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Are animacy effects in episodic memory independent of encoding instructions?

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ABSTRACT

The adaptive view of human memory [Nairne, J. S. 2010. Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 53 pp. 1–32). Burlington: Academic Press; Nairne, J. S., & Pandeirada, J. N. S. 2010a. Adaptive memory: Ancestral priorities and the mnemonic value of survival processing. *Cognitive Psychology*, *61*, 1–22, 2010b; Memory functions. In *The Corsini encyclopedia of psychology and behavioral science*, (Vol 3, 4th ed. pp. 977–979). Hokoben, NJ: John Wiley & Sons] assumes that animates (e.g., *baby*, *rabbit* presented as words or pictures) are better remembered than inanimates (e.g., *bottle*, *mountain*) because animates are more important for fitness than inanimates. In four studies, we investigated whether the animacy effect in episodic memory (i.e., the better remembering of animates over inanimates) is independent of encoding instructions. Using both a factorial (Studies 1 and 3) and a multiple regression approach (Study 2), three studies tested whether certain contexts drive people to attend to inanimate more than to animate things (or the reverse), and therefore lead to differential animacy effects. The findings showed that animacy effects on recall performance were observed in the grassland-survival scenario used by Nairne, Thompson, and Pandeirada (2007. Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *33*, 263–273) (Studies 1–3), when words were rated for their pleasantness (Study 2), and in explicit learning (Study 3). In the non-survival scenario of moving to a foreign land (Studies 1–2), animacy effects on recall rates were not reliable in Study 1, but were significant in Study 2**,** whereas these effects were reliable in the non-survival scenario of planning a trip as a tour guide (Study 3). A final (control) study (Study 4) was conducted to test specifically whether animacy effects are related to the more organised nature of animates than inanimates. Overall, the findings suggest that animacy effects are robust since they do not vary across different sets of encoding instructions (e.g., encoding for survival, preparing a trip and pleasantness).

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According to evolutionary psychologists, some items are of greater importance for survival and/or reproduction than others, that is to say that these are of greater fitness value (Buss, 2014; Saad, 2011). They therefore assume that these items should be prioritised for processing. Likewise, animate things are more important for fitness than inanimate things because the former consist of animals or persons and these can be potential predators, prey, sexual partners or rivals. More specifically, by animates we mean living things that are capable of independent movement and can suddenly change direction without warning.[1] Indeed, several lines of evidence indicate that animates are processed differently from inanimates. In the domain of perception, there is empirical evidence showing that animates are detected faster than inanimates and delay visual disengagement (Abrams & Christ, 2003; Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001; New, Cosmides, & Tooby, 2007; Pratt, Radulescu, Guo, & Abrams, 2010). For example, a recent study has shown that dangerous animals capture and hold the attention of modern humans (Yorzinski, Penkunas, Platt, & Coss, 2014).

Of importance for the purposes of the present studies is the finding that animates are better remembered than inanimates. These effects have been found across different tasks: with non-words associated with animate vs. inanimate properties (VanArsdall, Nairne, Pandeirada, & Blunt, 2013), in word paired-associate learning (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015), in free recall (Bonin, Gelin, & Bugaïska, 2014; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013) and tasks measuring the number of recognition hits (Bonin et al., 2014). These effects have been found with non-words (VanArsdall et al., 2013), words (Bonin et al., 2014; Nairne et al., 2013) and pictures (Bonin et al., 2014). However, we still do not know whether animacy effects in memory vary across different sets of encoding instructions. Therefore, in the present work, we examined this issue since it should help constrain the theoretical interpretation of these effects. In the first

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study, we focused on animacy effects in incidental encoding tasks and addressed the issue of the ubiquity of animacy effects in episodic memory. So far, animacy effects have been found in explicit learning memory tasks (Nairne et al., 2013), as well as in incidental encoding tasks (e.g., Bonin et al., 2014; VanArsdall et al., 2013). We are not aware of any study that has examined whether animacy effects are observed in clear-cut survival situations where obviously they should be found. Nairne and colleagues' studies (e.g., Nairne & Pandeirada, 2008, 2010a, 2010b; Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007) have repeatedly shown that words rated for their relevance in an imaginary scenario in which one must survive amongst the grasslands of a foreign land (where one consequently has to find food and drinking and protect oneself against predators), are better remembered than words processed in comparable deep encoding conditions in which survival processing is not required (e.g., words are processed in non-survival scenarios, such as moving to a new country, or are rated for their pleasantness). In the grassland-survival scenario used by Nairne and colleagues (e.g., Nairne et al., 2007, 2008), the instructions, among other things, explicitly indicate to the participants that they have to imagine themselves in a situation where they have to protect themselves from predators. Predators can be either dangerous animals or other humans. Importantly, these are animate entities. In the grassland-survival situation used by Nairne et al. (2007, 2008), animates should be given processing priority over inanimates, and they should therefore be better remembered than inanimates (but see below for a different prediction). Observing that inanimate things are better remembered than animate things in such a survival situation would certainly be at odds with the evolutionary account of animacy effects. However, at the same time, we are aware that certain inanimate things (e.g., *a bottle*) can also be useful when faced with a survival situation (e.g., to store water, to be used as a weapon).

Since animacy effects are also observed in tasks that require explicit learning (Nairne et al., 2013), this suggests that the animacy dimension is an "intrinsic" property of concepts that is taken into account at encoding, and therefore that animacy effects should also be observed in certain non-survival scenarios or in incidental memory tasks such as in pleasantness rating in which no encoding schema is activated. Thus, it could be argued that animacy effects in memory are not context-dependent. They are captured whatever the encoding context. However, if we consider that processing is flexible, it is possible that stimuli in the environment are not always attended to the same extent for fitness purposes: Certain contexts can possibly cause people to attend to inanimate more than to animate things, for instance when thinking about how to deal with objects, for example, when transporting one's belongings to move into a new house. In sum, it is important to assess the generality of animacy effects in episodic memory: Are these effects context-independent or are they obtained under specific encoding conditions? We addressed this issue in three studies (Study 1–3).

From a theoretical point of view, it is also possible to anticipate a totally different outcome if it is assumed that the same mechanism (or sets of mechanisms or module) underpins both animacy and survival-processing effects. It has been hypothesised that when memory processes are redundant across different encoding tasks, there is generally no longer any retention advantage. There is evidence suggesting that the repeated use of the same mechanism (redundancy; Burns, Hart, Kramer, & Burns, 2014) does not bring about additional benefits at the level of memory performance (e.g., Hunt & Einstein, 1981). Burns et al. (2014) put forward this line of reasoning to account for the finding that the activation of death-related thoughts underpins the survival memory effect. In one experiment, the participants had to encode words according to either a survival scenario or a moving scenario. Before this encoding episode, they were required to either write about their own death (thus inducing death-related thoughts) or about dental pain. The findings showed that the survival memory benefit was no longer observed when participants had previously thought about death rather than about dental pain. According to Burns et al. (2014), since survival processing entails the activation of the concept of death, redundancy occurs when a task requires both survival and death processing, with the result that the survival advantage is no longer observed (but see also Bugaiska, Mermillod, & Bonin, 2015). If this line of reasoning is applied to animacy and survival-processing effects, no animacy effect in memory should be observed in a situation in which participants have to encode both animate and inanimate words for their survival value.

Study 1: animacy effects in survival and non-survival contexts—a factorial approach

In the first study, we used the grassland scenario taken from Nairne et al. (2007) in which participants have to imagine they are stranded in the grasslands of a foreign land and have to survive with no basic supplies. A list of unrelated words was then presented and they had to rate each word for its survival relevance. As a non-survival scenario, we used the "moving scenario", which has often been used as a control scenario for evaluating the survival processing advantage (e.g., Nairne et al., 2007). In this situation, the participants have to imagine that in a few months they will have to find a house, transport their belongings, etc. and then rate the relevance of each word accordingly.

Method

Participants

Sixty students (52 females; mean age 19.6 years) at the University of Bourgogne participated in the study and were divided into two groups ($n = 30$ in each group) that differed on encoding condition. The participants, who were all native speakers of French, received course credits for their participation and none were taking medication known to affect the central nervous system.

Stimuli

Twenty-eight French 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 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 neighbours and orthographic uniqueness point; and the *semantic variables* of conceptual familiarity, imageability, concreteness and emotional valence. The statistical characteristics of the words are provided in Table 1.

