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The Breadth of Animacy in Memory: New Evidence from Prospective Memory

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Keywords:	Animacy effect, Adaptive memory, Prospective memory

The Breadth of Animacy in Memory: New Evidence from Prospective Memory

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Author's Note:

Part of the results from Studies 1a and 1b were presented as posters at the 2021 APS Virtual Conference and the 62nd Annual Meeting of the Psychonomic Society (online; New Orleans LA, USA), and orally presented at the Research Summit 2020 and 2021 (Aveiro, Portugal). Study 2 was partly presented as a poster at the 63rd Annual Meeting of the Psychonomic Society (Boston MA, USA).

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Abstract

Studies using retrospective memory tasks have revealed that animates/living beings are better remembered than inanimates/non-living things (the animacy effect). However, considering that memory is foremost future-oriented, we hypothesized that the animacy effect would also occur in prospective memory (i.e., memory for future intentions). Using standard prospective memory (PM) procedures, we explored this hypothesis by manipulating the animacy status of the PM targets. Study 1a reports data collected from an American sample; these results were then replicated with a Portuguese sample (Study 1b). Study 2 employed a new procedure, and data were collected from a broader English-speaking sample. In these three studies, animate (vs. inanimate) targets consistently led to a better PM performance revealing, for the first time, that the animacy advantage extends to PM. These results strengthen the adaptive approach to memory and stress the need to consider animacy as an important variable in memory studies.

Keywords: Animacy effect; Adaptive memory; Prospective memory

Evolutionary Psychology postulates that human cognition (e.g., memory) evolved to help solve adaptive problems, such as finding food and shelter (Cosmides & Tooby, 1992; Nairne et al., 2017). Thus, researchers have hypothesized that there is a memory tuning for fitness-relevant information (i.e., information that enhances our odds of survival and/or reproduction). An example of fitness-relevant information relates to animacy, as animates are fitness-relevant in many ways (e.g., they can represent predators, prey, sexual mates, among others; Nairne et al., 2017). Animacy has been operationalized in many ways (e.g., as a synonym of *agency* and *livingness*; for an overview, see Félix et al., 2023). According to VanArsdall and Blunt (2022), the *livingness* construct loads highly onto the *animacy* factor; thus, animacy will be conceived here as *livingness* (as in most memory research; e.g., Nairne et al., 2013), or the distinction between living beings (e.g., humans and nonhuman animals) and nonliving things (e.g., objects). Indeed, people tend to remember animates better than inanimates, a phenomenon called the "animacy effect".

Since the first report showing that animacy is one of the best predictors of free recall (Nairne et al., 2013), the animacy effect has proved to be robust in retrospective memory tasks (i.e., memory for past events); it has been reported using a variety of procedures, types of to-be-encoded stimuli, and in different languages (e.g., free recall, with French words and pictures as the to-be-remembered stimuli: Bonin et al., 2014; metamemory/judgements of learning in English: DeYoung & Serra, 2021; implicit memory in Spanish: Laurino & Kaczer, 2019; working memory: Daley et al., 2020; directed forgetting in English: Murphy & Castel, 2022). There are, however, some circumstances in which evidence is less clear (e.g., recognition: Bonin et al., 2014; Leding, 2020; cued recall: Popp & Serra, 2016; but see VanArsdall et al., 2015).

Allied with the importance of retrieving information from the past, some authors have suggested that our memory is foremost future-oriented: one of our memory's main function is to store information from the past in order to help solve problems in the present and predict/get prepared for future events, which is crucial for survival (Ingvar, 1985; Klein, 2013; Nairne & Pandeirada, 2008; Schacter et al., 2007). This relates directly with prospective memory (PM), which is the memory for upcoming plans, events, actions or intentions to be performed in the future (Einstein & McDaniel, 1990). Everyday examples of PM tasks are to remember to deliver a message to a friend when he/she is encountered, to take the pills after lunch, or to remember to return books at the library the following day. Importantly, prospective memory tasks mostly involve other people (i.e., animates), and PM successes or failures can impact individuals themselves, as well as their relations with others, thus having clear adaptive consequences. For instance, there would be a benefit conferred by remembering to avoid cheaters in future encounters; likewise, remembering to maintain positive interactions with cooperators in the future would also be advantageous (Schaper et al., 2022). Failure to remember to pick up the kids from school or to remove a clamp from the patient's abdomen (Brandimonte & Ferrante, 2008; Dembitzer & Lai, 2003) also illustrate this point. In the present work, we aimed to combine these two adaptive elements—the animacy variable and prospective memory—and explore whether animates also confer an advantage in PM performance.

Prospective memory has been studied in the laboratory using several types of tasks (see Kvavilashvili and Ellis, 1996, for further details). Our work focused on event-based tasks, in which the moment to perform the intention is signaled by the presence of a specific event–the PM target (e.g., whenever you see John [target], give him a message [PM response]). Laboratory PM studies usually employ a dual-task paradigm, that is, the PM response occurs while another task is ongoing. In a typical procedure, participants first respond to the ongoing task (e.g., a lexical decision task) which provides a baseline to their performance on that task alone; these are called the *baseline trials*. Then, the PM instructions are presented: participants are tasked to provide an alternative response (the PM response) whenever specific targets appear (e.g., press F1 whenever the syllable "TOR" appears; McDaniel & Einstein, 2000) while performing the ongoing task. The trials involving the target words are the *target trials*, whereas those regarding the ongoing task are now named the *filler trials*. Although animacy has never been systematically manipulated or analyzed in PM (i.e., was not an independent variable in such studies), animates (e.g., animals) and/or inanimates (e.g., clothing, furniture) have been used as PM targets in event-based PM tasks (e.g., Chen et al., 2014; Marsh et al., 2009). For example, in one of the seminal works on PM (Einstein et al., 2005), among the targets we find an animate (*tortoise*), an inanimate (*dormitory*) and an ambiguous word (*tornado*; although classified as an inanimate, it can be perceived as an animate, due to the sense of self-propelled motion and agency; Lowder & Gordon, 2015). Other studies (e.g., Moyes et al., 2019) have asked participants to provide the PM response whenever targets from a specific category were presented, including categories of animate items (e.g., four-footed animals), ambiguous words (e.g., flowers, fruits), and inanimate words (e.g., metals); once again, no information was provided regarding the influence of animacy on PM performance.

Here, in a series of three studies, we explored the animacy effect in PM. We expected higher PM performance when the target was an animate (e.g., "horse"), comparatively to when it was inanimate (e.g., "shirt"). No strong predictions were made about the animacy effect for the baseline and filler trials. However, as it has been suggested that animates capture attention more automatically than inanimates (e.g., Bugaiska et al., 2019), the former would capture participants' attention and divert it from the ongoing task. As a result, it would be reasonable to anticipate a decline in the ongoing task (baseline and filler trials) presenting animate words compared to inanimate ones.

Again, our main interest was to explore the animacy effect on the PM target trials. Three factors explain the prediction of an animacy advantage in PM: First, both PM and the animacy variable entail adaptive value. Second, people tend to judge animates as more memorable than inanimates for a future memory test (e.g., DeYoung & Serra, 2021); considering that there is a correlation between those judgements of learning and the actual PM performance (Schnitzspahn et al., 2011), it is conceavable that an interplay among metacognitive judgments, animacy, and prospective memory may occur leading to an animacy advantage in PM. Third, most theories on PM were developed based on knowledge about retrospective memory functioning (McDaniel & Einstein, 2000). Consistently, several variables known to influence retrospective memory also influence prospective memory. For instance, emotional words/targets, as compared to neutral ones, enhance both retrospective (e.g., Dewhurst & Parry, 2000) and PM performance (Hostler et al., 2018; May et al., 2015). Also, Smith (2003) found that *distinctive words* (i.e., targets with a distinctive orthography, such as *sphinx*), as compared to *common orthography words*, improved both prospective memory and recognition performance. Given that animates (vs. inanimates) are best remembered in retrospective memory tasks (e.g., free recall: Nairne et al., 2013; working memory: Daley et al., 2020), one could expect the same advantage to occur in PM (e.g., see the relation between working memory and PM, Brewer et al., 2010).

Study 1a

This study used a well-known PM procedure: while performing an ongoing color-matching task (Smith & Hunt, 2014), participants were required to provide an alternative response (PM response) whenever either of two predefined target words (one animate and one inanimate) appeared. Across studies, we included a baseline phase (color-matching task only) and a PM phase (ongoing color-matching task with an embedded PM task). Of particular interest will be the results regarding the PM performance.

Method

Participants

Using G*Power 3.1.9.7 (Faul et al., 2007), we pre-determined that a sample size of 109 participants was needed to obtain a small-medium effect size, $dz = .35$, with $\alpha = .05$ and power = .95. A total of 351 Purdue University undergraduate students participated in exchange for course credits. Form those, 175 participants were excluded from the analyses: 51 participants were non-English native speakers; 54 did not provide any PM response; 42 reported having cheated and/or not paid attention to the study or had extremely long survey durations (> 7.4 hours; which may reveal low engagement with the task and/or low attention, or a start-and-stop behavior throughout the task despite the instruction to respond to the task in just one sitting); 13 participants did not recognize one (or both) target word(s) and did not provide any PM response to those target trials; 10 had more than 50% missing responses to the ongoing task; four participants had low performance on the filler trials/ongoing task (< Grand Mean - 3*SD*); and another participant was underaged. See Supplemental Materials for additional information about the sample.

The final sample was composed of 176 participants (31.3% females and 68.8% males; Mean age = 19.43; *SD* = 1.17). They were all English native speakers or bi-/multi-lingual [being proficient in English and other(s) language(s)]. Forty to 46 participants were allocated to each version of the task (see procedure).

Material

Animate and inanimate words were selected from VanArsdall (2016), which reports animacy norms for a large set of words. Sixteen words were selected for the baseline phase. For the PM phase, a new set of 24 filler and two pairs of targets words were selected to increase the generalizability of the results. Two additional words were selected for the practice trials. In all cases, half the words were animate and the other half were inanimate (see Supplemental Materials). The animate and inanimate words were matched along a number of relevant mnemonic variables (see Table 1).

