Learning Biases for Syncretic Morphological Systems

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Abstract

Morphological syncretism occurs in languages when one morphological category 'merges' with another. Cross-linguistic research on the prevalence and types of syncretic patterns has revealed that some types of syncretism are more common than others. For example, syncretism in nominal morphology is more likely to occur in non-singular categories (Baerman et al., 2005). In two artificial language learning experiments, participants were exposed to words from a miniature language with suffix markings for gender (feminine and masculine) and number (singular, dual, and plural). Participants in Experiment 1 showed no evidence of a bias for syncretism in non-singular forms. However, participants in Experiment 2 showed a general bias to infer that a suffix that marked a novel category should be identical to a known form. This bias was strongest for non-singular items, in line with the cross-linguistic typology of syncretism. Implications for learnability and typology are discussed.

Keywords: syncretism; morphology; linguistics; artificial language learning; linguistic categories

Introduction

Syncretism is a linguistic phenomenon whereby morphological forms 'merge' together to share the same form for multiple, but related meanings. For example, in Russian, the dative plural suffix /-am/ applies to all four noun classes, while the instrumental singular affix /-oj/ applies only to Class II nouns (Parker, 2016). Cross-linguistic studies of syncretism have revealed that syncretic forms are more likely to occur in nominal morphology for non-singular forms compared to the singular (Baerman et al., 2005).

There are several possible explanations for why non-singular forms are more likely to show syncretism, many related to frequency. Singular forms tend to be highly frequent in language use, particularly compared to dual or trial forms. Because learners generally never get the full range of stem-affix combinations in their input, the language learner must infer morphological forms from limited input, making overgeneralization more probable (Ambridge et al., 2013; Harmon & Kapatsinski, 2017).

Another reason that syncretism may be favored in non-singular forms could be related to the fact that non-singular forms are generally considered to be 'more marked' than the singular. This is true for several senses of markedness (Haspelmath, 2006). Singular forms are more likely to receive 'zero' morphological marking than non-singular forms. In addition, dual is considered to be both semantically and cognitively marked, and often receives more structurally complex linguistic analyses (Nevins, 2006, 2011). Syncretism could therefore favor structurally marked categories because it reduces the number of forms required to linguistically mark that category. It could also ease the burden on the learner, reducing the number of forms that the learner must discover.

However, there is reason to believe that syncretism can pose challenges for learners. Syncretism creates ambiguity and complexity through homophony (Storme, 2022). Because learners are biased against homophony (Yin & White, 2018), specific conditions such as systematicity (Finley & Wiemers, 2015), or an increased number of forms with the same affix (Finley 2022) may be required to learn languages with syncretic forms.

The conditions that help learners acquire syncretic forms may help explain the typological tendencies in syncretism. Typologically frequent patterns tend to be easier to learn and generalize compared to typologically less frequent patterns in artificial language learning settings (Culbertson, 2012; Culbertson et al., 2012, 2020; Finley & Badecker, 2009; Wilson, 2006). Artificial language learning experiments allow the researcher to control several factors in the language, such as frequency, and number of forms.

Previous studies focusing on learnability of syncretism have shown a bias towards systematic syncretism (Finley & Wiemers, 2015; Pertsova, 2011). For example, a language with systematic syncretism might have the same affixes for masculine and feminine in the plural, effectively neutralizing the gender distinction for plural items. When syncretism neutralizes a category, it reduces the number of forms to learn, and decreases ambiguity relative to syncretism that is not systematic.

Other studies have shown that learners may be biased towards syncretism in the dual (Finley, 2022; Lee, 2020). Lee (2020) showed better learning for dual-plural syncretism compared to singular-dual and singular-plural syncretism, supporting a view that the structural/grammatical properties of the dual may bias learners towards syncretism in the dual.

Finley (2022) trained adult learners on an artificial language with suffix markers for gender (masculine, feminine, and neuter) and number (singular, dual, and plural). Training consisted of six forms for each morpheme (e.g., six masculine dual items). However, syncretism neutralized gender for one number category (depending on the condition). For example, in the Dual condition, the same suffix marked dual masculine, dual feminine, and dual neuter, meaning 18 of the 54 training items were marked with the same phonological content. This increase in form frequency created a significant advantage to learning syncretic categories. In addition, the benefit to syncretism seemed to be stronger for dual compared to other categories, suggesting

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the benefit of syncretism may be larger for non-singular categories. Such a benefit may provide important insights to understanding the formal properties of the representations of grammatical number.

