Does Learner's Preference Match the Typological Pattern of Animacy Hierarchy in Morphological Marking?

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1 Introduction

Across the world's languages, patterns of marking tend to follow an animacy hierarchy in which Human > Animate > Inanimate (Smith-Stark 1974, Dixon 1994, Silverstein 1976, Croft 2002, among others). If nouns are differentially marked for some feature according to animacy, nouns highest in the hierarchy are more likely to be marked (e.g. human, animates) and those lower in the hierarchy are more likely to be unmarked (Aissen 2003, Bossong 1989, Smith-Stark 1974, Comrie 1989). Further, while animates can often be the only marked nouns, if inanimate nouns are marked, then animates must be as well.

Such animacy-based rules underlie differential plural marking in many languages. For example, in Mandarin Chinese, the plural marker *-men (们)* is only used with definite animate nouns (Li 1999, Munn et al 2009). In Kharia, pronouns and animate nouns are marked for plural while inanimate nouns are not (Biligiri 1965). And in Tiwi, human nouns require plural marking while non-human nouns do not (Osborne 1974). While the previous examples are all deterministic animacy-based rules, differential plural marking patterns can also be probabilistic. In Korean, for example, it is optional to apply the plural marker -tul, but 90% of the time it is used on animate nouns (Song 1975, Park 2010, Kim 2005).

What drives languages to settle on this universal tendency for marking animate? One possibility is that patterns in language reflect the conceptual complexity of categories, sometimes referred to as semantic markedness (Clark and Clark 1978, Mayerthaler 1987). Under semantic markedness, *human* is the least marked semantic category and *inanimate* is the most marked (Croft 2002) because humans are more similar (and therefore more accessible) entities to the speaker (Mayerthaler 1987). Under this account, animates are more robustly represented in our minds and more easily accessed during language processing, so it is less effortful to make finer semantic distinctions (e.g. number) on them. In other words, the distinction between plural marking between animates and inanimates gets made at the level of linguistic-encoding, because there is a distinction at the level of conceptual representation. Only for animates, the more robust category, is a semantic feature like singular/ plural represented.

A second possibility comes from usage-based approaches, which emphasize the effects of frequency on cognitive representations of linguistic structures and therefore patterns in natural language typology (Bybee 1985, Bybee 2006). Under usage-based theories, the Animacy Hierarchy may arise because learners have encountered or produced more tokens of plural-animate — due to their importance for communicative purposes — compared to plural-inanimates.

A third possibility is that typological patterns like the Animacy Hierarchy emerge due to domain-general learning biases (Fedzechkina, Jaeger and Newport 2012, Finley and Badecker 2008, Berent, Lennertz, Jun, Moreno and Smolensky 2008, Culbertson, Smolensky and Legendre 2012, Maldonado and Culbertson 2019, Wilson 2006, among others). For example, learners prefer novel words whose syllables follow the universal hierarchy of sounds organized by sonority (Berent et al. 2008). Under this account, language structures that are more learnable are promoted, whereas those that are difficult to learn are eliminated. Furthermore, such biases are found to be more pronounced in children than in adults (e.g. Culbertson and Newport 2015).

In the present work, we use an artificial language learning task to ask whether a plural marking system that follows the Animacy Hierarchy is easier to learn than one that does not, whether adult learners will shift languages that violate the Animacy Hierarchy toward a more typologically natural language (Experiment 1), and whether learning biases for animacy-marking emerge in children

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during the critical period of first language acquisition (Experiment 2) .

2 Experiment 1

2.1 Methods

2.1.1 Participants

Participants were 80 adults (age range 18-46) recruited online through Prolific Academic (www.prolific.co). All participants were monolingual native-English speakers with normal to corrected-to-normal hearing and vision. Each participant was rewarded with $ 3 for participating in the 20-minute experiment.

