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Brief Report

A processing advantage in favor of animate entities in incidental word learning in young children

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ABSTRACT

Because of their evolutionary importance, it has been proposed that animate entities would be better remembered than inanimate entities. Although a growing body of evidence supports this hypothesis, it is still unclear whether the animacy effect persists under incidental learning conditions. Furthermore, few studies have tested the robustness of this effect in young children, with conflicting results. Using an incidental learning paradigm, we investigated whether young children (4- and 5-year-olds) would be better at learning words that refer to either human or animal entities rather than vehicle entities using pictures as stimuli. A sample of 79 children were asked to play digital Memory games while associations between pictures and words were presented incidentally. Consistent with the adaptive view of memory, the results showed that words associated with human and animal entities were better learned incidentally than words associated with vehicle entities. The visual complexity of the pictures did not influence this animacy effect. In addition, the more exposure to the pictures, the more incidental learning occurred. Overall, the results confirm the robustness of the animacy effect and show that this processing advantage can be found in an incidental learning task in children as young as 4 or 5 years. Furthermore, it is the first study to show that this effect can be obtained with pictures in children. The demonstration of the animacy effect with pictures, and

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not just words, is a prerequisite for an ultimate explanation of this effect in terms of survival.

Introduction

Numerous biases influence the way our cognitive system processes information from an early age, such as a preference for human voices over other sounds (Vouloumanos et al., 2010) and a particular attraction to patterns that resemble human faces (Cassia et al., 2004). Inspired by an evolutionary view of human memory (Nairne, 2016) and attention (Tooby & Cosmides, 2005), much work over the past twenty years has helped to uncover a processing advantage in favor of animate entities over inanimate ones (e.g., "baby" vs. "hat"). Animate entities benefit from more efficient visual and attentional processing than inanimate entities (Altman et al., 2016) and are better remembered in a variety of tasks, including free recall (Nairne et al., 2013) and recognition (Bonin et al., 2014).

Most of the work on the animacy effect in memory has focused on adults (Nairne et al., 2017). However, the distinction between animate and inanimate objects emerges early in development (Opfer & Gelman, 2011). Loucks et al. (2020) reported that 4-year-olds reconstructed a sequence of actions better when it involved an animate agent rather than an inanimate agent. Using a paired-associate learning task, Aslan and John (2016) showed that, like adults (VanArsdall et al., 2013), children aged 4 to 11 years better remembered nonwords associated with animate properties rather than inanimate properties, suggesting developmental invariance of this memory advantage. However, using a remember–know paradigm, Bugaiska et al. (2023) reported an animacy effect in children aged 10 to 12 years, but not in children aged 6 and 7 years.

According to the adaptive memory view of Nairne and colleagues (e.g., Nairne, 2016), the animacy effect in memory should be observed regardless of learning intention given that the influence of this dimension is rooted in the deep past of human evolution and provided survival advantages to our hunter–gatherer ancestors. Indeed, animacy effects are ultimately interpreted as evidence that our memory systems have evolved to be tuned to remember things that might help us to survive. Animals and humans tend to be more relevant to survival than inanimate things. Consistently, animates have been shown to be better remembered than inanimates, regardless of whether the encoding instructions provided in the study phase are explicit, eliciting intentional learning (Gelin et al., 2017; Nairne et al., 2013) or incidental learning (e.g., participants are told to count the number of letters in the words; Komar et al., 2023a), with participants unaware that they will be performing a surprise recall task. Félix et al. (2019) even found a larger animacy effect when learning was incidental, suggesting that the attentional priority given to animates is more efficient when explicit memorization strategies do not interfere. Gelin et al. (2017) did not report a difference in the magnitude of the animacy effect after an incidental or intentional encoding condition, but they did confirm the sensitivity of incidental learning to the animacy advantage. In contrast, using a visual statistical learning paradigm that relies on incidental learning of statistical regularities in the perceived environment, Cox et al. (2022) reported that statistical learning works equally well whether adults were exposed to drawings of animate or inanimate entities.

