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Adaptive Memory: Longevity and Learning Intentionality of the Animacy Effect

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Abstract

The animacy effect – the finding that animates are better remembered than inanimates – is proving to be a robust empirical phenomenon. Considering the adaptiveness of the animate advantage, one might expect it to remain after long retention intervals and also to be present irrespectively of an intention to learn. The present study explores these two aspects. Different groups of participants learned (intentional learning) or rated the pleasantness (incidental learning) of animate and inanimate words; memory was tested immediately or after a 48h delay. A significant animacy effect was obtained after both retention intervals and in both learning conditions. Two significant interactions revealed a larger animacy effect, as well as a larger effect of the retention interval, when learning was incidental. Our findings reinforce the robustness of the animacy effect and provide some insight into possible proximate mechanisms of the effect.

Keywords: Animacy, Adaptive Memory, Intentional learning, Incidental Learning, Retention Interval

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The animacy effect refers to a processing advantage of animate (living) over inanimate (nonliving) items. From an evolutionary perspective, animate items should receive priority processing because they were (and remain) important environmental stimuli. Living beings (as animals or humans) may be potential predators, prey, sexual mates, enemies, kin, friends and partners for social interaction (Nairne, VanArsdall, & Cogdill, 2017). Note that all these cases carry potential impact to the individual's chances of survival and reproduction. Accordingly, animates seem to have a special status in various cognitive processes (e.g., perceptual, attentional and memory processes). For example, animates capture faster attention and hold it longer than inanimate items (e.g., Calvillo & Hawkins, 2016), the animate/inanimate distinction appears very early in development and drives the acquisition of conceptual representations (e.g., Opfer & Gelman, 2011), affects language (Radanovic, Westbury, & Milin, 2016), and appears to have specific neurological substrates (Caramazza & Shelton, 1998).

People also recall animate items better than inanimate items. Indeed, Nairne and collaborators (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013) found that animacy is one of the best predictors of free recall. Furthermore, this advantage has been found using cued recall (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015; although see Popp & Serra, 2016), free recall (Bonin, Gelin, Laroche, Méot, & Bugaiska, 2015; Nairne et al., 2013; VanArsdall, Nairne, Pandeirada, & Cogdill, 2016), recognition, and with word and picture stimuli (Bonin, Gelin, & Bugaiska, 2014). The spatial and temporal context in which animate items occur is also better retained than for inanimates (Gelin, Bonin, Méot, & Bugaiska, 2018). Metamemory judgements (i.e., judgements about the probability that recently learned items will be later on remembered) are affected by animacy (Li, Jia, Li, & Li, 2016). Nonwords processed as animates are better remembered that those processed as inanimates too (VanArsdall, Nairne, Pandeirada, & Blunt, 2013). Furthermore, the animacy effect has been obtained in both incidental and intentional learning (Gelin, Bugaiska, Méot, & Bonin, 2017; Nairne et al., 2013). Thus, the mnemonic animacy effect is a robust phenomenon that has been reported in various laboratories and under a variety of conditions.

Despite the recent interest in this effect, no attention has been given to its longevity as all studies have employed short retention intervals between encoding and recall; these have ranged from no delay between presentation and recall (e.g., Popp & Serra, 2018) to five minutes (e.g., Gelin et al., 2017). Some studies do not clearly specify the duration of the retention interval but considering the total duration of the procedure (e.g., 15 min; Meinhardt, Bell, Buchner, & Röer, 2018) we assume it was relatively short. It has been shown that the survival processing effect – the finding that people remember items better when considered in a survival context – can be obtained at long retention intervals. Survival processing advantages have been found against various control conditions (e.g., pleasantness, rating words to a moving scenario) and using recall and recognition tasks, after delays of 12, 24 and 48 hours (Abel & Bäuml, 2013; Raymaekers, Otgaar, & Smeets, 2013). The most recent study replicated the survival effect after a 96-hour delay (Clark & Bruno, 2016). No significant interactions have been found between encoding condition and delay indicating that the size of the survival effect is not influenced by the passage of time (although see Nairne, Coverdale, & Pandeirada, 2019, for a different result using a different procedure). These results also suggest that the rate of forgetting after survival processing may not differ from that of other forms of encoding (e.g., pleasantness or moving scenario ratings). In the same vein, and considering the fitness relevancy of animacy, one might expect the animacy effect to remain robust at long retention intervals.

The influence of the retention interval in the animacy effect is also informative about the possible involvement of emotional arousal as a proximate mechanism for the effect. One of the signature characteristics of the emotional memory effect (the mnemonic advantage for emotionally-arousing information compared to non-arousing information) is that the effect typically gets larger with longer retention intervals (Kensinger, 2009). Hence, the assessment of the animacy effect at different retention intervals provides an important test for the relevance of arousal in the animacy effect. Specifically, a larger animacy effect would be expected after longer delays if indeed it is mediated by this variable.

