F0 transition as a perceptual cue of lexical tones in Mandarin

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Previous views on the lexicon argue for abstract representations only, but we join a usage-based view (e.g. Port & Leary 2005) that speakers store phonetic details and extract contrastive cues for the identification of sound categories. Researchers (e.g. Lin & Samuel 2004) found minute secondary cues such as syllable duration and amplitude curve for Mandarin tonal contrasts when major cues (pitch height and pitch shape; e.g. Gandour 1981, 1983) are absent. In this paper, we investigate the contribution of f0 transitions, short pitch movements in non-vocalic segments between two different tonal targets, as a minor cue in Mandarin. Three main pieces of evidence lead us to suspect that listeners use f0 transitions to identify lexical tones: (1) tonal speakers are sensitive to coarticulated f0 changes and compensate tonal coarticulation in their perception (e.g. Xu 1993), (2) tonal speakers can extract tonal information from segments as short as 30 ms (e.g. Gottfried & Suiter 1997, Lee 2009), and (3) speakers can identify vowels with only short formant transitions (e.g. Strange et. al 1986) and may have the same performance at suprasegmental level.

We presented blocked disyllabic and trisyllabic non-sense auditory stimuli, recorded by a male native Mandarin speaker, to 34 native Mandarin-speaking listeners. The second syllable of the disyllabic stimuli had the rhyme removed. For each stimulus, listeners heard two words (each one syllable) that when combined are not meaningful (e.g. [ʂu^{55} nau^{24}]), in the first block either the entire second syllable was removed (e.g. [ʂu^{55} ___]) or the rhyme of the second syllable (e.g. [ʂu^{55} n__]). Participants were asked to identify the second word associated with one of four Mandarin lexical tones (55, 24, 213, 51), which were visually presented in Mandarin simplified characters on a computer screen. In the next block, the rhyme of the second syllable was removed from trisyllabic sequences. Participants listened to trisyllabic stimuli with [ʂu^{55} n__ muɔ^{55}] or without an onset [ʂu^{55} n__ _uɔ^{55}] for the *third* syllable, testing the contribution of a following f0 transition.

We find: First, when disyllabic stimuli were presented, the subjects had difficulty distinguishing 24 and 213. This is not surprising since both 24 and 213 have a low initial pitch and thus a low f0 transition. Further, it has been shown that these two tones are perceptually confusing (e.g. Huang 2001). Second, f0 transitions, when realized as distinct pitch movements, resulted in a three-way perceptual contrast for the second syllable (i.e. 55, 51, 24/213). This pattern coincides with previous findings (e.g. Chandrasekaren et. al 2010, Guion & Pederson 2007) that Mandarin listeners are perceptually more sensitive to pitch movement than to pitch height. Finally, when onset and offset f0 transitions are present in trisyllabic stimuli, the tones 24 and 213 are more easily distinguished. The current results extend work on vowel identification with the onset and offset of formant transition, illustrating a similar pattern in tone identification. In sum, f0 transitions, though frequently obscured by voiceless segments, can be adapted by Mandarin speakers as a secondary cue of tonal perception.

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