The current study aimed to contribute to this growing body of research by investigating whether young children aged 4 and 5 years would be better at learning words designating animate entities rather than inanimate entities in an original incidental paired-associate learning task developed by Vinter et al. (2022), who incidentally taught letter shape–letter name associations to young children using a digital Memory game. In contrast to previous studies (Aslan & John, 2016; VanArsdall et al., 2013), in the current experiment children were presented with real words associated with their real corresponding pictures and were not required to learn these associations. We needed to choose words that most 4- and 5-year-olds would not yet be able to evoke when they saw their pictures but that would still be attractive. So, we chose human and animal figures for the animate category and vehicles for the inanimate category. According to the findings of Félix et al. (2019) and Gelin et al. (2017), both human- and animal-related words should be better learned incidentally than vehicle-related words as long as the animacy effect also appears in young children, which still remains an open question (Bugaiska et al., 2023). Alternatively, it could also be that the animacy effect did not manifest itself in an incidental learning task, as reported by Cox et al. (2022) in adults. Following Aslan and John (2016), we also wondered whether the animacy advantage might be greater for children with human entities rather than animal entities given that the animacy effect in children could either reflect intensive developmental experience with humans (human advantage) or be rooted in evolution (human and animal advantage). Therefore, we presented the three types of entities (human, animal, and vehicle) in equal proportions to allow for direct comparisons among them.

Method

Participants

A sample of 79 children aged 4 to 5 years 10 months (M_{age} = 5 years 0 months, SD = 17 months; 40 boys and 39 girls) participated in the study. Using G*Power analysis to calculate sample size and selecting an effect size of d =.40, 69 participants were required to achieve 80% power in two-tailed paired t tests with an alpha error of .0166 (as determined after Bonferroni correction). However, we included all additional willing children who completed the experiment (n = 10). They attended preschool or kindergarten in a middle-class urban neighborhood. All were native French speakers, although 21 of them came from families where another language was spoken at home in addition to French. Written informed consent was obtained from the parents, and only willing children were included in the study. The study was approved by a local ethics committee.

Material and procedure

The digital Memory game (grid of 6 $\times$ 4) used to elicit incidental learning of words naming human, animal, and vehicle entities was described in Vinter et al. (2022). Essentially, a paired-associate learning task was implemented in which associations between colored drawings and their respective names were taught incidentally as the children played. Each time the children touched a card, the drawing appeared and its name was sounded simultaneously. However, the children's attention was never drawn to these visuoverbal associations, nor was their task to learn them; rather, their task was to find pairs of identical drawings and thus to remember the location of each drawing they saw.

There were 12 items in each type of entity (e.g., dentist for humans, all represented by their professions; peacock for animals; gondola for vehicles). These specific items were chosen with the help of the children's teachers to ensure that the exact names of most of them were unknown to the children. The mean percentages of words already known at pretest were indeed below 30%, but with a significantly lower percentage for humans (M_{humans} = 14.9%, SD = 14.0) than for the other two types of entities ($M_{animals}$ = 28.2%, SD = 24.0; $M_{vehicles}$ = 24.5%, SD = 20.1), as indicated by Wilcoxon tests (ps <.001, rs < $-$.60).

The colorized drawings used in the study were created by the same graphic artist who contributed to IMABASE (Bonin et al., 2020), and one third of them were taken from that database. The agreement between the drawings and their respective names was assessed by a group of 30 adults, who were presented with the entire set of drawings in a random order. They were asked to rate them on a scale from 1 (*no agreement*) to 7 (*complete agreement*). The mean agreement ratings for the drawing names did not differ across the three entities (M_{humans} = 6.72, SD = 0.17; $M_{animals}$ = 6.58, SD = 0.31; $M_{vehicles}$ = 6.74, SD = 0.28), as shown by the Kruskal–Wallis test, $H(2)$ = 2.97, p =.22, ε^2 =.08, confirming that the drawings represented the different items equally well regardless of the type of entity.