Procedure

The participants were assigned to one of the two encoding conditions (survival vs. moving) and were given the following instructions (taken from Nairne et al., 2007):

> *Survival condition:*
>
> In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any survival equipment. In the coming months, you will have to find stable supplies of food and water and protect yourself from predators. We will present you with a list of words and want you to rate the relevance of each word in the survival situation. Some of the words may be relevant and others not, it's up to you to decide. You must use a rating scale of 1 (totally irrelevant) to 5 (extremely relevant) (p. 264).
>
> *Moving condition:*
>
> In this task, we would like you to imagine that you will be moving to a foreign country. In the coming months, you will need to find and buy a new house and must transport all of your personal belongings. We are going to show you a list of words in which you must evaluate to what extent each word is relevant to this moving scenario. Certain words may be relevant and others may be irrelevant; it's up to you to decide. You must use a rating scale of 1 (totally irrelevant) to 5 (extremely relevant) (p. 264).

In each encoding condition, the words were presented in the centre of the screen until the participant's response. A different random order was used for each participant. The participants indicated their responses by pressing a key (labelled 1 through 5 on the keyboard) corresponding to their choice. The test phase was administered after a five-minute retention interval. During this period, the participants had to perform two interference tasks: the "X-O" letter-comparison task, (Salthouse, Toth, Hancock, & Woodard, 1997) and the "plus-minus" task from Jersild (1927) and Spector and Biederman (1976). At recall, the participants were told that they had five minutes to write down the previously presented words in any order they liked.

Results

The mean encoding times and the mean ratings (together with their standard deviations) are reported in Table 2.

Encoding times (*msec*). As far as the time taken to rate the words is concerned, the analysis of variance (ANOVA) did not indicate a reliable main effect of Encoding condition, $F < 1$, $\eta^2_p = .01$, but did reveal a main effect of type of words, $F(1, 58) = 5.75$, $p = .02$, $\eta^2_p = .09$, with animate words being rated faster than inanimate words. Importantly, there was a reliable interaction between Encoding condition and Type of words, $F(1, 58) = 4.89$, $p = .03$, $\eta^2_p = .07$. *t*-Test comparisons indicated no reliable difference in reaction times (RTs) between animate and inanimate words for the Survival encoding condition, $t(29) = -.15$, but a significant difference for the Moving encoding condition, $t(29) = -2.95$, $p = .006$, showing that animate words were rated faster than inanimate words (see Table 2).

Ratings. As far as the rating scores are concerned, a reliable main effect of Encoding condition was found, $F(1,$

Table 1. Statistical characteristics (mean, standard deviation, range, minimum–maximum, *t*-test of the means) of the control variables for animate and inanimate stimuli used in Study 1.

	Animate				Inanimate				*t*-Test
	Mean	sd	Range	Min–max	Mean	sd	Range	Min–max	
Number of letters[a]	6.14	1.81	7	3–10	6	1.77	6	4–10	$p = .84$
Bigram frequency (per million words)[a]	8823.21	2898.64	9396	4058–13,454	9358.14	3124.96	11,616	2360–13,976	$p = .65$
Book frequency[a]	22.29	46.64	186.35	0.61–186.96	20.63	43.96	175.13	0.07–175.2	$p = .93$
Subtitle frequency[a]	31.94	61.30	188.2	0.21–188.2	17.38	39.27	154.07	0.06–154.13	$p = .48$
Age-of-acquisition (1–5)[b]	2.44	0.75	2.6	1.15–3.75	2.81	0.91	2.97	1.23–4.2	$p = .26$
Number of orthographic neighbours[a]	3.43	3.92	13	0–13	3	3.93	10	0–10	$p = .78$
Orthographic uniqueness point[a]	5	2.20	10	0–10	4.07	2.02	8	0–8	$p = .27$
Conceptual familiarity (1–5)[b]	2.39	0.79	2.83	1.07–3.90	2.74	0.84	3.34	1.63–4.97	$p = .29$
Imageability (1–5)[c]	4.28	0.38	1.28	3.64–4.92	4.05	0.51	1.56	3.24–4.8	$p = .20$
Concreteness (1–5)[c]	4.59	0.28	0.77	4.09–4.86	4.57	0.46	1.81	3.05–4.86	$p = .93$
Emotional valence (1–5)[c]	3.33	0.55	1.96	2.48–4.44	3.04	0.60	1.92	2.2–4.12	$p = .21$

[a] Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).
[b] All the scales are five-point scales. The values were obtained from Bonin, Peereman, et al. (2003) and from Alario and Ferrand (1999).
[c] All the scales are five-point scales. The values were obtained from Bonin, Méot, Aubert, Malardier, Niedenthal, & Capelle-Toczek (2003).

Table 2. Mean ratings, mean categorisation times and mean proportions of extra-list intrusions as a function of the different encoding conditions and type of words in Studies 1, 2 and 3.

Study 1

	Survival				Moving			
	Animate		Inanimate		Animate		Inanimate	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Encoding times	1974.89	431.65	1980.98	425.91	1816.4	450.83	1966.5	327.41
Ratings	2.54	0.46	2.47	0.58	1.74	0.77	2.77	0.6
Intrusions	.04	.09	.07	.15	.03	.06	.06	.11

Study 2

	Survival				Moving				Pleasantness			
	Animate		Inanimate		Animate		Inanimate		Animate		Inanimate	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Encoding times	1874.89	729.71	1934.27	672.89	1490.12	558.90	1808.09	632.36	1903.72	755.97	1925.65	773.71
Ratings	2.44	1.47	2.70	1.50	1.27	0.75	2.70	1.51	2.92	1.23	3.18	1.21
Intrusions	.03	.08	.13	.22	.04	.07	.12	.19	.03	.07	.11	.21

Study 3

	Survival				Tour Guide				Explicit learning			
	Animate		Inanimate		Animate		Inanimate		Animate		Inanimate	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Encoding times	2190.2	444.79	2245.16	388.76	2048.52	320.6	2118.95	281.21	–	–	–	–
Ratings	2.23	0.43	2.46	0.42	2.43	0.56	2.05	0.38	–	–	–	–
Intrusions	.03	.05	.03	.04	.03	.04	.06	.08	.04	.13	.09	.15

Note: "–": no encoding times and no rating times were collected in the explicit learning condition.

58) = 4.46, $p = .04$, $\eta_p^2 = .07$, indicating that the words were perceived as more relevant in the Survival in comparison to the Moving condition. A main effect of Type of words was found, $F(1, 58) = 20.18$, $p < .001$, $\eta_p^2 = .26$, showing that inanimate words were given higher scores than animate words. Finally, the interaction between Encoding condition and Type of words was significant, $F(1, 58) = 26.31$, $p < .001$, $\eta_p^2 = .31$. *t*-Test comparisons revealed no significant difference between animate and inanimate words in the Survival scenario, $t(29) = .58$, but a reliable difference between the two types of words in the Moving scenario, $t(29) = -5.76$, $p < .001$, thus indicating that inanimate words were scored higher than animate words.

Recall rates. We did not find a significant main effect of Encoding condition on correct recall rates, $F < 1$, $\eta_p^2 = .01$. Otherwise, animate words were recalled better than inanimate words, $F(1, 58) = 4.75$, $p = .03$, $\eta_p^2 = .08$. Importantly, as shown in Figure 1, the interaction between Encoding condition and Type of words was significant, $F(1, 58) = 19.53$, $p < .001$, $\eta_p^2 = .25$. *t*-Test comparisons showed no reliable difference on recall rate between animate and inanimate words in the Moving condition, $t(29) = -1.42$, $p > .10$, but a significant difference in the Survival condition, $t(29) = 5.36$, $p < .001$, with more animates than inanimates being recalled ($m = .40$ and $m = .26$). Importantly, the interaction between Encoding condition and Type of words remained significant when encoding times and relevance ratings were introduced as covariates.

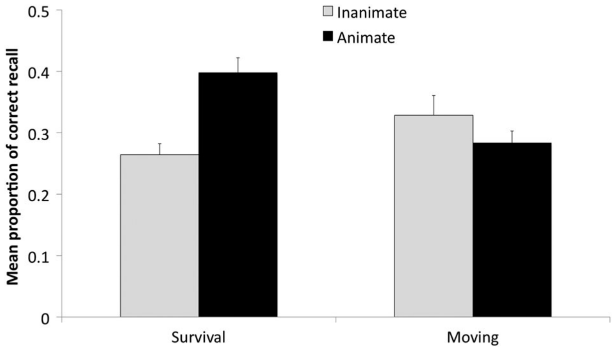

Figure 1. Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. moving) and Animacy (animate vs. inanimate stimuli) in Study 1.