We should note that the role potentially played by arousal on the animacy effect has been addressed in previous studies, mostly by using matched animate and inanimate word lists. However, the term "arousal" has been used in various ways by authors; some referred to mental arousal (Popp & Serra, 2018), others referred to threat and related it to emotional arousal (Leding, 2018), and still others referred directly to emotional arousal (Meinhardt, et al., 2018). Importantly, each considered "arousal" to be closely related to emotional arousal. In the current study, we also equated our word lists on "arousal", here considered as emotional arousal, that is, the degree of activation a given stimulus can induce (varying from very calming to very exciting; as per the norming information provided by Soares, Comesaña, Pinheiro, Simões, and Frade, 2012). Testing the effect of delay on the animacy effect offers an alternative investigation for the hypothesis that arousal is implicated in this effect.

From a fitness perspective, one might also expect the animacy effect to be independent of the intentionality to retain the information. Some studies have used intentional learning – that is, simply telling participants to memorize a list of words containing animate and/or inanimate stimuli (e.g., Nairne et al., 2013); others have used incidental learning with attention to the animacy dimension being required in some cases (e.g., decide if a word refers to an animate or an inanimate item; Bonin et al., 2014). Two studies used an incidental learning task which involved rating the relevance of the words to various scenarios (e.g., survival and moving), performing a pleasantness evaluation of the words (Gelin et al., 2017), or under various levels of processing (e.g., Leding, 2018). The animacy advantage has been replicated in each case (the only exception was in Study 1 of Gelin et al., 2017). However, whether the size of the animacy effect is influenced by the intentionality of the learning remains largely unexplored. To the best of our knowledge, only two studies have directly compared an intentional learning condition with incidental tasks. Gelin et al. (2017) compared the intentional learning condition with two incidental conditions that involved rating the relevance of words to two scenarios (survival scenario and planning a trip as a tour guide). An animacy effect was obtained in all conditions and the results from the tour guide condition did not differ from those of the intentional condition; the typical survival effect was also obtained. More recently, Gelin, Bugaiska, Méot, Vinter and Bonin (2019) reported that the animacy effect size does not differ significantly when an intentional task was compared to an incidental animacy categorization task. Considering that the incidental conditions used in these studies somehow relied on a schematic or relational form of processing, it is still an open question whether the same results would be obtained with an incidental task that focuses more on each individual item (e.g., a pleasantness rating task; Burns, Hart, Griffith, & Burns, 2013). The existing literature suggests that the animacy effect should occur equally in both learning conditions.

In sum, the aim of this work was to study the longevity of the animacy effect (immediate *vs*. a 48h delayed recall) in two learning conditions (incidental *vs*. intentional learning); animacy of the items was manipulated within-subject whereas the remaining variables were all manipulated between-subjects (four groups). We predicted a main effect of the animacy manipulation similar to the results obtained with survival processing (e.g., Raymaekers et al., 2013). We also expected a main effect of the retention interval: proportion of recall should be higher in the immediate than in the delayed recall condition (Clark & Bruno, 2016; Ebbinghaus, 1885). Whether the animacy effect will interact with retention interval remains an open question, although previous work suggests that emotional arousal may not be an important determinant of the effect (e.g., Leding, 2018; Meinhardt et al., 2018; Popp & Serra, 2018).

Regarding the effect of learning intentionality, we expected no difference between intentional and incidental conditions, nor a significant interaction between the animacy effect and learning condition. We based this prediction on the results obtained by Gelin and colleagues (2017, in press), although their incidental encoding tasks relied on scenario-based and relational processing rather than an item-based encoding task as used here. We opted to use the pleasantness rating task as our incidental learning condition as it has long been considered to induce item-specific processing (e.g., Burns et al., 2013) as well as excellent levels of retention (e.g., Packman & Battig, 1978). Furthermore, this was the encoding task used in two of the studies that explored the longevity of the survival effect (Abel & Bäuml, 2013; Clark & Bruno, 2016), and has also been used as a deep-processing control in animacy experiments (e.g., Leding, 2018). Finally, rating the pleasantness of the items likely draws the participants' attention away from variable that is being manipulated (animacy). We also explored the nature of the intrusions committed by participants, as has been done in previous studies on the animacy effect, as these can inform about mechanisms underlying this effect (e.g., Bonin et al., 2015).

Method

Participants

The sample size was calculated *a priori* using G*Power 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007) considering the possibility of a small interaction occurring. With α = .05, *power* (1-β) = 0.95, and a small effect size, f = 0.10, N was set as 216 participants. We used a convenience sample with data collected after contacting several professors from various institutions who allowed the collection of the data in the context of their classes; thus, we were unable to control for the exact number of participants contributing to each condition. For the delay groups we contacted professors of the same groups of students who were teaching their class with an approximate interval of 48 hours; sometimes the same professor would have this schedule.

Our final sample included a total of 220 participants (78.2% female; M_{age} = 19.63; SD = 2.34; *age range:* 18 – 34). Participants were all undergraduate students and were European Portuguese native speakers. Written informed consent was obtained from all participants prior to their participation. Data from an additional 147 participants were excluded because they were not European Portuguese native speakers (n = 28), did not complete the two phases of the study (n = 49), did not respond to the final questions of the procedure (n = 4), were not naïve to the incidental learning nature of the task or tried to memorize the words in the incidental learning conditions (n = 26), were aware of the duration of the retention interval in the delayed conditions (n = 26) or were older than 35 or younger than 18 years old (n = 14; a criterion employed to maintain a more homogeneous sample)[1].