2.1.2 Stimuli

To examine whether an animate-marking rule is easier for learners to acquire than an inanimate-marking rule, we created an artificial language consisting of six novel nouns (clidam, daffin, mawg, spad, flugat, and geed) and one plural marker (ka). Each noun was randomly assigned to one of six objects that were either animate (pig, sheep, cow) or inanimate (car, truck or wheelbarrow). Singular nouns were always unmarked (as in English), but plural marking was conditioned on animacy according to one of four different language conditions. In the first two conditions, this animacy marking was deterministic. In the Animate 100 condition, only animate nouns receive the plural marker "ka"; in the Inanimate 100 condition, only inanimate nouns did. If participants have a strong learning bias that favors the typologically attested animacy marking, we would expect participants to learn a language in which only animates are marked (Animate 100) more accurately than a language in which only inanimates are marked (Inanimate 100).

In order to detect more subtle preferences for systems that follow the Animacy Hierarchy, we also created two conditions in which plural marking was probabilistically conditioned on animacy. In Animate 67, animate plurals were marked 67% of the time (unmarked 33%) and inanimate plurals were marked 33% of the time (unmarked 67%). Inanimate 67 is the opposite: animate plurals were marked 33% of the time, and inanimate plurals were marked 67% of the time. Following the Mixture-Shift Paradigm (Culbertson et al. 2012), learners exposed to probabilistic inputs are expected to shift the language, allowing us to observe the direction of this shift. If a learning bias underlies the Animacy Hierarchy, learners are expected to shift towards a language that obeys typologically natural animacy-marking patterns. The distribution of the plural marker in the four conditions is summarized in Table 1.

In all conditions, each of the six nouns occur with equal frequency and have the same probability of being marked.

Type of conditioning	Language condition	Animate	Inanimate
Deterministic	Animate 100	100	0
	Inanimate 100	0	100
Probabilistic	Animate 67	67	33
	Inanimate 67	33	67

Table 1. Proportion of plural trials marked -ka during exposure.

2.1.3 Procedure

The experiment was created with the JsPsych javascript package (de Leeuw 2015) and conducted online through Prolific Academic (www.prolific.co). The experiment consists of three parts: an exposure phase, a production test, and a survey. During exposure, participants were told to listen carefully as a speaker of an unfamiliar language described some pictures in the language. Their task was to learn how to describe the pictures in the new language themselves. On each of the 72

exposure trials, participants saw either a singular or a plural picture and heard the corresponding sentence. To ensure they were paying attention, after hearing the sentence, we asked them to select which of two sentences they had just heard. Every 18 trials, we gave participants a short break and asked them to click a next button when they were ready to continue. After exposure, participants completed 54 production test trials. On each trial, they saw a plural picture and were asked to select which of two possible sentences (one marked and one unmarked) a speaker of the language would use to describe that picture. Lastly, to determine whether participants were explicitly aware of the animacy marking pattern, we asked them (1) how they decided which sentence to pick and (2) whether they noticed any patterns to when the marker was used during exposure.

2.2 Results and discussion

2.2.1 Is an animate-marking rule easier to acquire than an inanimate-marking rule?

To determine whether an animacy-marking rule was easier to acquire than an inanimate-marking rule, we first asked whether adults in the Animate 100 condition were more likely to be correct on the production test than those in the Inanimate 100 condition. Using mixed-effect logistic regression, we predicted use of the correct form by Condition (Animate 100 v. Inanimate 100) and Noun-Animacy (animate v. inanimate) with by-participant and by-noun random intercepts. To our surprise, and contrary to our prediction, we found that learners were better at acquiring the language that violates the Animacy Hierarchy (Inanimate 100) than the one that obeys it (Animate 100). Learners in the Inanimate 100 condition had extremely high log-odds of selecting the correct form (b= 6.709, *SE* = 1.047, *z* = 6.411, p < 0.001), though they were more likely to be correct on animate than inanimate trials (b= -1.198, *SE* = 0.361, *z* = -3.321 p < 0.001). If the Animate 100 language were easier to learn, we would expect to find log-odds of selecting the correct form to significantly increase, but learners in the Animate 100 condition were actually significantly less likely to select the correct form (*b* = -2.422, *SE* = 1.148, *z* = -2.106, *p* < 0.05). These data are shown in Figure 1.

