

Prosodic effects on allophonic creaky voice: A case study of Mandarin lexical tones.

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Except for the function of expressing phonological contrast, studies have shown that creaky voice can be produced allophonically in various phonetic conditions. In American English, creaky voice can be realized as coda glottalization (Pierrehumbert 1995, Dilley et al 1996, Huffman 2005, Gordon & Ladefoged 2001), and phrase final creak (Huffman 2005, Garellek 2013, 2015). In a tonal language, creaky voice can be produced in the lexical tones with low pitch targets (Esposito 2012, Kuang 2013). Studies (for example, Esposito 2012) have demonstrated that "creaky voice" in fact covers a relatively wide range of voice qualities with distinct acoustic features.

The interaction between prosody and allophonic glottalization in American English has received much attention (Pierrehumbert 1995, Garellek 2013, 2014, 2015, Redi et al 2001, Hunter 1986). Stress and phrase final position has been found to exert broad effects on the realization of initial creak (Pierrehumbert 1995) and coda glottalization (Huffman 2005, Garellek 2013, 2014, 2015). The interaction between the creaky voice as the result of prosody and the ones resulted from pitch requirements of lexical tones, on the other hand, are different from the interaction discussed above in nature, in that the target of complete glottal closure is missing in both conditions. For this reason, such interaction is better understood under the broader discussion of the interaction between lexical tone and intonation. However, little is known about this interaction in the case of creaky voice production.

Given the different nature of the two kinds of interaction of creaky voice and the similarity in pragmatic functions of creak at prosodic level, the present study attempts to better our understanding of the creaky voice in tonal languages by examining its acoustic realizations at both prosodic and lexical level, and how prosody affects the creaky voice of lexical tones. Using data drawn from a corpus of spontaneous speech of Mandarin, we first present a careful acoustic classification of creaky voice observed in the data. The acoustic properties of creaky voice by prosodic positions and by lexical tones are then discussed.

The classification identified four types of creaky voice under the current classification paradigm (tense, vocal fry, multiply pulsed voicing and aperiodic voicing). Post hoc acoustic validation justifies such classification by finding the expected acoustic correlates within each category. Based on this classification scheme, it has been found that different prosodic position (phrase final, utterance final, phrase medial and phrase initial) has different distribution of types of creaky voice ($\chi^2 = 92.8198$, $df = 9$, $p < 0.001$), although aperiodic voicing constitutes the majority of creaky voice at all positions. Different distribution of lexical tones is also found to have different distribution at each prosodic position ($\chi^2 = 265.4617$, $df = 12$, $p < 0.001$), while the distribution of creak types is not different across lexical tones ($\chi^2 = 19.9866$, $df = 12$, $p = 0.0673$). A mixed-effect analysis, in which the measurement of periodicity (CPP) is predicted by tone type, prosodic position as fixed effects, speaker as random effect, shows that only prosodic position predicts the acoustic realization of creak ($\beta = -0.17$, $t = -3.12$, $\chi^2 = 9.827$, $p < 0.01$).

This result suggests that prosody has a stronger effect on the acoustic realization of creaky voice than lexical tones. In fact, the different distribution of lexical tones at different prosodic positions is evident by different frequency of the neutralized tone, whose occurrence is partly conditioned by prosody. This finding offers further evidence in support of the claim that prosody has broad effects on allophony (Pierrehumbert 1995) not only at segmental level, but also in the domain of allophonic tonal realizations. The result also supports the interaction discovered between intonation and lexical tone, in which lexical tones are not fully realized in order to fit the intonation pattern (Ma et al 2007).

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