Lenition, learnability, and the P-map: An artificial grammar learning study

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The synchronic driver of intervocalic lenition has long been of interest to phonologists. The perception-based framework ("Continuity") [2,3] posits that intervocalic lenition is the manifestation of a preference for higher intensity within prosodic constituents and lower intensity at boundaries to aid the listener in distinguishing prosodic boundaries. The production-based framework ("Effort") [4,5] proposes that speakers seek to minimize articulatory effort: gestures requiring movement that is further and/or faster are dispreferred. The Effort hypothesis predicts that intervocalic lenition should be sensitive to the height of the surrounding vowels; those who learn /iti/ → [iθi] should generalize the process to an environment where lenition reduces effort more, /ata/ → [aθa], but not vice versa. The Continuity hypothesis predicts that lenition processes should generalize at the same rate regardless of vowel height. I conducted a Poverty of Stimulus artificial grammar learning experiment [9] to explore the extent to which surrounding vowel height influences how readily learners generalize intervocalic spirantization.

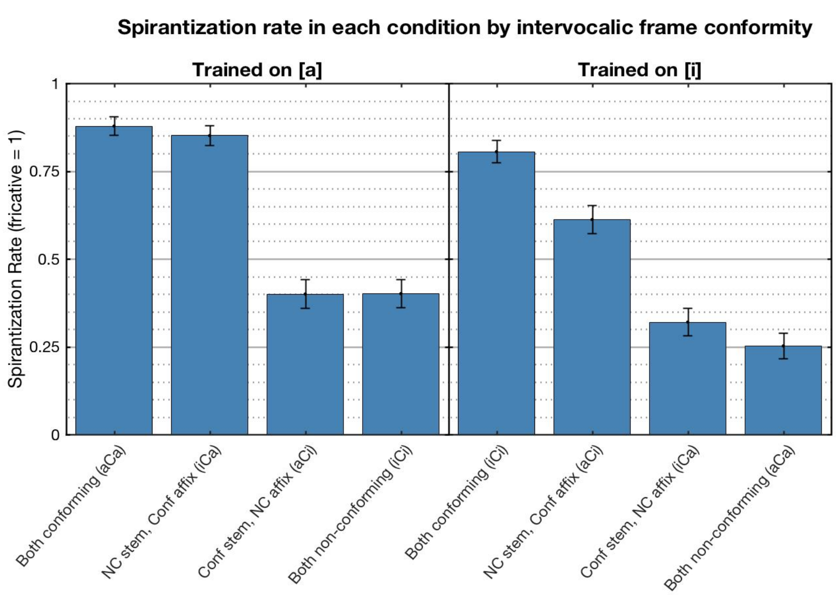
As it turns out, a third hypothesis, Perceptual Saliency, best explains the results. This hypothesis claims that phonological processes are shaped by pressure to maintain perceptual similarity between corresponding forms [1,6,7]. Under the Saliency hypothesis, speakers are sensitive to the perceptual salience of potential sound changes as characterized by the universal P-Map [7]. The more salient the change, the more resistant the speaker will be to incorporating that change into their grammar.

The experiment was between-subjects with two conditions: training on stems with a final [a] vowel and generalizing to stems with final [i], and vice versa. Sample items can be seen in Table 1 below:

Condition	Singular	Plural	Diminutive	Gloss
Filler	milom	milomal	milomin	camel
Train on [i]	tonit	toniθal	toniθin	bat
Train on [a]	dolat	dolaθal	dolaθin	cow

Table 1:Example training stimuli. Greyed cells never appear in training/testing phase so as to preserve Poverty of Stimulus

The task consisted of two phases: the training phase and the generalization phase. In the training phase, the experimenter produced the stimulus, and the participant repeated it. Next, the participant was presented with two pictures, heard the singular form and was asked to produce the affixed form corresponding to the second picture. Feedback was given for incorrect responses. After displaying competency on the pattern (≥ 80% accuracy on two training lists,) the participant completed the generalization phase, consisting of 24x3 novel items (8 stems which conformed to the training items (e.g. *rolad* if trained on [a]), 8 non-conforming stems (*lanit*) and 8 fillers.)



The responses of 40 participants were coded as either stop or fricative based on the perception of the author and an undergraduate research assistant. Non-obstruent responses were excluded (=1183 tokens, 11 exclusions). Mean frication rates with standard error are shown in the figure. In the fully conforming condition (both stem and suffix vowels match training; leftmost bar in each plot), participants spirantized at a rate of .88/.81 (training condition [a]/[i]). With a non-conforming stem vowel but conforming suffix (*iCa/aCi*), spirantization rates were .85/.61. With a conforming stem vowel and non-conforming suffix (*aCi/iCa)*, spirantization rates were .39/.32. In the fully non-conforming case, spirantization rates were .40/.25. The means suggest that participants trained on [a] are more likely to generalize the rule to novel environments than participants trained on [i]. In both conditions, participants were more likely to spirantize if the suffix vowel conformed to the training condition. These results were confirmed through statistical analysis.

A linear mixed effects regression analysis showed that three main effects were significant. The first two main effects were unsurprisingly highly significant. First, the main effect of stem vowel conformity was significant ($p=.001$), meaning participants were more likely to spirantize in conforming stem types. Second, the main effect of suffix vowel conformity was highly significant ($p<<.001$), meaning participants were more likely to spirantize in words with the trained suffix. Interestingly, the third main effect of condition was also significant ($p=.02$), meaning participants trained on [a] were more likely to spirantize across the board than participants trained on [i]. This finding goes against both the Continuity and the Effort hypotheses.

These results are best explained by the Perceptual Saliency hypothesis. If the shift from [ata] to [aθa] is more perceptually salient than [iti] to [iθi], as evidenced by affrication specifically before high vowels in Japanese and Québecois French [4], these results are consistent with the Saliency hypothesis. This perceptual hierarchy also makes sense from a phonetic perspective. The tongue forms a narrow channel with the hard palate when producing a high vowel, leading to a noisier release burst for [t] between high vowels than between low vowels [4]. Due to this noisy burst, [iti] is more perceptually similar to [iθi] than [ata] is to [aθa]. A phonetic perception experiment is underway to further substantiate this claim.

The more salient sound change is learned by participants in the [a] training condition, and so they are willing to generalize to the less salient environment. In the [i] condition, the pattern is learned in the less salient environment, and as such participants are less willing to generalize to the more salient environment. These results suggest that learners generalize spirantization patterns in accordance with pressures to maintain perceptual similarity as described by the universal P-Map.

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