating task. Here we adopted the imagery-interactive task used by Kroneisen et al. (2013). However, the reasoning that led Kroneisen and colleagues to their predictions concerning the effect of interactive imagery instructions on the survival-processing effect does not transfer directly to animacy effects. In Study 4, our aim was to test the hypothesis that animate words trigger interactive imagery (of acts or the contexts in which they occur) more spontaneously and more easily than inanimates. Interactive imagery has been claimed to be a powerful mnemonic mechanism (e.g., Bower, 1970; Bower & Winzenz, 1970; Wilton, 2006). Using interactive imagery should have a beneficial influence on memory performance on both types of items. However, if interactive imagery is the mechanism that mediates animacy effects, explicit instructions to make use of interactive imagery would equate animate and inanimate words with regard to interactive imagery processing.

Method

Participants

Fifty-six students (6 males, mean age 20.48 years) from the University of Bourgogne took part in the experiment in exchange for course credits. They were divided into two groups according to the encoding condition (interactive imagery vs. animacy). None were taking any medication known to affect the central nervous system.

Stimuli

The word list was the same as that in the Bonin et al. (2014) study. Fifty-six nouns were divided into two lists of animate versus inanimate words.

Procedure

The participants were tested individually in a quiet room. They were randomly assigned to one of the two encoding conditions (interactive imaging vs. animacy rating). The instructions for the animacy-rating condition were the same as used in Study 2 and in the Bonin et al. (2014) study. The specific instructions used in the interactive imaging condition were very similar to those used in the Kroneisen et al. (2013, p. 497) study:

“I am going to present you with a list of words. For each word, I am going to ask you to imagine A SITUATION in which you are interacting with the object, animal, or person to which the word refers. The situation in question can be real (refers to an object that you have already interacted with) or fictional (you have never interacted with this object, but it could happen). In addition, I want you to rate each word on a scale to indicate whether the task of imagining this interaction with the object,

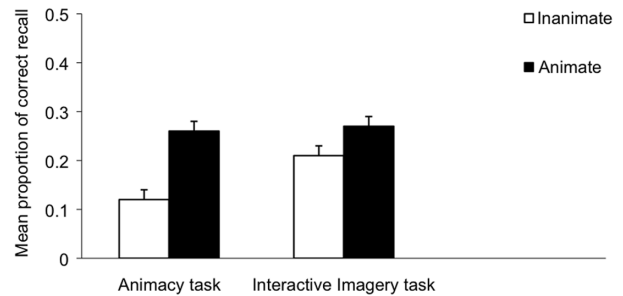


Figure 3. Mean proportions and standard errors of correct recall as a function of encoding condition (animacy task vs. interactive imagery task) and Type of words (animate vs. inanimate words) in Study 4.

animal or person was easy or very difficult. In order to do this, you will have a 5 point scale, with 1 indicating “very difficult to imagine interacting with this object” and 5 indicating “very easy to imagine interacting with this object”. For example, if you see the word FORK, you could imagine yourself in your kitchen, using the fork to eat; if you see the word ZEBRA, you could imagine yourself in a zoo, feeding the zebra, etc.”

Results of Study 4

Animate words were not reliably categorized faster than inanimate words, $F(1, 54) = 2.46, p > .10, \eta_p^2 = .04$ (see Table 2). The words in the animacy condition were categorized significantly faster than the words in the interactive imagery condition, $F(1, 54) = 71.74, p < .001, \eta_p^2 = .57$. The interaction effect between the two factors failed to reach significance, $F(1, 54) = 3.42, p > .05, \eta_p^2 = .06$.

As far as the ratings in the interactive imagery condition are concerned, animates received lower scores ($m = 3.42, SD = 0.66$) than inanimates ($m = 3.61, SD = 0.59$), $t(28) = -2.17, p < .05$. However, the difference in the time taken to make these ratings for animates ($m = 3,267, SD = 1,299$) and inanimates ($m = 3,257, SD = 1,328$) was not significant, $t(27) = .15, p > .10$.

