Learning bias as a factor in phonological typology

It has been proposed that phonological typology arises from phonologization of phonetic precursors, and that Universal Grammar does not favor one phonological pattern over another (Ohala 1990, 2005; Buckley 2000:11; Hale & Reiss 2000; Hume & Johnson 2001; Blevins 2004:19–21, 41, 281–285). This study finds, on the contrary, that typology is shaped by cognitive biases which make learners more receptive to some patterns than others, and shows how one such bias can be derived in a UG-based framework.

We show that (A) phonological patterns relating the height of two vowels are more frequent than patterns relating vowel height to consonant voicing; (B) the phonetic precursors of the height-height and height-voice patterns are equally robust, eliminating that explanation for (A); and (C) in two experiments, English speakers learned a height-height pattern and a voice-voice pattern better than a height-voice pattern.

(A) The phonological literature was searched for height-height and height-voice patterns meeting the criteria in (1). To guard against double-counting cases of shared inheritance, language families (top-level Ethnologue categories) were counted instead of individual languages. The tally was 6 to 0 (or 9 to 2 by laxer criteria).

(B) The phonetic literature was searched for estimates of the effect on F_1 of, first. vowel-to-vowel coarticulation, and, second, the interaction between obstruent voicing and vowel height. These estimates, plotted in (2), show that the height-height effect is no larger than the height-voice effect. This eliminates precursor robustness as an explanation for (A).

(C) ***Exp. 1: CVCV vs. C VCV*** We hypothesized that learners are more receptive to height-height than height-voice patterns. This was tested using two artificial languages built from [t d k g i u ae a]. In the "Height-Height" condition, participants listened to, and repeated aloud, 32 synthesized $C_1V_1C_2V_2$ words in which V_1 and V_2 were both high or both low. They then heard 32 pairs of novel test words, one conforming to the pattern and one violating it, and judged which one was likelier to be in the language. The "Height-Voice" condition was the same, only the pattern was that V_1 was low if and only if C_2 was voiceless. 24 native English speakers participated; 12 did the Height-Height condition first; 12 did it second. The conforming word was chosen more often in the Height-Height condition than in the Height-Voice condition ($p < 0.001$). Height-harmonic items were preferred only in the Height-Height condition, while items fitting the height-voice pattern were not preferred in either condition. Thus, participants showed better learning of the typologically frequent pattern, suggesting that the typological asymmetry is caused by a learning bias.

Exp. 2: CVCV vs. C VCV As to the nature of this bias, we considered two possibilities. One is that the patterns which learners detect most readily are precisely the ones which are typologically common—in this case, vowel harmony. The other is that a pattern is apprehended faster if it is simpler in terms of features or autosegmental tier structure. To distinguish these alternatives, the Height-Height condition of Exp. 1 was replaced with a Voice-Voice condition, in which C_1 and C_2 were both voiceless or both voiced—a very rare pattern (Rose & Walker 2004). A different group of 24 English speakers participated. The conforming word was chosen more often in the Voice-Voice condition than the Height-Voice condition ($p < 0.05$).

These results support the hypothesis that typology is influenced by a learning bias which discourages interaction between height and voicing This bias can be derived via a learning algorithm in which the learner chooses between OT constraint sets based on how probable they make the training data ("Bayesian Constraint Addition", author's reference, to appear). A height-harmony constraint interacts only with other height constraints, whereas a height-voice constraint interacts with both height and voice constraints. A height-voice process therefore involves more crucial rankings, reducing its prior probability and retarding acquisition relative to a height-height or voice-voice process. This is shown in a simulation.

Previous studies of learning bias have compared "natural" with "unnatural" patterns and so do not prove that a typological asymmetry is due to learning bias ("natural" patterns have precursors, which could explain the typology by phonologization). This study removes that confound by comparing two "natural" patterns to show that learning bias affects typology.

(1) Criteria for typological survey:

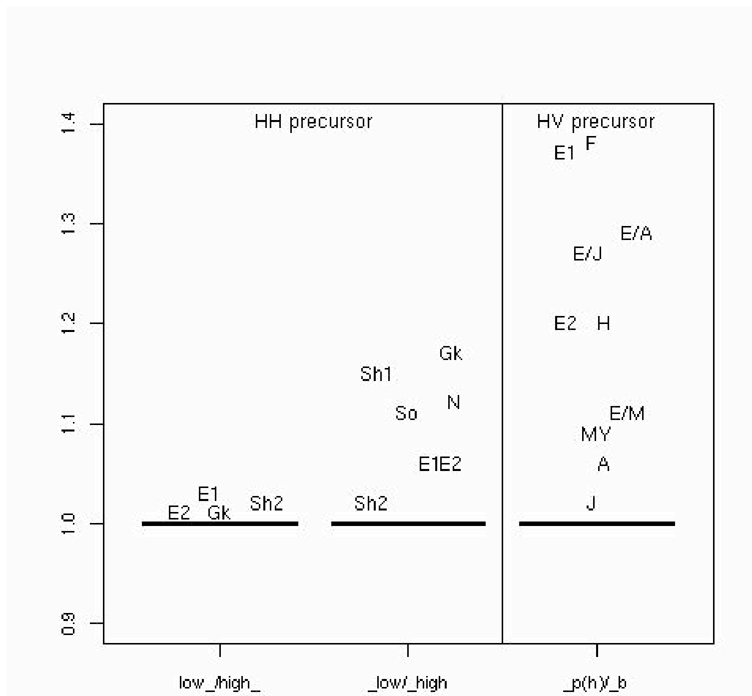
(a) Language must have height contrast and voicing or aspiration contrast
(b) Pattern (process or phonotactic restriction) must neutralize one of those contrasts
(c) Patterns that apply only to a single morpheme were not counted
(d) Language must be described alive (reconstructed languages were excluded)

(2) Phonetic effect of an adjacent vowel (high vs. low), and the effect of an adjacent consonant (voiced vs. voiceless). Each plotting symbol is one study of one language. Y-axis shows ratio of vowel F1 in raising context (e.g., high_ or _high) to F1 in lowering context (e.g., low_ or _low). Measurements were made at the point in the target vowel as indicated (onset/offset/midpoint).

Crucial point: The HH precursor (left panel) is *not* larger than the HV precursor (right panel) (i.e., the plotting symbols are *not* further away from the 1.0 line; if anything, they are closer to it).

Large effect
(F1 higher in context of low vowel than in that of high vowel, or higher in context of voiceless obstruent than in that of voiced obstruent)

No effect
(Same F1 regardless of context)



Key: *So* = Sotho, *Sh1* = Shona, *N* = Ndebele (Manuel 1990); *Sh2* = Shona, *E1* = English (Beddor et al. 2002); *F* = French (Fischer-Jørgensen 1972); *Gk* = Greek, *E2* = English (Koenig & Okalidou 2003); *H* = Hindi (Lampp & Reklis 2004); *A* = Arabic (de Jong & Zawaydeh 2002); *J* = Japanese (Kawahara 2005); *E1* = English (Wolf 1978); *E2* = English (Summers 1987); *E3* = English, *E/J* = L2 English (Japanese), *E/M* = L2 English (Mandarin), *E/A* = L2 English (Arabic) (Crowther & Mann 1992), *MY* = Moba Yoruba (Przezdziecki 2005).

Selected references

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