Here and in the studies reported below, for each participant, the proportion of intrusions was calculated as the number of extra-list items divided by the total number of items recalled by the participant. The extra-list items were first categorised into animates and inanimates by the authors of the paper. In order to ensure that our classification of intrusive words into animates and inanimates was not biased, we adopted a procedure that we had used in a previous study (Bonin, Gelin, Laroche, Méot, & Bugaïska, in press) and asked five independent adults to classify the intrusive words obtained in Studies 1–4 on a 3-point scale (1 = clearly referring to an animate, 2 = ambiguous and 3 = clearly referring to an inanimate). Across all studies, the agreement between the five raters was almost perfect (Fleiss' $\kappa = .94$ for the five judges and .95 with the addition of the original categorisation). (There was one word (*facteur* [meaning postman or factor], in Study 4) on which the raters did not agree and which was therefore ambiguous. When this word was excluded from the intrusion analysis of Study 4 [see below], we found exactly the same results as those that included it.)

As can be seen in Table 2, there were more inanimate (I) than animate (A) extra-list intrusions, but the difference was not significant, $F(1, 58) = 2.51$, $p > .10$, $\eta^2_p = .04$. Neither the main effect of Encoding condition, $F < 1$, $\eta^2_p = .003$, nor the interaction between Encoding condition and Type of words, $F < 1$, $\eta^2_p = .001$, was significant.

Discussion of Study 1

We found a significant animacy effect on recall rates in a survival scenario but not in a non-survival situation, that is, moving to a new house in a foreign land. Taken together, these findings suggest that in situations where there is (a priori) a greater need to pay more attention to inanimates than to animates, the latter are no longer remembered better than the former. However, before going further in our interpretation of these findings, we thought it important to replicate and extend them. In Study 2, we once again examined the issue of whether animacy effects can be modulated by varying the encoding contexts or tasks. However, this time we used a multiple regression approach. We therefore selected concrete and imageable words from three different semantic categories and we included, as in Study 1, the survival and the moving encoding conditions. Pleasantness processing was also included in this study because it has often been used as a control task in survival-processing experiments (Nairne, Pandeirada, VanArsdall, & Blunt, 2015). As claimed by Nairne et al. (2015), the pleasantness rating task represents a quintessential form of deep processing.

An important aspect of Study 2 is that we deliberately chose to include fewer animate than inanimate words. The proportion of animates to inanimates was 1 to 3. We think that finding a superior recall of animates over inanimates in a context where there are more inanimate than animate words in the lists would provide an even stronger argument in support of the robustness of animacy effects in episodic memory. Moreover, it would suggest that animacy effects are not just a function of the more organised nature of the animate items relative to the inanimate items, that is to say 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. This issue will also be addressed specifically in Study 4.

Study 2: replicating and extending the findings from Study 1 using a multiple regression approach

Study 2 aimed at replicating and substantiating the findings of Study 1, but using a different set of items and adopting a multiple regression approach. According to several researchers (e.g., Baayen, 2010; Balling, 2008), the factorial approach has certain disadvantages when compared to the multiple regression approach, one of which is the loss of power and influence of confounding variables. We think that the two approaches are both useful and complementary. The multiple regression approach has already been employed by Nairne et al. (2013) to investigate animacy effects in memory. In effect, Nairne et al. (2013) reanalysed Rubin and Friendly's (1986) recall data and included animacy as a predictor variable in their multiple regression analyses. They found that animacy accounted for a large part of the variance in predicting recall rates. In the present study, we explored the influence of animacy effects on recall rates by using lists that contained about one-third of animate items. This was done in order to reduce the potential saliency of the animate items and to make sure that animacy effects on recall rates are not just a function of the more organised nature of animate items.

As in Study 1, we included the grassland-survival scenario and the control moving scenario as well as a non-schematic encoding condition: pleasantness rating. In line with the findings of Study 1, we expected animacy effects to be observed in both the survival and pleasantness conditions because in neither of these two conditions is there any special emphasis on inanimate things. In contrast, and in line with the findings of Study 1, we did not predict that animates would be remembered better than inanimates in the moving encoding condition since this situation clearly requires participants to focus more on objects than on persons or animals.

Method

Participants

A total of 151 students (130 females; mean age 19.83 years) from the University of Bourgogne were involved in the study (9 participants were excluded due to atypical reaction times or ratings during the encoding phase). All the participants received course credits for their participation and, as in the previous study, all were native French speakers and none were taking medication known to affect the central nervous system.

Stimuli

There were 2 lists of 30 words. Each list comprised three different semantic categories (animals, objects and food) and were matched on the following variables: number of letters, number of phonemes, book and subtitle frequency, age-of-acquisition, orthographic neighbourhood as measured by orthographic Levenshtein distance 20 (old20), imageability, concreteness, emotional valence and sensory experience (generally referred to as "SER"). Sensory experience for words is a recently introduced variable that corresponds to the degree to which words elicit sensory and perceptual experiences (it is measured using a Likert scale, Bonin, Méot, Ferrand, & Bugaïska, 2015; Juhasz & Yap, 2013). The statistical characteristics of the controlled variables for the two lists are presented in

Table 3. Overall, the animate (A) and inanimate (I) words were also matched on number of letters (A: $m = 7.47$, sd $= 1.62$; I: $m = 7.40$, sd $= 1.77$; $p = .895$), word frequency (A: $m = 0.86$ [log transformed], sd $= .39$; I: $m = 1.01$, sd $= .39$; $p = .196$), age-of-acquisition (A: $m = 2.29$, sd $= .53$; I: $m = 2.20$, sd $= .57$; $p = .552$), old20 (A: $m = 2.38$, sd $= .87$; I: $m = 2.17$, sd $= .61$; $p = .293$), imageability (A: $m = 4.54$, sd $= .27$; I: $m = 4.59$, sd $= .25$; $p = .475$), concreteness (A: $m = 4.77$, sd $= .08$; I: $m = 4.82$, sd $= .12$; $p = .083$), emotional valence (A: $m = 2.99$, sd $= .67$; I: $m = 3.34$, sd $= .60$; $p = .058$) and SER (A: $m = 3.96$, sd $= .71$; I: $m = 3.94$, sd $= .91$; $p = .937$).

Procedure

The participants were comfortably seated in a quiet room and were randomly assigned to one of the three encoding conditions (survival [$n = 46$], moving [$n = 49$] or pleasantness [$n = 47$]) and to one of the two lists of words. None of them was informed that the experiment was about memory. They were only told that their task would require them to rate words along a certain dimension. The instructions for the survival and the moving scenarios were the same as in Study 1. In the pleasantness encoding task, the participants were required to rate each word on a five-point scale in order to assess the degree to which each word evoked a positive connotation for them. More precisely, they were given the following instructions: "In this task, we would like you to rate the pleasantness of the words. Some of the words may be pleasant and others may not be—it's up to you to decide." In this second experiment, stimuli were presented on computers running E-prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002).

The words were presented individually for five seconds in the centre of the screen in a different random order for each participant. The participants produced their responses by pressing a key (labelled 1 through 5 on the keyboard) corresponding to their choice. After the participants had completed the encoding phase, they performed the same two distractor tasks as were used in Study 1. These two interference tasks lasted for approximately five minutes. A surprise memory test was then given to the participants. They were asked to recall as many of the previously presented words as they could by writing them down in any order they liked within a period of five minutes.

Results

The mean encoding times and the mean rating scores (together with their standard deviations) are provided in Table 2.

By-trials RTs and ratings were analysed using linear mixed models with participants and items treated as random factors that served as the basis for intercept adjustments in accordance with the mixed model procedure set out in SPSS 21. We were interested in the effects of animate/inanimate category, scenarios and their interaction. Number of letters, film subtitle frequency (in log), age of acquisition, orthographic neighbourhood as measured by OLD20, sensory experience ratings, concreteness, imageability and emotional valence were all included as control variables.

Encoding times (*msec*). As far as the times taken to rate the words is concerned, the main effect of animacy was significant, $F(1, 47.96) = 31$, $p < .001$, with encoding times being faster for animates than for inanimates. The main effect of Type of scenarios was also significant, $F(2, 143.62) = 7.04$, $p = .001$, with no reliable difference between the survival and pleasantness conditions, $t < 1$, and significantly faster rating times for the moving scenario than for the survival scenario, $t(143.58) = -3.17$, $p = .002$, and the pleasantness condition, $t(143.64) = -3.3$, $p = .001$. The interaction between Type of words and Type of scenario was significant, $F(2, 3966.09) = 22.39$, $p < .001$. Pairwise comparisons reveal that animates were rated faster than inanimates only in the moving scenario, $t(198.04) = -8.74$, $p < .001$. Finally, as far as the covariates are concerned, only SERs and emotional valence had significant facilitatory effects, $t(47.8) = -2.82$, $p = .007$ and $t(49.23) = -2.71$, $p = .007$.

