

## F0 and segment interaction in Shanghai Chinese

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It is often observed that fundamental frequency (F0) is higher at the edges of vowels next to voiceless obstruents than next to voiced ones. There are two opposing views on the underlying mechanisms of such an interaction of voicing and F0. One argues that it is due to perturbation of F0 by some aerodynamic and/or laryngeal settings whose intended purpose is to control obstruent voicing (see Ohala 1978 for summary on early works). The other proposes that such an interaction is due to speakers' voluntary control either to enhance the voicing contrast (Kingston & Diehl 1994) or as learned covariation (Holt, Lotto, and Kluender, 2001).

Shanghai Chinese presents an interesting case for studies on the interaction of consonant and tone. It has five lexical tones, with co-occurrence constraint on the onset consonant of the tone-bearing syllable. Tones that start high (Tone 1: high falling; Tone 2: high rising; Tone 4: short high) only occur with voiceless (both aspirated and unaspirated) stops; while tones that start low (Tone 3: low rising; Tone 5: short low rising) only occur with voiced stops (with some breathiness) (Cao & Maddieson 1992). In other words, the commonly observed f0 raising effect of voiceless obstruents and lowering effect of voiced obstruents have been phonologized in Shanghai Chinese and therefore must be learned by speakers. When syllables are combined, they form tone sandhi domains. The domain-initial syllable maintains the tonal contrast but voiceless unaspirated and voiced stops show no significant difference in voice onset time (VOT). In other words, the three-way opposition neutralize to two-way opposition in terms of VOT values. The non-initial syllables, however, lose their underlying tonal contrast and their f0 contours are affected by the tone of the initial syllable. At the same time, the three-way voicing contrast (manifested as VOT) over the onset stops becomes salient. It is not clear, however, how voicing and f0 of these non-initial syllables interact.

The study that I will report was therefore designed to address this question. Bi-syllabic nouns, which form tone sandhi domains, were elicited within template sentences. I varied 1) the tone of the initial syllable (i.e. high falling, high rising, and low rising); 2) the voicing of the onset stop of the second syllable (i.e. voiceless aspirated, voiceless unaspirated, and voiced); and 3) the vowel of the second syllable (2 vowels). I also varied the focus condition with which the bi-syllabic nouns were elicited. Data from six subjects were elicited with three repetitions from each speaker.

Preliminary results suggest that in general the vowels following voiceless unaspirated stops have higher f0 than those following voiced stops. The f0 of the vowels following voiceless aspirated stops, however, sometimes patterned with plain voiceless ones (i.e. showing higher f0) and sometimes with voiced ones (i.e. showing lower f0). More data are being analyzed and results will be discussed with regard to the mechanisms that have been proposed in the literature. Implications of this study on the phonetics and phonology of segment and f0 interaction will also be discussed.