Table 1.

Characterization of the Animate and Inanimate Words Used in Studies 1a, 1b and 2.

	Study 1a and Study 2								
	Baseline words (*n* = 16)			Filler words (*n* = 24)			Target words (*n* = 4)		
	Animates	Inanimates	*p*	Animates	Inanimates	*p*	Animate	Inanimate	*p*
Anim.[a]	6.83 (0.10)	1.07 (0.04)	***	6.84 (0.15)	1.01 (0.02)	***	6.78 (0.14)	1.02 (0.03)	**
AoA [b]	3.00 (0.48)	3.18 (0.24)	.408	2.95 (0.56)	3.33 (0.75)	.176	4.70 (1.83)	2.72 (0.22)	.366
Arou.[c]	4.85 (0.93)	3.96 (0.98)	.085	4.44 (0.53)	4.26 (0.70)	.506	5.42 (0.82)	4.11 (0.96)	.283
Conc. [d]	5.96 (2.92)	5.94 (2.87)	.896	5.94 (0.31)	5.95 (0.18)	.944	5.73 (0.21)	6.08 (0.23)	.263
Dom.[c]	5.44 (0.99)	5.11 (0.47)	.412	5.38 (0.55)	5.28 (0.40)	.618	5.43 (0.83)	4.61 (0.24)	.385
Fam.[d]	5.37 (0.60)	5.63 (0.45)	.332	5.42 (0.48)	5.60 (0.39)	.306	5.36 (0.01)	5.71 (0.29)	.341
Freq.[e]	100.88 (93.35)	54.63 (58.74)	.259	41.33 (63.42)	27.83 (20.34)	.495	24.00 (9.90)	65.00 (15.56)	.108
Img.[d]	6.07 (1.86)	5.97 (2.37)	.379	5.98 (0.18)	5.95 (0.15)	.637	5.84 (0.47)	6.03 (0.23)	.673
Length	4.50 (1.07)	5.50 (1.93)	.226	4.75 (1.48)	4.75 (0.87)	>.99	5.50 (0.71)	5.50 (0.71)	.999
Val.[c]	6.26 (0.98)	5.94 (0.98)	.468	5.85 (1.05)	5.64 (0.85)	.612	6.61 (0.75)	6.12 (0.04)	.525
	Study 1b								
	Baseline words (*n* = 16)			Filler words (*n* = 24)			Target words (*n* = 4)		
	Animates	Inanimates	*p*	Animates	Inanimates	*p*	Animate	Inanimate	*p*
Anim.[f]	6.65 (0.12)	1.52 (0.11)	***	6.76 (0.06)	1.50 (0.08)	***	6.64 (0.10)	1.44 (0.06)	**
AoA [g]	3.03 (1.02)	2.34 (0.62)	.130	2.54 (0.67)	2.87 (0.90)	.302	1.66 (2.34)	2.11 (0.48)	.831
Arou.[h]	4.36 (0.40)	3.89 (0.69)	.120	4.15 (0.39)	4.05 (0.44)	.586	2.85 (4.03)	3.27 (NA)	NA
Conc.[i]	6.38 (0.21)	6.36 (0.40)	.890	6.42 (0.38)	6.46 (0.30)	.785	6.11 (0.05)	6.71 (0.01)	.033
Dom.[h]	5.08 (0.58)	5.13 (0.61)	.868	5.17 (0.45)	5.11 (0.45)	.742	1.89 (2.67)	4.45 (NA)	NA
Freq.[i]	21.15 (23.35)	58.87 (82.03)	.246	21.81 (24.13)	24.49 (39.83)	.844	24.40 (33.94)	17.82 (5.72)	.830
Img.[i]	5.64 (0.22)	5.84 (0.32)	.155	6.05 (0.30)	6.06 (0.27)	.972	5.24 (0.56)	5.96 (0.29)	.284
Length	5.63 (1.19)	5.50 (1.31)	.844	5.50 (1.57)	6.00 (1.28)	.401	5.50 (0.71)	6.50 (0.71)	.293
S.Freq. [i]	4.50 (1.10)	5.15 (1.19)	.275	4.69 (0.93)	4.91 (1.16)	.623	3.82 (1.15)	5.36 (1.19)	.317
Val.[h]	5.54 (0.87)	5.80 (0.55)	.495	6.04 (1.00)	5.60 (0.70)	.258	2.01 (2.84)	5.55 (NA)	NA

Notes: Mean values presented, with standard deviations in parentheses; *n* = Number of words (containing half animate and half inanimate); NA = Not Available; *p* = p-value obtained by independent t-tests (animate vs. inanimate); Baseline words = Words used in the baseline trials; Filler words = Filler words used in the PM phase; Target words = Words used in the target trials in the PM phase.

Anim. = Animacy; AoA = Age of Acquisition; Arou. = Arousal; Conc. = Concreteness; Dom. = Dominance; Val. = Emotional Valence; Fam. = Familiarity; Freq. = Written frequency; Img. = Imagebaility; Length = number of letters of the words; S. Freq. = Subjective Frequency.

Word data for Studies 1a and 2 retrieved from: [a] VanArsdall and Bunt (2022) [7-point scale]; [b] Cortese and Khanna (2008) and Schock, Cortese, Khanna, et al. (2012) [7-point scale]; [c] Bradley and Lang (1999) [9-point SAM scale]; [d] MRC database (Wilson, 1988) [transformed into a 7-point scale]; [e] Kucera and Francis (1967) as available in the MRC database (Wilson, 1988). Baseline words: The word "jug" missed values for concreteness and imageability; No age of acquisition information was available for the words "umbrella" and "horse". Filler words: No data on emotional valence, arousal and dominance were available for the words "monkey" and "jacket". Target words: Data on emotional valence, arousal and dominance for the word "phone", and data on AoA for the word "dancer" were retrieved from VanArsdall (2016).

Word data for Study 1b retrieved from: [f] Félix et al. (2020) [7-point scale]; [g] Average data from Cameirão & Vicente (2010) and Leitão et al. (2010) [transformed to a 7-point rating scale]; [h] Soares et al. (2012) [9-point SAM scale]; [i] Soares et al. (2017) [7-point scale]. Target words: Data on emotional valence, arousal, and dominance for the word "camisa [shirt]" were not available in the few existing European Portuguese databases that also contain a reduced number of words.

*** *p value* < .001; ** *p value* < .01

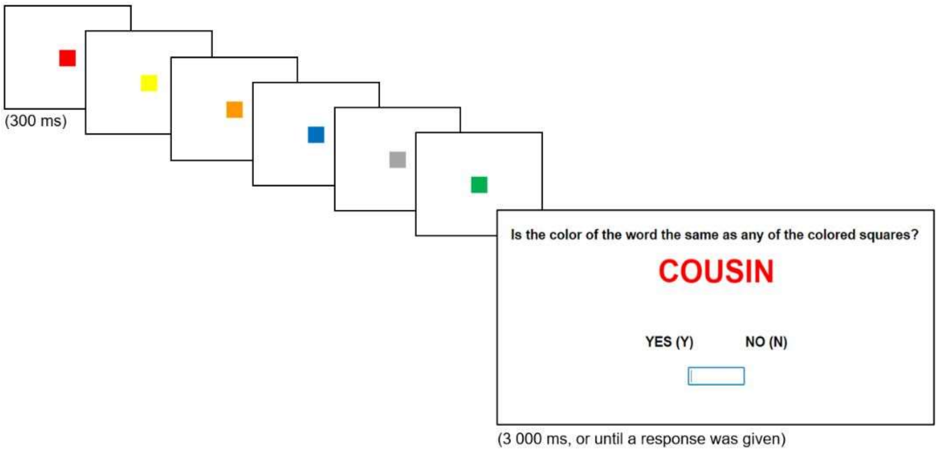
Procedure

Data were collected online using Qualtrics, in sessions lasting, on average, 25 minutes. The procedure was similar to that used by Smith and Hunt (2014), except that words were presented in a fixed order to every participant (their order was pseudo-randomized, ensuring that each quarter of the list had a balanced number of animates and inanimates), and we used fewer trials, aiming for a shorter task; however, we used the same proportion of target trials during the PM phase as in their work (~8%). There were two predetermined presentation orders in the PM phase to ensure that, in each position of the list, an animate and an inanimate item was presented an equal number of times across participants. We also used one out of two sets of PM targets (*dancer* and *bottle* / *nurse* and *phone*) in each of these versions; their presentation order was predetermined within the list of items and counterbalanced across participants such that, animate and inanimate targets appeared equally in each target position. Therefore, there were four versions of the task to which participants were randomly assigned.

After consenting to participate, participants received the instructions for the ongoing task. Specifically, they were told that six colored squares would be presented, one at a time, each one in a different color (red, yellow, blue, green, pink, orange, or gray). Then, a word would be presented in a colored font. Participants had to decide whether the color font of the word matched the color of any of the just-presented squares by pressing the Y (yes) or the N (no) keys (see Fig. 1 for an illustration of the procedure). Participants started by responding to two practice trials to get familiar with the task. Then, they were reminded of the ongoing task instructions and performed the baseline phase (16 trials; color-match ongoing task only). Throughout the experiment, half of the trials (animate and inanimate) were match-trials (i.e., the color font matched the color of a square), and the other half were nonmatch-trials.

Fig. 1.

Example of a Match-trial, and Representation of the Presentation Times of Each Stimulus (Study 1a)



Note. In this example, the colors of the squares are presented in the following order: red, yellow, orange, blue, gray, and green. The word "COUSIN" is in a red-colored font; the correct response for this trial would be Y (yes).