Materials

A set of 24 nouns (12 animate and 12 inanimate) were selected from a larger pool of words previously normed on animacy (Félix, Pandeirada & Nairne, in preparation). Because other word dimensions can also influence memory performance, these two sets of words were carefully matched along 10 potentially relevant mnemonic dimensions (e.g., Bonin et al., 2015), namely: relatedness[2] (Landauer, Foltz, & Laham, 1998), emotional valence, arousal, dominance[2], written frequency (Soares, et al., 2012), age of acquisition (Cameirão & Vicente, 2010; Marques, Fonseca, Morais, & Pinto, 2007), imageability, concreteness (Soares, Costa, Machado, Comesaña, & Oliveira, 2017), pleasantness (Félix, 2018) and number of letters; the descriptive values and statistical comparisons are reported in Table 1 (see Supplemental Material for the words used in the study). Two additional words selected using the same criteria (an animate and an inanimate) were used in the practice trials.

Procedure

This study used a 2 x 2 x 2 mixed design, with type of word (animate *vs*. inanimate) as a within-subject variable, and learning (incidental *vs.* intentional) and retention interval (immediate *vs.* delayed) as between-subjects variables. The proportion of correctly recalled words was the main dependent variable, although we explored the nature of intrusions as well.

After providing written consent, participants were tested in groups (5 to 30 participants per group). The instructions and stimuli (words) were projected as black uppercase letters in the center of a white screen in the participants' classroom and good visibility from all participants was ensured. Each word was presented for five seconds (as in Nairne et al., 2013), with a one-second inter-trial interval. The presentation order of the 24 words was previously determined in a pseudo-random fashion while certifying that each quarter of the list included three animate and three inanimate words (see Appendix). Order of presentation remained constant for all participants. Two practice trials preceded the presentation of the target list to allow familiarization with the task and presentation times.

In the encoding phase, about half of the participants was asked to memorize the presented words for a later free-recall task (intentional learning group, n = 111) and the other half was asked to rate the pleasantness of each word on a 5-point scale, ranging from *very unpleasant* (value of 1) to *very pleasant* (value of 5) (incidental learning group, n = 109). In the pleasantness rating task, each word was presented along with a number in the upper right corner which corresponded to a number in a paper sheet provided by the researcher (the words were not on the sheet); the rating of each word was recorded by the participant on the numbered sheet. After the presentation of the stimuli, all participants completed a one-minute distractor task (a consecutive subtraction task of three units starting with the number 597). About half of the participants (n = 125) then performed a free-recall task (immediate condition; this was a surprise memory task for the incidental learning group); the remaining participants (n = 95) performed the recall task after a 48-hour interval (delayed condition). In the encoding session, the participants from the intentional-delayed condition were instructed to memorize the presented words and told they would be asked to recall them at a later point in time. Participants from the incidental-delayed condition were simply instructed to rate the pleasantness of a set of words (no mention was made about the delayed task). In the recall phase all participants were asked to recall as many of the previously presented words as they could; this task came as a surprise for the participants in the incidental conditions.

All participants from the delayed conditions were unaware of the duration of the retention interval (as noted in the Participants' description, the data from those who inadvertently became aware of the duration of the delay interval were excluded). The testing environment for both the delayed and the immediate recall groups were similar as they were both classroom environments. The researcher was present in the room during data collection, which refrained participants from sharing information during the task.

Table 1. Statistical characteristics (Mean, Standard Deviation, p-value from the t-tests, and range of the evaluation scale) of the variables controlled between the animate and inanimate stimuli.

Dimension	Animate			Inanimate			*p-value*	Scale
	M	*SD*	*Range*	*M*	*SD*	*Range*		
Animacy [a]	6.71	0.11	6.53 - 6.89	1.59	0.21	1.22 - 1.91	<.001	1-7
Imageability [b]	5.99	0.31	5.49 - 6.50	5.98	0.33	5.50 - 6.52	.93	1-7
Concreteness [b]	6.29	0.35	5.55 - 6.72	6.36	0.44	5.53 - 6.84	.71	1-7
Age of acquisition [c,d]	3.05	1.02	1.91 - 5.08	2.81	0.68	1.56 - 3.82	.50	9 / 8
Pleasantness [e]	3.50	0.74	1.64 - 4.73	3.55	0.40	2.36 - 4.27	.74	1-5
Emotional valence [f]	5.86	0.84	4.60 - 7.13	5.64	0.52	4.81 - 6.42	.44	1-9
Arousal [f]	4.19	0.60	3.02 - 5.39	3.98	0.57	3.42 - 5.10	.39	1-9
Dominance [f]	5.22	0.60	4.44 - 5.84	5.04	0.51	4.29 - 5.83	.33	1-9
Written frequency [f]	104.35	171.46	2.96 - 625.71	35.49	32.14	2.71 - 112.21	.19	----
Number of letters	5.58	1.68	3.00 - 9.00	6.17	1.47	4.00 - 9.00	.37	----
Relatedness (LSA) [g]	0.08	0.09	-0.03 - 0.45	0.08	0.07	-0.05 - 0.27	.57	----

