

Substantive bias in learning phonological variation

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Research on learning biases in phonology has produced fruitful results (see Moreton & Pater 2012a,b for a review) but work in this field has predominantly assumed *categorical* phonology. For instance, Saffran and Thiessen (2003) trained one group of learners on a language where patterns targeted [p, t, k] vs. [b, d, g] and compared the learning outcome to another language where patterns targeted [p, d, k] vs. [b, t, g], from which they found supporting evidence for the structural simplicity bias. Results from categorical pattern learning provide insights into phonological learning biases, but natural language phonology does not purely exhibit categorical patterns. In fact, variable patterns are prevalent in languages. If the goal of the learning bias research program is to link laboratory evidence to language acquisition and typology, it becomes equally imperative to understand the role of learning biases in the context of learning probabilistic and nondeterministic variable patterns.

Learning bias work on phonological variation is limited. To our knowledge, Mooney & Do (2018) is the only learning bias study in phonology whose primary focus is on the learning of artificial languages characterized by inherent variability. Mooney and Do tested the role of substantive bias in learning variable rounding (dis)harmony and showed that adult learners modulate the probabilistic distributions of variants toward rounding harmony. They propose that learning of phonological variation is substantively biased. Using a modification of Mooney and Do's experimental design, we trained Cantonese speaking preschoolers ($n=39$) on two artificial languages – one with dominant rounding harmony patterns (RH language) and another with dominant non-rounding harmony patterns (NH language). Cantonese does not show any harmony patterns, so the setting ensured no L1 transfer effect. Six animals in CV.CV form (e.g., *kenu*) were depicted performing one of two motions. The name of each animal was realized with a CV suffix, alternating to create height-conditioned rounding (dis)harmony with the stem-final vowel (*-be* ~ *-bo*, *-ri* ~ *-ru*). To test whether learning reflects typological principles of rounding harmony (Kaun 2004), stem-final vowels and suffix vowels were either non-high or high; half of the items exhibited height agreement between the two vowels and the other half did not. To create free variation in RH and NH languages, dominant patterns were shown in 66.7 % of the training items and undominant patterns were shown in 33.3% (66.7% harmony in RH language vs. 66.7% disharmony in NH language). Participants saw each animal + motion pairing (6 animals x 2 motions) three times before proceeding to the test session. The test session included motion descriptions of seen animals as well as three unseen animals. Participants were asked to choose how to describe the motion of the given animal and three answer choices were provided: a. a suffix with dominant (dis)harmony pattern (*kenu-bo* in RH; *kenu-be* in NH), b. a suffix with undominant (dis) harmony pattern (*kenu-be* in RH; *kenu-bo* in NH), c. an incorrect form with a wrong suffix (e.g., *kenu-ma*). Except for two who did not learn the exhibited suffix alternations (answer choice of (c) over 50%), all participants' data entered the analysis, shown in Figure 1.

Across RH and NH languages, participants chose the harmony patterns more often than disharmony. (RH language: $F = 18.54$, $P < .001$; NH language: $F = 7.79$, $P < .01$), confirming an overall bias toward harmony over disharmony. While the preference to choose vowel harmony was observed from both RH and NH languages, there were notable differences when the results from seen vs. unseen items are concerned. As for the seen items, a significantly higher rate of harmony compared to its proportion in input was observed from both RH language ($t(19) = 4.89$, $P < .001$) and in NH language ($t(18) = 4.24$, $P < .001$). For unseen items, answer distributions in

harmony vs. non-harmony patterns very much reflect the proportions attested in the input in RH language (62% vs. 67%), showing no significant difference from the input variable distribution ($t(19) = -1.31, P = .206$). Notably, harmony patterns were chosen at a much higher rate than its proportion in the input in NH language (72% vs. 33%), and the choice of non-harmony patterns was significantly discouraged (25% vs. 67%): the difference between the input and answer distributions for all unseen items reached significance ($t(18) = 9.87, P < .001$). A linear regression for the combined harmony productions across RH and NH languages reached significance ($F = 1.94, P < .001$). There was a significant effect of target height ($t(37) = 2.42, P < .01$) while no significant effects for either trigger height ($P = .76$) or height agreement ($P = .98$) was observed.

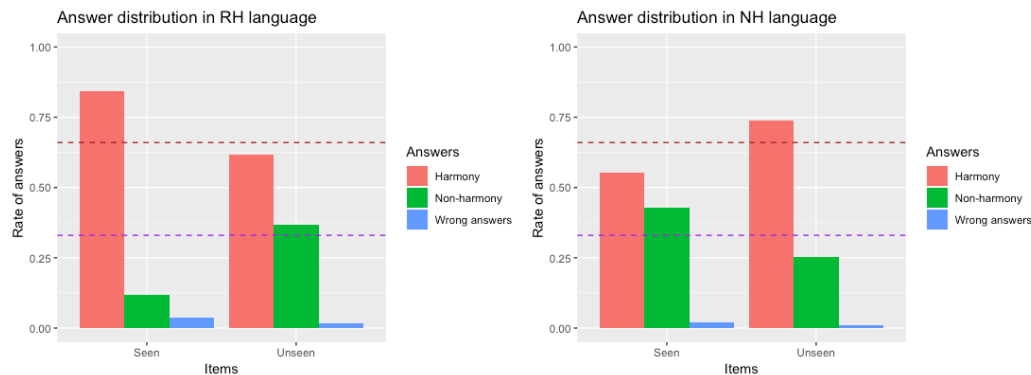


Figure 1. Answer choices in RH and NH languages for seen and unseen items. Two dotted lines indicate proportions of harmony and non-harmony in input, matching 0.33 (bottom) and 0.67 (top).

A main finding of the study is that variable phonological learning is substantively biased toward more natural variants overall. However, such a tendency was not observed from unseen items in RH language: when learners were exposed to a language exhibiting a dominant natural variant, they learned and generalized the variant distribution without imposing a substantive bias. When learners were exposed to a language with a dominant but *unnatural* variant, they generalized patterns in a highly biased way, resulting in a high degree of discrepancy from the input. Results from this study provide insight for cases of phonological variability that remains stable over time in distribution and frequency of variants, such as the English *-ing/in'* alternation (Labov 1989). It is only our unnatural language (NH) that is greatly restructured by learners to exhibit a much more natural (although still variable) pattern, suggesting that a pattern or variant must be unnatural enough to provoke the learner to amend or adjust it. Such a proposal requires future experimental conditions that test variable patterns in different proportional distributions.

References **Kaun, A.** 2004. The typology of rounding harmony. *Phonetically based phonology* 87416. **Labov, W.**, 1989. The child as linguistic historian. *Language variation and change*, 1(1), pp.85-97. **Mooney, S, & Do Y.** 2018. Learners change artificial languages to constrain free variation in line with typological principles. Paper presented at the 15th Old World Conference in Phonology, London. **Moreton, E, & Joe P.** 2012a. Structure and Substance in Artificial-phonology Learning, Part I: Structure. *Language and linguistics compass* 6:686–701. **Moreton, E, & Joe P.** 2012b. Structure and substance in artificial-phonology learning, part II: Substance. *Language and linguistics compass* 6:702–718. **Saffran, J. R., & Tiessen, E. D.** 2003. Pattern induction by infant language learners. *Developmental Psychology*, 39 (3), 484–494.