More words were correctly recalled in the interactive imagery condition than in the animacy condition, $F(1, 54) = 7.86, p < .01, \eta_p^2 = .13$. Also, more animate words were recalled correctly than inanimate words, $F(1, 54) = 54.28, p < .001, \eta_p^2 = .50$. Finally, the interaction between Encoding condition and Type of words was significant, $F(1, 54) = 7.13, p < .01, \eta_p^2 = .11$. As shown in Figure 3, the difference between animates and inanimates was greater in the animacy condition than in the interactive imagery condition. The recall rate of animate words was similar in the interactive imagery and animacy conditions, $t(54) = .52, p > .10$, whereas more inanimate words were recalled in the interactive encoding condition than in the

animacy encoding condition, $t(54) = 3.81$, $p < .001$. Interestingly, the results showed that the difference between animate and inanimate words was still reliable in the interactive imagery condition, $t(27) = 3.36$, $p < .01$, thus indicating that animate words were again recalled better than inanimate words in this condition.⁴ The analysis performed on the number of intrusions revealed no significant difference between the “animacy” group and “interactive imagery” group, $F(1, 54) = 2.78$, $p > .10$. A significant effect of Type of words appeared: There were more intrusions on inanimate words ($m = 1.27$, $SD = 1.71$) than on animate words ($m = .66$, $SD = 1.01$), $F(1, 54) = 10.42$, $p < .01$. The raw data can be found online (see ESM 5).

Discussion of Study 4

The findings from Study 4 have important theoretical implications. Unlike the survival-processing effects, which are no longer observed when individuals process words using interactive imagery (Kroneisen et al., 2013), Study 4 revealed that the animacy effect on free-recall, though reliable, was reliably reduced in an interactive imagery condition. More importantly, the reduction of the animacy effect was entirely due to inanimates being better recalled when an interactive imagery strategy was used compared to a condition in which the participants were not made aware of this strategy. Also interestingly, the ratings in the interactive imagery condition were higher for inanimates than animates. Given that animates did not benefit from the interactive encoding procedure, this suggests that the processing of animate items triggers more the use of interactive imagery. Thus, interactive imagery has no effect on animate items in our study but instead increased performance on inanimates. Nevertheless, because inanimate words were not recalled in the same proportion as animate words in our interactive imagery condition, we can assume that another factor must be involved in the processing of animate words. Further studies will be needed in order to identify this additional factor.

The creation of interactive images from animate words was, however, estimated to be slightly more difficult than from inanimate words, even though this was not reflected in the time taken to create these visual images. We also found no evidence suggesting that attentional resources are allocated differently to animates compared to inanimates (Studies 2 and 3). Given the findings from Study 4, which suggest that interactive imagery contributes to animacy effects, one implication is that interactive imagery is resource-free. In the Introduction, we claimed that elaboration is thought to be a resource-demanding process. Some authors have proposed the idea that interactive imagery could be a form of elaboration (e.g., Willoughby, Wood, Desmarais, Sims, & Kalra, 1997). If this idea is correct, then our findings suggest that this type of elaborative processing is not resource-demanding.

General Discussion

The finding that animates are remembered better than inanimates is new in the literature on episodic memory. It has been accounted for within the adaptive view of memory according to which the functional characteristics of human memory are the product of selective pressures encountered during our distant past (Nairne, 2010, 2013; Nairne & Pandeirada, 2010b). Because animate things have a stronger fitness value than inanimates, they are prioritized during processing and are remembered better. However, even if we are not concerned, and/or do not subscribe to the evolutionary account of these effects, it is nevertheless worthwhile examining the proximate mechanisms of animacy effects given that these effects represent a potent new variable in the memory literature. Indeed, the aim of the present study was to investigate the “how” of animacy effects in episodic memory. The findings obtained from a series of four studies are clear-cut and help delineate certain functional characteristics of the mechanisms underlying animacy effects.

First of all, we were able to replicate the findings initially reported by Nairne et al. (2013). Animacy is therefore a very important dimension that leads to better memory traces for animates than for inanimates. The memory-load studies showed that the memory mechanisms underlying animacy effects are not resource-demanding. It is important to remember that the survival-processing advantage has been found to be reliably modified by a memory-load manipulation (e.g., Nouchi, 2013) and that this has led certain researchers to claim that elaboration, which is a resource-demanding process, is a potential proximate mechanism of this memory effect (Kroneisen et al., 2013; Nouchi, 2013). The findings of Studies 2 and 3 do not fit well with a strong elaboration account of animacy effects. In Study 4, we aimed at testing the hypothesis that animate words trigger interactive imagery more spontaneously and more easily than inanimates. Although using interactive imagery should have a beneficial influence on memory performance on both types of items, the idea was that if interactive imagery is the mechanism that mediates animacy effects, the requirement to use interactive imagery would place animate and inanimate words on an equal footing. In line with this account, a key finding from Study 4 was that the animacy effect, although significant, was reliably reduced in the interactive imagery condition because the encoding of inanimates was boosted by the use of an imagery encoding strategy. By contrast, animates did not benefit from interactive imagery. It is important to stress that the animacy advantage was found with both concreteness and imageability controlled for. This finding rules out the idea that animates may be better remembered than inanimates because the former are easier to represent by means of mental images (and/or are more concrete) than the latter. It is already clear that the survival and animacy effects are not mediated by exactly the same set of mechanisms.

