Rapid phonotactic generalization: Behavioral evidence and a Bayesian model

Sounds that share articulatory or perceptual properties tend to have similar phonotactic distributions. Speakers use these commonalities to generalize phonotactic constraints across classes of sounds; for example, the fact that [sl] and [ʃɹ] are attested syllable onsets in English (*slip*, *shrink*) contributes to the acceptability of the unattested [sɹ] (*srip*) (Albright, 2009; Hayes & Wilson, 2008; Scholes, 1966). It has been argued that phonotactic constraints involving specific sounds need to be acquired before class-based generalizations can be formed (Adriaans & Kager, 2010; Albright, 2009). Contrary to this assumption, participants in a recent artificial language learning experiment acquired patterns involving abstract classes before showing evidence of having acquired patterns involving individual sounds from those classes (Linzen & Gallagher, 2014). We replicate this finding using a new artificial language, and develop a computational model that simulates this behavior.

Behavioral experiment: We created a set of artificial languages, based on Cristia, Mielke, Daland and Peperkamp (2013). Words in all of the languages had the prosodic shape CVCV. The onsets of the words were drawn from a set of five obstruents that were either all voiced or all voiceless (e.g., {[g], [v], [z], [ð], and [b]}). The particular set of obstruents and the value of the voicing feature was randomized acrossed participants. Participants passively heard 1, 2, 4 or 8 sets of training items. Each set included a single example of each onset, i.e. five words in each set (70 participants in each exposure group). Following exposure to the language, participants made acceptability judgments on novel words of one of three types:

1. CONFORMING ATTESTED: words whose onset was attested in exposure (e.g., *bamu* for the language given above).
2. CONFORMING UNATTESTED: words whose onset conformed to the abstract generalization but was not attested in exposure (*damu*).
3. NONCONFORMING: words whose onset did not conform to the generalization (*tamu*).

Participants were able to learn the abstract generalization—that is, distinguish NONCONFORMING from CONFORMING items of either type—after a single exposure set. Among patterns that conformed to the generalization, participants did not begin to distinguish CONFORMING ATTESTED from CONFORMING UNATTESTED items until they received two or more sets of exposure.

Computational model: The model conceptualizes phonotactic knowledge as a *mixture* of templates. Each word is assumed to be generated from one of the templates. Abstract representations are available to the learner in advance of encountering the language; each of the templates may incorporate constraints at varying levels of abstraction, e.g., [+voiced] or [+voiced, +continuant, labial]. The number of templates is not fixed in advance; instead, a Dirichlet process prior is placed on their number. This prior enforces a parsimony bias: a description of the entire language using a single constraint ([+voiced]) is favored over a disjunction of multiple more elaborate constraints. As the learner receives more exposure to the language, the absence of CONFORMING UNATTESTED onsets forces it to overcome its bias and represent the language using a disjunction of more detailed constraints. Simulations showed that this model derived the general-then-specific pattern exhibited by human participants.