After the baseline phase, participants read the PM task instructions which informed them that they were to memorize two new words (an animate and an inanimate word; PM targets). Also, participants were told they would need to press the SPACEBAR (PM response), instead of Y/N, whenever any of these words appeared during the color-matching task. The target words were then displayed simultaneously for one minute. A 2-min distractor task followed (a 3D mental rotation task; Ganis & Kievit, 2015) to prevent participants from rehearsing the PM instructions.

Next, the PM phase began without further reminders of the PM instructions. In this phase, participants were presented with two target- and 24 filler-words (half animate, half inanimate). To increase the number of PM target trials during the task, each target was presented twice. The filler words were also repeated to prevent target words from becoming distinctive (Smith, 2003); they appeared in a different color each time, once in a match and once in a nonmatch-trial, totalizing 48 filler trials. The PM target trials were presented in the 11^{th}, 24^{th}, 36^{th}, and 51^{st} trials/positions of the list.

Upon completion of the PM phase, participants were asked to recall the instructions they received for the task. They also performed a target recognition test: participants were presented with a short series of six words, one at a time, and asked whether each word corresponded to a PM target (yes/no); both the targets presented in the task and four lures (half animates and half inanimates) from the PM phase were presented. A color-naming task followed. These words and colors were presented one at a time, in a random order for each participant. Finally, participants provided sociodemographic information (age, gender, and native language); also, they responded to "honesty questions" regarding whether they paid attention and answered honestly to the task (Rouse, 2015). They were asked to provide optional feedback regarding the study, were thanked, and debriefed.

Data Analyses

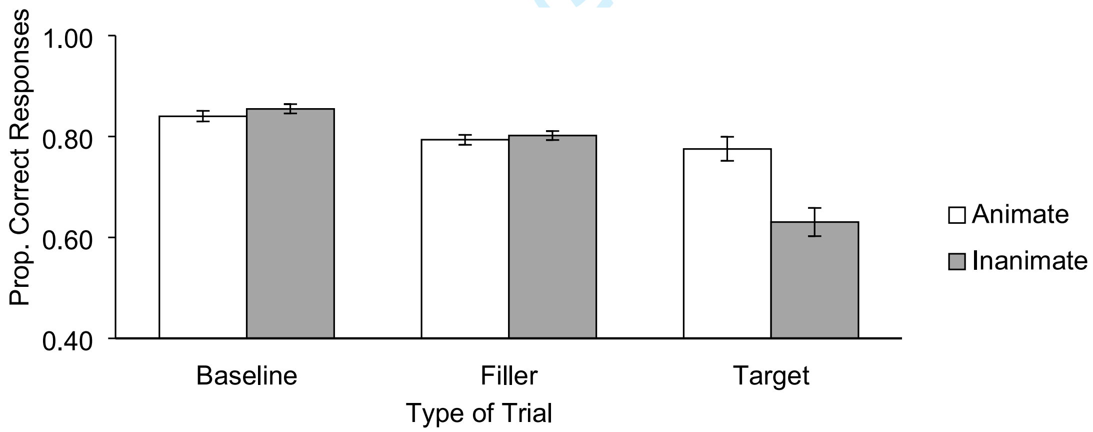
Data from all the three studies were analyzed using SPSS 28. The main dependent variable was the proportion of correct responses (i.e., press the correct key—Y, N, or SPACEBAR—in match, nonmatch and target trials, respectively). We conducted a 2 (Animacy: animates vs. inanimates) x 3 (Type of trial: baseline vs. filler vs. target) repeated measures ANOVA (we report the Greenhouse-Geisser corrected data as the sphericity assumption was violated in all analyses). We used additional paired-sample t-tests with Bonferroni corrections ($p < .05/3$) to clarify some results. Supplemental Materials present additional analyses, namely: on response times, excluded participants, false alarms, as well as data confirming that the overall results here reported hold when we consider the different sets of PM targets used across experiments.

Results

Results are presented in Fig. 2. A significant Animacy main effect was observed, *F*(1, 175) = 12.48, $p = .001$, $\eta_p^2 = .067$, revealing that performance was better for the animate than the inanimate stimuli. The main effect of Type of trial also reached significance, *F*(1.29, 224.89) = 38.87, $p < .001$, $\eta_p^2 = .166$. A significant Animacy X Type of trial interaction was also obtained, *F*(1.20, 209.31) = 18.36, $p < .001$, $\eta_p^2 = .095$. The follow-up paired t-tests performed on each type of trial revealed that the animacy advantage was significant only on the target trials, *t*(175) = 4.39, $p < .001$, *dz* = .33. No animacy advantage was obtained for the baseline, *t*(175) = -1.27, $p = .206$, or filler trials, *t*(175) = -1.08, $p = .281$.

Fig. 2.

Mean Performance Obtained in Baseline, Filler (Ongoing Task) and Target Trials (PM Task), in Study 1a. Error Bars Represent Standard Errors of the Mean



Study 1b

Study 1a was the first study reporting an animacy advantage in PM: animate targets elicited better PM performance than the inanimate targets did. As with any first discovery, more empirical evidence is needed for the effect to be considered reliable. Study 1b aimed to replicate the findings from Study 1a with a group of participants from another country and language. The same procedure was employed, except that participants in this study were Portuguese, and a new set of stimuli was selected from existing norms for European Portuguese.

Method

Participants

Using G*Power 3.1.9.7, *N* was set as 76 participants (α = .05, power = .85) to achieve a small to medium effect size (*dz* = .35). A convenience sample of 163 university students participated in exchange for course credits or a prize draw. From those, 85 participants were excluded from the data analysis: 38 did not provide any PM response; 18 were non-naïve as they took part in other PM studies from our lab; 14 participants stated not having paid attention, having cheated during the experiment, or had extremely long survey durations (> 3.7 hours); 10 were non-European Portuguese native speakers or did not reveal their native language; two did not recognize one target and did not provide PM responses to those target trials; one gave no responses to more than 50% of the ongoing task trials; another was excluded due to a technical problem with the stimuli presentation; and another was underaged. Additional information is available in the Supplemental Materials.

The final sample was composed of 78 European Portuguese native speakers (Mean age = 21.60; *SD* = 4.39; one participant was a Portuguese-English bilingual). Of those, 82.1% identified themselves as females, 16.7% as males, and 1.3% preferred not to reveal their gender. Each version of the task had 17 to 22 participants.

Material and Procedure

The procedure was the same as in Study 1b, except that participants were asked to press S or N, for Yes [*Sim*] or No [*Não*] responses, respectively. Animate and inanimate

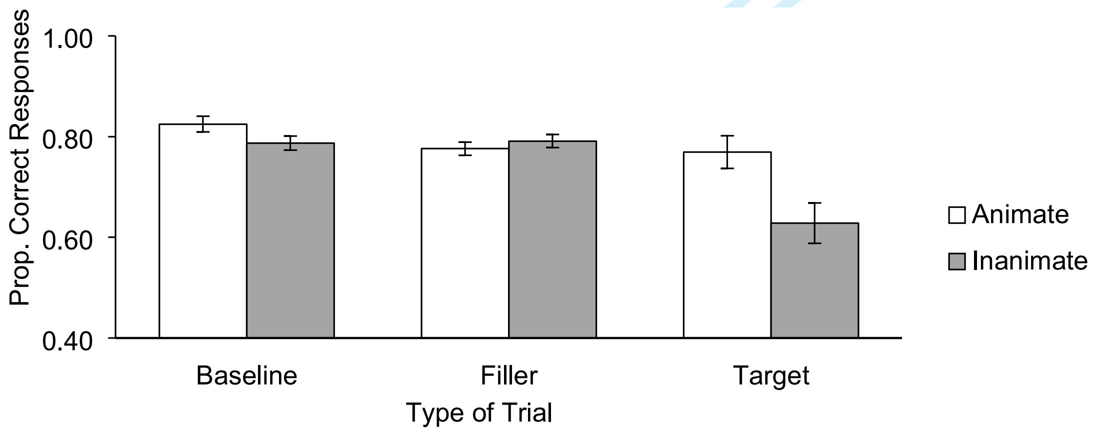
European Portuguese words were selected from Félix et al. (2020) and matched along several variables (Table 1; selected words available as Supplemental Materials). Participants took, on average, 33 minutes to complete the task.

Results

Results are depicted in Fig. 3. The Animacy main effect was significant, $F(1, 77) = 10.96$, $p < .001$, $\eta_p^2 = .125$, as was the Type of trial main effect, $F(1.28, 98.77) = 10.21$, $p < .001$, $\eta_p^2 = .117$. Furthermore, the Animacy X Type of trial interaction reached significance, $F(1.33, 102.50) = 6.29$, $p = .002$, $\eta_p^2 = .076$. Follow-up paired t-tests revealed, again, a significant animacy advantage only on the target trials, $t(77) = 2.93$, $p = .005$, $dz = .33$. No animacy effect was obtained in the filler, $t(77) = -1.11$, $p = .270$, or on the baseline trials, $t(77) = 2.15$, $p = .035$ (a non-significant result considering the Bonferroni correction).

Fig. 3.

Mean Performance Obtained in Baseline, Filler (Ongoing Task) and Target Trials (PM Task), in Study 1b. Error Bars Represent Standard Errors of the Mean



Study 2

Study 1b replicated the findings from Study 1a: the animacy effect was obtained on PM target trials. In Study 1b, a new set of stimuli was used, and the study was conducted with participants from another country and language, allowing the generalizability of the results and revealing that the effect is not language dependent. Looking for more evidence of the animacy effect in PM, Study 2 used a new ongoing task (a visuospatial task) as the main procedure.

Method

Participants

The sample size was calculated as in Study 1b. A total of 130 participants were recruited from Testable Verified Minds (https://www.testable.org/) using the following pre-screeners: age (18-40 years old), first language (English), location (USA, UK, Ireland, New Zealand, Canada, or Australia). Following the pre-registered exclusion criteria, 51 participants were excluded: 22 did not perform any PM response; 16 had a low performance in the filler trials (< Grand Mean - 3*SD*); five participants were non-English native speakers or preferred not to reveal their native language; three participants did not provide any response to 50% or more trials; another three did not recognize one of the targets and did not perform any PM response to those target trials; and, another two failed both attention checks. Additional information is available as Supplemental Materials.