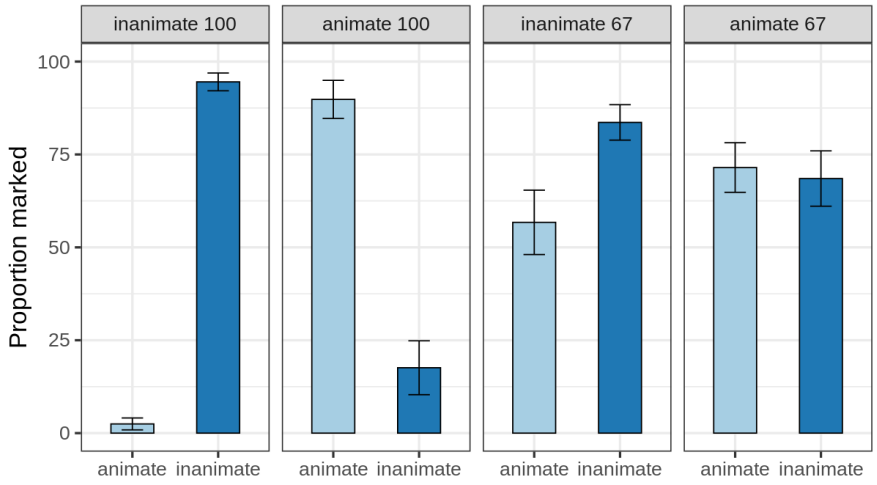

Figure 1: Proportion of using the plural marker -ka on animate (light blue) and inanimate (dark blue) trials in all four conditions. Error bars are standard errors.

2.2.2 Do learners shift the language in typologically expected directions?

We next asked whether learners shifted the language in typologically expected directions. To illustrate, we plotted the proportion with which each participant used the plural marker for animate nouns (x-axis) and inanimate nouns (y-axis) as (x, y) coordinates in Figure 2. For each condition, the (x, y) coordinate for the input language is shown with an asterisk.

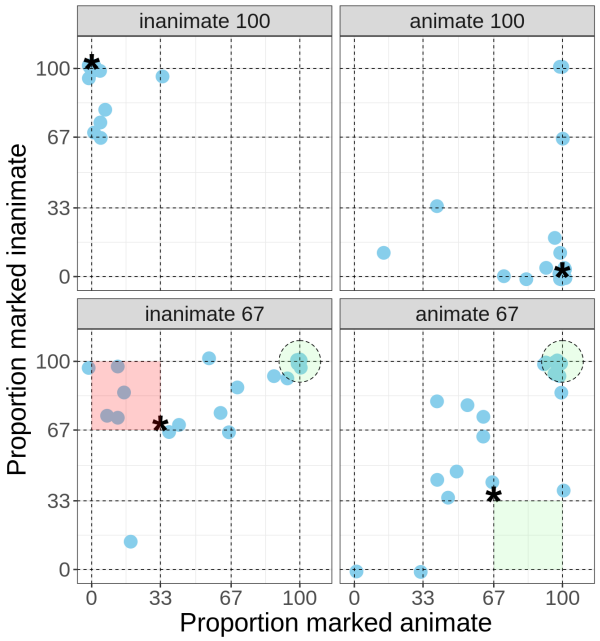

Figure 2: Plot of P(animate marking) by P(inanimate marking) for each adult. Positions of stars indicate input language. Red area symbolizes impossible destinations for shifting according to the Animacy Hierarchy. Green area symbolizes likely destinations for shifting.

The top two panels show learners in the two deterministic conditions. Most participants cluster around the input language, meaning they acquired the deterministic plural marking pattern they were exposed to. However, participants in Inanimate 100 cluster more centrally around the input, whereas more participants in Animate 100 deviate from the input. This corresponds with our previous group-level observation that participants in the Inanimate 100 condition were more likely to choose the correct marker on the production test.

Turning next to our probabilistic conditions, learners are expected to shift the language in one of two directions if their learning biases reflect the Animacy Hierarchy: toward the top-right corner, representing a language in which all plurals are marked regardless of animacy (as in English), and toward the bottom-right corner, representing a language in which only animate plurals are marked (as in languages like Kharia). Learners are not expected to shift the language toward the bottom-left corner, in which no plurals are marked (a pattern that eliminates all plural marking), or toward the top-left corner, in which only inanimate plurals are marked (a pattern that is unattested in natural language).