Notes: Written frequency mean values were medium to high, according to the authors (Soares et al., 2017). [a]Data from Félix, Pandeirada & Nairne (in preparation). [b]Data from Soares et al., 2017. [c]Data from Cameirão & Vicente, 2010. [d]Data from Marques et al., 2007; [e]Data from Félix, 2018; [f]Data from Soares et al., 2012. [g] Values determined using latent semantic analysis (Landauer et al., 1998). The presented Age of acquisition is a combination of data from [c] and [d] (r = .94; p = .01)

Responses for the pleasantness-rating task (incidental learning group), the distractor task, and the final recall task were provided on sheets of paper designed for each of these tasks and distributed by the researcher. To prevent eventual influences of time of day in performance (e.g., Hidalgo et al., 2004) and to keep a similar retention interval across groups, the delayed recall phase occurred at about the same time-of-day (± 3 hours) as the encoding phase. At the very end of the experiment, all participants provided sociodemographic data (age, gender and native language). Finally, all participants were debriefed about the true goals of the experiment. Participants from the incidental group were also asked to provide again their informed consent due to the unexpected nature of the memory task.

Data were analyzed using IBM SPSS Statistics 20. Mixed 3-Way ANOVAs (2 x 2 x 2) were conducted including the variables type of word (within-subject variable), retention interval and learning condition (between-subjects variables). Follow-up paired and independent t-tests were conducted to clarify significant interactions.

Results

As presented in Figure 1, a significant main effect of type of word was obtained[3], showing a higher proportion of recall of animate (M = 0.48; SD = 0.21) than inanimate words (M = 0.34; SD = 0.19), $F(1, 216) = 132.07$, $MSE = .015$, $p < .001$, $\eta^2_p = .38$. Of the total of 220 participants, 154 (70.0%) recalled a higher proportion of animate over inanimate words, whereas only 32 participants (14.5%) produced the opposite result. A main effect of the retention interval was also obtained, $F(1, 216) = 106.19$, $MSE = .042$, $p < .001$, $\eta^2_p = .33$, indicating significantly higher performance in the short (M = 0.50; SD = 0.15) than in the long retention interval (M = 0.29; SD = 0.15). The proportion of correct recall did not differ significantly depending on the nature of the learning task, $F(1, 216) = 0.40$, $MSE = .042$, $p = .842$, $\eta^2_p < .001$ (incidental learning: M = 0.41; SD = 0.19; intentional learning: M = 0.41; SD = 0.17).

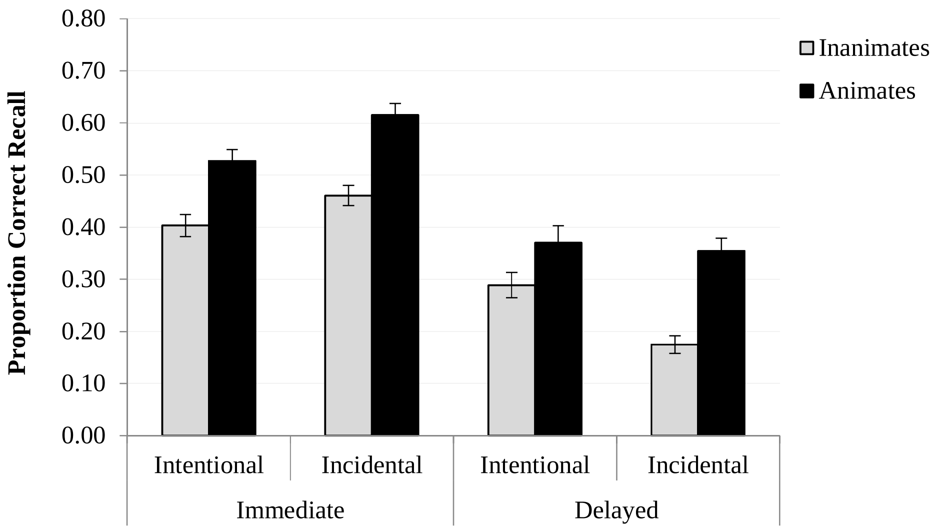

Figure 1. Mean proportion of correct recall across all conditions. Error bars represent standard errors of the mean.

The interaction between type of word and learning condition, $F(1, 216) = 7.58$, $MSE = .015$, $p = .006$, $\eta^2_p = .03$, as well as the interaction between retention interval and learning condition, $F(1, 216) = 12.07$, $MSE = .042$, $p = .001$, $\eta^2_p = .05$, reached levels of statistical significance. Regarding the first, follow-up paired t-tests revealed that participants recalled significantly more animate than inanimate words in both the incidental, $t(108) = 10.32$, $p < .001$, $d = 0.99$, and the intentional learning conditions, $t(110) = 6.47$, $p < .001$, $d = 0.61$. However, the animacy effect was larger in the incidental condition than in the intentional condition. Regarding the second significant interaction, an independent t-test revealed a significant effect of the retention interval in both incidental, $t(107) = 11.02$, $p < .001$, $d = 2.11$, and intentional, $t(109) = 4.37$, $p < .001$, $d = 0.85$, learning tasks. Again, the effect of the retention interval was larger in the incidental learning task. The lack of a significant interaction between animacy (type of word) and retention interval, $F(1, 216) = 0.15$, $MSE = .015$, $p = .704$, $\eta^2_p = .001$, as well as the nonsignificant 3-way interaction, $F(1, 216) = 2.03$, $MSE = .015$, $p = .156$, $\eta^2_p = .01$

suggests that the animacy effect is not influenced by the retention interval[4].