Seventy-nine participants were included in the data analysis (Mean age = 30.33; *SD* = 6.52; one participant did not reveal his/her age; 48.1% were females and 51.9% males). Seventeen to 22 participants responded to each version of the task.

Material and Procedure

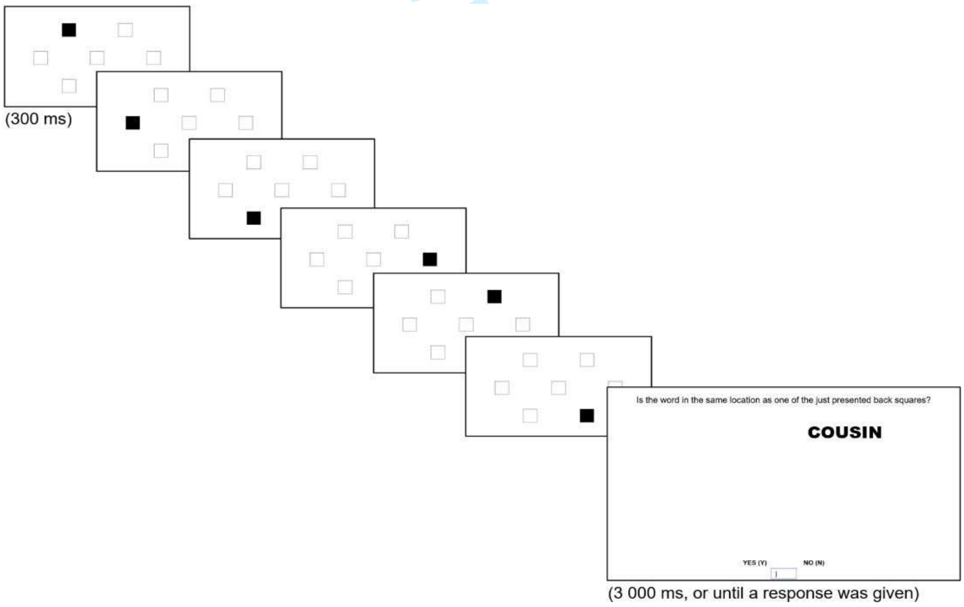
We used the same stimuli and procedure as in Study 1a, except for the ongoing task: participants now performed a visuospatial task. Also, the distractor task was an even/odd task. Finally, the experiment presented two attention checks: one right after the practice and the other after the baseline phases ("Have you ever walked on Mars?" and "Can you fly with invisible wings?" – yes/no responses), which served to exclude inattentive participants (i.e., those who responded "yes" to both questions; VanArsdall, 2016). On average, the experiment lasted 26 minutes.

In the ongoing task (

Fig. 4), inspired by Costa et al. (2013), seven white squares were displayed on the screen. One at a time, six of them turned black, each one in a different location. Then, a word was presented in one of the seven possible square positions. The participants had to decide if the word's location matched the location where a black square was displayed by pressing Y (yes) or N (no). For the PM phase, participants were instructed to press the SPACEBAR whenever any of the targets (an animate and an inanimate) was presented while performing the ongoing task.

Fig. 4.

Example of a Match-trial, and Representation of the Presentation Times of Each Stimulus (Study 2)



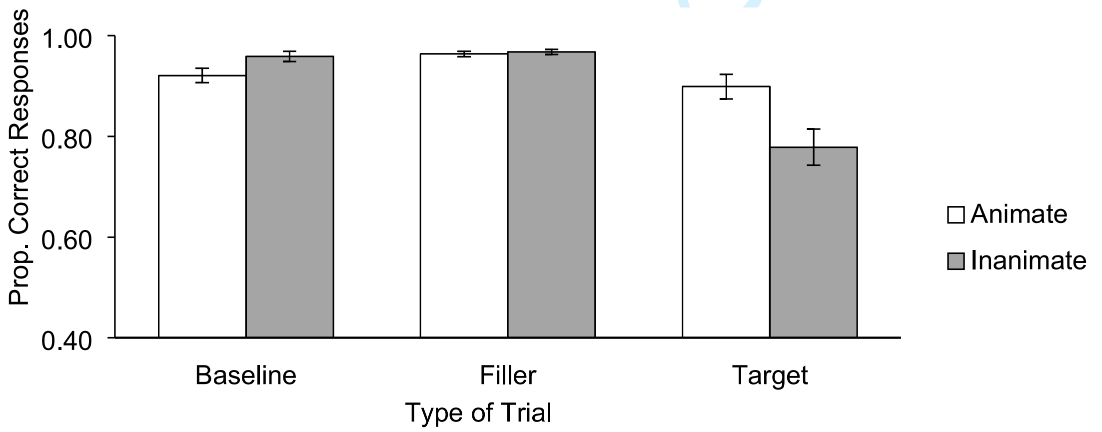
Results

Results are depicted in

Fig. 5. The Animacy main effect did not reach conventional levels of significance, $F(1, 78) = 3.51$, $p = .065$, $\eta_p^2 = .043$, but the main effect of Type of trial was significant, $F(1.32, 103.24) = 19.18$, $p < .001$, $\eta_p^2 = .197$. The Animacy X Type of trial interaction was also significant, $F(1.22, 95.03) = 11.83$, $p < .001$, $\eta_p^2 = .132$. This was due to a higher performance for inanimate (vs. the animate) words in the baseline trials, $t(78) = -2.99$, $p = .004$, $dz = -.34$; and, more importantly, due to a significantly higher PM performance towards animate targets, as compared to the inanimate ones, $t(78) = 3.05$, $p = .003$, $dz = .34$. No animacy effect was obtained on the filler trials, $t(78) = -0.70$, $p = .486$.

Fig. 5.

Mean Performance Obtained in the Baseline, Filler (Ongoing Task) and Target Trials (PM Task), in Study 2. Error Bars Represent Standard Errors of the Mean



General Discussion

The proposal that memory should be tuned to remembering animates/living beings (as compared to inanimates/nonliving things) follows from the assumption that animates typically have a high fitness-relevant value (Nairne et al., 2017). Empirical evidence of the animacy advantage exists in retrospective memory but not in prospective memory. Combining two adaptive features of memory—its tuning toward animates and its future orientation—we predicted that the animacy effect would also occur in PM.

In a series of three studies using typical PM procedures, we reported, for the first time, that PM is also sensitive to the animacy dimension, at least in the type of tasks employed here (event-based tasks; cf. Einstein & McDaniel, 2005). Indeed, PM performance was consistently better in response to animate than to inanimate targets. Most participants had better performance for the animate targets (62% in Study 1a and in Study 2; and 55% in Study 1b), a smaller percentage had better PM performance for the inanimates (20%, 26% and 21% in Studies 1a, 1b and 2, respectively), and there were around 19% ties across studies (i.e., equal performance for animates and inanimates)[1]. We should note that, in each study, we only used two different PM targets (one animate and one inanimate) to prevent a high cognitive load and, consequently, low levels of PM performance (Anderson et al., 2019), while maintaining the usual proportion of target/ongoing trials (Smith & Hunt, 2014). Still, we opted to use different sets of possible targets to increase the generalizability of our results. It is also noteworthy that the present results were obtained using different ongoing tasks and in two languages (Portuguese and English), which further reinforces the relevance and generalizability of the present findings.

Considering that knowledge about PM has been derived from retrospective memory theories, we consider how the two main accounts that have been proposed to explain the animacy effect in that context might explain the current results: the attention-based and the richness of encoding accounts. The richness of encoding account suggests that animates tend

[1] For these analyses, participants performing at 100% on the PM task were excluded, as no room existed for a possible effect to occur (59 participants in Study 1a, 20 in Study 1b, and 45 in Study 2).

to be better recalled because they naturally lead to the generation of more ideas and/or have more features than inanimates (e.g., Meinhardt et al., 2020; Rawlinson & Kelley, 2021). Those ideas/features/associates potentially work as retrieval cues and might improve performance (for animates) in free recall. When the existence of multiple cues is irrelevant to the task at hand, such as in cued recall, there is sometimes no animacy effect (e.g., Popp & Serra, 2016). In the case of PM, having multiple cues associated with the target could hinder the access to the PM intention memory trace (association: target-intention), thus impairing the PM performance for the animate targets (McDaniel & Einstein, 2000). In the same vein, a previous study has shown that when the PM target is paired with other words/associates in a study phase, the PM performance decreases; also, the more associates are paired with the PM target, the lower the PM performance is (Cook et al., 2006). All together, these data, along with the present findings, suggest that the richness of encoding is unlikely to account for the animacy advantage reported here. As the main aim of this work was to explore, for the first time, a possible animacy advantage in PM, further studies using procedures designed specifically to disentangle the potential mechanisms are needed.

The attentional account posits that animates tend to be better recalled because they recruit attentional resources in a more automatic manner, thus requiring lower activation thresholds to be detected (e.g., Bugaiska et al., 2019). In our studies, the monitoring of the animate targets during the PM task might have benefited from this automatic-attention capture; that is, their detection would be facilitated as compared to the inanimate items, promoting more correct PM responses.

Following this latter account, one could also speculate about possible effects of animacy on the baseline and filler trial performance. In particular, the automatic attention captured by animates could impair performance in these trials as compared to the inanimate ones. Such a prediction was confirmed only in our Study 2, whereas no effect of animacy was observed in neither Study 1a or 1b. Moreover, the response time data has also been used as an indicator of the attentional mechanisms associated with animacy. For example, the response times in a color-naming Stroop task are longer when the word refers to an animate than to an inanimate (e.g., Bugaiska et al., 2019). In our case, no effect of animacy was found on the response times of the baseline and filler trials (see Supplemental Materials). In sum, the predictions based on this account are not consistent with our results (see also Rawlinson & Kelley, 2021), revealing that the animacy effect in PM may not be explained solely by the attention-prioritization account. Other studies manipulating the characteristics of the target and the baseline/filler words, for example, in terms of emotionality, have found similar results: an enhancement of the PM performance for the emotional (target) words, as compared to the neutral ones, but no difference between them on the ongoing task (filler trials; May et al., 2012).