Ratings. Turning to the rating scores, both main effects were reliable, Type of words: ($F(1, 49.04) = 16.14$, $p < .001$, and Type of scenario: $F(2, 163.45) = 89.94$, $p < .001$, with lower ratings for animates than for inanimates and lower

Table 3. Statistical characteristics (mean, standard deviation, range, minimum–maximum, *t*-test of the means) of the control variables in Study 2 for list 1 and list 2.

	List 1				List 2				*t*-Test
	Mean	sd	Range	Min–max	Mean	sd	Range	Min–max	
Number of letters[a]	7.77	1.71	7	5–12	7.07	1.59	7	4–11	$p = .11$
Number of phonemes[a]	5.67	1.46	5	4–9	5.07	1.29	6	3–9	$p = .10$
Book frequency[a]	14.96	17.52	70.14	0.27–70.41	14.95	14.47	71.96	0.95–72.91	$p = .99$
Subtitle frequency[a]	12.33	12.464	41.82	0.51–42.33	12.45	12.11	52.16	1.45–53.61	$p = .97$
Age-of-acquisition[b]	2.3	0.59	2.04	1.23–3.27	2.17	0.51	2.01	1.35–3.36	$p = .40$
Orthographic Levenshtein distance 20 (old20)[a]	2.34	0.75	3.35	1.5–4.85	2.13	0.59	2.65	1.4–4.05	$p = .23$
Imageability[c]	4.54	0.27	1.12	3.8–4.92	4.61	0.24	0.92	4.08–5	$p = .32$
Concreteness (1–5)[c]	4.80	0.13	0.64	4.36–5.00	4.82	0.10	0.36	4.59–4.95	$p = .53$
Emotional valence (1–5)[c]	3.36	0.61	2.56	1.84–4.40	3.16	0.61	3.04	1.52–4.56	$p = .27$
Sensory experience ratings (SER)[d]	3.94	0.96	3.76	2.36–6.12	3.9	0.73	2.85	3.03–5.88	$p = .83$

[a] Values taken from Lexique (www.lexique.org; New et al., 2004).
[b] All the scales are five-point scales. The values were obtained from Bonin, Peereman, et al. (2003), and from Alario and Ferrand (1999).
[c] All the scales are five-point scales. The values were obtained from Bonin, Méot, et al. (2003).
[d] Sensory experience ratings (SER): Values on a seven-point scale taken from Bonin et al. (2015).

ratings for the moving scenario than for the other two encoding conditions: survival: $t(163.04) = -7.27$, $p < .001$ and pleasantness: $t(163.39) = -13.38$, $p < .001$. Moreover, as can be seen from Table 2, the rating scores were lower in the survival scenario than in the pleasantness condition, $t(163.94) = -5.98$, $p < .001$. The interaction between Type of words and Type of scenario was significant, $F(2, 3964.82) = 82.74$, $p < .001$, with pairwise comparisons indicating no reliable differences between animates and inanimates in the survival and pleasantness conditions (all $ts < 1$), whereas animates were rated reliably lower than inanimates in the moving scenario, $t(76.49) = -9.47$, $p < .001$). Finally, concerning the covariates, there were significant positive effects of word frequency and imageability, $t(49.057) = 2.07$, $p < .05$ and $t(50.064) = 2.28$, $p < .05$, respectively.

Recall rates. Analyses of recall rates were performed using mixed logistic regressions with participants and items defining intercept random effects. Every item recalled within the five-minute recall interval was coded 1 and otherwise 0. A first analysis included the same fixed effects as those used in the analyses of encoding times and rating scores. In a second analysis, fixed effects of encoding times and rating scores were introduced as controlled variables.

As far as the first analysis, in which encoding times and rating scores were not controlled for, is concerned, the main effect of animacy was significant, $F(1, 4174) = 6.3$, $p = .012$, with animates being better recalled than inanimates ($m = 0.4$ and $m = 0.3$). The main effect of Type of scenario was also significant, $F(2, 4174) = 7.38$, $p < .001$, with no reliable difference between the moving and pleasantness conditions, $t < 1$ ($m = 0.32$ in both scenarios), and significantly better recall for the survival scenario ($m = 0.40$) compared to the moving scenario, $t(4174) = 3.39$, $p < .001$ and to the pleasantness condition, $t(4174) = 3.42$, $p < .001$. The interaction between Type of words and Type of scenario was significant, $F(2, 4174) = 3.81$, $p = .022$. Pairwise comparisons revealed that animates were better recalled than inanimates in both the survival, $t(4174) = 2.72$, $p = .007$; $m = 0.47$ and $m = 0.34$) and pleasantness conditions, $t(4174) = 2.87$, $p = .004$; $m = 0.39$ and $m = 0.26$), but not in the moving scenario, $t < 1$ ($m = 0.34$ and $m = 0.3$). Finally, as far as the covariates are concerned, only concreteness and imageability had significant facilitatory effects, $t(4174) = 2.23$, $p = .025$ and $t(4174) = 2.28$, $p = .023$, respectively.

In the analysis in which encoding times and rating scores were introduced as covariates, the main effect of animacy was significant, $F(1, 4130) = 9.62$, $p = .002$, with animates being recalled better than inanimates ($m = 0.42$ and $m = 0.29$). The main effect of Type of scenario was also significant, $F(2, 4130) = 8.25$, $p < .001$, with all differences being significant: survival vs. moving, $t(4130) = 1.99$, $p = .047$, $m = 0.4$ and $m = 0.35$; survival vs. pleasantness, $t(4130) = 4.07$, $p < .001$, $m = 0.4$ and $m = 0.30$; moving vs. pleasantness, $t(4130) = 2.00$, $p = .046$, $m = 0.35$ and $m = 0.30$. Importantly, the interaction between Type of words and Type of scenario (Figure 2) was not significant, F < 1.[2] In addition, both encoding times and rating scores had positive effects on recall, $t(4130) = 4.6$, $p < .001$ and $t(4130) = 5.52$, $p < .001$, respectively. As found in the first analysis reported above, significant facilitatory effects of concreteness and imageability were also observed, $t(4130) = 2.06$, $p = .039$ and $t(4130) = 2.14$, $p = .032$.

With regard to intrusions (see Table 2), the main effect of Encoding condition was not significant, $F < 1$, $\eta_p^2 = .002$. The interaction between Encoding condition and Type of intrusions was also not significant, $F < 1$, $\eta_p^2 = .001$. However, there was a significant main effect of Type of intrusions, $F(1, 139) = 30.82$, $p < .001$, $\eta_p^2 = .18$. There were less animate (A) than inanimate (I) intrusions in the survival scenario, $t(45) = -3.93$, $p < .001$, in the moving scenario, $t(48) = -2.91$, $p < .01$, and in the pleasantness condition $t(46) = -2.93$, $p < .01$.

Given that there were food-related words in the lists of Study 2, the question arises as to whether these items were remembered better than other inanimate things. In effect, food items, though inanimate, are nevertheless relevant for survival. We therefore performed an additional analysis on recall rates in order to examine whether food items were better recalled than other inanimate items (and also how they compared to animate items) across the different encoding conditions. In this analysis, we included encoding times and rating scores as covariates together with the same fixed effects (e.g., imageability, emotional valence) as those used in the analyses reported above. The main effect of Type of items was significant, $F(2, 4127) = 5.49$, $p = .004$, with animates being recalled better than inanimates ($m = 0.42$ and $m = 0.28$, $t(4127) = 3.26$, $p = .001$). However, animates did not significantly differ from food items ($m = 0.33$, $t(4127) = 1.46$, $p = .14$), and food items also did not significantly differ from the other inanimate items, $t(4127) = 1.01$, $p = .31$. The main effect of Type of scenario was also significant, $F(2, 4127) = 6.74$, $p = .001$: Both the survival and moving scenario yielded better

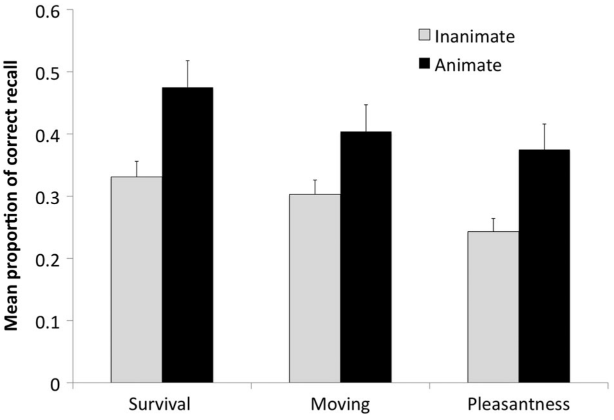

Figure 2. Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. moving vs. pleasantness) and Animacy (animate vs. inanimate stimuli) in Study 2.

recall than the pleasantness condition, $t(4127) = 3.56$, $p < .001$ and $t(4127) = 2.6$, $p < .01$. The interaction between Type of words and Type of scenario was not significant, $F(4, 4127) = 1.18$, $p = .32$. In addition, concreteness and imageability had a positive influence on memory performance, $t(4127) = 4.6$, $p < .05$ and $t(4127) = 3.82$, $p < .05$, respectively. Finally, we also found that both encoding times and rating scores had positive effects on recall, $t(4127) = 33.45$, $p < .001$ and $t(4127) = 21.3$, $p < .001$, respectively. To sum up, we did not find any advantage of food items compared to other inanimate items. It must be stressed, however, that the number of food items in Study 2 was limited (there were only 9 food items) and these findings are therefore merely a potential indication.