Four other variables related to the drawings and their names were analyzed. Mean word length (number of letters) did not differ across entities (M_{humans} = 8.17, SD = 1.34; $M_{animals}$ = 6.92, SD = 1.83; $M_{vehicles}$ = 8.50, SD = 1.93), $F(2, 33)$ = 2.82, p =.08, η_p^2 =.15, nor did the mean number of oral syllables (M_{humans} = 2.75, SD = 0.45; $M_{animals}$ = 2.17, SD = 0.93; $M_{vehicles}$ = 2.50, SD = 0.90), $F(2, 33)$ = 1.66,

p =.21, η_p^2 =.08. Mean word frequencies were obtained from the French database Lexique.org (New et al., 2004). These frequencies did not vary as a function of entity type, as indicated by a Kruskal–Wallis test (M_{humans} = 2.57, SD = 2.00; $M_{animals}$ = 7.67, SD = 8.57; $M_{vehicles}$ = 5.44, SD = 6.55), $\chi^2(2)$ = 4.57, p =.10, ε^2 =.143, although the frequencies of the human occupations tended to be lower than those of animal entities (p =.09), which is consistent with the results of the children's pretest. With respect to the drawings, the mean visual complexity of the images (assessed by the number of bytes in JPEG format, expressed in 10^3 bytes; see Bonin et al., 2020) was significantly lower for animals ($M_{animals}$ = 234, SD = 83) than for vehicles and humans ($M_{vehicles}$ = 284, SD = 53; M_{humans} = 288, SD = 40), $Us(22) < 28$, ps <.009.

The same set of 36 drawings, each presented in the center of individual 5.5 × 5.5-cm cards, was used 1 week before and 1 week after the play period to assess the children's vocabulary. The cards were presented in a random order, and the experimenter asked the children, "Do you know what this is? Can you name it? Can you tell me what this picture represents?" Children's response was coded as correct (1) if the corresponding word was produced exactly right or as incorrect (0) in all other cases.

In a short familiarization phase, the experimenters showed the children how to use the digital tablets, how to access their individual storage space, and how to play the Memory game. The game phase lasted for 3 weeks. As in a classic Memory game, the children were asked to find pairs of identical cards (see Vinter et al., 2022, for a full description of the procedure). They had access to the tablets during their free time at school but had no obligation to use them. They played individually and wore headphones. The order of presentation of the 36 items (i.e., the drawings and their names) was randomized with one constraint: For each child, all items of the same entity type (animal, human, or vehicle) needed to be presented once before any of them could be presented a second time. The three entity types were systematically combined in each game, with four items per entity type. In this way, all items were presented at least once after three games. It was crucial to verify that the children were exposed to each entity type with a similar frequency. Importantly, the average number of times the children were exposed to the different items throughout the play phase did not differ significantly among the entities (M_{humans} = 24.3, SD = 22.9; $M_{animals}$ = 24.4, SD = 23.0; $M_{vehicles}$ = 23.9, SD = 22.5), as shown by the Wilcoxon test (ps >.60, rs <.07). The interindividual variability in these mean frequencies of exposure to the different items was large regardless of entity type, ranging from 3.08 to 91.9 (M = 24.4, SD = 22.7). It resulted from both repetitions of the games (depending on the children's engagement) and failures to find the correct pairings, but our program did not allow us to separate these two sources of repetitions. This variability gave us the opportunity to test the effect of exposure frequency on incidental word learning.

The experiment ended with the posttest phase 1 week after the game session.

To assess incidental word learning, two learning gain scores were computed: an absolute gain score (the percentage of known words in the posttest minus the percentage of known words in the pretest) and a relative gain score (the absolute gain divided by 100% minus the percentage of known words recorded in the pretest). This last score related the change between the pretest and the posttest to the children's remaining margin of progress, as measured by their prior knowledge on the pretest. It was necessary to calculate relative learning gain scores because the initial level of vocabulary shown by the children in the pretest was not identical for the three types of entities. We compared these learning scores as a function of entity type using Wilcoxon tests (W values) because their distribution did not conform to normality (Shapiro–Wilk test, ps <.05). The significance threshold was set at.0166 after Bonferroni correction. Note that the gender effect did not affect the results reported below.