⁴ When the times taken to perform the animacy versus interactive imagery task (z -transformed) were introduced as covariates in the analyses, the pattern of recall rates remained the same.

While not completely ruling out the idea that the animacy effect might be due to an inherent property, yet to be identified, that makes animates easier to remember, we believed it is unlikely given the high number of dimensions that were controlled for in our studies. In sum, one important factor that helps to explain the advantage of animate words is interactive imagery. Furthermore, the findings of the memory-load studies are indicative that interactive imagery is resource-free. The influence of interactive imagery on animacy effects is consistent with the recent findings of VanArsdall et al. (2015) in paired-associate learning. One interesting aspect of their data was the finding that 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, thus suggesting, as stated by VanArsdall et al. (2015), that “(...) *the locus of the animacy advantage is in the association itself. Animate concepts are simply easier to associate with matched stimulus terms.*” (p. 662). Given that a major role has been ascribed to interactive imagery in paired-associate learning (Bower, 1970), and because strong animacy effects are found in such tasks, it makes great sense to assume that imagery processes contribute to animacy effects.

Are animacy effects dependent on the type of tests used to assess long-term retention? Indeed, the type of measure used for assessing memory is a critical issue (see Tse & Altarriba, 2010 and Schwartz & Brothers, 2013 for discussions of this issue with reference to the survival-processing advantage). If animacy effects were to be found only in recall as found in earlier studies (Bonin et al., 2014; Nairne et al., 2013; VanArsdall et al., 2013), this would certainly represent a serious limitation. However, they have also been found in recognition hits (Bonin et al., 2014) and in an associative learning task involving paired-associate learning (VanArsdall et al., 2015).

Skeptical readers might think that animacy effects are just a function of the more organized nature of the animate items relative to the inanimate items. They may object to our favored evolutionary account of these effects which is dismissed by appealing to the fact that the “animate” condition provides participants with a related category (i.e., moving animals) in which one item may cue other items at the time of recall. We do not think that such an account of animacy effects is satisfactory for the following reasons. First of all, as reviewed above, animacy effects have been found in memory tasks (e.g., recognition, paired-associate

learning) in which it is less easy to rely on category-based organizational strategies. Second, VanArsdall et al. (2015) compared animate items with pieces of furniture (a very salient category) and strong animacy effects were still found. These findings thus make it difficult to argue that animate items provide special access to some kind of categorical information. Third, in the Nairne et al. (2013) study, the regression analyses showed strong animacy advantages and the recall values for these items were taken from the Rubin and Friendly (1986) recall rates in which randomly selected lists were used. The recall rates for the animate items were not taken from lists containing a high proportion of animate items. Fourth, the analyses of extra-list intrusions in the current studies showed that there were always more intrusions for inanimates than animates (but reliably so only in Studies 2, 3B, and 4), even when the animacy dimension was made explicit. This latter result does not fit well with an organizational hypothesis of animacy effects in free-recall because such a hypothesis would predict more intrusions on animate words. It is important to stress that there were about twice as many inanimate as animate intrusions. If anything, this therefore suggests that the organizational structure of the inanimates has a detrimental impact on the animacy effect. Finally, we examined the semantic similarity of the items within the animate and inanimate categories using the Normalized Google Distance (NGD). This measure is derived from the number of hits returned by the Google search engine for a given set of words (Cilibrasi & Vitanyi, 2007; Hutson & Damian, 2014). Words that co-occur in the search space take on values close to zero, whereas those words that never co-occur take on infinite values. Using Google.fr, we computed NGD values for all pairs of animates and all pairs of inanimates. The average NGD value was 0.475 for the animate category and 0.482 for the inanimate category, and the difference was not significant, $t(180) = -.174$, $p > .10$. Thus, the items in the animate category were not closer to one another than the items in the inanimate category.⁵

