Effects of phonological contrast on phonetic variation in Hindi and English stops

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Introduction: Lindblom (1986) offers a hypothesis about the interaction between phonological contrast and phonetic variation: "the phonetic values of vowel phonemes should exhibit more variation in small than in large systems." While this is often assumed to be true, questions arise when trying to test the prediction: What counts as a "system"? How is variation measured? This study seeks to clarify these questions by examining within-category variation in Hindi and English stop consonants. The results show that within-category variation cannot always be predicted by phoneme inventory size, suggesting the need for a more nuanced approach. We propose that the relevant "system" must be defined by the phonetic dimensions used in phonological contrast, not a phoneme inventory or sub-inventory.

Hindi has four stops at each place of articulation and English has two. Under a phoneme inventory definition of "system", Hindi stops (larger inventory) should vary less than English stops. Therefore, we might expect that voiceless aspirated stops in Hindi will vary less in voice onset time (VOT; voiceless lag time) relative to English (Fig. 1, left panel). If we define the "system" according to phonetic dimensions instead of number of phonemes, we expect no difference in VOT variation as both languages use VOT to distinguish one contrast (Table 1). We do expect to see more variation in degree of *prevoicing* in English relative to Hindi as Hindi uses the voicing dimension for additional constrasts which English does not have.

Methods: Hindi and English stops were elicited in a lab. The participants were 7 native speakers each of Hindi and English, all between the ages of 20-30. In both languages, the stimuli were CVC words and non-words with vowels [i a u] in carrier phrases ("Say X again" in English; "Dobara X doharao" in Hindi). All stops were elicited in the word initial context.

Results: VOT was measured on voiceless aspirated stops in both languages from the start of the burst to the onset of voicing. To abstract over differences in mean values between speakers, VOT values were centered around within-speaker means for each phonological category. The results shown in Fig. 1 are collapsed over speaker (Levene's Test showed no significant difference in variation between speakers of each language). Lindblom's hypothesis predicts less variation in Hindi (left panel). The experimental results for coronal stops (right panel) are representative of the results for the other places of articulation and show similar amounts of within-category variation in both languages (Levene's Tests not significant).

Prevoicing on all stops was classified according to three categories: no prevoicing (voicing through 0-25% of the stop closure), partial prevoicing (25-75%), and full prevoicing (75-100%). Fig. 2 shows results for phonologically voiced stops; error bars show standard deviation between speakers. In Hindi, almost all voiced stops are produced with full prevoicing and this is consistent across speakers. In English, there is more variation in degree of prevoicing both within- and between-speaker. While Hindi speakers all consistently fully prevoice voiced stops, English speakers show individual preferences for degree of prevoicing. Some English speakers fully prevoice almost all voiced stops while others almost never prevoice stops.

Discussion: These results offer some clarity on how to further develop Lindblom's original hypothesis. Based on this data, we propose that the "systems" for comparing within-category variation are best defined by phonetic dimensions instead of phonological inventory categories like "stops" or "vowels". Referring to dimensions of contrast provides a more nuanced and generalizeable approach by incorporating the fact that inventories of phonological contrasts exploit many phonetic dimensions. Relatively less within-category variation should be expected along phonetic dimensions which are primary cues to the perception of a phonological contrast (prevoicing on Hindi stops). Non-primary phonetic cues (prevoicing on English stops) are predicted to show more variation both within- and between-speaker as this does not threaten the maintenance of phonological contrast.

Table 1: Phonetic dimensions in Hindi and English stops
(Ohala 1983b, Dutta 2007, among others)

	voiced			voiceless		
Hindi:	g	↔	g^h	k	↔	k^h
English:	∅	↔	∅	g	↔	k^h

Figure 1: Predicted VOT distributions (left) and actual experimental distributions (right), VOT in ms

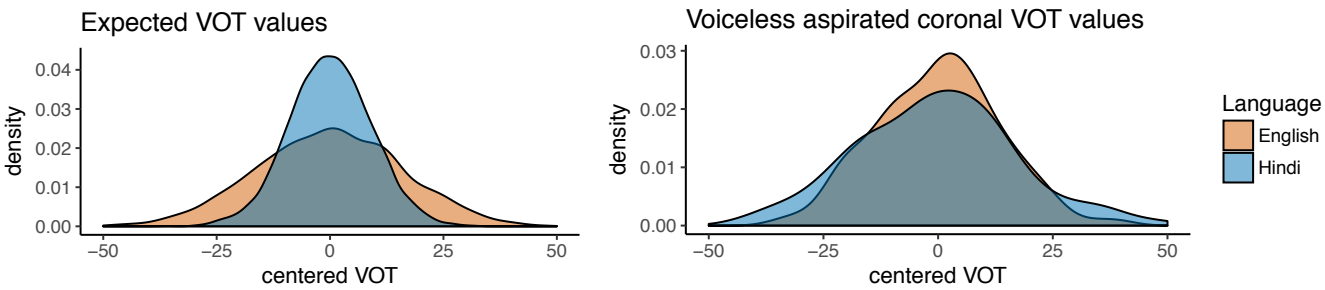
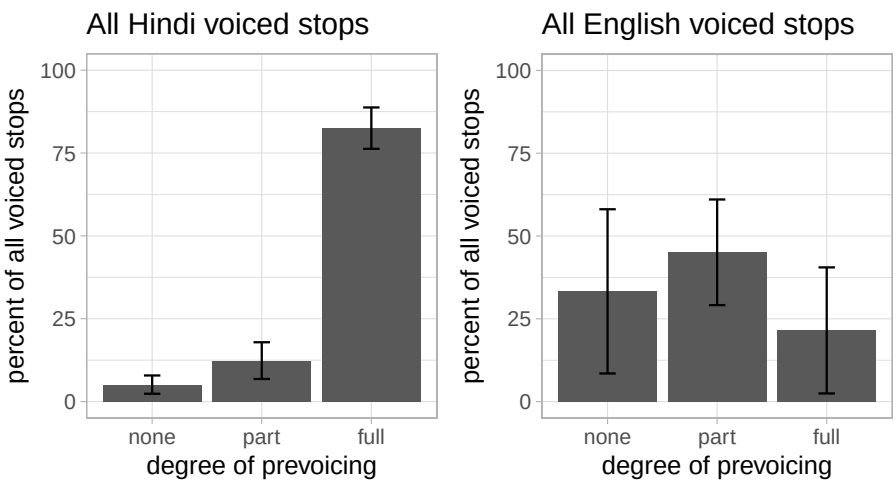


Figure 2: Degree of prevoicing on voiced stops



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