However, it is unclear if the benefit to category neutralization via syncretism found in previous research holds when the number of forms for each affix is held constant. When the total number of items from the syncretic categories was reduced to six (two masculine, two feminine, and two neuter forms), learning was severely disrupted (Finley, 2021). Thus, in order to better understand the role of form frequency in learning noun class categories in artificial settings, the language may need to be simplified (i.e., including two gender categories instead of three).

The present study tests two hypotheses related to learning noun class categories. First, that syncretism that neutralizes a category increases learnability of the category, even when number of forms is controlled for (Experiment 1). Second, that learners are biased towards syncretism in non-singular forms over singular forms (Experiments 1 and 2).

Experiment 1

Participants were exposed to a miniature language that consisted of nouns with complex nominal morphology marked as suffixes. This morphology contained three numbers (singular, dual, and plural), and two 'genders' (masculine and feminine), for a total of six possible morphemes. In each condition, training consisted of six items for each morpheme, with one exception: either singular, plural or dual only had six items (three for feminine, three for masculine). In the Syncretic conditions, these six items were both marked with the same affix (go), while in the matched Control (Non-Syncretic) conditions, there were two separate affixes (go) and (mi). If syncretism improves learning outcomes for affixes with fewer training items, participants will show greater learning of the critical (low form frequency) items when they neutralize a category via syncretism. If this bias is greater for non-singular items, the benefit of syncretism to learning will be stronger for dual and plural items compared to singular items.

Method

Participants Adult, native American English speakers located in the USA, were recruited from Amazon's Mechanical Turk, and were paid $5 for their participation. Final data analysis included 146 participants (25 participants in NonSyncDual and SyncSingular conditions, and 24 participants in the other 4 conditions). An additional six participants were excluded from analysis because they indicated (in a post-completion survey) that they wished their data to be discarded.

Design and Materials Participants were auditorily exposed to a miniature, artificial language that contained CVCV stems (denoted by animals) with -CV suffixes denoting the gender ('masculine', and 'feminine') and number (singular, dual, and plural) of the lexical item, creating six possible affixes. As described above, participants were trained on 6 items for each affix, except for two critical 'low form frequency' affixes, with three items each. In the Syncretic conditions, the critical affix was always /-go/, while in the NonSyncretic conditions, the critical affixes were /go/ and /mi/, as shown in Table 1. For example, in the SyncSing condition, the feminine and masculine singular were both /-go/, but in the NonSyncSing condition, masculine was /-go/ and feminine was /-mi/.

This design created 30 training items, with three items each of masculine and feminine forms in the critical affixes, and six items for the other four categories. For example, in the SyncSing condition, there were three items in the training set that were masculine singular (/-go/), three items that were feminine singular (/-go/), and six items that were masculine dual. In the Syncretic conditions, the critical affixes were identical, thereby neutralizing the gender distinction for the critical, low form frequency affixes.

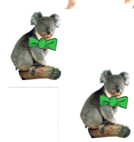
Table 1: Number of forms for each affix (Exp 1).

	Masculine			Feminine		
	1	2	PL	1	2	PL
SyncSing	**go** 3	me 6	ge 6	**go** 3	di 6	po 6
SyncDual	me 6	**go** 3	ge 6	di 6	**go** 3	po 6
SyncPlural	me 6	ge 6	**go** 3	di 6	po 6	**go** 3
NonSyncSing	**go** 3	me 6	ge 6	**mi** 3	di 6	po 6
NonSyncDual	me 6	**go** 3	ge 6	di 6	**mi** 3	po 6
NonSyncPlural	me 6	ge 6	**go** 3	di 6	po 6	**mi** 3

The language contained 12 different stems, each denoted by an animal (e.g., donkey, koala, giraffe, etc.). Number was indicated by the number of the animals in the picture display: one, two, or more than two. Gender was indicated using stereotyped accessories: bowtie for "masculine", and purse for "feminine". Because these stereotyped accessories are not transparent, it is best to consider the markers as markers for an abstract grammatical gender system, rather than marking strict biological gender. While many languages show a correlation between grammatical gender and biological gender, many languages show noun class genders with no such distinction (Corbett, 2012).