Results

The children's mean absolute and relative gain scores for the three types of entities are shown in Fig. 1.

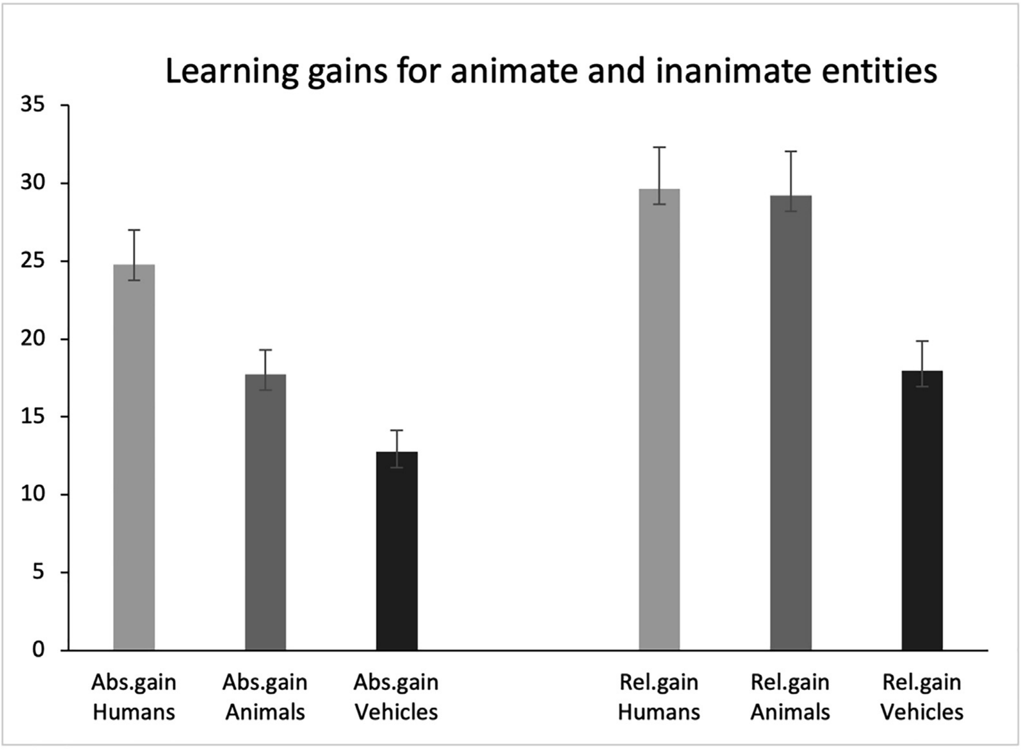

Fig. 1. Absolute (left panel) and relative (right panel) learning gain scores for animate entities (humans and animals) and inanimate entities (vehicles). Abs.gain, absolute learning gain score; Rel.gain, relative learning gain score. Lines represent standard errors.

Were human-related words better learned incidentally than vehicle-related words?

Fig. 1 shows that the mean absolute learning gains (M = 24.78, SD = 19.79) and relative learning gains (M = 29.64, SD = 23.37) for humans were significantly higher than those for vehicles (M = 12.76, SD = 12.21 and M = 17.95, SD = 17.04, respectively), W = 1571, p <.001, r =.775 and W = 2081, p <.001, r =.674 respectively. These results indicated that children were better at incidentally learning human-related words than inanimate moving objects, such as vehicles.

Were animal-related words better learned incidentally than vehicle-related words?

As shown in Fig. 1, the same pattern of results was obtained when comparing animals and vehicles. The mean word learning gains for animals, either absolute (M = 17.72, SD = 14.0) or relative (M = 29.20, SD = 25.3), were significantly higher than those for vehicles, W = 1196, p =.003, r =.446 and W = 1720, p <.001, r =.603, respectively. Words naming animals were learned better than words naming vehicles.

Were human-related words better learned incidentally than animal-related words?