Discussion of Study 2

The animacy effect on recall rates was replicated in the survival scenario. It is important to note that the animacy effect was obtained using lists of items that contained fewer animates than inanimates (there were about one-third of animate items). This is an important finding because it shows that animates are not recalled better than inanimates because of their more organised nature. However, we will return to this issue in Study 4. Indeed, more animates than inanimates were also recalled correctly in a non-schematic encoding task, namely the pleasantness rating task. In this latter task, there is no special emphasis on animates or inanimates since both can potentially be judged positively or negatively. Since animacy effects have already been found in explicit learning (Nairne et al., 2013), these effects were expected in this task.

Regarding the moving condition, the results were different from those obtained in Study 1. This time the animacy effect was not reversed. It is important to stress that, even in the moving encoding scenario for which we predicted that attention might be drawn more to objects than to persons or animals, as well as in the context of lists with more inanimates than animates, animates were still better remembered than inanimates. Study 2 also revealed that in the moving scenario, animates were rated as being less relevant than inanimates and, moreover, these ratings were made quickly. Nevertheless, animates were remembered better than inanimates. The findings from Study 1 and 2 regarding animacy effects in non-survival scenarios are somewhat ambiguous. We therefore decided to design a third study that was conceptually similar to Studies 1 and 2, except that a different non-survival scenario was used. In addition, we changed the non-schematic encoding task from a pleasantness rating task to an explicit learning task.

Finally, we did not find any advantage of food items compared to other inanimate items. Also, the recall of food items was not significantly better than the recall of the animate items. Interestingly, a recent study by Clark and Bruno (in press) found that location memory for food items (presented as pictures) was greater when they were processed in a survival context than in a non-survival context (see also Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Unfortunately, inanimate non-food items were not included in this study. It will therefore be interesting in the future to determine whether location memory for food items is better than that for inanimate non-food items.

Study 3: animacy effects in survival, planning a trip as tour guide and intentional learning

In this study, we further explored animacy effects on long-term retention as a function of different encoding situations. The major changes in Study 3 were the following. First, we used another non-survival encoding scenario. More specifically, we designed a scenario "planning a trip as a tour guide" which, as yet, has not been used in the literature on adaptive memory. A variety of scenarios have been used as controls for comparison with the survival processing condition (e.g., bank robbery [Kang, McDermott, & Cohen, 2008], suicide in a space capsule [Bell, Röer, & Buchner, 2013]). However, the moving scenario has often been used in the past as a control scenario for the survival scenario (e.g., Nairne et al., 2007; Nairne & Pandeirada, 2010a; Weinstein, Bugg, & Roediger III, 2008). We thought it important to assess whether animacy effects can be obtained in a non-survival scenario different from the moving scenario, since the findings from Studies 1 and 2 were ambiguous regarding this issue. Second, the non-schematic control condition was changed to an explicit learning situation which is known to produce excellent long-term retention (Nairne & Pandeirada, 2008). Finally, as in Study 1, we used a factorial design.

Method

Participants

Ninety students (78 females; mean age 19.77 years) at the University of Bourgogne participated in the study in exchange for course credits. None were taking medication known to affect the central nervous system and all were native speakers of French.

Stimuli

A total of 56 nouns were selected from Snodgrass and Vanderwart's (1980) and Bonin, Peereman, et al. (2003) databases. The words were divided into 2 sets of 28 items that referred to either an animate or an inanimate object. The words were matched on exactly the same set of variables as listed in Study 1. The statistical characteristics of the controlled variables can be seen in Table 4.

Procedure

The participants were tested individually and were seated comfortably in a quiet room. They were randomly assigned to one of the three encoding condition ($n = 30$ in each

Table 4. Statistical characteristics (mean, standard deviation, range, minimum–maximum, *t*-test of the means) of the control variables for animate and inanimate stimuli used in Study 3.

	Animate				Inanimate				*t*-Test
	Mean	sd	Range	Min–max	Mean	sd	Range	Min–max	
Number of letters[a]	6.50	1.90	7	3–10	6.61	1.91	7	3–10	$p = .83$
Bigram frequency (per million words)[a]	8220.43	3193.09	12,024	1430–13,454	9447.93	2675.39	11,616	2360–13,976	$p = .13$
Book frequency[a]	16	36	186.89	0.07–186.96	22	45	175.13	0.07–175.2	$p = .60$
Subtitle frequency[a]	20	47	188.26	0.15–188.41	13	30	154.07	0.06–154.13	$p = .48$
Age-of-acquisition[b]	2.52	0.65	2.6	1.15–3.75	2.75	0.80	2.97	1.23–4.2	$p = .22$
Number of orthographic neighbors[a]	2.14	3.40	13	0–13	2.50	3.70	11	0–11	$p = .71$
Orthographic uniqueness point[a]	4.78	2.27	10	0–10	5.00	2.74	9	0–9	$p = .37$
Conceptual familiarity[b]	2.14	0.79	2.83	1.07–3.9	2.49	0.85	3.79	1.18–4.97	$p = .11$
Imageability[c]	4.42	0.37	1.32	3.64–4.96	4.20	0.49	1.6	3.24–4.84	$p = .06$
Concreteness[c]	4.60	0.31	1.27	3.64–4.91	4.67	0.37	1.95	3.05–5	$p = .50$
Emotional valence[c]	3.29	0.68	3.24	1.32–4.56	2.99	0.64	2.6	1.52–4.12	$p = 09$

[a] Values taken from Lexique (www.lexique.org; New et al., 2004).

[b] All the scales are five-point scales. The values were obtained from Bonin, Peereman, et al. (2003) and from Alario and Ferrand (1999).

[c] All the scales are five-point scales. The values were obtained from Bonin, Méot, et al. (2003).

condition): survival scenario, tour guide scenario or explicit learning. The instructions given to the participants in the survival condition were exactly the same as described in the procedure section of Study 1. The instructions given to the participants in the "tour guide" condition were as follows:

> In this task, please imagine that you are working in a travel agency as tour guide. Over the next few months, you'll need to organize a trip for a group of people: find accommodation, meals and attend to administrative procedures (e.g., insurance, reservations). We would like you to rate how relevant the word would be for you in this situation. Some of the words may be relevant and others may not be—it's up to you to decide.

In these two encoding conditions, the participants were asked to rate the words on a 5-point scale, with 1 indicating totally irrelevant in the described scenario and 5 = extremely relevant. The participants responded by pressing a key on the keyboard (1 through 5) corresponding to their choice. Each participant was told to respond within five seconds of word presentation, and no mention was made of a later retention test.

As far as the explicit learning condition is concerned, the participants were informed that the experiment involved memory but were not given any information about the different types of words (i.e., animates vs. inanimates) that would be presented. During the encoding phase, the words were presented at the rate of five seconds per word, in a different random order for each participant. The participants were told to read the words carefully in order to remember them for a test that would be administrated later.

In each encoding condition, two interference tasks followed the presentation of the words. These tasks were the same as used in the previous studies. These two interference tasks lasted five minutes. After these two interference tasks, the participants were asked to recall (by writing them down) as many of the words as they could remember from the encoding phase during a period of ten minutes.

In all the encoding conditions, the stimuli were presented individually in the centre on the screen of a Macintosh computer running Psyscope v.1.2.5 software (Cohen, MacWhinney, Flatt & Provost, 1993).