Looking first at Animate 67, we see that most participants who changed the language did so in a typologically expected direction. These participants preferred to mark all plurals deterministically (top-right corner), a pattern that retains plural marking but eliminates animacy conditioning. Only one participant shifted in an unexpected direction — eliminating plural marking — and no participant shifted the language to mark inanimates but not animates (a pattern that violates the Animacy Hierarchy). Perhaps surprisingly, no learner shifted the language toward the bottom-right corner (a pattern in which only animates are marked that aligns with language typology). Instead, the remaining participants are loosely scattered around the middle of the space, more or less on the line y = x, meaning that their productions showed probabilistic marking that is not conditioned by animacy.

Looking next at Inanimate 67, we see that, as in Animate 67, many learners changed the language to mark all plural regardless of animacy (top-right corner), and all but one avoided shifting to the bottom-left corner (eliminating all plural marking). However, and again to our surprise, while no learners shifted toward marking only animates (the other typologically attested pattern), many learners shifted the language toward marking only inanimate. This red area in the upper-left corner was expected to be avoided, since moving in this area requires shifting the language towards

marking inanimates, but not animates, which is a pattern that violates the Animacy Hierarchy.

We tested these patterns statistically in two ways. First, to determine whether learners were more likely to change the language such that animacy conditioning was eliminated (marking all plurals), we ran a mixed-effects logistic regression predicting use of the marked form by condition and noun-animacy (with by-participant random intercepts). Log-odds of using the marked form were not significantly above chance in either condition (all ps > 0.20). Instead, patterns of marking reflected the participants' input: learners in Inanimate 67 were more likely to mark inanimate nouns ($b = 2.165$, $SE = 0.198$, $z = 10.952$, $p < 0.000$) while learners in Animate 67 were less likely to mark inanimate nouns ($b = -2.417$, $SE = 0.262$, $z = -9.23$, $p < 0.000$).

Second, to determine whether learners were more likely to change the language in a typologically attested direction (marking only animates rather than only inanimates), we asked which condition was more likely to regularize to the dominant animacy marking pattern. In the Animate 67 condition, most of the animates are marked and most of the inanimates are unmarked, so a reasonable shift — one that requires minimal reorganizing — would be to mark only animates. In the Inanimate 67 condition, learners are exposed to the opposite pattern, such that the minimal shift to a fully conditioned language would be to mark only inanimates. For each production test trial, we coded whether or not the participant matched this 'minimal shift' direction. The results of the mixed-effect logistic regression, with Condition as fixed effect and participants and nouns as random effects, suggest that participants are more likely to adopt the corresponding animacy-conditioning pattern in Inanimate 67 ($b = 0.6445$, $SE = 0.1925$, $z = 3.348$ $p < 0.001$) than the Animate 67 condition ($b = -0.578$, $SE = 0.217$, $z = -2.661$, $p < 0.01$). This suggests that learners were more likely to change the language in a direction that *violates* the animacy hierarchy rather than obeys it.

2.2.3 Do learners match the probability of markers in their input?

While conditioning the language (either toward fully regular plural marking or plural marking conditioned on animacy) is one possible response to inconsistent patterns of marking, another is to match the probability with which forms occur in their relevant contexts. As shown in Figure 2, adult learners matched input probabilities more accurately on animate trials than on inanimate trials at test. Using Wilcoxon Signed Rank Tests, we found participants' use of the marker on animate trials matched the probability with which animates were marked in the input in three of the four conditions: Animate 100, Inanimate 100, and Animate 67 (all ps > 0.05). On the other hand, participants marked inanimate trials significantly different from the probability of inanimates being marked in the input language (Animate 100: $p < 0.01$; Inanimate 100: $p = 0.04$; Animate 67: $p < 0.001$; Inanimate 67: $p < 0.001$). This suggests that adult learners were better at retaining the input probability of the marker on animate trials and were less likely to distort this probability, whereas the input probability of the marker on inanimate trials are more susceptible to change.