Each training trial consisted of a picture of one of 12 animal stems varying by gender and number (e.g., one donkey with a purse), and a sound file to denote the meaning of the word (e.g., "satego"). The CVCV-CV words contained a mix of consonants from the set [b, d, g, k, m, n, p, s, t, v, w, z] and a mix of vowels from the set [a, e, i, o, u]. No item shared a close resemblance to known English words. Examples of the picture-sound pairings can be found in Table 2. Note that the images were resized to fit the tables in the paper.

Table 2: Example training trials (Singular conditions).

Meaning/Sound	Picture
Singular-Fem "satego"	
Dual-Masculine "tiseme"	

The language contained a total of 72 possible picture-sound pairings (12 stems x 6 affixes). The 30 items in the exposure phase were presented five times each in a random order. A subset of the remaining items was held out for use in testing.

Learning was assessed via a two-alternative forced choice task with 36 items (12 for each singular, dual, and plural). The task required participants to select the best (audio) form for the given (picture) meaning. A single picture was shown, and two different audio forms were presented, both with the same stem, but a different ending. This ensured that that the participant relied on knowledge of the suffixes to determine the correct response. The incorrect (foil) response was always the same suffix for the same gender, but a different number. The incorrect response was split evenly between the two other possible numbers, where possible. For example, if the target picture contained two male ladybugs, the incorrect response would be the word for either one male ladybug, or plural male ladybugs. Examples of test items can be found in Table 3. Full materials and data analysis code can be found at: https://osf.io/mn3xb/.

Procedure The experiment took place online using FindingFive (FindingFive Team, 2019). Participants were instructed to complete the entire experiment in one sitting, using headphones, and in a quiet location with stable internet connection. Participants were asked to check their internet connection and audio using a test sound ([udvu]). Participants were told that they were learning a novel language, and would be hearing words from the language, with a picture that denoted the meaning of each word. Participants were required to press a 'Continue' button after each sound file played. Following training, participants were encouraged to take a short break, and continue to the test phase. Participants were asked to pick which of two words best matched the meaning of the picture, the first or the second, and were given options to click on the corresponding choices or to press the 'a' key to indicate the first word, and the 'l' key to indicate the second word. The audio and image files were always presented simultaneously.

Upon completion, participants were given written debriefing, as well as a chance to place any feedback, and to recuse themselves from inclusion in data analysis. The entire experiment took approximately 20 minutes to complete.

Table 3: Example test trials (Singular conditions).

Correct Item	Foil Item	Picture
vopidi	vopipo	
pazige	pazigo	

Results

Mean proportion of correct responses for each condition in Experiment 1 are displayed in Figure 1. Dots indicate means for individual participants. Data from all eligible participants were included, but any trial that lasted longer than 10s were dropped (n = 134). The data were fit into generalized linear mixed effect models fit by the Laplace approximation using the lme4 (Bates et al., 2015) package in R (R Development Core Team, 2018) via R Studio (RStudio Team, 2020). All models included random intercepts for subjects and items; more complex models failed to converge.

If syncretism improves learning outcomes for affixes with fewer training items, then we expect to see a greater proportion of correct responses in the critical grammatical number for Syncretic conditions compared to Non-Syncretic conditions. If learners are biased towards syncretism in non-singular forms, then there should be bigger differences between the Syncretic and Non-Syncretic conditions for critical items in non-singular forms compared to the singular.

Due to convergence errors, a full model exploring interactions of syncretism by number of training items by grammatical number could not be performed. Instead, four models were run. The first three models compared subsets isolated by the critical grammatical number (e.g., SyncSing vs. NoSyncSing), dummy coded with the Syncretic condition and critical items set as the baseline. The fourth model compared the critical items across all conditions (excluding non-critical items).

Singular Conditions The model comparing SyncSing and NonSyncSing conditions showed a significant intercept, β = 1.16, SE = 0.31, z = 3.76, p <0.001, suggesting above chance performance for critical items in the Syncretic condition. There was a significant difference between the SyncSing and NonSyncSing conditions for critical (singular) items, β = 0.74, SE = 0.37, z = 1.99, p = 0.046, suggesting a benefit to syncretism for learning the singular. There was no significant difference between critical and non-critical forms in the Syncretic condition, β = 0.26, SE = 0.25, z =1.04, p = 0.30, and there was no interaction, β = 0.15, SE = 0.23, z = 0.62, p = 0.54.