Given that we were able to identify a potential proximate mechanism – interactive imagery – that nicely accounts (at least in part) for animacy effects in memory, and because interactive imagery belongs to a powerful set of domain-general encoding processes (Bower, 1970), it might be argued that it challenges the evolutionary account of animacy effects. However, an evolutionary (ultimate) account of animacy effects cannot be dismissed simply because these effects can also be accounted for by proximate

⁵ As suggested to us by one anonymous reviewer, one interesting possibility to account for animates being recalled better than inanimates is “output interference,” that is to say inanimates were recalled less than animates because they suffered from the recall of animates. We examined the serial recall of the words in the animacy-rating condition of Study 4 (we chose this particular condition for the analyses because it has been used several times in the literature, e.g., Bonin et al., 2014). The correlation coefficient between the position of a word in the recalled sequence and the percentage of participants recalling an animate at this position was $-.50$, $p < .05$, which indicates that this percentage decreases with the position in which words were recalled. Descriptive statistics showed that most of the first three recalled items were animates (89%, 64%, and 82% in positions 1, 2 and 3, respectively). Importantly, in no position in the recall sequence were inanimates recalled by the majority of the participants. We found the same result when comparing the mean percentages of animates among the first $n/2$ recalls made by each participant with the means among the last $n/2$ recalls, where n corresponds to the total number of recalls made by the participant (for odd values of n , we did not count the word recalled at the median position). The difference in means was not significant, $t(27) = 1.46$, $p > .10$, and each mean percentage was above $.50$ (first $n/2$ recalls: $t(27) = 8.02$, $p < .001$, $m = .75$; last $n/2$ recalls: $t(27) = 4.72$, $p < .001$, $m = .68$), indicating that animates were recalled better than inanimates at both the beginning and the end of the recall sequence.

mechanisms (e.g., self-encoding, richness of encoding). In order to explain why animates are remembered better than inanimates, we must also look at the different kinds of mechanisms – qualified as belonging to domain-general encoding processes (e.g., elaboration, self-reference) – that are able to produce such a memory boost.

Before concluding, there are two important aspects that need to be discussed.

First of all, we wish to stress here that adopting a functional perspective to investigate memory is a very fruitful strategy because it helps to reveal findings, in this case animacy effects, which would perhaps otherwise have gone unnoticed (Nairne, 2005). Surprisingly, these effects have not previously been explored as a mnemonic dimension, unlike word characteristics such as word frequency or imageability, which have been frequently investigated (Nairne et al., 2013). Second, we have identified a proximate mechanism – interactive imagery – that mediates animacy effects in episodic memory. Moreover, we have found that a memory load did not alter these effects, thus leading us to suggest that this mechanism is relatively free of cognitive resources. However, this does not mean that evolved mechanisms, in general, possess the feature of automaticity, that is, they require no cognitive effort or are automatically prioritized. The idea that evolved mechanisms are necessarily automatic in their operation has been previously put forward in the literature (DeSteno, Bartlett, Braverman, & Salovey, 2002). However, as pointed out by Barrett et al. (2006), evolutionary psychologists invoke the central concept of functional specialization (Pinker, 1997) rather than referring to a particular list of function features such as automaticity. Evolutionary psychologists have clearly emphasized the *flexible nature of evolved processes*, and thus, evolved processes are not always automatically prioritized (Gonzaga, Haselton, Smurda, Davies, & Poore, 2008).

In conclusion, our findings help constrain theoretical interpretations of animacy effects in memory and strongly reinforce the conclusion that animacy is an important dimension that needs to be carefully taken into account in memory research.

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Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at <http://dx.doi.org/10.1027/1618-3169/a000308>

ESM 1. Table (Excel sheet).
Recall data for Study 1.

ESM 2. Tables (Excel sheet).

Recall data, reaction time, and secondary task for Study 2.

ESM 3. Tables (Excel sheet).

Recall data, reaction time, and secondary task for Study 3A.

ESM 4. Tables (Excel sheet).

Recall data, reaction time, and secondary task for Study 3B.

ESM 5. Tables (Excel sheet).

Recall data, reaction time for Study 4.

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