2.2.4 Why do our learners apparently disobey the animacy hierarchy?

Contrary to what is predicted by the learning bias account, in Experiment 1 we found that learners were better at acquiring inanimate-marking languages than animate-marking languages, and were more likely to shift probabilistic marking patterns in this same (typologically unexpected) direction. Why did our learners prefer to violate the animacy hierarchy? One possibility is native language bias. Plural marking is obligatory in English, but some highly frequent animate nouns are exceptions to this rule (e.g. family, sheep, deer). It is possible that our adult learners regularized to a language in which animates were unmarked because they have observed this pattern on some animates in their native language. A second possibility is that animate nouns are particularly salient to our adult learners. We found that adults were better able to match the probabilistic marking patterns in their input on animate trials than inanimate trials, regardless of language condition. One interpretation is that adults were paying closer attention to animate trials (due to their salience), and this combined with a general bias toward probability matching (e.g. Hudson Kam & Newport 2009) made them less likely to boost in Animate 67 condition, because that would involve distorting the probability represented from the input.

3 Experiment 2

While adult learners in Experiment 1 did not show a learning bias that favored languages that follow the Animacy Hierarchy, it is possible that child learners would show such a bias. In previous work investigating whether learning biases reflect typological preferences, the strongest effects have been observed in children (e.g., Culbertson and Newport 2015). To test this possibility, in Experiment 2 we asked whether a language that obeys the Animacy Hierarchy is easier for children to learn than a language that violates it.

3.1 Methods

3.1.1 Participant

Participants were 32 English-learning children (age 5.00-8.99 years) recruited from three local schools in Philadelphia: Lansdowne Friends School, Friends Select School and Chester A Arthur school. Children received stickers and a book for their participation.

3.1.2 Stimuli and Procedure

We used the two deterministic languages from Experiment 1: Animate 100, in which animate nouns were always marked and inanimate nouns were never marked, and Inanimate 100, which had the opposite pattern.

The procedure was as in Experiment 1 with two exceptions: (1) children participated at their school with a research assistant from our lab, and (2) during the production phase, children performed a wug test (Berko 1958) rather than the 2AFC test. On each production test trial, children were presented with a new singular noun and asked "if this one is said [NOUN], how would you say this one?" (a prompt to describe the plural picture of the same noun in the language)

3.2 Results

If the Animacy Hierarchy is a reflection of underlying learning biases, we expect the language that aligns with this hierarchy (Animate 100) to be easier for children to acquire than the language that does not (Inanimate 100). To test this hypothesis, we ran a mixed-effect logistic regression model, predicting use of the correct form by Condition (Animate 100 v. Inanimate 100) and Noun-Animacy (animate v. inanimate) with by-participant and by-noun random intercepts. Children were significantly more likely to use the correct marker than expected by chance in the Inanimate 100 condition ($b = 3.7352$, $SE = 0.6333$, $z = 5.898$, $p < 0.000$), while children in the Animate 100 condition had significantly lower log-odds of using the correct marker ($b = -4.4464$, $SE = 0.8579$, $z = -5.183$, $p < 0.000$).

Our model suggests that children's learning patterns do not reflect the Animacy Hierarchy either. However, as revealed in Figure 3a: children had a difficult time learning the marking pattern in both languages. Although the input language requires marking on either animate or inanimate plural nouns (100%), children only use the marked form when it is required about 30% of the time. Looking more closely at each child's pattern of marking reveals that many children never used the marker, leaving both inanimate and animate noun plurals unmarked regardless of condition (see dots clustered around the point (0, 0) in Figure 3b). Since using a bare stem (or in other words, omitting inflectional markers) are the most common error children make in language acquisition and often seen as an index of the lack of the grammatical rule (e.g. Brown and Fraser 1973), this further indicates that these children have not yet acquired any plural marking rule.

On the other hand, nearly all children who learned to use the plural marker reproduce their input pattern faithfully (see dots clustered near the asterisk, representing the input language (Figure 3b). Dots cluster especially closely in the Animate 100 language, which suggests that for children who learned the plural marking pattern, they learned the input pattern more successfully in the Animate 100 language. Unlike our adult learners, no children move the language to fully regular - marking all plural nouns regardless of animacy.

