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Towards substantively biased typology: Effects of environment on P-map biases

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When is Typology Natural?

In constraint-based phonological theories, typology is often modeled by factorial re-ranking or re-weighting to yield the gamut of languages possible under those constraints.

- An implicit assumption of this method is that any ranking / weighting of constraints is equally likely, given sufficient learning data.

However, this assumption is patently false:

- Data from artificial grammar learning experiments (AGLs) find *substantive bias* in that not all rankings of constraints are equally likely, given an equal quantity of learning data ([1–4]).
- Specifically, there is a bias for phonetically-minimal alternations as supported by Steriade's theory of the perceptual map (P-map; [5,6]).

Previous work on substantive bias has primarily considered the overall saliency of the difference between pairs of phones. However, the environment of a sound must affect the saliency of a difference ([6,7]).

Here, we examine **the effect of P-map biases in particular phonological environments**. We present empirical evidence that, holding data and constraint inventory constant, it is **not** the case that all languages are equally easy to learn. However, **not** all of the P-map's predictions are borne out.

Questions to Address

- Do P-map biases against environment-specific salient alternations affect learning (the way non-specific biases do)?
- If so, how do we incorporate them into our theories of typology?
- If not, how do we explain these results in light of earlier work on non-specific P-map biases?

Experiment

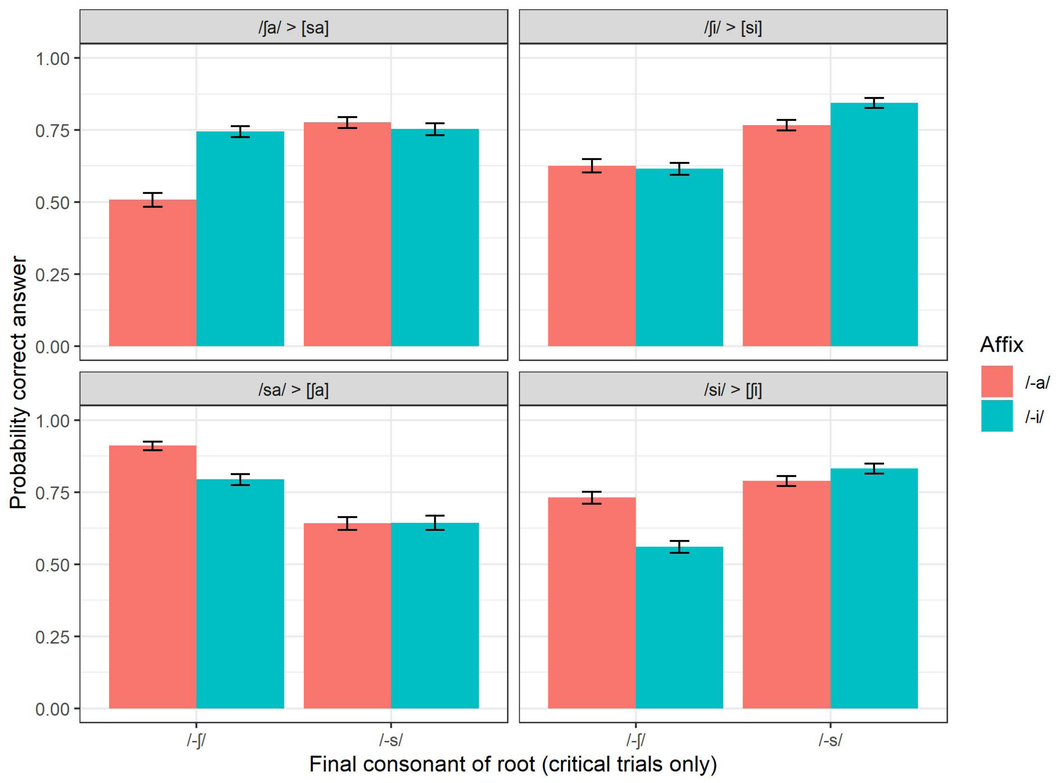
122 participants (79 female; 9 not given) from the UCLA SONA system took part in 4 online AGL studies (~30 participants each). Participants had to learn exactly one alternation in each AGL:

	salient env.	nonsalient env.
/ʃ/ alternates	/ʃa/ > [sa]	/ʃi/ > [si]
/s/ alternates	/sa/ > [ʃa]	/si/ > [ʃi]

