Phonetically-grounded structural bias in learning tonal alternations

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Structural simplicity bias in phonology hypothesizes that learners may more easily learn sound patterns with simpler featural descriptions. Despite abundant evidence for structural bias (Moreton & Pater, 2012a), the focus has been primarily on segmental phonology. This study explores structural bias in learning tone alternations. We apply the concept of structural bias from the literature on segmental phonology to tone learning and hypothesize that the directionality of tone alternations will shape a structural component in learning. The structural bias in this study refers to the tendency to prefer uni-directional tone alternations to bi-directional ones. Our experimental results show a learning bias towards uni-directional patterns, but only when the uni-directionality is right-dominant. We argue that structural bias affects tone alternation learning, but the simplicity should be grounded on phonetics and cognitive factors. The results are consistent with our survey data of tone sandhi directionality across 17 Chinese dialects, suggesting that the asymmetry of directionality could reflect the phonetically-grounded structural learning bias.

In Experiment 1, we designed three languages (see Table 1) where two adjacent vowels are merged into one, resulting in a tone alternation. Language 1 is complex since the preserved tone is either on the left or right syllable. Languages 2 and 3 are simple where the preserved tone is always from a single position, either left- or right-dominant. In the training, Mandarin speakers (n=49) heard the names of a blank monster, a color, followed by a colored monster for each item. In the test, they were asked to choose the name of a colored monster from two options exhibiting the correct segments with the two tonal options (one from left or from right). As shown in Figure 1, Language 3 was learned better than the other two languages. Binomial logistic regressions revealed that uni-directional patterns were learned better than bi-directional ones (β=-0.8702, p<.001); and right-dominant patterns were learned better than left-dominant ones (β=-1,2187, p<.0001). The right-dominant bias is phonetically motivated by a syllable's contour tone bearing ability. The left syllable has relatively insufficient duration (Zhang, 2007), thus the left tone tends to be alternated. Moreover, the right-dominant bias obeys Temporal Sequence (i.e., left-to-right rule application is in tandem with speech planning (Chen, 2000)). We argue that the simplicity of directionality affects learning (uni- vs. bi-direction), but crucially the nature of the simplicity should be phonetically-and-cognitively grounded (i.e., right-dominant preference). A mere structural bias (simply uni-directional) may not suffice to explain the observed tone learning. Phonetically-grounded simplicity facilitates learning than arbitrary simplicity. Note that the results may be attributed to L1 transfer, as Mandarin tone sandhi is generally right-dominant (Zhang 2007).

To see whether the right-dominant preference is due to L1 transfer, Experiment 2 trained Cantonese native speakers with bare knowledge of Mandarin (n=31) either on Language 2 or 3. Cantonese does not exhibit tone alternation conditioned by adjacent tones and its tone change does not have a dominant directionality (Matthews &Yip, 2011). As shown in Figure 2, right-dominant patterns were learned better than left-dominant ones (β=1.4438, p<.0001), which suggests that the right-dominant bias in Experiment 1 is not purely due to L1 transfer.

Language	Target tone patterns (26 items)		Fillers: no tonal alternation (48 items)	
1 (bi-directional)	/ + — → —	\ + / → \	/ + / → /	∨ + ∨ → ∨
2 (left-dominant)	/ + — → /	\ + / → \	— + — → —	∨ + ∨ → ∨
3 (right-dominant)	/ + — → —	\ + / → /	\ + \ → \	∨ + ∨ → ∨
—, /, ∨, \ represent Mandarin level, rising, dipping-rising and falling tones respectively				
Audio stimuli: CV + V/VN (N: nasal) → CV/CVN[1]				
Visual stimuli: blank monster + color → colored monster				

Table 1: Stimuli

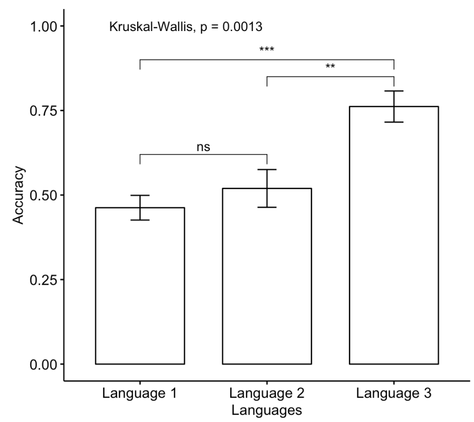

Figure 1: The average accuracy scored by Mandarin native speakers

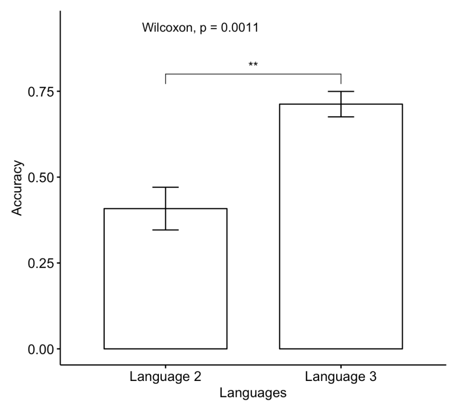

Figure 2: The average accuracy scored by Cantonese native speakers

References

Casali, R. F. (1996). *Resolving Hiatus.* Los Angeles: University of California.
Chen, M. Y. (2000). *Tone sandhi: Patterns across Chinese dialects*. Cambridge, UK: Cambridge University Press.
Matthews, S. and Yip, V. (2011). *Cantonese:A Comprehensive Grammar*. 2nd edition. London: Routledge.
Moreton, E. and Pater, J. (2012a). Structure and Substance in Artificial-phonology Learning, Part I: Structure. *Language And Linguistics Compass*, *6*(11), 686-701.
Zhang, J. (2007). A directional asymmetry in Chinese tone sandhi systems. *Journal Of East Asian Linguistics*, *16*(4), 259-302

[1] The adjacent vowels across syllable boundaries are combined into a vowel which takes the height of the left vowel and the frontness of the right vowel. It is a typological resolution to vowel hiatus (Casali 1996).