Fig. 1 shows that human-related words were learned better than animal-related words when the absolute learning gain scores, W = 441, p =.001, r = −.49, but not the relative learning gain scores, W = 987, p =.45, r = −.11, were considered. Recalling that the children initially knew fewer words related to humans than to animals, and given this initial start, they made similar progress in learning both types of words.

Did the visual complexity of the pictures play a role in the animacy effect?

We examined whether the visual complexity of the pictures played a role in the animacy effect given that the three types of items differed on this variable to the detriment of the animals. For each item, we calculated the associated mean absolute and relative learning gain scores averaged across participants. The correlations between visual complexity and learning scores were not significant whether absolute scores, $r(36) = .08$, $p = .64$, or relative scores, $r(36) = -.12$, $p = .48$, were considered.

Did the frequency of exposure to the items play a role in the learning gain scores?

Finally, we examined whether the frequency of exposure to the items, which varied considerably across children, played a role in the children's propensity to incidentally learn new vocabulary. The correlations (unilateral Pearson test) between the children's mean frequency of exposure to the items and their learning gain scores were significant for vehicle entities [absolute gain scores: $r(79) = .39$, $p = .002$; relative gain scores: $r(79) = .21$, $p = .03$], for human entities [absolute gain scores: $r(79) = .51$, $p < .001$; relative gain scores: $r(79) = .38$, $p < .001$], and for animal entities when the absolute gain scores, $r(79) = .36$, $p = .001$, but not the relative gain scores, $r(79) = .15$, $p = .09$, were considered.

Discussion

The purpose of the current study was to investigate whether young children would be better at learning words that refer to animate entities rather than inanimate entities using an incidental learning condition and pictures associated with their names as stimuli.

Words referring to animate entities, whether human or animal, were learned better incidentally than words referring to inanimate moveable entities, such as vehicles. This finding supports the claim that the animacy effect can manifest under incidental encoding conditions, which is consistent with the findings of Félix et al. (2019) and Gelin et al. (2017), but contradicts those of Cox et al. (2022). There are several possible explanations for these conflicting results. As Cox et al. themselves noted, the lack of an animacy effect in their study could be due to the task design. These authors manipulated the animacy variable as a between-participants factor rather than as a within-participants factor, as is commonly done. In addition, they used line drawings without critical features that could enhance object recognition, such as texture. Perhaps the use of this type of stimulus, which is less ecological than colored drawings (Rossion & Pourtois, 2004), prevented the expression of the animacy effect in their task.

It could be argued that a low-level property of the items, visual complexity, may have influenced our results. Perceptual effects can indeed modulate incidental learning performance by influencing the tendency of stimuli to attract the participants' attention (Perruchet & Vinter, 2002). However, this is unlikely in our study because the correlations between the visual complexity of the pictures and the learning gain scores were not significant, and the animal drawings were the least visually complex, whereas their names were learned better incidentally than those of more visually complex inanimate entities (vehicles).

The so-called "proximal" explanations for the animate effect remain something of a mystery (Meinhardt et al., 2020). However, the permeability of incidental learning processes for this effect should help to rule out any explanation that relies on explicit or conceptually based processing mechanisms, such as categorization, mental imagery, and richness of encoding. The richness-of-encoding account (Bonin et al., 2022; Komar et al., 2022; Meinhardt et al., 2020) has been put forward as one promising candidate mechanism to explain animacy effects in memory (but see Komar et al., 2023b). However, this type of elaborative process can hardly intervene in our incidental learning task with young children, whose episodic memory is certainly not sufficiently mature (Scarf et al., 2013). None of the more automatically elicited mechanisms, such as arousal (Popp & Serra, 2018) or sensory experience (Bonin et al., 2014), has been clearly shown to support the animacy advantage. The attentional capture hypothesis, which claims that animates recruit more attention during encoding than inanimates (Bugaiska et al., 2019), has also recently been questioned (Komar et al., 2023a). In the current study, no information was provided about the status of the items, and the children's attention was never drawn to memorizing the drawings and their names. Although we cannot rule out the hypothesis that the animate "drawings + labels" pairs attracted more attention than the inanimate pairs, there is nothing in the data to support this.

