Cross-linguistic differences in the production and perception of consonant and vowel intrinsic F0 effects

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It is well known that vowels vary systematically in F0 based on intrinsic properties of the vowel itself and on intrinsic properties of the preceding obstruent; F0 tends to be higher (i) for high vowels compared to low vowels and (ii) following voiceless obstruents compared to voiced obstruents [1,2,3]. Within the literature on vowel and consonant intrinsic F0 effects (henceforth VF0 and CF0), these patterns have been attested in most of the languages in which they have been studied. However, across studies, findings show variable effect sizes within and across languages [4,5,6,7]. A corpus analysis of 20 languages showed Mandarin had smaller effect sizes for both CF0 and VF0 than English and, within each language, both C and V effects were approximately the same size, while for others (e.g. French, German) one effect was larger than the other [8]. Previous work has also shown perceptual effects of CF0 in English and Mandarin [9,10]. However, there is very little work on perception of VF0 and to our knowledge VF0 effects in perception have not been tested across languages. By testing both production and perception of CF0 and VF0 across English and Mandarin speakers, we will better understand how intrinsic F0 effects are cross-linguistically represented in speakers' grammars.

Methods: 32 monolingual English and 25 monolingual Mandarin speakers completed an online experiment involving a production task and a perception task. **Production task:** participants were asked to read monosyllabic CV words (C=/b,p,t,d,m/, V=/aj, i/) displayed on the screen. Target words were chosen to create real words in English and Mandarin (presented in hanzi characters and in pinyin). In total, each participant completed 114-120 production trials (English=10 CV syllables x 12 reps; Mandarin=(10 CV syllables x 4 tones – 2 gaps) x 3 reps). **Categorization task:** On each trial, participants heard a CV syllable (/baj/, /paj/, /bi/, /pi/) manipulated to (i) be in one of four Mandarin tones, (ii) differ along a VOT continuum (0-48 ms; 7 steps) and (iii) differ along two onset F0 levels (high, low; difference of 90 Hz). On each trial, participants were presented with two choices on the screen and asked to click which word they heard. Perception stimuli were the same across English and Mandarin groups; Each participant heard 336 syllables in total (7 VOT x 2 F0 x 2 vowels x 4 tones x 3 reps).

Results: Production data has not yet been analyzed. Participants whose perception did not show a significant effect of VOT were excluded (n=2 English, 1 Mandarin). Figures 1 and 2 show the proportion of /p/ responses over the VOT continuum for (1) high vs low onset F0 and (2) high (/i/) vs low (/aj/) vowel. A logistic mixed-effects model predicted voiceless responses. Factors were VOT (ms, centred), F0 (low = -0.5, high=0.5), VOWEL (i = -0.5, aj = 0.5), LANGUAGE (English=-0.5, Mandarin=0.5), and their interactions. The random effects structure included by-PARTICIPANT random intercepts and by-PARTICIPANT random slope adjustments to VOT, F0, and VOWEL. Results showed both higher onset F0 and a low vowel increased voiceless judgements, consistent with F0 being a cue to voicing and listeners compensating for the expected context effect of vowel height. Results also indicated that the CF0 effect was larger for English compared to Mandarin speakers, while the VF0 effects were comparable across the two languages. F0 measurements from production data will allow us to compare production and perception results directly.

Conclusion: The current study is the first to test perception of both CF0 and VF0 effects across languages. While CF0 effects have been tested using voicing judgements in previous studies, our results show that VF0 effects can also be examined through the same methodology. Thus, we can directly compare VF0 and CF0 effects within and across languages. Our perception results showed differences between English and Mandarin speakers such that CF0 varied between languages more than VF0. Finally, this study allows for further cross-linguistic investigation of the link between production and perception of intrinsic F0 effects.

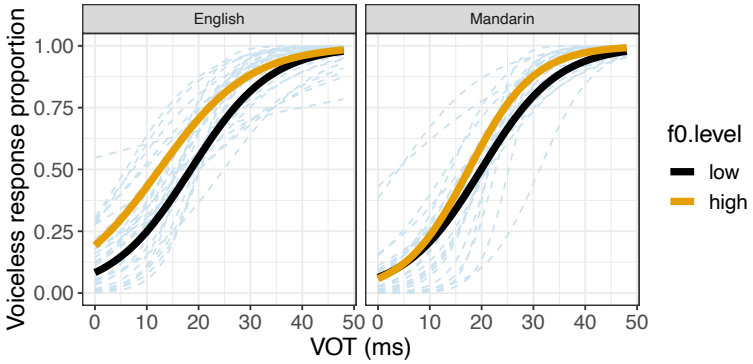

Figure 1. Predicted proportion of /p/ responses over the VOT continuum for the high (orange) vs. low (black) f0 level, for monolingual English (left) and monolingual Mandarin (right) speakers. Dashed blue lines represent regression lines for individual speakers' responses to VOT, averaging over f0 and vowel.

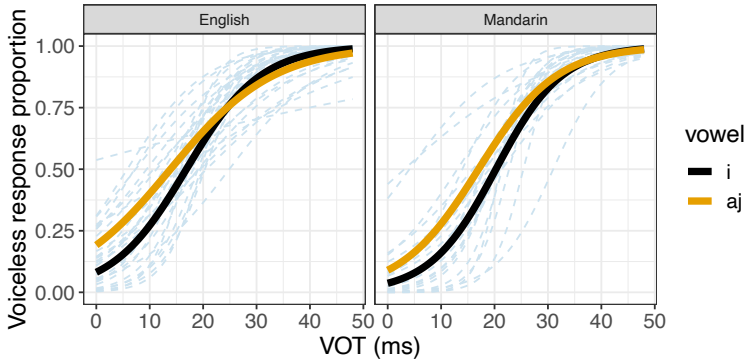

Figure 2. Predicted proportion of /p/ responses over the VOT continuum for the low (orange) vs. high (black) vowel categories, for monolingual English (left) and monolingual Mandarin (right) speakers. Dashed blue lines represent regression lines for individual speakers' responses to VOT, averaging over f0 and vowel.

Table 1. Results of a mixed-effects logistic regression model. Coefficients represent the effect of a given factor on the probability of eliciting a "voiceless" (vs. "voiced") response.

Effect	Voiced vs. Voiceless		
	β	z	p
Intercept	0.8120	0.45	<0.001
VOT	4.9471	17.23	<0.001
vowel	0.3903	3.66	<0.001
f0	0.5671	7.96	<0.001
language:vowel	0.2124	0.98	0.33
language:f0	-0.3921	-2.80	<0.01

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