All in all, the present work reinforces the importance of animacy in memory functioning and adds PM to the list of processes that benefit from animacy. Additionally, not considering such variable might lead to disparate results. For example, emotionally-valenced items are more likely to involve animates than neutral ones (e.g., May et al., 2012, 2015). Prospective memory research has also used materials that are ambiguous with respect to animacy (Félix et al., 2023; Lowder & Gordon, 2015). These include categories such as fruits, plants, body parts and natural forces (e.g., Guynn, 2003; Moyes et al., 2019; Thomas & McBride, 2016). At this point we cannot inform if and how this animacy category affects PM. Finally, we would encourage researchers to consider the variable of animacy when selecting their research materials, as is usually done for other variables (e.g., arousal, word frequency; May et al., 2012). Recent work has reported some differences on animacy ratings depending on the participants' language and age; thus, specific language and age-group norms should be used (Félix et al., 2023).

Besides the theoretical relevance of the animacy effect in PM, one can speculate about the potential interest of these results to more applied contexts. Considering that PM is crucial to maintain a functional and independent life, one needs (and uses) PM ubiquitously. At the same time, most of our daily memory failures are PM-related (Cockburn, 1995), which can have severe consequences (e.g., a surgeon forgetting to remove a clamp at the end of surgery; Dembitzer & Lai, 2003). Thus, it is crucial to find the best tools to improve PM functioning. Our results suggest that using the naturally existing mnemonic tuning toward animates might be one such tool.

Declarations

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Conflicts of interest/Competing interests

The authors have no competing interests to declare.

Ethics approval

All studies were conducted in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Study 1a was approved by the Purdue IRB (Ref: 1301013109). Study 1b was approved by the Ethics and Deontology Committee of the University of Aveiro (Ref: 34/2019). Study 2 was approved by the City, University of London Psychology Research Ethics Committee (Ref: ETH2122-0271).

Consent to participate

All individual participants provided their informed written consent prior to take part in the study.

Consent for publication

All individual participants provided their written informed consent regarding publishing their anonymized data.

Availability of data and materials (data transparency)

The datasets generated during and/or analyzed during the current study are available in the OSF repository, https://osf.io/g6uqt/?view_only=f6071ae74b824740b98cc6698ed8c97e.

Code availability (software application or custom code)

Not applicable

Authors' contributions

All authors contributed to the design of the studies, the selection of the materials, and the discussion of the results. SBF programmed the experiments, and collected and analyzed the data with the contribution of JNSP. SBF wrote the first draft of the manuscript. All authors revised, edited, and approved the final version of the manuscript for submission.

Open Practices Statement

The data for all studies are publicly accessible via OSF (https://osf.io/g6uqt/?view_only=f6071ae74b824740b98cc6698ed8c97e). The materials used in all studies are available as Supplemental Materials. At the time Studies 1a and 1b were conducted, preregistration was not yet a common practice. Study 2 was preregistered before starting data collection (available at: https://aspredicted.org/P2Y_592).

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The Breadth of Animacy in Memory: New Evidence from Prospective Memory

Supplemental Material

Words Used in Studies 1a, 1b and 2

Selected Words for Study 1a and Study 2

	Animate words	Inanimate words
Practice phase	COUSIN	SHIRT
Baseline phase	BOY	BUILDING
	DOCTOR	CROWN
	DOVE	JUG
	HORSE	KEY
	KING	PENCIL
	LION	PILLOW
	RABBIT	PLANE
	WIFE	UMBRELLA
PM phase: Filler words	BROTHER	BOWL
	CAT	CELLAR
	FROG	COIN
	HAWK	DRESS
	LAMB	FLAG
	MONKEY	FORK
	OWL	GOLD
	PRIEST	JACKET
	QUEEN	KETTLE
	RAT	LAMP
	TEACHER	STOVE
	WOMAN	TRUCK
PM phase: Target words		
Version DB	DANCER	BOTTLE
Version NP	NURSE	PHONE

Supplemental Material 2

Selected Words for Study 1b

	Animate words		Inanimate words	
	Portuguese word	**English translation**	**Portuguese word**	**English translation**
Practice phase	BORBOLETA	BUTTERFLY	CANDEEIRO	LAMP
Baseline phase	COELHO	RABBIT	BARRIL	BARREL
	DENTISTA	DENTIST	BEBIDA	DRINK
	DOUTOR	DOCTOR	CARTA	LETTER
	FALCÃO	HAWK	CHAPÉU	HAT
	IRMÃO	BROTHER	LAÇO	RIBBON
	PADRE	PRIEST	MESA	TABLE
	RAPAZ	BOY	PAPEL	PAPER
	SAPO	FROG	REBUÇADO	CANDY
PM phase: Filler words	ADULTO	ADULT	BANCO	BANK
	ATOR	ACTOR	CADEIRA	CHAIR
	CÃO	DOG	CESTO	BASKET
	CORUJA	OWL	CHAVE	KEY
	CRIANÇA	KID	DIAMANTE	DIAMOND
	ESCRITOR	WRITER	GARRAFA	BOTTLE
	GALINHA	CHICKEN	LÁPIS	PENCIL
	GATO	CAT	MARTELO	HAMMER
	PÁSSARO	BIRD	OURO	GOLD
	POMBA	DOVE	TARTE	PIE
	PORCO	PIG	TESOURA	SCISSORS
	VACA	COW	VESTIDO	DRESS
PM phase: Target words				
Version CJ	CAVALO	HORSE	JANELA	WINDOW
Version AC	ATLETA	ATHLETE	CAMISA	SHIRT

Details about the Procedure, Data Analyses and Fine-Grained Results

Additional Information about Excluded Participants

The PM literature is not consistent regarding the inclusion/exclusion of participants who did not provide any correct PM response (e.g., Horn & Bayen, 2015, included those participants, while Gilbert, 2015, excluded them). In our study, as data were collected online, we opted to exclude those participants because missing PM responses could be due to a normal PM failure, or to other non-controlled factors (e.g., misreading instructions, PM responses not being registered due to nonstandard keyboard layouts, cf. Gilbert, 2015–supplementary information). However, for each study, we conducted an additional 2 (Animacy: animates vs. inanimates) x 3 (Type of trial: baseline vs. filler vs. target) repeated measures ANOVA, including also the participants who were excluded for not performing any PM response. Across studies, the results revealed the same pattern as when excluding them (Supplementary Table S1), including the follow-up paired t-tests used to disentangle the interactions.

Supplementary Table S1.

Statistical Analysis for Performance Including the Participants Who Did Not Perform Any PM Response in Each Study

Study	Animacy	Type of trial	Animacy X Type of Trial	Follow-up paired t-tests
Study 1a	$F(1, 229) = 7.26$,	$F(1.17, 268.50) = 120.88$,	$F(1.32, 301.22) = 19.68$,	**B**: $t(229) = -2.34$, $p = .020$
($N = 230$)	$p = .008$, $\eta_p^2 = .031$	$p < .001$, $\eta_p^2 = .345$	$p < .001$, $\eta_p^2 = .079$	**F**: $t(229) = -1.48$, $p = .139$
				T: $t(229) = 4.34$, $p < .001$, $dz = .29$
Study 1b	$F(1, 114) = 6.15$,	$F(1.15, 130.71) = 71.81$,	$F(1.51, 172.46) = 6.42$,	**B**: $t(114) = 0.58$, $p = .562$
($N = 115$)	$p = .015$, $\eta_p^2 = .051$	$p < .001$, $\eta_p^2 = .386$	$p = .002$, $\eta_p^2 = .053$	**F**: $t(114) = -1.27$, $p = .206$
				T: $t(114) = 2.88$, $p = .005$, $dz = .27$
Study 2	$F(1, 93) = 2.16$,	$F(1.10, 102.07) = 39.87$,	$F(1.23, 114.31) = 13.04$,	**B**: $t(93) = -3.68$, $p < .001$, $dz = -.38$
($N = 94$)	$p = .145$	$p < .001$, $\eta_p^2 = .300$	$p < .001$, $\eta_p^2 = .123$	**F**: $t(93) = -1.36$, $p = .178$
				T: $t(93) = 3.02$, $p = .003$, $dz = .31$

Notes: N = Sample size after including the participants who did not give any correct PM response. The Bonferroni correction was applied to the follow-up paired t-tests ($p < .0167$). "B", "F" and "T" stand for "Baseline trials", "Filler trials" and "Target trials", respectively.

Exclusion of Trials from the Analysis on Performance

Following previous studies (e.g., Smith & Hunt, 2014), trials immediately after the target trials were excluded, as performance on these trials may incur an additional cost due to the PM response. Trials with missing responses were also excluded from the analyses (as in, for example, Strickland et al., 2020). In **Study 1a**, a total of 0.7% of the baseline, 2.0% of the filler and 1.0% of the target trials were excluded from the analyses for those reasons. In **Study 1b**, these corresponded to 2.2% of the baseline, 3.3% of the filler and 2.6% of the target trials. In **Study 2**, 1.4% of the baseline, 0.9% of the filler and 1.6% of the target trials were excluded for the same motives.

Versions of the Task

In Studies 1a and 2, versions 1DB and 2DB presented the target words "bottle" and "dancer", whereas versions 1NP and 2NP presented "nurse" and "phone" as targets. In Study 1b, versions 1CJ and 2 CJ presented the target words *"cavalo"* [horse] and *"janela"* [window], whereas *"atleta"* [athlete] and *"camisa"* [shirt] were presented in versions 1AC and 2AC. In the PM phase, words were presented in a fixed order to every participant but counterbalanced between versions: where an animate word was presented in Version 1, an inanimate was presented in Version 2 (and vice-versa). For each study, participants were allocated to the experimental versions as follows: **Study 1a**: Version 1DB (n = 40), 2DB (n = 46), 1NP (n = 46), 2NP (n = 44); **Study 1b**: 1CJ (n = 19), 2CJ (n = 22), 1AC (n = 20), 2AC (n = 17); and **Study 2**: 1DB (n = 19), 2DB (n = 22), 1NP (n = 17), 2NP (n = 21).