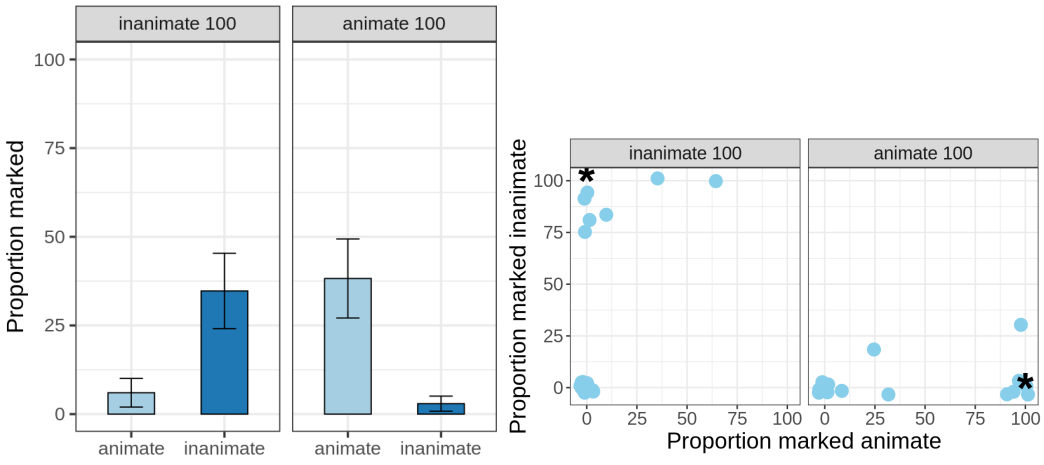

Figure 3: (a) Proportion of using the plural marker -ka on animate (light blue) and inanimate (dark blue) trials by children in the two conditions. Error bars are standard errors. (b) Plot of P(animate marking) by P(inanimate marking) for each child. Position of the star indicates input language.

While our data on individual child can be argued to reflect a slight preference for languages that obey the Animacy Hierarchy for children who have learned to use the plural marker, it is important to emphasize that at least half of the children did not learn to use the plural marker at all in either condition. This is a substantial (and unexpected) failure to learn and suggests that a single training session is not long enough to ensure all children this age to acquire an artificial language with a grammatical rule conditioned on animacy. A second possibility is that external factors such as distractions at the child's school were responsible for children's failure to learn.

From these very preliminary results, we can only conclude that our data do not support the hypothesis that the typologically common pattern following Animacy Hierarchy is easier for children to learn than the typologically unattested one. More investigation is needed with more robust learning in order to assess whether this pattern of results indeed reflects an underlying learning bias.

4 General Discussion

Across two experiments, we used an artificial language learning paradigm to ask whether the Animacy Hierarchy observed in natural language typology reflects an underlying learning bias. We found that, while a language that obeyed the animacy hierarchy was easier for children to acquire than one that did not, many children were unable to learn any marking pattern at all, suggesting that the language was too difficult for them to acquire in a single session. Adult learners on the other hand appeared to have an easier time acquiring the inanimate-marking language than the animate-marking language, the opposite pattern predicted by the Animacy Hierarchy. When exposed to probabilistically marked languages, adults did not appear to shift towards a language respecting the Animacy Hierarchy, either. In fact, adult learners showed significantly more regularization in the inanimate-marking predominant language, shifting it towards a language that exclusively marks inanimates.

These results were initially surprising, but they are not necessarily unexpected in the context of the literature on learning biases and language universals. However, as Smith et al (2017), Culbertson et al (2012), and others point out, weak learning biases can often accumulate as language is transmitted from one learner to the next, resulting in very strong typological patterns. On the other hand, strong learning biases can be partially or completely overridden by other linguistic or social factors, resulting in language universals that are more reflective of these latter factors than the learners' biases. Our results suggest that learners do not have a bias in favor of languages that obey the typological pattern of animacy marking, but rather a bias towards those that violate the typological pattern. If it is confirmed that the current observed pattern does not arise from native

language influence of our particular set of participants, Animacy Hierarchy serves as a case where learners' preferences are completely overridden by these other factors during language transmission and use, such as semantic and pragmatic salience of animates.