Even though we equated the animate and inanimate words on the pleasantness dimension based on previous data, variations might occur among samples. Therefore, we explored if the pleasantness ratings obtained in our sample between animates and inanimates remained equated. The number of non-rated words was similar across participants both for the animates and inanimates (M = 0.05, SD = 0.25 and M = 0.04, SD = 0.19, respectively; $t(108) = 0.33$, $p = .741$, $d = 0.03$). The average pleasantness values obtained for the animates was 3.43 (SD = 0.39) and for the inanimates it was 3.45 (SD = 0.28). A paired-sample t-test confirmed the lack of a significant difference on the pleasantness ratings between these two groups of words, $t(108) = 0.44$, $p = .663$, d = 0.04. The obtained values are very close to those obtained in the previous norming study (see Table 1).

Intrusions were classified as animate or inanimate by the first author, according to the animacy definition proposed by Nairne et al. (2013), that is, those that clearly represented a living thing were classified as animates and those that clearly represented a non-living thing were classified as inanimates. Seven words that could not be clearly classified according to these definitions (e.g., [*correr*] to run, or [*felicidade*] happiness) were not considered in this analysis. As can be seen in Table 2, intrusions were not frequent. The pattern of results obtained from the 3-way mixed ANOVA was the opposite of the one reported for correct recall. A significant main effect of type of intrusion was obtained $F(1, 216) = 13.87$, $MSE = .523$, $p < .001$, $\eta^2_p = .06$, but here, participants made more inanimate (M = 0.57; SD = 1.13) than animate (M = 0.33; SD = 0.68) intrusions. Also, a significant main effect of retention interval was obtained, $F(1, 216) = 38.26$, $MSE = .994$ $p < .001$, $\eta^2_p = .15$, reflecting the higher number of intrusions in the delayed (M = 1.55; SD = 2.00) than in the immediate (M = 0.41; SD = 0.77) recall condition. The main effect of learning condition also reached significance, $F(1, 216) = 8.50$, $MSE = .994$, $p = .004$, $\eta^2_p = .04$, denoting that the participants from the intentional groups committed more intrusions (M = 1.09; SD = 1.93) than those from the incidental learning task (M = 0.70; SD = 0.99).

The interaction between type of intrusion and retention interval, $F(1, 216) = 4.60$, $MSE = .523$, $p = .033$, $\eta^2_p = .02$, and the interaction between type of intrusion and learning condition, $F(1, 216) = 5.51$, $MSE = .523$, $p = .020$, $\eta^2_p = .03$, were also significant. The results of the follow-up paired t-tests, revealed that the difference between the number of animate and inanimate intrusions was larger in the delayed than in the immediate test [$t(94) = 2.69$, $p = .008$, $d = 0.28$, and $t(124) = 2.22$, $p = .028$, $d = .20$, respectively], and that the difference was significant when learning was intentional but not when it was incidental [$t(110) = 3.33$, $p = .001$, $d = .32$, and $t(108) = 1.64$, $p = .247$, respectively]. A significant interaction between retention and learning was also found, $F(1, 216) = 4.15$, $MSE = .994$, $p = .043$, $\eta^2_p = .02$; this was due to a larger increase on the number of intrusions from the immediate to the delay test when learning was intentional than when it was incidental. The 3-way interaction did not reach significance levels, $F(1, 216) = 0.59$, $MSE = .523$, $p = .443$, $\eta^2_p = .003$.

Table 2. Mean number of animate and inanimate intrusions (and standard deviations) in each of the four conditions.

Condition	N	Animate	Inanimate
Immediate Intentional	68	0.13 (0.34)	0.35 (0.66)
Immediate Incidental	57	0.16 (0.37)	0.16 (0.49)
Delayed Intentional	43	0.72 (1.14)	1.35 (1.93)
Delayed Incidental	52	0.46 (0.61)	0.65 (0.88)

N = number of participants in each condition.

Discussion

To the best of our knowledge, up to this point the animacy effect has been studied only using short retention intervals. However, the study of delayed recall periods is of major interest to help clarify the functional benefits of mnemonic tunings (e.g., Raymaekers et al., 2013), in this case, of animacy. As noted by Clark and Bruno (2016), “for an encoding procedure to be considered effective (…) information must be retained and be usable over a relatively lengthy period of time” (p. 1165). The present data suggest that the animacy effect is still present approximately two days after encoding, in both incidental and intentional learning tasks. Furthermore, this was the first test of this effect in a new language (European Portuguese) which used a new set of words.