Due to the slightly unbalanced number of participants allocated to each version, we explored if the variable Version of the experiment influenced our results in any way, by conducting a 2 (Animacy: animates vs. inanimates) x 3 (Type of trials: baseline vs. filler vs. target) x 4 (Version) mixed ANOVA, for each study. Across studies, neither the main effect of Version of the experiment, nor the interactions involving this variable, were significant (**Study 1a**: lowest *p* = .505; **Study 1b**: lowest *p* = .147; **Study 2**: lowest *p* = .114). This suggests that the animacy effects reported in all studies are not restricted to one specific animate / inanimate PM target, nor to a specific order of presentation of the PM targets (i.e., being presented first with an animate or an inanimate target did not influence the overall PM performance).

False Alarms

The false alarm response rate (i.e., giving a PM response to a filler trial) was negligible and did not differ between animates across studies, as presented in Supplementary Table S2.

Supplementary Table S2.

Average Number of False Alarm Responses Given to Animate and Inanimate Trials, and Corresponding Comparisons (Paired T-Tests), for Each Study

Study	Animates (*SD*)	Inanimates (*SD*)	Paired t-tests
Study 1a	0.04 (0.20)	0.03 (0.17)	$t(175) = 0.63$, $p = .529$
Study 1b	0.03 (0.16)	0.01 (0.11)	$t(77) = 0.58$, $p = .567$
Study 2	0.03 (0.16)	0.03 (0.16)	$t(78) < 0.01$, $p > .999$

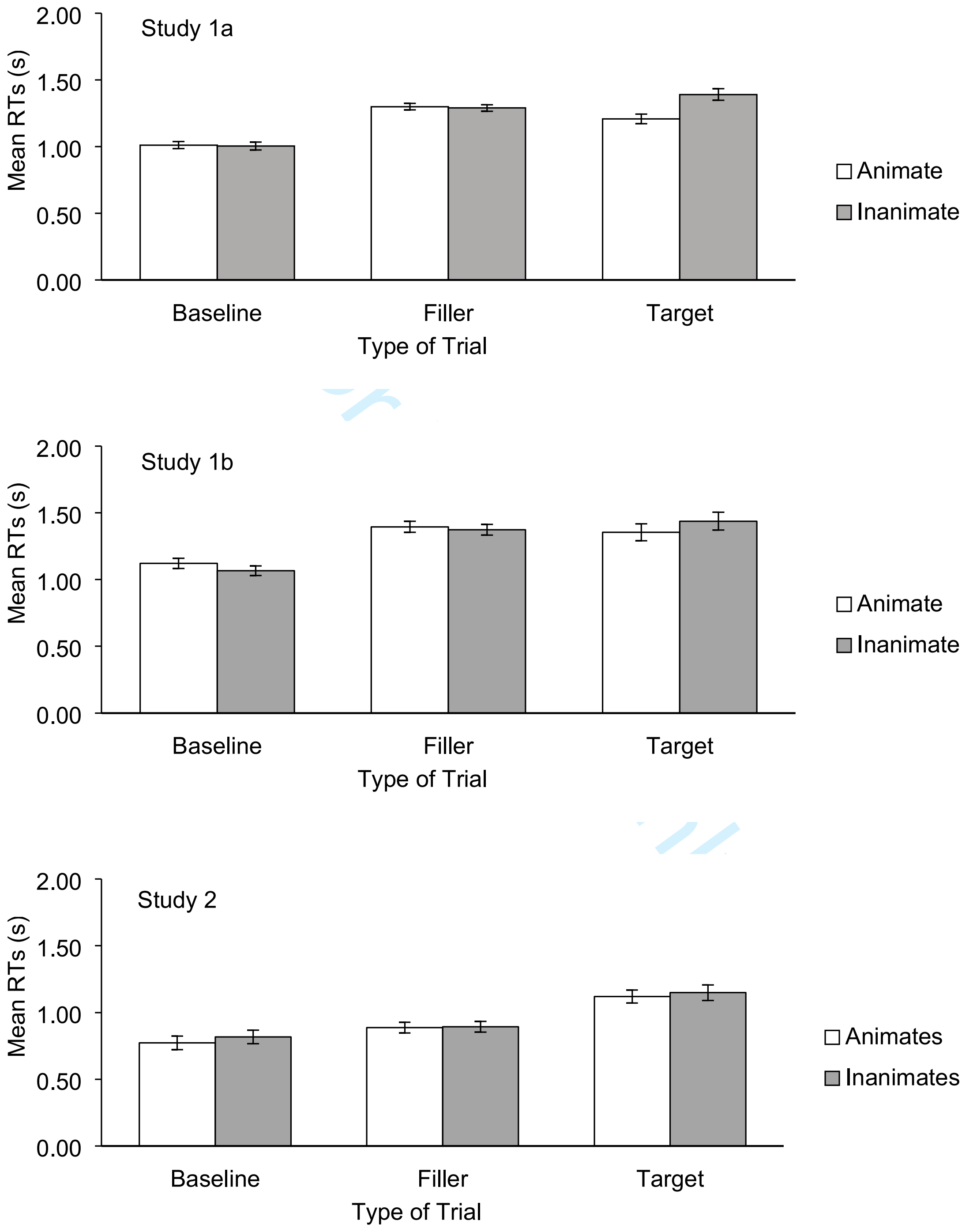
Analyses of the Response Times (RTs)

The baseline phase provides a "purer" measure of the participants' performance in the ongoing task only, allowing us to explore the cost/interference of performing the ongoing task with an embedded PM task (PM phase). Such cost/interference is usually indexed by the participants' response times. As data were collected online, analyses of response times assumed a secondary role in this work, as these data might vary due to several uncontrollable factors (e.g., the participants' internet speed).

Only the RTs from correctly-responded trials were considered (i.e., press Y, N or SPACEBAR in color-match, color-nonmatch and target trials, respectively). In these analyses, we only included the participants that provided correct responses to both animate and inanimate stimuli across all types of trials. Missing-response trials were not considered in these analyses (as in Strickland et al., 2020). Following previous studies RTs were trimmed separately for animate and inanimate trials (e.g., Rummell et al., 2017 used a lexical decision task, and trimmed RTs separately for words and nonwords); those trials with RTs below *M*-3*SD* or above *M*+3*SD* from each participant's mean were excluded (Matos et al., 2020; as similarly done by Smith and Hunt, 2014). RTs from target trials were not trimmed, otherwise there would be too few trials/datapoints to analyze. This trimming procedure resulted in the exclusion of 0.1% of the total trials in **Study 1a**, 0.1% of the baseline and 0.4% of the filler trials in **Study 1b**, and 1.0% of the total trials in **Study 2**. Results are depicted in Supplementary Fig. S1, and the statistical analyses are presented in Supplementary Table S3.

Supplementary Fig. S1.

Response Times Obtained in Studies 1a (N = 132), 1b (N = 63) and 2 (N = 72). Error Bars Represent Standard Errors of the Mean



Supplementary Table S3.

Statistical Analyses on the Response Times for Each Study

Study	Animacy	Type of Trial		Animacy X Type of Trial
	Main effect	Main effect	Follow-up paired t-tests	Interaction
Study 1a	**$F(1, 131) = 10.36$,**	**$F(1.49, 195.33) = 65.33$,**	**B vs. F: $t(131) = -15.13$, $p < .001$, $dz = -1.32$**	**$F(1.29, 169.38) = 12.12$,**
($N = 132$)	**$p = .002$, $\eta_p^2 = .073$**	**$p < .001$, $\eta_p^2 = .333$**	**B vs. T: $t(131) = -8.11$, $p < .001$, $dz = -0.71$**	**$p < .001$, $\eta_p^2 = .085$**
			F vs. T: $t(131) = 0.54$, $p = .59$	
Study 1b	$F(1, 62) = 0.004$,	**$F(1.51, 93.63) = 30.20$,**	**B vs. F: $t(62) = -9.75$, $p < .001$, $dz = -1.23$**	$F(1.30, 80.38) = 2.58$,
($N = 63$)	$p = .948$	**$p < .001$, $\eta_p^2 = .328$**	**B vs. T: $t(62) = -5.56$, $p < .001$, $dz = -0.70$**	$p = .103$
			F vs. T: $t(62) = 0.06$, $p = .953$	
Study 2	$F(1, 71) = 1.38$,	**$F(1.66, 117.88) = 51.45$,**	**B vs. F: $t(71) = -3.21$, $p = .002$, $dz = -0.38$**	$F(1.21, 85.98) = 0.26$,
($N = 72$)	$p = .245$	**$p < .001$, $\eta_p^2 = .420$**	**B vs. T: $t(71) = -8.19$, $p < .001$, $dz = -0.97$**	$p = .658$
			F vs. T: $t(71) = -7.92$, $p < .001$, $dz = -0.93$	

Notes: N = Sample included in the RTs analyses (i.e., participants that provided correct responses to both animate and inanimate stimuli across all types of trials). B = Baseline trials; F = Filler trials; T = Target trials. Statistically-significant results are presented bolded.

The Animacy X Type of Trial interaction found in Study 1a was explored with paired t-tests. Those revealed faster response times towards the animate (than inanimate) stimuli, but only in target trials, $t(131) = -3.75$, $p < .001$, $dz = -.33$.

