

Testing the Competing Grammar Theory of Vowel Mergers

Yang (2009) models how vowel mergers may spread through phoneme acquisition during early childhood. While some implications of the model have been explored (Ahern, 2014; Djarv, 2017; Kodner, 2020), its robustness to differing parameters has not been systematically tested. In this work, I re-implement Yang’s model with a variety of linguistically-realistic parameters to test its generalizability, identifying a serious issue with its present formulation.

In Yang’s model, grammars compete on successfully parsing input, penalized for each incorrect parse. This competition occurs at the word level for phonemic systems, with word misidentifications penalizing that grammar’s acquisition. Equation 1 shows the penalty for merged grammars, and Equation 2 shows the penalty for unmerged grammars; w_a and w_b are vowel a and b ’s respective minimal pair frequencies, ϵ_a and ϵ_b are the chance of confusing a for b and vice versa, and $P(G_{M+})$ is the proportion of input which is merged.

$$penalty_{M+} = \frac{\sum_i [\min(w_a^i, w_b^i)]}{\sum_i [w_a^i + w_b^i]} \quad (1)$$

$$penalty_{M-} = \frac{\sum_i [P(G_{M+}) \cdot (w_a^i - \epsilon_b w_a^i - \epsilon_a w_b^i) + (\epsilon_a w_a^i + \epsilon_b w_b^i)]}{\sum_i [w_a^i + w_b^i]} \quad (2)$$

As vowel mergers happen over years rather than decades, Yang contends that children use a winner-takes-all approach, selecting the grammar that best accounts for >50% of observed phonemes. Yang formalizes these properties to predict the proportion of merged input a child needs to acquire a merged system; this formula simplifies to Equation 3.

$$P(G_{M+}) = \frac{\sum_i [\min(w_a^i, w_b^i) - (\epsilon_a w_a^i + \epsilon_b w_b^i)]}{\sum_i [(w_a^i - \epsilon_b w_a^i - \epsilon_a w_b^i)]} \quad (3)$$

Notably, while Equation 3 is intended to return a proportion, nothing guarantees the output will be between zero and one, or even positive. To ensure this is not due to faulty implementation, I first replicate Yang’s modeling of the cot-caught merger, and then test the model with different, linguistically realistic parameters: (1) developmentally-realistic minimal pairs and (2) regionally-specific vowel confusion rates.

The first test uses the original vowel confusion rates from Peterson and Barney (1952) alongside four novel minimal pair sets: one drawn from Kuperman et al. (2012), two from the CHILDES North American English subcorpora (MacWhinney, 2000), and a version of Yang’s original minimal pair list with proper names removed. All four minimal pair sets result in negative values instead of proportions.

The second test uses the original set of minimal pairs but adopts dialect-specific vowel confusion matrices from Labov (2011), reflecting how often English listeners from Chicago, Philadelphia, and Birmingham misidentified each English vowel produced by speakers from each city. Notably, all three cities’ dialects lack the caught-cot merger, making these predictions relevant to possible future changes. Unlike in the first test, several test parameters produce interpretable results; however, one third still result in negative predictions.

These tests show that altering either major parameter of the model can result in impossible predictions. This occurs even with parameters obtained from observed data, suggesting the flaw must be in the formalization itself. Despite this problem, I argue the approach laid out by Yang (2009) is worth pursuing, as it makes assumptions explicit and offers directly testable quantitative predictions about the conditions of future phonological changes. Moreover, the particular model may be salvageable by adding a normalization factor or otherwise tweaking the underlying assumptions to make it robust to differing parameters inevitable across dialects and acquisition contexts.

References

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