AGLs were 2-AFC:

- 300 trials presented in random order.
- Each trial, participants were aurally presented with a CVCV{s,ʃ,t} word and an image. They were also presented with another image that determined the affix, [-a] or [-i], to be attached to the first word. They then heard a faithful [s,ʃ,t]and an alternated [ʃ,s,ʧ] option and had to pick the correct choice.
  — CVCVt words were fillers; the faithful answer was always correct.
- Feedback was given after each trial; we did not include a training block.
- Dependent variable was overall accuracy for each type of stimulus.

Bias, Discovered



Not all languages were learned equally well:

(1) /ʃa/ > [sa] was notably not learned at all.
  — Salient alternations being considered implausible is P-map compliant.

(2) Participants learned /ʃi/ > [si] but (wrongly) also learned /ʃa/ > [sa].
  — The P-map does not explain this inference.

(3) Participants learned /sa/ > [ʃa] but (wrongly) also learned /si/ > [ʃi].
  — Unexpected, given (1)! Still, the inference of /si/ > [ʃi] is predicted by the P-map on the basis of environment-specific saliency.

(4) /si/ > [ʃi] was learned, but participants mislearned nonalternating /ʃi/.
  — The P-map does not explain why /ʃi/ gave participants trouble.

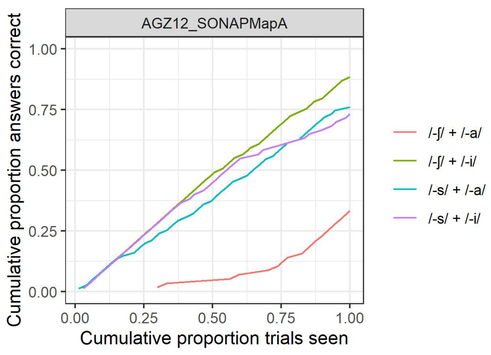
- We also found a *ʃ effect, following standard markedness assumptions.

Discussion

- Our results provide some contradictory support for the existence of environment-specific P-map biases in alternation learning. Little work has empirically tested these predictions (though cf. [8] and citations therein).
- Factorial typology is not a good measure of the probability of possible languages. Though it may succeed at enumerating possibilities, it would predict that each of these languages should be identical.
- Results like ours can be used to model the range of relative prior weights on constraints in future computational modeling studies of phonological acquisition.

Further Research

- Individual behavior can be mined to test and refine models of online phonological learning. Consider the data at right from one participant learning the /ʃa/ > [sa] language.



[1] B. Hayes & J. White. (2015). "Saltation and the P-map". *Phonology* 32(2):1–36. [2] E. Glewwe. (2019). "Bias in phonotactic learning: Experimental studies of phonotactic implicationals". UCLA dissertation. [3] J. White. (2017). "Accounting for the learnability of saltation in phonological theory: A maximum entropy model with a P-map bias". *Language* 93(1):1–36. [4] C. Wilson. (2006). "Learning phonology with substantive bias: An experimental and computational study of velar palatalization". *Cognitive Science* 30(5):945–982. [5] D. Steriade. (2001a). "Directional asymmetries in place assimilation: A perceptual account". In E. Hume & K. Johnson (Eds.), *The role of speech perception in phonology* (pp. 219–250). San Diego, CA: Academic. [6] D. Steriade. (2001b). "The phonology of perceptibility effects: The P-map and its consequences for constraint organization". Unpublished manuscript, MIT. [7] K. Zuraw. (2013). "*MAP constraints". Unpublished manuscript, UCLA. [8] C. Hall. (2020). "Testing the P-Map: Lenition and position". In *Proceedings of AMP 2019*.

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This poster