Although this finding is beyond the scope of the current study, we showed that the more exposure to the different items, whether animate or inanimate, the more incidental paired-associate learning occurred. Exposure effects are indeed pervasive in associative learning and are especially expected in Perruchet and Vinter's (2002) theoretical view of incidental (implicit) learning (see Vinter et al., 2022) irrespective of learning content. However, for the animals, the correlation between exposure frequency and relative learning score was not significant. The reason for this is not clear to us, but it may be because the children showed the highest percentage of already known words in this category on the pretest, making it more likely that some of them reached full knowledge after only a few repetitions of the limited still-unknown vocabulary.

Our results support the hypothesis of a mnemonic advantage for animates over inanimates in children aged 4 and 5 years. This is consistent with some of the literature (e.g., Aslan & John, 2016). Given that the evolutionary pressures associated with animacy (avoiding predators or dangerous conspecifics) act on both adults and children, it is indeed plausible to find the animacy effect in young children. However, Bugaiska et al. (2023) found no evidence for the animacy effect in children aged 6 and 7 years. It is worth noting, however, that the experimental paradigm they used—a remember–know paradigm—is not well-suited for young children (Brainerd et al., 2004). Task demands, such as the need to make introspective judgments, may hinder the expression of the animate advantage in young children. Furthermore, Bugaiska et al.'s (2023) explanation in terms of a lack of mental imagery in young children is questionable in the light of our results showing an animacy effect in even younger children.

Finally, our findings are rather inconclusive regarding a potential advantage for humans over animals within the animate entities. Children learned more human words than animal words in absolute terms, but not considering their initial level of knowledge. From an evolutionary perspective, it is likely that humans are prioritized in processing compared with inanimates. For example, studies have shown prepared processing of human faces from the very beginning of life (Farroni et al., 2002). However, animal-related information has been equally important throughout our evolutionary history, and research shows that it is also prioritized in learning, for example, dangerousness (Barrett & Broesch, 2012). In short, from an evolutionary developmental perspective, it seems reasonable that children assign processing priority not only to humans but also to animals, as suggested by Aslan and John's (2016) data and some of the current data.

One potential limitation of the study should be noted. The observed animacy effect may have been influenced by the uneven proportion of animate and inanimate items shown to children in each Memory game, making the animate category more salient in the overall task. However, research on adult memory tasks has shown that the "salience" of the animate category does not appear to play a role in the animacy effect. VanArsdall et al. (2015) found in cued recall that animates were remembered better than inanimates when controlling for category size, and importantly, the animacy effect was still observed even when target items (animates vs. inanimates) were embedded in filler items (predominantly inanimates), so that the semantic categories of the items were not readily identifiable (VanArsdall et al., 2017, Experiment 3).

Conclusion

The current study confirms the robustness of the animacy effect and shows that this processing advantage can be found in an incidental learning task in children as young as 4 or 5 years. This provides strong support to an evolutionary perspective on childhood (Bjorklund, 2020). Furthermore, it is the first study to show that this effect can be obtained with pictures in children. Indeed, the demonstration of the animacy effect with pictures (see Bonin et al., 2014, for a demonstration in adults), and not just words, is clearly a prerequisite for an ultimate explanation of this effect in terms of survival.[1] However, further research is needed to better clarify the proximal explanation of such a processing advantage.

CRediT authorship contribution statement

Elodie Lhoste: Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing, Investigation. **Patrick Bonin:** Conceptualization, Supervision, Writing – review & editing. **Patrick Bard:** Software. **Bénédicte Poulin-Charronnat:** Conceptualization, Supervision, Writing – review & editing. **Annie Vinter:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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[1] Insofar as the pictures were accompanied by their labels spoken aloud, and the learning test was based on the retrieval of verbal labels, the animacy effect was not, strictly speaking, obtained from the pictures alone. It should be noted that in the Bonin et al. (2014) study, the pictures presented for encoding were also accompanied by written labels, and recall was achieved by writing the names of the pictures. To our knowledge, no study to date has reported an animacy effect in memory from the strict presentation of pictorial items without the intervention of any verbal information.

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