Recent studies have suggested that the animacy effect is independent of intentionality of learning. Specifically, the animacy effect has been reported in both intentional and scenario-based incidental learning tasks (Gelin et al., 2017), after performing an animate-inanimate categorization task (Gelin et al., 2019), as well as when participants engage in incidental deep or shallow processing tasks (Leding, 2018). In our study, we directly compared an intentional with an incidental learning task considered to activate deep item-specific (instead of schematic or relational) processing: a pleasantness rating task (Burns, et al., 2013; Craik & Lockhart, 1972). The pleasantness rating task also seemed to be a good alternative to other incidental learning tasks (such as an animacy rating task) as it does not direct the participants' attention towards the variable that is being manipulated. In all, these findings show that the animacy effect remains robust across different forms of deep processing (either item-specific or schematic-based processing) and does not depend on the intentionality of learning.

Interestingly, we found a significant interaction between type of word and intentionality denoting a larger animacy effect when learning was incidental. It could be that during the incidental learning, animate items naturally captured more attention than inanimates affording better retention compared to the inanimate items. This increased attention to the animate items could also be occurring while trying to memorize the items (that is, when learning was intentional) but, in this case, the participants' own strategies to memorize the information might have mitigated the effect of increased attention to the animates; still, a strong animacy effect was obtained in this condition. Such explanation would be consistent with the idea that this mnemonic tuning can be at least partially mediated by an attentional priority to animates, as proposed by other authors (e.g., Bugaiska et al., 2018; Leding, 2018; Nairne et al., 2017; New, Cosmides, & Tooby, 2007). However, the data recently reported by Gelin et al. (2019) indicating that the size of the effect when learning was intentional did not differ from that obtained after an incidental learning animacy-categorization task are not easy to reconcile with this idea as full attention was being given to the animacy dimension in the latter condition. More research is needed to unpack the animacy effect under various encoding conditions, which, nevertheless seems to be a reliable effect regardless of form of encoding.

The manipulation of the retention interval also speaks to the role played by arousal in the animacy effect; a strong involvement of arousal in the effect would predict a larger animacy effect after a long retention interval, similarly to what has been reported in studies exploring the effect of arousal in memory (e.g., Kensinger, 2009). As noted earlier, studies that have controlled or manipulated the level of arousal conveyed by the animate and inanimate items suggest that arousal cannot fully account for the animacy effect (Leding, 2018; Meinhardt et al., 2018; Popp & Serra, 2018). The absence of a significant interaction of the animacy effect with retention interval in our study, along with the fact that our animate and inanimate lists were matched for both arousal and emotional valence, provides another form of evidence consistent with this conclusion.

The results from previous studies regarding the nature of the intrusions have been mixed with some studies obtaining significant differences in some of their experiments but not in others (e.g., Gelin et al., 2017; Leding, 2018; VanArsdall et al., 2016). Importantly, in all cases, the intrusions classified as inanimate outnumbered those classified as animates; in our case, this difference was significant. This result is also relevant to the discussion about the potential proximate mechanisms underlying this effect. In particular, more intrusions of a given type could denote a categorical or organizational-based recall strategy which normally improves recall (e.g., VanArsdall et al., 2016). The pattern of results that has been obtained across studies suggests that the animacy effect is not likely due to such strategies (see also VanArsdall et al., 2016). Other proximate mechanisms have also been explored, such as elaboration and interactive imagery (Bonin et al., 2015; Gelin et al., 2019) but, to this date, none has fully been able to account for this effect (Nairne et al., 2017).

A potential caveat to this study is the different group sizes across conditions which we were unable to control given the classroom-based sampling procedure that was used. However, the size of each group clearly exceeded the minimum required in our power analysis. The constant word order presentation may also be considered a limitation but the animacy effect has been demonstrated with various lists of words and in different countries. In addition, we presented the same proportion of animate and inanimate words in each quarter of the word list, and animacy has been shown to be a strong predictor of recall using a large variety of items (Nairne et al., 2013).

In conclusion, the current study replicated and extended the robustness of the animacy effect in memory. To our best knowledge, this is the first demonstration of the longevity of the animacy effect, which reinforces the ultimate adaptive value of this mnemonic effect. The outcomes concerning the intentionality of learning also support an adaptive account as people recalled more animate over inanimate words both when they were and were not aware they were performing a memory task. The lack of an interaction between the size of the effect and retention interval also reinforces the idea that this effect is not solely mediated by arousal.

Footnotes

1. The different group sizes across conditions are due to the nature of the procedure used to collect the data. Additionally, this procedure led to the exclusion of a large number of participants in the delayed condition and even more so in the incidental learning condition. Still, the number of participants per group exceeds the one that has been used in previous studies with similar comparisons (e.g., Gelin et al., 2017).

2. According to the study that provides norms for these dimensions, *Dominance* "reflects the degree of control a subject feels over a specific stimulus, varying from 'in control' to 'out of control'" (Soares et al., 2012, p. 257). *Relatedness* refers to semantic relatedness and was calculated using latent semantic analysis following Landauer et al. (1998).

