

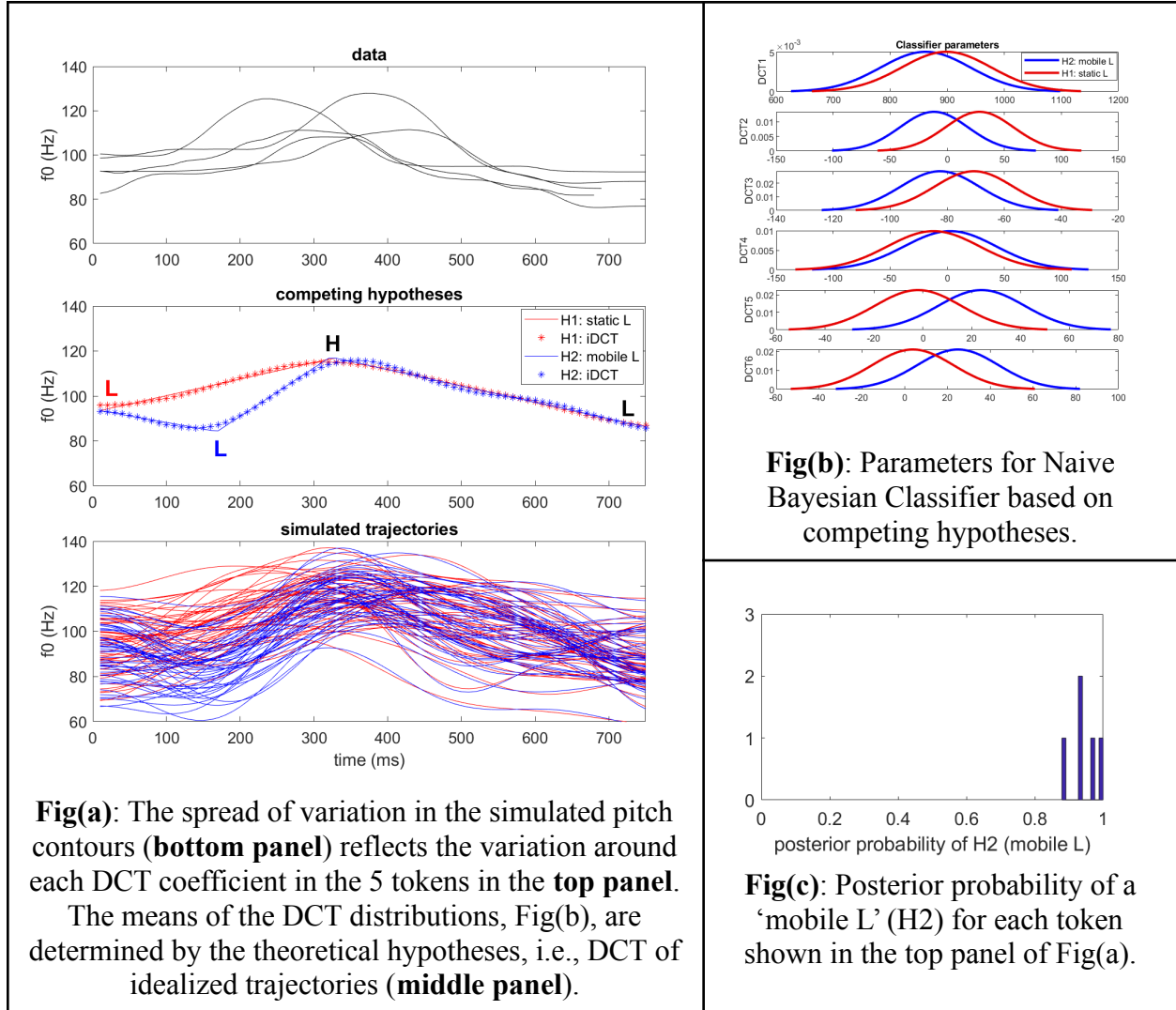
Assessing intonational grammars through simulation and classification of pitch trajectories: the case of mobile boundary tones in Blackfoot

Overview: A standard LabPhon method is to evaluate theories through experiments which isolate variables of interest in two or more conditions, while controlling other factors. Here, we introduce an alternative. We evaluate competing theoretical proposals of Blackfoot (Algonquian) intonational phonology using methods of simulation and classification (Shaw & Kawahara 2018; Kawahara et al. 2021). Stochastic generative models of pitch trajectories are created for two competing theoretical hypotheses, and used to assign posterior probabilities of the hypotheses to data, on a token-by-token basis. Instead of comparing across experimental conditions, we compare each pitch trajectory directly against our hypotheses. This method of hypothesis testing has different data requirements than the standard approach, potentially enabling robust evaluation of theoretical hypotheses from smaller and less controlled datasets.

Mobile boundary tones: Blackfoot has been argued to have ‘mobile boundary tones’, i.e., tones introduced by prosodic constituents that surface away from the prosodic boundary edge (Weber & Shaw 2022). Blackfoot words have a rise-fall (or LHL) pitch contour, with the rise centered on the location of lexical stress (Frantz 2017). Weber & Shaw (2022) argue that the first L tone (in LH₁L) is a ‘mobile’ boundary tone, which surfaces on the stressed syllable preceding the H. Support for their analysis comes from a comparison of f₀ turning points in words with first and second syllable stress. Crucially, this standard methodology relies on comparing the timing of the L across two conditions, i.e. words with first vs. second syllable stress. In what follows, we analyze the entire pitch contour of two syllable words in terms of two competing hypotheses that differ in the status of the leftmost L: in H₁, ‘static L’, the L tone is anchored to the left edge of the word; in H₂, ‘mobile L’, the L tone occurs between the left edge and the H on the stressed syllable. This analysis does not rely on a comparison to words with first syllable stress.

Method: We demonstrate our method with data from one speaker of the Weber & Shaw (2022) corpus, who produced 5 tokens of /ma.'min.ni.(^sts)/ ‘wing(s)’, a stem with second syllable stress. The top panel of Fig (a) shows the pitch contour of the tokens, extracted using YAAPT (Zahorian & Hu 2008). We used Discrete Cosine Transform (DCT) to decompose each token into six DCT coefficients. The middle panel shows our idealized pitch trajectories based on the theoretical hypotheses (solid lines) and a re-generation of those trajectories using inverse DCT (from six DCT coefficients). To turn our hypotheses into stochastic generators, we defined Gaussian distributions over the six DCT coefficients (Fig b), with the mean of the distribution determined by DCT analysis of our idealized trajectories, Fig(a): middle, and the variance determined by the standard deviation of the DCT coefficients in the data (top panel). The bottom panel of Fig (a) shows 50 tokens generated from each hypothesis by randomly sampling from the six DCT distributions (Fig b). Finally, we used our stochastic generator of each hypothesis to train a Bayesian classifier and assigned a posterior probability to each token.

Results and discussion: Fig (c) shows the posterior probability that each token belongs to H₂, the ‘mobile L’ hypothesis. All show at least 0.8 probability of belonging to H₂. Two other speakers from Weber & Shaw (2022) had enough tokens of these words to analyze through simulation and classification and showed similar results (average posterior probabilities of 0.98 and 0.61 favoring H₂). This provides converging evidence for the mobile boundary tone hypothesis. More broadly, these methods enable theoretically-guided analysis of continuous phonetic data that is computationally rigorous but less data-intensive than other approaches.



References

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