Production of Mandarin Tones in Patients with Parkinson’s Disease

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Parkinson’s disease (PD) is one of the neurodegenerative diseases in the middle-aged and elderly people, with typical motor impairments such as bradykinesia, hypokinesia, akinesia, muscle rigidity, and rest tremor. In addition, 70%-90% of PD patients also suffer from hypokinetic dysarthria, which may have developed for years before the appearance of obvious clinical motor symptoms and hence may be an indicator for early diagnose of PD. Hypokinetid dysarthria in PD is manifested in all dimensions of speech production. Especially, prosodic characteristics of PD speech include monotone, monoloudness, abnormal speech rate, and disfluency. In tone languages like Mandarin, monotone (i.e., a reduced pitch variability) in PD speech has been acoustically evidenced by a global analysis of F0 contours of continuous utterances [1–3], but F0 variations of lexical tones have not been specifically investigated.

Speech disorders and gait disorders are both axial symptoms (i.e., disorders of body axis) in PD, thus having some common mechanisms. Like freezing of gait when turning in PD [4], formant transitions (F2 slopes) within diphthongs in speech are slower in PD than in healthy controls [5]. These not only share the same mechanisms with monotone in PD speech, but also lead us to wonder whether local pitch transition of lexical tones is a better indicator of PD in tone language speakers than the global F0 variability, and if so, in which tonal contexts the indicator will be more effective.

Thus, the present work investigated PD’s production of four tones of Mandarin, i.e., T1 (HH), T2 (LH), T3 (LL) and T4 (HL). Two groups of Mandarin-speaking participants were recruited: 13 patients with Parkinson’s disease (PD) who were at the modified H&Y stage of 1-3 without dementia, depression, anxiety or other neurological diseases, and 13 gender- and age-matched healthy controls (HC). For tonal coarticulation, it is known that carryover effect is primary while anticipatory effect plays a secondary role. Therefore, for each participant, 40 monosyllabic words (10 for each of four tones), 80 disyllabic words (5 for each of 16 tonal combinations), and 20 trisyllabic words (5 for each of the four combinations: T4-T1-T2, T1-T2-T2, T1-T3-T4, and T4-T4-T1, in all of which pitch targets switch from L to H or vice versa across syllable boundaries) were recorded. Growth curve analyses with quadratic polynomials were conducted on F0 contours. The means, slopes, and curvatures of F0 contours in all target syllables were then analyzed using linear mixed-effects models.

In monosyllabic words (Fig. 1), in the latter syllables of disyllabic words (Fig. 2), as well as in the intermediate syllables of trisyllabic words (Fig. 3), the PD group showed a lower slope for T2, a lower curvature for T3, and lower absolute slope and curvature for T4 than the HC group. Results indicated smaller F0 variations in the PD group, which coincided with subjective impression on PD’s monotonous voice of tone, suggesting degraded F0 manipulation in PD. Moreover, in the di- and tri-syllabic words with reversed pitch targets across syllable boundaries (i.e., L-H or H-L, as shown in red in Figs. 2–3), the PD group exhibited significantly smaller F0 shifts at syllable boundaries than the HC group, while in the disyllabic words without any change of pitch target across syllable boundaries (i.e., H-H or L-L, as shown in green in Figs. 2–3), no significant difference in F0 shift was found between the two groups.

In sum, a reduced pitch variation in PD speech of Mandarin can be better exposed in polysyllabic words with reversed pitch targets across syllable boundaries. This suggests that for speakers of tone languages that generally have faster F0 variation than non-tone languages due to the existence of lexical tones, the words in particular tone sequences can be very effective materials not only for early diagnosis of PD but also for speech therapy in PD patients.
References