3. The raw data files can be obtained by request to the authors or via our lab website.

4. We also repeated the same 3-way ANOVA including the participants from the incidental learning conditions who suspected they were performing a memory task or reported to have memorized the words (n = 26) and the participants from the delayed conditions who were aware of the duration of the retention interval (n = 26; only 15 of these performed the recall phase and were included in this analysis). The pattern of results was similar to that reported without these participants. However, in this overall analysis, the 3-way interaction also reached significance, $F(1, 257) = 4.40$, $MSE = .014$, $p = .04$, $\eta^2_p = .02$. Thus, even including participants who could carry a set of potential confounding variables, the main effects of animacy and of the retention interval remained significant.

References

Abel, M., & Bäuml, K.-H. T. (2013). Adaptive memory: The influence of sleep and wake delay on the survival-processing effect. *European Journal of Cognitive Psychology*, *25*, 917–924. doi: 10.1080/20445911.2013.825621

Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition*, *42*, 370–382. doi: 10.3758/s13421-013-0368-8

Bonin, P., Gelin, M., Laroche, B., Méot, A., & Bugaiska, A. (2015). The "how" of animacy effects in episodic memory. *Experimental Psychology*, *62*, 371–384. doi: 10.1027/1618-3169/a000308

Bugaiska, A., Grégoire, L., Camblats, A.-M., Gelin, M., Méot, A., & Bonin, P. (2018). Animacy and attentional processes: Evidence from the Stroop task. *Quarterly Journal of Experimental Psychology*, (advance online publication). doi: 10.1177/1747021818771514

Burns, D. J., Hart, J., Griffith, S. E., & Burns, A. D. (2013). Adaptive memory: The survival scenario enhances item-specific processing relative to a moving scenario. *Memory*, *21*, 695–706. doi: 10.1080/09658211.2012.752506

Calvillo, D. P., & Hawkins, W. C. (2016). Animate objects are detected more frequently than inanimate objects in inattentional blindness tasks independently of threat. *Journal of*

General Psychology, *143*, 101–115. doi: 10.1080/00221309.2016.1163249

Cameirão, M. L., & Vicente, S. G. (2010). Age-of-acquisition norms for a set of 1749 Portuguese words. *Behavior Research Methods*, *42*, 474–480. doi: 10.3758/BRM.42.2.474

Caramazza, A., & Shelton, J. R. (1998). Domain-specifc knowledge systems in the brain: The animate-inanimate distinction. *Journal of Cognitive Neuroscience*, *10*, 1–34. doi: 10.1162/089892998563752

Clark, D., & Bruno, D. (2016). Fit to last: Exploring the longevity of the survival processing effect. *Quarterly Journal of Experimental Psychology*, *69*, 1164–1178. doi: 10.1080/17470218.2015.1076864

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671–684. doi: 10.1016/S0022-5371(72)80001-X

Ebbinghaus, H. (1885). *Memory: A contribution to experimental psychology*. Leipzig: Duncker & Humblot.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. doi: 10.3758/BF03193146

Félix, S. B. (2018). Adaptive memory: The longevity and encoding independence of the animacy effect and its evidence in people with dementia. (Master’s thesis, University of Aveiro, Portugal).

Félix, S. B., Pandeirada, J. N. S., & Nairne, J. S. (in preparation). Animacy norms for 224 European Portuguese words.

Gelin, M., Bonin, P., Méot, A., & Bugaiska, A. (2018). Do animacy effects persist in memory for context? *The Quarterly Journal of Experimental Psychology*, *71*, 965–974. doi: 10.1080/17470218.2017.1307866

Gelin, M., Bugaiska, A., Méot, A., & Bonin, P. (2017). Are animacy effects in episodic memory independent of encoding instructions? *Memory*, *25*, 2–18. doi: 10.1080/09658211.2015.1117643

Gelin, M., Bugaiska, A., Méot, A., Vinter, A., & Bonin, P. (2019). Animacy effects in episodic memory: Do imagery processes really play a role? *Memory*, 27, 209-223, doi: 10.1080/09658211.2018.1498108

Hidalgo, M. P., Zanette, C. B., Pedrotti, M., Souza, C. M., Nunes, P. V, & Chaves, M. L. (2004). Performance of chronotypes on memory tests during the morning and the evening shifts. *Psychological Reports*, *95*, 75–85. doi: 10.2466/pr0.95.1.75-85

Kensinger, E. A. (2009). Remembering the details: Effects of emotion. *Emotion Review*, *1*, 99–113. doi: 10.1177/1754073908100432

Landauer, T. K., Foltz, P. W., & Laham, D. (1998). An introduction to latent semantic analysis. *Discourse Processes*, *25*, 259–284. doi: 10.1080/01638539809545028

Leding, J. K. (2018). The animacy advantage in memory: Manipulations of levels of processing and survival processing. *The American Journal of Psychology*, *131*, 273–281.

