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The role of IF0 in supporting phonological contrasts: A study of the IF0 effect in the Hong Kong Cantonese tone system

The intrinsic F0 (IF0) effect is the tendency for high vowels to have higher F0 than low vowels. This study investigates the IF0 effect in Hong Kong Cantonese, a tonal language, by comparing the magnitude of the IF0 effect in the six Hong Kong Cantonese tones.

According to the physiological-enhancement hypothesis proposed by Van Hoof and Verhoeven (2011), IF0 is physiologically determined, but may be enhanced or restrained by speakers to help with the perception of phonological contrasts in a language. They further proposed that the size of the IF0 effect may depend on the extent to which a language 1) exploits it to enhance vowel contrasts or 2) restrains it to preserve tonal contrasts. The first proposal was attested by Van Hoof and Verhoeven in two non-tonal languages (Arabic and Dutch). However, the second proposal has not been attested yet. It is plausible that tonal languages with vowels of different heights may also need to enhance the vowel height contrasts. Therefore, according to the mixed physiological-enhancement hypothesis, there might be a tension in tonal languages between exaggerating IF0 to enhance the vowel height contrast and suppressing IF0 to maintain the tonal contrast. Different tones in one tonal language may also show different IF0 effect sizes, as the need for suppressing IF0 to maintain the tonal contrast may be different in different tones.

Previous cross-linguistic studies that compared the size of the IF0 effect between tonal languages and non-tonal languages also indicated that there might be a tension within the IF0 effect in tonal languages, as 1) tonal languages do not always show smaller IF0 effects than non-tonal languages; 2) tonal languages with a larger tone inventory size do not always show smaller IF0 effects than those with a smaller tone inventory size (Sonderegger et al., 2017). However, when comparing tonal languages to non-tonal languages, these cross-linguistic studies did not take into account the need for enhancing vowel height contrasts to be similar among languages. The current study addresses that concern by comparing the size of the IF0 effect (measured by calculating the F0 difference of /si/ and /sɛ/ produced on each tone) of the six Cantonese tones. Two female native speakers of Hong Kong Cantonese produced 12 CV syllables (/si/ and /sɛ/ on six tones), with each syllable embedded in a sentence and repeated ten times. F0 curves of each syllable were extracted using Praat. Then, the sizes of the IF0 effects were analyzed using linear models, with by-point random slopes for the effect of vowel heights and random effects for speakers and repetitions.

Figure 1 and Figure 2 show that the size of the IF0 effect from the largest to the smallest is: T2 > T1 ⩾ T5 > T6 ⩾ T4 > T3. The mixed physiological-enhancement hypothesis is supported by three findings: First, T2 and T5 show a larger size of the IF0 effect than T6 and T3. T2 and T5, and T6 and T3 are both easily confusable tone pairs (Fung & Lee, 2019). While T3 and T6 are level tones distinguished by average F0 values, T2 and T5 are contour tones distinguished by the magnitude of F0 change. Therefore, according to the mixed hypothesis, T2 and T5 have a weaker need of suppressing the IF0 effect to keep the tonal contrast, thus showing a larger size of the IF0 effect. Second, T1 shows a relatively larger size of the IF0 effect. According to the mixed hypothesis, T1 is not easily confusable with the other five tones, so it has a weaker need of suppressing the IF0 effect to keep the tonal contract, thus showing a relatively larger IF0 effect. Finally, T4 shows a relatively smaller IF0 effect. This result supports previous findings that the IF0 effect disappears or decreases at the low end of a speaker's F0 range cross-linguistically (Whalen & Levitt, 1995), which implies that the IF0 effect is likely to be constrained by physiological factors.

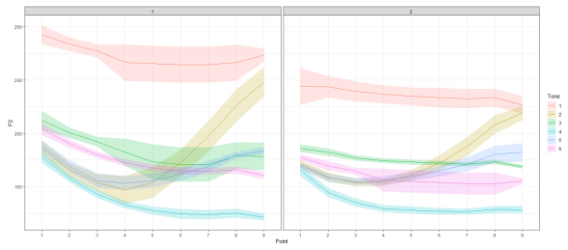

Figure 1. The F0 curves of the six tones produced by each speaker with collapsed vowel heights.

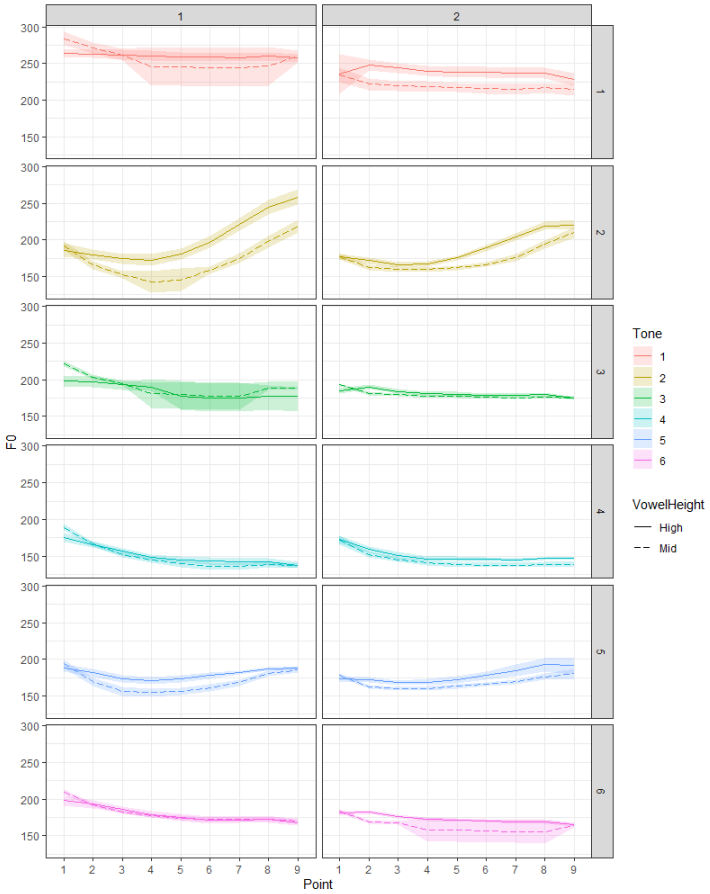

Figure 2. The F0 curves of the six tones for each vowel height, showing data for Speaker 1 (left) and Speaker 2 (right)

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