The further exploration of the main effect of type of trial revealed, **across studies**, a cost to the ongoing task with an embedded PM task (filler trials), as compared to the baseline trials (i.e., performing the ongoing task only). These results further asseverate the non-focal nature of the task (where a more effortful/strategic retrieving of the targets may occur; Anderson et al., 2019; McDaniel & Einstein, 2000; Smith, 2003). Additionally, in Studies 1a and 1b, responses were also slower in the target trials, as compared to the baseline, but no difference was obtained between the filler and the target trials. This reveals that participants had similar performances in the task, although being conducted in different languages. In Study 2, responses to the target trials were slower than to both the baseline and the filler trials.

Additionally, as presented in Supplementary Fig. S1., RTs from Studies 1a and 1b were very similar. Indeed, both studies followed the same procedure, although in different languages and with different sets of participants. These results further asseverate similar manipulations of the stimuli in both studies, although conducted in different languages.

Performance in the Recognition and Color Naming Tasks

Supplementary Table S4 shows the mean performance in the final recognition and color naming tasks. In the recognition task, participants were presented with words, one at a time, and their task was to decide if those words corresponded to the target trials they were asked to memorize (yes/no forced response). All the targets and four lures (half animates and half inanimates) had been presented during the PM phase.

Supplementary Table S4.

Mean Performance in the Final Target Recognition and Color Naming Tasks in Studies 1a, 1b and 2

Study	Recognition Task		Color naming task
	Targets	Lures	
Study 1a	1.00 (0.04)	0.99 (0.05)	0.98 (0.05)
Study 1b	1.00 (0.00)	0.98 (0.13)	0.98 (0.05)
Study 2	0.97 (0.14)	0.99 (0.08)	--

Note: *SD* is presented in parentheses. The color naming task was implemented only Studies 1a and 1b. The mean performance in the recognition task for Targets corresponds to *hits* and the performance for Lures corresponds to *correct rejections*.

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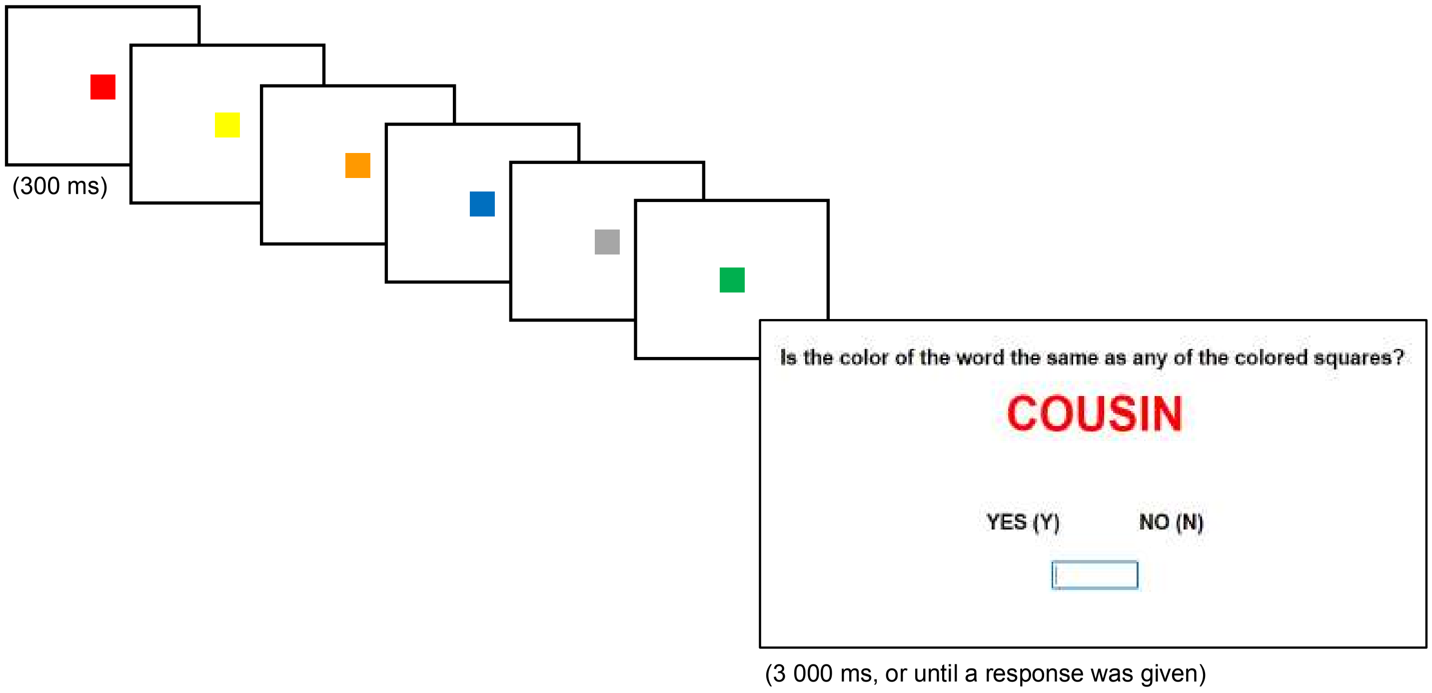
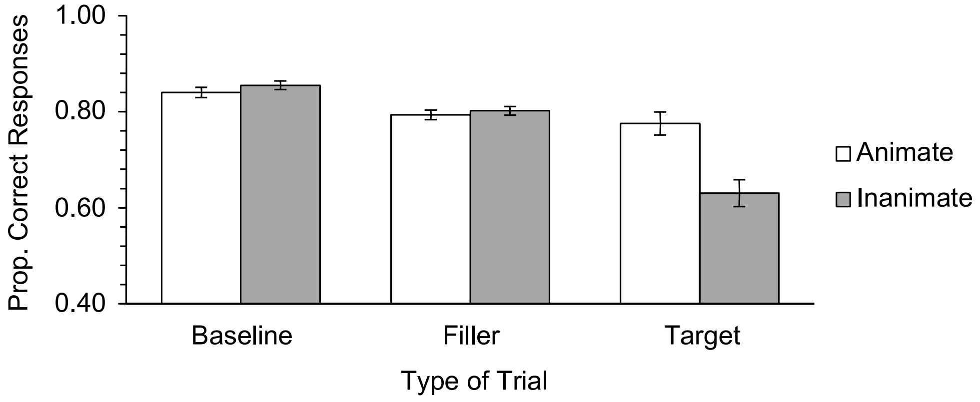
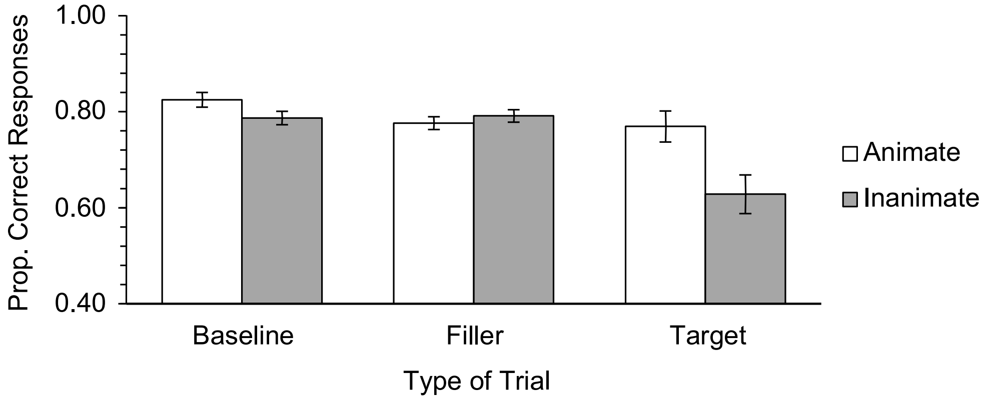
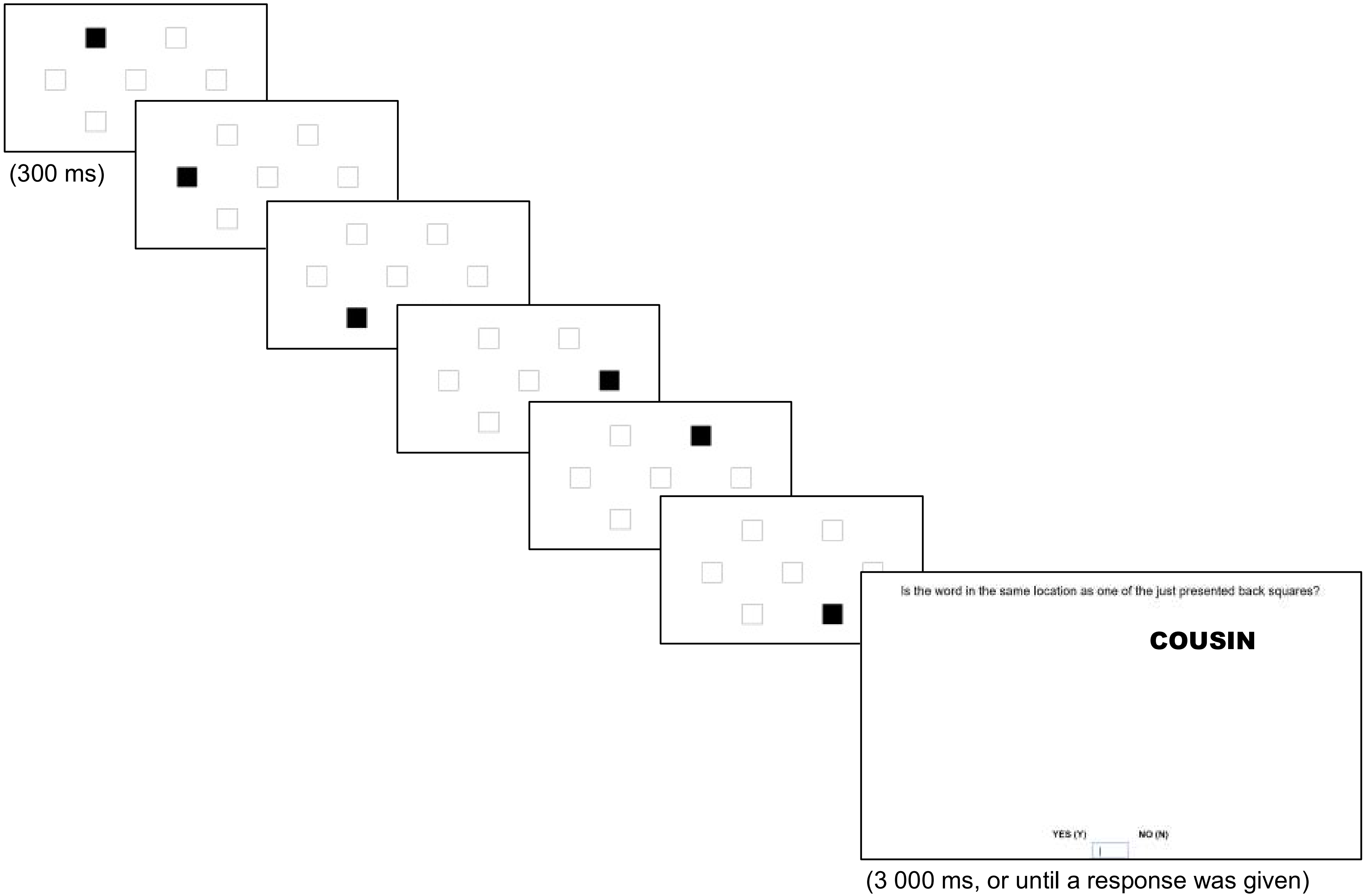