Li, P., Jia, X., Li, X., & Li, W. (2016). The effect of animacy on metamemory. *Memory & Cognition*, *44*, 696–705. doi: 10.3758/s13421-016-0598-7

Marques, J. F., Fonseca, F. L., Morais, S., & Pinto, I. A. (2007). Estimated age of acquisition norms for 834 Portuguese nouns and their relation with other psycholinguistic variables. *Behavior Research Methods*, *39*, 439–444. doi: 10.3758/BF03193013

Meinhardt, M. J., Bell, R., Buchner, A., & Röer, J. P. (2018). Adaptive memory: Is the animacy effect on memory due to emotional arousal? *Psychonomic Bulletin & Review*, *25*, 1399-1404. doi: 10.3758/s13423-018-1485-y

James S. Nairne, J. S., Coverdale, M. E., & Pandeirada, J. N. S. (2019). Adaptive memory: The mnemonic power of survival-based generation. Journal of Experimental Psychology: Learning, Memory, and Cognition. Doi: 10.1037/xlm0000687

Nairne, J. S., VanArsdall, J. E., & Cogdill, M. (2017). Remembering the living: Episodic memory is tuned to animacy. *Current Directions in Psychological Science*, *26*, 22–27. doi: 10.1177/0963721416667711

Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., Cogdill, M., & LeBreton, J. (2013). Adaptive memory: The mnemonic value of animacy.

Psychological Science, *24*, 2099–2105. doi: 10.1177/0956797613480803

New, J., Cosmides, L., & Tooby, J. (2007). Category-specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences*, *104*, 16598–16603. doi: 10.1073/pnas.0703913104

Opfer, J. E., & Gelman, S. A. (2011). Development of the animate-inanimate distinction. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of childhood cognitive development* (pp. 213–238). West Sussex: Wiley-Blackwell. doi: 10.1002/9781444325485

Packman, J. L., & Battig, W. F. (1978). Effects of different kinds of semantic processing on memory for words. *Memory & Cognition*, *6*, 502–508. doi: 10.3758/BF03198238

Popp, E. Y., & Serra, M. J. (2016). Adaptive memory: Animacy enhances free recall but impairs cued recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*, 186–201. doi: 10.1037/xlm0000174

Popp, E. Y., & Serra, M. J. (2018). The animacy advantage for free-recall performance is not attributable to greater mental arousal. *Memory*, *26*, 89–95. doi: 10.1080/09658211.2017.1326507

Radanovic, J., Westbury, C., & Milin, P. (2016). Quantifying semantic animacy: How much are words alive? *Applied Psycholinguistics*, *37*, 1477–1499. doi: 10.1017/S0142716416000096

Raymaekers, L. H. C., Otgaar, H., & Smeets, T. (2013). The longevity of adaptive memory: Evidence for mnemonic advantages of survival processing 24 and 48 hours later. *Memory*, *22*, 19–25. doi: 10.1080/09658211.2013.791321

Soares, A. P., Comesaña, M., Pinheiro, A., Simões, A., & Frade, C. (2012). The adaptation of the Affective Norms for English words (ANEW) for European Portuguese. *Behavior Research Methods*, *44*, 256–269. doi: 10.3758/s13428-011-0131-7

Soares, A. P., Costa, A. S., Machado, J., Comesaña, M., & Oliveira, H. (2017). The Minho word pool: Norms for imageability, concreteness and subjective frequency for 3800 Portuguese words. *Behavior Research Methods*, *49*, 1065–1081. doi: 10.3758/s13428-016-0767-4

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology*, *60*, 172–178. doi: 10.1027/1618-3169/a000186

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Cogdill, M. (2015). Adaptive memory: Animacy effects persist in paired-associate learning. *Memory*, *23*, 657–663. doi: 10.1080/09658211.2014.916304

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Cogdill, M. (2016). A categorical recall strategy does not explain animacy effects in episodic memory. *Quarterly Journal of Experimental Psychology*, *70*, 761–771. doi: 10.1080/17470218.2016.1159707

Disclosure of Interest

The authors report no conflict of interest.

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Appendix

Words used in the experiment and respective order presentation.

Presentation Order	European Portuguese Word	English Translation	Animacy
1	*Bebida*	Drink	Inanimate
2	*Escritor*	Writer	Animate
3	*Avião*	Airplane	Inanimate
4	*Sapo*	Toad	Animate
5	*Caneca*	Mug	Inanimate
6	*Atleta*	Athlete	Animate
7	*Chave*	Key	Inanimate
8	*Padre*	Priest	Animate
9	*Tesoura*	Scisors	Inanimate
10	*Cavalo*	Horse	Animate
11	*Cesto*	Basket	Inanimate
12	*Vaca*	Cow	Animate
13	*Rapaz*	Boy	Animate
14	*Relógio*	Clock	Inanimate
15	*Coruja*	Owl	Animate
16	*Laço*	Bow	Inanimate
17	*Candeeiro*	Lamp	Inanimate
18	*Rei*	King	Animate
19	*Massa*	Pasta	Inanimate
20	*Pomba*	Dove [+]	Animate
21	*Elevador*	Elevator	Inanimate
22	*Borboleta*	Butterfly	Animate
23	*Pintura*	Painting	Inanimate
24	*Mulher*	Woman	Animate

[+] Although the more correct translation of *pomba* would be "pigeon", we used the translation used in Soares et al., (2017), as well as their normative values.