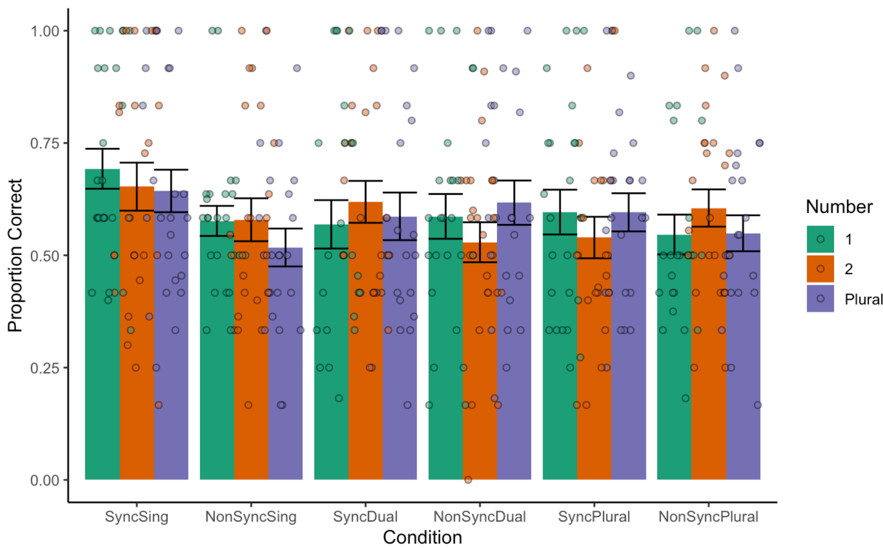


Figure 1: Experiment 1 results (means and standard errors); dots represent individual participant means.

Dual Conditions This model showed a significant intercept, $\beta = 0.69$, SE = 0.27, z = 2.57, p =0.010, suggesting above chance performance for critical items in the SyncDual condition. There was no significant difference between critical (dual) and non-critical items in the SyncDual condition, $\beta = 0.20$, SE = 0.19, z = 1.06, p = 0.29, and no significant difference between the SyncDual and NonSyncDual conditions for critical (dual) items, $\beta = 0.48$, SE = 0.35, z = 1.36, p = 0.17, suggesting no benefit to syncretism for learning the dual. However, there was a significant interaction, $\beta = 0.53$, SE = 0.23, z = 2.32, p = 0.020, suggesting that the dual was relatively harder to learn in the NonSyncDual compared to the SyncDual condition.

Plural Conditions This model showed a significant intercept, $\beta = 0.46$, SE = 0.22, z = 2.15, p =0.031, suggesting above chance performance for critical items in the SyncPlural condition. There was no significant difference between critical (plural) and non-critical items in the Syncretic condition, $\beta = 0.090$, SE = 0.17, z = 0.53, p = 0.60. There was no significant difference between the SyncPlural and NonSyncPlural conditions for critical (plural) items, $\beta = 0.22$, SE = 0.29, z = 0.73, p = 0.46, and no interaction, $\beta = 0.21$, SE = 0.22, z = 0.93, p = 0.35.

Critical Items This model showed no significant differences between syncretic conditions for critical items. There was no difference between singular and dual critical items, $\beta = 0.41$, SE = 0.35, z = 1.17, p = 0.24, or singular and plural critical items, $\beta = 0.54$, SE = 0.35, z = 1.56, p = 0.12. There was also no significant syncretism by number interactions between singular and dual, $\beta = 0.16$, SE = 0.42, z = 0.40, p = 0.69, or for singular and plural, $\beta = 0.41$, SE = 0.42, z = 0.98, p = 0.33. These results suggest that there were no differences in the learnability of the critical items across syncretic conditions, and no significant benefits to syncretism compared to non-syncretism for the different number categories.

Discussion

Participants in Experiment 1 learned the critical low form frequency affixes when they were syncretic, as shown by the significant intercepts of the models. However, there was no clear support for a bias for syncretism in non-singular items. If anything, the effect was stronger for singular items.

One possible explanation for the mixed results is that participants, being native English speakers, were likely biased against dual forms, since dual is not present in English, and has low frequency even in languages that mark the dual. If learners must sort out that dual and plural are distinct, this could result in making dual and plural harder to learn, which may explain why responses were generally higher in the singular conditions (since there were more dual and plural affixes).