Results

Encoding times. Concerning the time taken to rate the words (see Table 2), the ANOVA did not reveal a reliable main effect of Encoding condition, $F(1, 58) = 2.20$, $\eta_p^2 = .04$, but did indicate a significant main effect of Type of words, $F(1, 58) = 5.80$, $p = .02$, $\eta_p^2 = .09$, with animate words being rated faster than inanimate words. The interaction between Encoding condition and Type of words was not significant, $F < 1$, $\eta_p^2 = .001$.

Ratings. For the rating scores (see Table 2), neither the main effect of Encoding condition, $F(1, 58) = 1.15$, $\eta_p^2 = .02$, nor the main effect of Type of words, $F(1, 58) = 1.16$, $\eta_p^2 = .02$, was significant. However, the interaction between Encoding condition and Type of words was significant, $F(1, 58) = 22.31$, $p < .001$, $\eta_p^2 = .28$. *t*-Test comparisons revealed significant differences between animate and inanimate words in the Survival scenario condition, $t(29) = -2.29$, $p = .03$, as well as in the Tour Guide scenario, $t(29) = 4.79$, $p < .001$, with inanimate words being given higher rating scores than animate words in the Survival condition whereas the opposite was observed in the Tour Guide scenario.

Recall rates. As far as correct recall rates are concerned, the two main effects of Encoding condition, $F(2, 87) = 11.99$, $p < .001$, $\eta_p^2 = .22$, and of Type of words, $F(1, 87) = 39.22$, $p < .001$, $\eta_p^2 = .31$, were significant. The interaction between Encoding condition and Type of words was not significant, $F < 1$, $\eta_p^2 = .01$ (see Figure 3). Pairwise comparisons revealed no significant difference between the Explicit learning and Tour Guide condition, $t < 1$, whereas the differences between these latter two conditions and the Survival condition were both reliable: Explicit learning vs. Survival, $t(87) = -4.52$, $p < .001$, and Tour Guide vs. Survival, $t(87) = -3.9$, $p < .001$, thus indicating that the Survival scenario condition led to better recall performance than either the explicit learning or the Tour Guide encoding conditions. Finally, the difference between animate and inanimate words on recall rates was reliable in the three encoding conditions. More animates were recalled than inanimates in the Explicit learning condition, $t(29) = 6.00$, $p < .001$ ($m = 0.40$ and $m = 0.30$), in the Tour Guide condition, $t(29) = 2.32$, $p < .05$ ($m = 0.37$ and $m = 0.30$) and in the Survival condition $t(29) = 3.65$, $p < .01$ ($m = 0.48$ and $m = 0.41$). (In an ANOVA including only the Tour Guide and Survival conditions with ratings and encoding times introduced as covariates, animates were still significantly better recalled than inanimates in both scenarios. There was also a reliable difference between the two scenarios for animates, whereas this was only marginally significant for inanimates.)

As far as intrusions are concerned, the main effect of Encoding condition was not significant, $F(2, 87) = 1.32$, $\eta_p^2 = .03$. The main effect of Type of intrusions was

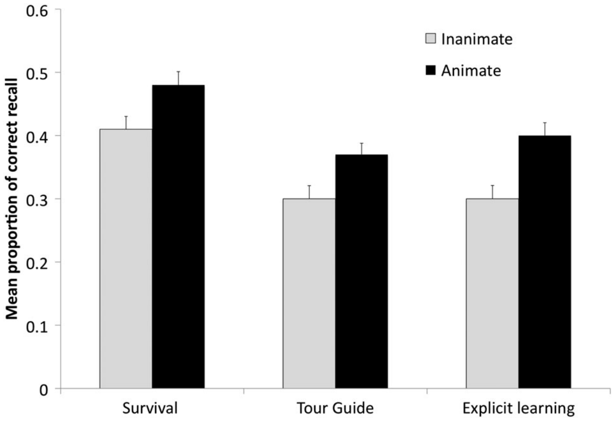

Figure 3. Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. tour guide vs. explicit learning) and Animacy (animate vs. inanimate stimuli) in Study 3.

significant, $F(1, 87) = 13.78$, $p < .001$, $\eta_p^2 = .14$, as was the interaction between Encoding condition and Type of intrusions, $F(2, 87) = 3.35$, $p < .05$, $\eta_p^2 = .07$. As reported in Table 2, there were more inanimate (I) than animate (A) intrusions in the three encoding conditions. The difference was significant, however, only in the explicit learning condition, $t(29) = -3.18$, $p < .01$. In the tour guide scenario, the difference was marginally significant, $t(29) = -2.02$, $p = .052$, and it was not significant in the survival scenario, $t(29) = -.56$, $p > .10$.

Discussion of Study 3

Again, animates were better remembered than inanimates in the survival scenario. It was also the case in the explicit learning condition, as has been reported in previous studies (e.g., Nairne et al., 2013). Importantly, using a tour guide scenario as a non-survival encoding scenario resulted in reliable animacy effects on recall rates. It is worth stressing that the non-survival scenario that we used had never previously been used. We thought it appropriate to employ a scenario other than the moving scenario because, on the one hand, the latter scenario has often been used as a control scenario for the survival scenario and, on the other, because the findings concerning animacy effects in the moving condition were somewhat inconsistent across Studies 1 and 2. Also it is important to evaluate whether animacy effects can be obtained in other non-survival scenarios since it seems to be a very robust effect. It is important to stress that at no point we observe *a reliable reversal of the animacy effect* in the moving scenario where it might have been expected that more attention would be devoted to "non-living things" than to "living things". In effect, in Study 1, the difference in recall rates between animates and inanimates was not reliable (at a descriptive level the animacy effect was reversed), whereas in Study 2, the animacy effect reach significance. Finally, it is also worth mentioning that the survival scenario led to better recall than either the tour guide scenario or the explicit learning condition, replicating the survival processing advantage (e.g., Nairne et al., 2007; Nairne & Pandeirada, 2010a). Before going on to the General Discussion of our findings, we thought it important to directly address the issue of the relatedness of items among the animate and inanimate categories in a fourth and final study.

Study 4: animacy effects (in explicit learning): are they due to the more organised nature of animates?

In the three studies reported above, we were careful to control for a large number of variables (e.g., number of letters, orthographic uniqueness, familiarity, imageability, concreteness and valence) across animate and inanimate stimuli. However, we did not control for relatedness and category size. As a result, it could be that animate words have a higher degree of relatedness than inanimate words, thus favouring the retrieval of the former. In Study 4, we addressed this issue in an explicit memory task. The words were controlled on the same dimensions as those used in the previous study. However, we also controlled the number of categories and the relatedness among the items across the categories (indexed by frequency of mention). VanArsdall et al. (2015) took this issue into account when investigating animacy effects in a very recent study. However, so far, this study is the only one to have addressed this issue and it is important to assess its generalizability to recall (here free recall) since the authors tested memory with cued recall. More importantly, in their experiment, they used only two different categories: the four-footed animal category for animates and the furniture category for inanimates. It is impossible to determine whether semantic knowledge interfered with memory performance since both categories were very salient. In the current study, we used eight different semantic categories and free recall as in the previous studies. Based on the findings reported by VanArsdall et al. (2015), we anticipated that animate words would be recalled better than inanimates when category size and relatedness of the items across categories are controlled for. In our view, people remember animates better than inanimates because, ultimately, the former are more important for survival and/or reproduction than the latter and not because of the potential cohesiveness of animate items.

Method

Participants

Twenty-seven adults (14 females; mean age 46.81 years) participated in this experiment as part of a presentation for a foundation called "Rotary club." All participants included in this study were native speakers of French.

Stimuli

Thirty-two nouns were selected from the Snodgrass and Vanderwart (1980), Bonin, Peereman, et al. (2003) and Bueno and Megherbi (2009) databases. Each word referred to either an animate or to an inanimate object, with four categories for each type of item: insects, birds, animals with four legs and humans (identified by profession) for animate stimuli; furniture, tools, clothes and musical instruments for inanimate stimuli.

The words were divided into 2 sets of 16 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 neighbours, orthographic uniqueness point; and the *semantic variables* of conceptual familiarity, imageability, image variability, concreteness, emotional valence and *mention frequency*. The statistical characteristics of the words are provided in Table 5.

Table 5. Statistical characteristics (mean, standard deviation, range, minimum–maximum, *t*-test of the means) of the control variables in Study 4 for animate and inanimate stimuli.