(300 ms)
Is the color of the word the same as any of the colored squares?
COUSIN
YES (Y)
NO (N)
(3 000 ms, or until a response was given)

	Animate	Inanimate	SEM	SEM
Baseline	0.84	0.85	0.01	0.01
Filler	0.79	0.80	0.01	0.01
Target	0.78	0.63	0.02	0.03



	Animate	Inanimate	SEM	SEM
Baseline	0.82	0.79	0.02	0.01
Filler	0.78	0.79	0.01	0.01
Target	0.77	0.63	0.03	0.04




(300 ms)
Is the word in the same location as one of the just presented back squares?
COUSIN
YES (Y)
NO (N)
(3 000 ms, or until a response was given)

	Animate	Inanimate	SEM	SEM
Baseline	0.92	0.96	0.01	0.01
Filler	0.96	0.97	0.01	0.00
Target	0.90	0.78	0.02	0.04

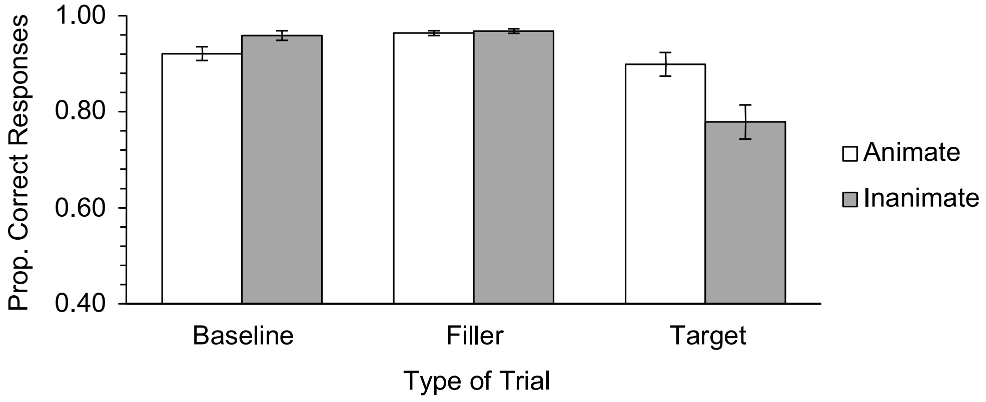


Table 1.

Characterization of the Animate and Inanimate Words Used in Studies 1a, 1b and 2.

				Study 1a and Study 2					
	Baseline words (*n* = 16)			Filler words (*n* = 24)			Target words (*n* = 4)		
	Animates	Inanimates	*p*	Animates	Inanimates	*p*	Animate	Inanimate	*p*
Anim.[a]	6.83 (0.10)	1.07 (0.04)	***	6.84 (0.15)	1.01 (0.02)	***	6.78 (0.14)	1.02 (0.03)	**
AoA [b]	3.00 (0.48)	3.18 (0.24)	.408	2.95 (0.56)	3.33 (0.75)	.176	4.70 (1.83)	2.72 (0.22)	.366
Arou.[c]	4.85 (0.93)	3.96 (0.98)	.085	4.44 (0.53)	4.26 (0.70)	.506	5.42 (0.82)	4.11 (0.96)	.283
Conc. [d]	5.96 (2.92)	5.94 (2.87)	.896	5.94 (0.31)	5.95 (0.18)	.944	5.73 (0.21)	6.08 (0.23)	.263
Dom.[c]	5.44 (0.99)	5.11 (0.47)	.412	5.38 (0.55)	5.28 (0.40)	.618	5.43 (0.83)	4.61 (0.24)	.385
Fam.[d]	5.37 (0.60)	5.63 (0.45)	.332	5.42 (0.48)	5.60 (0.39)	.306	5.36 (0.01)	5.71 (0.29)	.341
Freq.[e]	100.88 (93.35)	54.63 (58.74)	.259	41.33 (63.42)	27.83 (20.34)	.495	24.00 (9.90)	65.00 (15.56)	.108
Img.[d]	6.07 (1.86)	5.97 (2.37)	.379	5.98 (0.18)	5.95 (0.15)	.637	5.84 (0.47)	6.03 (0.23)	.673
Length	4.50 (1.07)	5.50 (1.93)	.226	4.75 (1.48)	4.75 (0.87)	>.99	5.50 (0.71)	5.50 (0.71)	.999
Val.[c]	6.26 (0.98)	5.94 (0.98)	.468	5.85 (1.05)	5.64 (0.85)	.612	6.61 (0.75)	6.12 (0.04)	.525
				Study 1b					
	Baseline words (*n* = 16)			Filler words (*n* = 24)			Target words (*n* = 4)		
	Animates	Inanimates	*p*	Animates	Inanimates	*p*	Animate	Inanimate	*p*
Anim.[f]	6.65 (0.12)	1.52 (0.11)	***	6.76 (0.06)	1.50 (0.08)	***	6.64 (0.10)	1.44 (0.06)	**
AoA [g]	3.03 (1.02)	2.34 (0.62)	.130	2.54 (0.67)	2.87 (0.90)	.302	1.66 (2.34)	2.11 (0.48)	.831
Arou.[h]	4.36 (0.40)	3.89 (0.69)	.120	4.15 (0.39)	4.05 (0.44)	.586	2.85 (4.03)	3.27 (NA)	NA
Conc.[i]	6.38 (0.21)	6.36 (0.40)	.890	6.42 (0.38)	6.46 (0.30)	.785	6.11 (0.05)	6.71 (0.01)	.033
Dom.[h]	5.08 (0.58)	5.13 (0.61)	.868	5.17 (0.45)	5.11 (0.45)	.742	1.89 (2.67)	4.45 (NA)	NA
Freq.[i]	21.15 (23.35)	58.87 (82.03)	.246	21.81 (24.13)	24.49 (39.83)	.844	24.40 (33.94)	17.82 (5.72)	.830
Img.[i]	5.64 (0.22)	5.84 (0.32)	.155	6.05 (0.30)	6.06 (0.27)	.972	5.24 (0.56)	5.96 (0.29)	.284
Length	5.63 (1.19)	5.50 (1.31)	.844	5.50 (1.57)	6.00 (1.28)	.401	5.50 (0.71)	6.50 (0.71)	.293
S.Freq. [i]	4.50 (1.10)	5.15 (1.19)	.275	4.69 (0.93)	4.91 (1.16)	.623	3.82 (1.15)	5.36 (1.19)	.317
Val.[h]	5.54 (0.87)	5.80 (0.55)	.495	6.04 (1.00)	5.60 (0.70)	.258	2.01 (2.84)	5.55 (NA)	NA

Notes: Mean values presented, with standard deviations in parentheses; *n* = Number of words (containing half animate and half inanimate); NA = Not Available; *p* = p-value obtained by independent t-tests (animate vs. inanimate); Baseline words = Words used in the baseline trials; Filler words = Filler words used in the PM phase; Target words = Words used in the target trials in the PM phase.

Anim. = Animacy; AoA = Age of Acquisition; Arou. = Arousal; Conc. = Concreteness; Dom. = Dominance; Val. = Emotional Valence; Fam. = Familiarity; Freq. = Written frequency; Img. = Imagebaility; Length = number of letters of the words; S. Freq. = Subjective Frequency.

Word data for Studies 1a and 2 retrieved from: [a] VanArsdall and Bunt (2022) [7-point scale]; [b] Cortese and Khanna (2008) and Schock, Cortese, Khanna, et al. (2012) [7-point scale]; [c] Bradley and Lang (1999) [9-point SAM scale]; [d] MRC database (Wilson, 1988) [transformed into a 7-point scale]; [e] Kucera and Francis (1967) as available in the MRC database (Wilson, 1988). Baseline words: The word "jug" missed values for concreteness and imageability; No age of acquisition information was available for the words "umbrella" and "horse". Filler words: No data on emotional valence, arousal and dominance were available for the words "monkey" and "jacket". Target words: Data on emotional valence, arousal and dominance for the word "phone", and data on AoA for the word "dancer" were retrieved from VanArsdall (2016).

Word data for Study 1b retrieved from: [f] Félix et al. (2020) [7-point scale]; [g] Average data from Cameirão & Vicente (2010) and Leitão et al. (2010) [transformed to a 7-point rating scale]; [h] Soares et al. (2012) [9-point SAM scale]; [i] Soares et al. (2017) [7-point scale]. Target words: Data on emotional valence, arousal, and dominance for the word "camisa [shirt]" were not available in the few existing European Portuguese databases that also contain a reduced number of words.

*** *p value* < .001; ** *p value* < .01