Another explanation for the mixed results in Experiment 1 is that even though there were six training items for each affix, the critical items represented two meanings (e.g., masculine and feminine). Thus, it may be impossible to completely control for form frequency.

A better way to address the question may be to test inferences and generalization (Wilson, 2006). Experiment 2 tests whether participants, trained on language with two genders (masculine, and feminine) and three numbers (singular, dual, and plural) without any sign of syncretism, will infer that novel neuter items have the same form as their gendered counterparts, or have a novel form.

Participants may avoid syncretism in order to avoid homophony (Yin & White, 2018). If learners are biased against homophony, they should infer that the novel category has a form distinct from the one heard in training, also in line with mutual exclusivity (Merriman et al., 1989). If learners are biased towards syncretism, they should infer that a novel grammatical category (neuter) should have the same form as heard in training (masculine or feminine). If there is an interaction between homophony avoidance and a bias towards syncretism in non-singular forms, participants should be more likely to select the novel affix for singular items compared to non-singular items.

Experiment 2

Experiment 2 further addresses questions related to homophony avoidance and biases towards syncretism for non-singular forms by exposing participants to a 2 (masculine feminine) x3 (singular, plural, dual) morphological paradigm with equal lexical frequency across categories, and no syncretism. At test, participants were exposed to a novel grammatical category (neuter), and given either a known form or a novel form. If participants are biased towards syncretism, they will select the known form more often than the novel form; if participants are biased towards homophony avoidance, participants will select the novel form more often than the known form. If there is a bias towards syncretism in non-singular forms, participants will be more likely to select the novel form for singular items compared to non-singular items.

Method

Participants All participants were adult, American English speakers, recruited from the Psychology subject pool at a university in the Pacific Northwest of the United States, and were given course credit for their participation. Participants did not previously participate in Experiment 1, or any similar morphological learning experiment. Final data analysis included 32 participants. One additional participant was run but excluded from analyses because they indicated that they wished their data to be discarded in a post-completion survey.

Design and Materials Experiment 2 made use of a similar design and stimuli set as Experiment 1, with several notable changes. First, none of the affixes in Experiment 2 were syncretic. Second, there were six forms for each (non-identical) affix. Third, the test asked participants to generalize to neuter items, which were not present in training. Holding out neuter items allows for a different test of biases towards syncretism. When presented with novel neuter items, participants, in a two-alternative forced-choice test can be asked whether a familiar affix is 'better' than a novel affix.

The training phase in Experiment 2 contained items from the same 12 stems used in Experiment 1, with six items for each suffix for a total of 36 training items. Each item in the training set was repeated five times in a different random order each time. The list of the suffixes used in Experiment 2 are presented in Table 4.

Like Experiment 1, each test item included a single picture, and participants were asked to choose between two auditory forms that differed only in terms of the suffix. There were 30 Gendered items and 30 Neuter items, with 10 items each for singular, dual, and plural. The Gendered items pit the correct form (heard in training) with an incorrect form of the same gender but a different number; all items were novel. The Neuter items pitted gendered items with the same grammatical number against the novel suffix /-mi/. Order of presentation was counterbalanced across items such that the 'correct' item was presented first on half of the trials. The order of presentation of items was presented in a different random order for each participant.

Table 4: Number of forms for each affix (Exp 2).

	1	2	Pl
Masc	me	go	ge
	6	6	6
Fem	di	wa	po
	6	6	6

Procedure The procedure was identical to Experiment 1.

Results

Means and 95% CIs for Experiment 2 can be found in Figure 2. Responses to Neuter items were coded as 'correct' if participants selected the novel affix (e.g., homophony avoidance). Data from all eligible participants were included, but any trial that lasted longer than 10s was dropped (n = 99). The data for Experiment 2 were analyzed in a similar manner to Experiment 1. Because the question of interest in Experiment 2 was how learners generalized the neuter items based on grammatical number, responses were divided into Gendered and Neuter. The models used simple contrasts, with singular items as the baseline. A significant intercept was interpreted as an overall difference from 50% chance.

Gendered Items The intercept of the model for gendered items was significant, $\beta = 0.85$, SE = 0.20, z = 4.24, $p < 0.001$, indicating that participants had learned the overall pattern. There were no differences between singular and dual items, $\beta = 0.00022$, SE = 0.21, z = 0.001, $p = 0.99$, or singular and plural items, $\beta = 0.33$, SE = 0.21, z = 1.56, $p = 0.12$, suggesting no bias for learning grammatical number.