	Animate				Inanimate				*t*-Test
	Mean	sd	Range	Min–max	Mean	sd	Range	Min–max	
Number of letters[a]	7	1.94	6	4,0–10	6.63	1.9	8	4.0–12	$p = .60$
Bigram frequency (per million words)[a]	8759.69	2339.42	8345	4462–12,807	8699.31	2274.68	7199	5151–12,350	$p = .94$
Book frequency[a]	19.38	27.17	108.92	1.35–110.27	47.78	79.33	340.61	0.47–341.08	$p = .20$
Subtitle frequency[a]	18.06	22.17	84.73	0.69–85.42	23.55	26.48	110.95	0.49–111.44	$p = .54$
Age-of-acquisition (1–5)[b]	2.08	0.41	1.45	1.35–2.8	2.26	0.48	1.65	1.35–3	$p = .26$
Number of orthographic neighbors[a]	2.94	3.99	14	0–14	1.88	2.62	8	0–8	$p = .40$
Orthographic uniqueness point[a]	5.19	2.32	9	0–9	5.69	2.11	9	0–9	$p = .54$
Conceptual familiarity (1–5)[b]	2.57	0.72	3.15	1.4–4.55	3.02	1.12	3.3	1.53–4.83	$p = .20$
Imageability (1–5)[c]	4.62	0.23	0.84	4.12–4.96	4.44	0.36	1.52	3.32–4.84	$p = .11$
Concreteness (1–5)[c]	4.63	0.32	1.22	3.69–4.91	4.79	0.21	0.86	4.14–5	$p = .14$
Emotional valence (1–5)[c]	3.3	0.77	3.19	1.25–4.44	3.32	0.62	2.68	1.64–4.32	$p = .95$
Mention frequency[d]	0.27	0.3	0.98	0–0.98	0.29	0.32	0.84	0.01–0.85	$p = .88$

[a] Values taken from Lexique (www.lexique.org; New et al., 2004).
[b] All the scales are five-point scales. The values were obtained from Bonin, Peereman, et al. (2003), and from Alario and Ferrand (1999).
[c] All the scales are five-point scales. The values were obtained from Bonin, Méot, et al. (2003).
[d] The values were obtained from Bueno and Megherbi (2009).

Procedure

The participants were tested collectively. They were comfortably seated facing a large screen. At the beginning of the session, they were told that they were about to participate in a cognitive psychology experiment involving memory. However, they were not informed about the different types of words that would be presented (i.e., animates vs. inanimates) and the associated categories (insects, birds, animals with 4 legs, humans, furniture, tools, clothes and musical instruments). During the encoding phase, the words were randomly presented on a large white screen via a Macintosh computer running the Psyscope v.1.2.5 software (Cohen et al., 1993) at the rate of five seconds per word. The participants were told to read the words carefully in order to remember them for a test that would be administered later. The retention test was presented following an interference task. This took the form of the digit symbol-coding task taken from the Wechsler Adult Intelligence Scale (WAIS-IV, Wechsler, 2011). This interference task lasted for two minutes. After this task, the participants were asked to recall in writing as many of the words they could remember from the learning phase during a period lasting four minutes.

Results

In line with previous findings obtained in an explicit learning task (Nairne et al., 2013), the proportion of correctly recalled animate words ($m = 0.44$, sd = .16) was higher than that of inanimate words ($m = 0.32$, sd = .17), $t(26) = 3.68$, $p = .001$. The analysis on the proportion of intrusions showed no significant difference between animate ($m = 0.04$, sd = .07) and inanimate intrusions ($m = 0.07$, sd = .13), $t(26) = 1.26$, $p = .22$.

Discussion of Study 4

In this study, we assessed whether the better memory performance for animates compared to inanimates was due to the structure of the animacy category. In line with VanArsdall et al.'s (2015) findings in cued recall, we found that animates were recalled better than inanimates when category size and cohesiveness of items across categories were controlled for. This is an important finding. A failure to observe that animacy effects persist when the cohesiveness of animates and inanimates is controlled for would have constituted a serious challenge to our favoured evolutionary interpretation of animacy effects. It should be remembered, however, that animacy effects have also been found in recognition hits (e.g., Bonin et al., 2014) where cohesiveness of items is less important. Finally, the fact that animate did not outnumber inanimate intrusions also argues against an organisational account of animacy effects in free-recall.

General discussion

In the present studies, we attempted to determine whether animacy effects in episodic memory are independent of encoding instructions. Our work was directly inspired by the adaptive memory view championed by Nairne and colleagues (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b). According to this view, certain functional characteristics of human memory were sculpted during our distant past due to selective pressures faced by our ancestors. In particular, and importantly, this view holds that learning and memory do not apply equally to all kind of items, but instead that some items—those that are relevant for fitness—are more important than others and are prioritised during processing. In other words, the brain is not a blank slate (Pinker, 2002). As reviewed in the Introduction, two types of evidence support the adaptive memory view: the survival processing advantage and animacy effects, on which we focus here. The survival processing advantage corresponds to the observation that items (words or pictures) that are rated according to a fictitious survival scenario are remembered better than items that are rated in response to a non-survival scenario (e.g., Nairne et al., 2007). Animacy effects correspond to the finding that animate things, because they have a greater fitness value than inanimates (they may be predators, prey, or potential mating partners and/or rivals), are prioritised during processing and are remembered better. At present, evidence for this memory effect is scarce but it appears to be a robust effect because it has been found in different labs with different stimuli (words and pictures) and several memory tasks (e.g., in free and cued-recall tasks, VanArsdall et al., 2013, 2015; in recognition tasks, Bonin et al., 2014; VanArsdall et al., 2013). However, thus far, the question of whether animacy effects in episodic memory vary as a function of encoding conditions has not been investigated.

In the first three studies, we found animacy effects in the grassland-survival scenario where they were clearly anticipated. In effect, in Study 1, in which a factorial design was used, we found that words referring to animate entities were better recalled than words referring to inanimate entities when participants had to rate the words for their relevance to an imaginary ancestral survival scenario. This effect was obtained with both rating scores and times taken to rate the words introduced as covariate factors. In Study 2, a multiple regression approach was used and, again, we found that animates were better remembered than inanimates in the survival scenario. It should be recalled that Nairne et al. (2013) found, using multiple regression analyses, that animacy was a reliable and strong predictor of the recall data taken from Rubin and Friendly (1986). Finally, animacy effects were again found in the survival scenario in Study 3.

As explained in the Introduction, at a theoretical level, a different pattern of outcomes was predicted based on the hypothesis that when memory processes are redundant across different encoding tasks, there is generally no longer any retention advantage (e.g., Hunt & Einstein, 1981). This hypothesis was put forward by Burns et al. (2014) to account for the finding that the activation of death-related thoughts underpins the survival memory effect (but see also Bugaiska et al., 2015 and Klein (2014) for further discussion). If animacy and survival-processing effects involved the same set of mechanisms, no animacy effect in memory should have been observed in a situation in which participants have to encode both animate and inanimate words for their survival value. However, the findings from Studies 1–3 were clearly at odds with the redundancy hypothesis since reliable animacy effects were found in survival-processing conditions. Interestingly, the survival processing advantage initially discovered by Nairne et al. (2007) was replicated in Studies 2 and 3 and was additive with animacy effects. An important theoretical implication of the current studies relating to the observation that survival and animacy effects are additive is that this strongly suggests that the proximate mechanisms underpinning these effects are different. However, these mechanisms still have to be more precisely identified in future research, and especially in the case of animacy effects which have only more recently been considered in the literature on episodic memory.

Turning to the non-survival scenarios, in Studies 1–3, the findings concerning the animacy variable were somewhat mixed. In Study 1, the animacy effect was not reliable and was descriptively reversed, with inanimates being recalled better than animates. However, in Study 2, the animacy effect on recall was in the A > I direction and reached significance, whereas in Study 3, it was significant. The most important finding across the three studies is that we never observed that inanimates were reliably recalled better than animates. Indeed, even in the moving encoding scenario, in which it might have been expected that attention would be drawn more towards objects than to persons or animals, and in particular in Study 2 that used lists comprising more inanimates than animates, inanimates were not remembered better than animates.

Taken as a whole, the findings across the three first studies show that the animacy effect in memory is a very robust effect since it is not only found in the context of a survival scenario—where it would be predicted by an evolutionary account—but also occurs in non-survival scenarios as well as in deep encoding conditions such as pleasantness (Study 2) or explicit learning (Studies 3 and 4).