The current results do not rule out the possibility that a weak learning bias toward languages that obey the Animacy Hierarchy does in fact exist and it is the current native language influence that masks it and even sets it to the opposite direction. How might we better detect such a bias? Besides testing a sample free from English influence, one possibility is that this bias could be observed more clearly if the distinction between animate and inanimate was made more salient. In the present work, animates were farm animals and inanimates were farm vehicles. Perhaps this distinction was not salient enough to provoke learners to arrange their plural marking rule along the Animacy Hierarchy. In future work, one might expect more robust findings if the animate category were human while the inanimate category were inert objects with no motion properties, and did not overlap via another meaningful category (e.g. things on a farm).

Another possibility is that the lack of additional linguistic context made learners unlikely or even unwilling to condition their rule around animacy in our experiments. As we pointed out in the introduction, many languages do indeed allow differential plural marking, such that marking is obligatory on higher animates in the hierarchy and optional on lower animates and inanimates. However, these natural language examples — and the rich linguistic contexts they are situated in — are quite different from the simple artificial language our learners were exposed to. Most notably, in our artificial language, singular forms were always unmarked and plural forms were differentially marked, either deterministically (obligatorily marking animates and never inanimates, or vice versa), or probabilistically (using the optional marker more often on animates than inananimates, or vice versa), but there was no additional *linguistic* cue to convey plurality. In natural language, morphological plural marking can occasionally or often be redundant with another linguistic cue. Consider for example the English phrases "one cow, two cows" compared to "one sheep, two sheep". Besides the presence of a plural marker, the numeral also clearly indicates plurality. In a hypothetical language where we had access to only bare nouns and their plural morphology, we could only distinguish between singular and plural for "cow" and never "sheep". We might expect such a natural language with this property to *also* avoid optional marking, because there is no alternative way of expressing number distinctions. The artificial language we used in this experiment is such a language with no numerals. In fact, it may be optimal in such a situation for the language to evolve toward full plural marking (a shift that many of our adult participants made in the present experiment). Future work could ask whether a language in which number distinctions can be made in another way would be more likely to allow optional marking patterns to emerge and persist in plural morphology than one that does not.

Finally, it is important to point out that finding or not finding a learning bias for languages that align with the Animacy Hierarchy would not rule out theories of semantic markedness (Croft 2002, Clark and Clark 1978) or usage-based approaches (Bybee 1985, Bybee 2006). In fact, these theories may offer a more nuanced explanation for such learning biases should we observe them in future work. For example, if learners indeed have an easier time learning languages that obey the Animacy Hierarchy, we would next want to ask why this is the case. One possibility consistent with semantic markedness is that entities at the higher end of the hierarchy (e.g. humans) are more salient to us, we attend to them more closely, and find it more necessary to distinguish between one or many them than we would for inanimates. Another possibility consistent with usage-based approaches is that we encounter more plural animates, perhaps due to the aforementioned desire to make clear number distinctions on animate entities, and therefore mark them more frequently in our own language use.

5 Conclusion

Our preliminary results suggest that adults' learning of conditioned plural marking does not align with the animacy-marking patterns we see across language. Learning a language in which only inanimates are marked was not more difficult, but easier than learning one in which only animates are marked. Further, when faced with inconsistent probabilistic input, adult learners do not necessarily regularize the input towards a pattern that aligns with typologically attested patterns in natural language: they have no trouble regularizing a probabilistic language into an unattested inanimate-marking language. However, our adult learners *were* more successful matching input

probabilities on animate trials than inanimate trials, which suggests that animates are particularly salient to learners. Our preliminary data do not support that children show a bias toward animacy-marking, but a plural marker conditioning on animacy (in either direction) was very difficult for 5-8 year old children to fully acquire in a single-session of language exposure.

Although there may be a cognitive basis underlying the widely-attested Animacy Hierarchy in morphological marking, we did not observe strong evidence for such a bias in the present work. However, as we pointed out in the discussion, learning biases are not the only source of pressure on natural language typology. The Animacy Hierarchy may emerge across languages due to a combination of pressures from language transmission, language use, and semantic markedness rather than simply an underlying learning bias in favor of animacy marking.

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