Neuter Items The intercept of the model for neuter items was significant and negative, $\beta = -0.84$, SE = 0.19, z = -4.42, $p < 0.001$, indicating that participants generally preferred the known affix, creating syncretism. There were significantly more novel affix responses for singular items compared to dual items, $\beta = -0.44$, SE = 0.18, z = -2.38, $p = 0.017$, and plural items, $\beta = -0.68$, SE = 0.19, z = -3.64, $p < 0.001$, suggesting that the bias towards syncretism was stronger for non-singular forms.

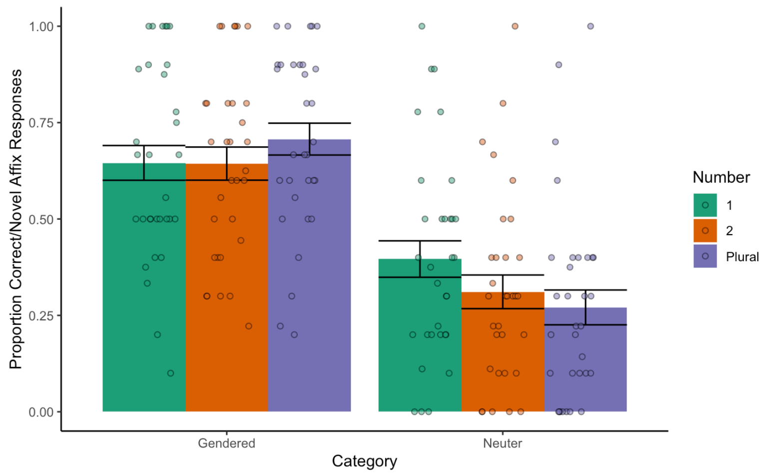


Figure 2: Experiment 2 results (means and standard errors); dots represent individual participant means.

Discussion

When participants were trained on a novel language with six affixes, two gender categories (masculine and feminine) by three number categories (singular, dual and plural), participants were more likely to select a known affix for novel neuter items, suggesting a bias towards syncretism in gender over number. This bias was stronger for non-singular items compared to singular items, in line with the typology of syncretism. The bias against selecting the novel affix represents trends found in iterative learning experiments that show a tendency for a loss of distinctions over time (Kirby et al., 2015).

General Discussion and Conclusions

The present study explored the role of syncretism in learning nominal morphology. In Experiment 1, participants showed a benefit to syncretism when there were fewer forms of the same affix. However, the benefit to syncretism was limited, and the biases for syncretism in non-singular forms may have been masked by general biases towards neutralizing the dual and the plural, as learning of the 3x2 language was relatively weak. However, when all forms were equally frequent (in Experiment 2), learning was relatively strong, suggesting that it is possible to overcome biases against dual and plural as separate affixes with enough training.

It is also possible that the results of Experiment 1 were mixed because of a bias to avoid homophony. However, Experiment 2 did not show the same bias against homophony as in previous studies (Yin & White, 2018). Rather, participants assumed that the neutered items had the same form as their known counterparts. This assumption was strongest for non-singular items, in line with the cross-linguistic typology. One reason that participants did not show a homophony bias is that the 'novel' affix was always /-mi/ and appeared in half of the test items. Thus, it may be that participants, particularly by the end of the study did not treat the item as novel.

One reason that Experiment 2 showed a bias while Experiment 1 did not was because the task in Experiment 2 was a generalization task. Generalization tasks may be easier than learning tasks, and therefore able to detect more subtle biases for syncretism. Future research could explore how inferences in learning and generalization might shape language learning and language change. While the biases for non-singular items to undergo syncretism were somewhat weak, it is possible that, over several generations of learners, this bias could emerge more strongly (Reali & Griffiths, 2009; Smith & Wonnacott, 2010). Future research could address this question using iterated methods of language learning (Kirby et al., 2008).

The present study adds to our understanding of how syncretism might affect language learning. Syncretism, especially when it neutralizes a category, may make learning novel categories easier. When faced with generalization to a novel category, learners may be more willing to use a novel form for singular items compared to non-singular items, in line with the cross-linguistic typology of syncretism. This finding adds to the growing body of research relating learnability to cross-linguistic frequency of phonological, morphological and syntactic patterns.

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