In the literature, there have been claims that the survival-processing effect could potentially be explained by the perceived relevance of words (e.g., Butler, Kang, & Roediger III, 2009). A number of studies have explicitly addressed this issue but failed to find support for the congruency account of the survival processing advantage (e.g., Nairne & Pandeirada, 2011). It now seems to be generally accepted that congruency does not account for the survival processing advantage (Erdfelder & Kroneisen, 2013). However, could the superior recall of animates over inanimates be due to the fact that the former are easier to integrate within different scenarios (e.g., survival, tour guide)? In Study 1, animate words were recalled better than inanimate words in the survival scenario even though there was no reliable difference in the relevance ratings, while in Study 3, animate words were recalled better than inanimate words despite being perceived as less relevant in the survival processing task. These findings are clearly at odds with the hypothesis that animate words are better remembered because they are considered to be more relevant than inanimate words in the survival scenario. Turning to the moving condition in Study 1, we found that although inanimates were judged to be more relevant than animates, there was no reliable difference in the recall rate. Is it possible that an animacy advantage was present but was masked by a relevance effect operating in the opposite direction?[3] This does not seem to be the case given that in Study 2, in which the effects of encoding times, ratings and animacy on memory were considered together in a regression analysis, the better recall of animates over inanimates was still reliable. Although the observation that the rated relevance of words varies across scenarios may be thought of as a limitation of the present studies, we hope that the current discussion makes clear that this does not undermine the findings of the current set of experiments. Moreover, it is worth stressing that animacy effects were found with intentional learning in Studies 3 and 4. Given that no ratings were made in these studies, the congruity argument cannot be used to explain the animacy advantage.

The survival processing advantage has been evaluated against numerous deep control encoding conditions (e.g., pleasantness, self-reference, imagery, see Nairne et al., 2008). It is therefore a strong mnemonic effect. Importantly, survival effects have been found with the use of other (non-survival related) schematic scenarios (e.g., bank robbery, in Study 3 here: tour guide). One of the most often used schematic control conditions is the moving scenario. In Study 1, but not in Study 2, the survival processing advantage was not found on recall rates when the moving scenario was considered as control encoding scenario. Why? Although it is always difficult to account for null results, we ran further analyses in order to try to find an explanation. First of all, we ran analyses at the level of individual items in order to determine whether the pattern of recall rates in Study 1 vs. Study 2 could be due to certain specific items. However, we found no indication that this might be the case. Second, we compared: (a) the rating scores and (b) encoding times across the two studies. We found that the pattern of rating scores was quite similar for animates and inanimates. This was true to a lesser extent of encoding times. Here, the most important aspect of note is that the time taken to rate animates in the moving condition was shorter in Study 2 than in Study 1. Finally, we directly examined the pattern of recall rates between Studies 1 and 2 with rating scores and encoding times introduced as covariate factors. We found that, in Study 2, animates were recalled better than inanimates in both scenarios and the same trend was observed in Study 1 in the survival condition. In the moving condition in Study 1, the recall rate for animates was similar to that for inanimates in Study 2 (the recall rates for inanimates were similar in the two studies). Thus, the failure to find a survival processing advantage in Study 1 could be rooted in the way different participants process animates in the moving condition. In sum, the moving condition certainly leads to more processing variability during encoding than the survival condition. However, we acknowledge that these supplementary analyses failed to provide a satisfactory account for the failure to find a survival processing advantage in Study 1. It is certainly the case that, probabilistically, failures to replicate most robust phenomena are expected to occur. Indeed, we are not the first to report a failure to replicate the survival processing advantage when the moving scenario was used as a control condition (Savchenko, Borges, & Pandeirada, 2014). However, Savchenko et al. (2014) did not include a standard replication of the survival vs. moving comparison (e.g., ad hoc categories were included, an intentional learning procedure was used).

It is important to reiterate that animacy effects in memory performance were obtained with a large number of potential confounding variables controlled for. In Study 2, in particular, animacy effects were obtained when using lists of unrelated words that comprised only one-third of animate items, that is to say lists in which inanimates were more numerous and rendered potentially more salient than animates. Importantly, Study 4 showed conclusively that animacy effects are not due to the more organised nature of animate items (see also VanArsdall et al., 2015) since these effects were found in recall rates with category size and cohesiveness of the items controlled for. Also an organisational account of animacy effects in free-recall would predict more animate than inanimate extra-list intrusions, whereas just the opposite was found across our studies in which there was a consistent pattern (at least at a descriptive level): There were always more inanimate than animate intrusions (even though the difference was reliable in all encoding conditions of Study 2, and the explicit condition of Study 3 only). Thus, at a theoretical level, these latter findings place constraints on the interpretations of animacy effects in recall in that they argue against an account of animacy effects that holds that they are the result of the more organised nature of animate items. It should be remembered that the finding that animacy effects are obtained in recognition hits (e.g., Bonin et al., 2014) in itself suggests that animacy effects in memory are unlikely to be fully explained in terms of the greater cohesiveness of animates. As far as Study 2 is concerned, it might be claimed that the use of lists with less animates than inanimates resulted in the creation of an isolation effect (i.e., von Restorff effect, Hunt, 1995) which was confounded with animacy, and thus, that the comparison would be improved by using a condition containing more animate than inanimate words.[4] It might seem reasonable to claim that decreasing the number of animate items in the list should enhance the animacy effect. In effect, distinctiveness accounts predict that reducing the number of animate items would increase the distinctiveness of those items, thereby improving their memorability (e.g., Hunt & Elliott, 1980). However, if we compare the recall rates of animate and inanimate items across studies, animates were not recalled more than inanimates in Study 2 (.39 vs. .32), in which they should have been more distinctive, than they were in Studies 1 and 3 in which there were equal numbers of items of each type (.34 vs. .30 and .42 vs. .34, respectively).

Readers who are sceptical about the evolutionary approach to episodic memory that we—following Nairne et colleagues—have championed might ask themselves whether our interpretation of animacy effects (i.e., that they are ultimately attributable to the fact that animates are more important than inanimates for fitness and are thus given processing priority, consequently leading to their better recall), is not, after all, a kind of "just-so story" (Gould, 2000; but see Kurzban, 2002). We would like to point out that had an evolutionary approach not been adopted in recent works on episodic memory, we doubt that the importance of the animacy dimension in memory would have been discovered. Animacy is one of the most important dimensions and accounts for a large amount of variance in recall rates as shown by both Nairne et al. (2013) and in our own studies. It is important to stress that the influence of concreteness, imagery or emotionality in memory has long been studied (Nairne et al., 2013), but it is only very recently that the power of the animacy dimension has been revealed. (It is worth mentioning, however, that animacy has been—and still is—a topic of much research in the fields of linguistics and psycholinguistics, e.g., Bock, Loebell, & Morey, 1992; DeDe, 2015.) Thus, adopting an evolutionary (or functionalist) approach to the study of episodic memory promises to be a fruitful endeavour. The strength of evolutionary psychology lies in its insistence on taking account of both proximate and ultimate explanations in order to achieve a comprehensive understanding of many aspects of human behaviour. Ultimate explanations are those that consider the selection pressures that have shaped the behaviour under study (in the current studies, remembering things in the long term) and which continue to do so today. However, we know that this view is not shared by certain researchers who think that it is difficult to propose ultimate explanations for a phenomenon (e.g., the survival processing advantage) if the proximate mechanisms have not yet been identified (Bell, Röer, & Buchner, 2015).

To conclude, by adopting an evolutionary perspective, that is to say by proposing that animates are of greater fitness value than inanimates, researchers have put forward the hypothesis that animates should be remembered better than inanimates (Nairne et al., 2013; VanArsdall et al., 2013), and they have therefore discovered that animacy is an important dimension. Now, there is an avenue for understanding how animacy effects come about, that is to say an insight into the proximate mechanisms that underpin these effects. We and others have begun to explore this important issue (Bonin et al., in press; Popp & Serra, in press; VanArsdall et al., 2015).

Notes

1. According to Gelman and Spelke (1981), the fundamental features that distinguish animates from inanimates are the following: (1) animates can move, whereas inanimates move only when the action is initiated by something or someone; (2) animates grow and reproduce; (3) animates are able to know, perceive, emote, learn and think; and (4) animates are made of biological structures that maintain life and allow reproduction.
2. It is important to note that the tests of the simple effects of the animacy factor realized at the means of the covariates were significant in all scenarios.
3. We thank an anonymous reviewer for having suggested this line of reasoning to us.
4. This was suggested to us by an anonymous reviewer. It should be noted that, strictly speaking, animate items were not isolated. Furthermore, in Study 2, the learning was incidental and certain studies suggest that von Restorff effects are not obtained under conditions of incidental learning (e.g., Postman & Phillips, 1954; Saltzman & Carterette, 1959). Interestingly, and related to this issue, a recent study (Popp & Serra, in press) has shown that presenting animates (animals) and inanimates (objects) as themed-lists (all animates or all inanimates) or mixed-lists (both animates and inanimates within the lists) does not change the size of animacy effects on recall rates.

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