Studies of Chinese Speakers with Dysarthria: Informing Theoretical Models

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Abstract

Most theoretical models of dysarthria have been developed based on research using individuals speaking English or other Indo-European languages. Studies of individuals with dysarthria speaking other languages can allow investigation into the universality of such models, and the interplay between language-specific and language-universal aspects of dysarthria. In this article, studies of Cantonese- and Mandarin-Chinese speakers with dysarthria are reviewed. The studies focused on 2 groups of speakers: those with cerebral palsy and those with Parkinson's disease. Key findings are compared with similar studies of English speakers. Since Chinese is tonal in nature, the impact of dysarthria on lexical tone has received considerable attention in the literature. The relationship between tone [which involves fundamental frequency (F_0) control at the syllable level] and intonation (involving F_0 control at the sentential level) has received more recent attention. Many findings for Chinese speakers with dysarthria support earlier findings for English speakers, thus affirming the language-universal aspect of dysarthria. However, certain differences, which can be attributed to the distinct phonologies of Cantonese and Mandarin, highlight the language-specific aspects of the condition.

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Dysarthria affects millions of children and adults worldwide, in both congenital and acquired forms. Speech-language pathologists and other professionals are involved in the diagnosis and management of dysarthria and its concomitant disorders. However, there is a lack of tests and treatment materials for many of the world's languages. It is important to have linguistically and culturally appropriate materials in order to best assist individuals with dysarthria, and efforts towards this end are ongoing.

Many research teams have investigated aspects of dysarthria internationally. However, it is probably fair to say that most of our theoretical models of dysarthria have been based upon studies of English speakers. Studies conducted with individuals with dysarthria who speak languages other than English offer an opportunity to investigate the extent to which such models are 'universal', and may permit a study of language-specific versus language-universal aspects of dysarthria.

An estimated 60–70% of the world's languages are tonal (i.e. fundamental frequency, F_0 , is used contrastively to signal meaning) [1], including most varieties of Chinese. Chinese, spoken by approximately 20% of the world's population, is the most commonly spoken language. Two of the main Chinese dialects/languages are Cantonese, which is spoken in Southern China and in many overseas Chinese communities, and Mandarin (Putonghua), the official national language. The differences in the phono-

logical systems of English and Chinese languages and, in particular, the presence of tone in Chinese languages makes Chinese a particularly interesting language in which to study dysarthria, and to compare findings with those established with English- and other Indo-European-language speakers.

There are a number of key differences between Cantonese and Mandarin phonologies. Mandarin has 4 contrastive tones, whereas Cantonese has 6 tones. Cantonese has a restricted fricative/affricate system (only 3 fricatives, one of which is /h/; and 2 affricates), whereas Mandarin has a very rich system, including an alveopalatal place of articulation for fricative and affricate. Mandarin also has retroflex consonants.

Two main groups of Chinese speakers with dysarthria have been studied and reported upon in the English-language literature: individuals (particularly adults) with cerebral palsy (both Cantonese- and Mandarin-speaking) and individuals with Parkinson's disease (PD; primarily Cantonese speakers). In the following sections, key findings from several of these studies will be reviewed, particularly in comparison with previous findings from English speakers. The relationship between tone and intonation disturbances in Chinese speakers with dysarthria will be another area of focus in this review.

Segmental and tonal errors produced by Cantonese-speaking young adults with cerebral palsy were determined, based on transcriptions of single words [2]. The findings were largely consistent with those found previously for English-speaking adults with cerebral palsy. For example, accuracy was lowest for initial consonants, followed by final consonants, then vowels. For initial consonants, nasals were the most accurate, and fricatives and affricates the least accurate. Most error patterns could be explained as a result of difficulties with velopharyngeal valving, laryngeal control, or fine motor control of the articulators. Of note was that most of the segmental errors were substitution errors. This appeared to be in contrast with classic descriptions of dysarthria as involving a high percentage of distortion errors [3]. However, this difference was attributed to methodological considerations (in particular, the use of a more narrow transcription method), rather than language-specific findings. Two error patterns were noted in this group of speakers which have not been commonly reported for English speakers with dysarthria, but which have been documented in other types of Cantonese speech disorder; namely, affrication (of /s/) and bilabial fricatives as a substitution for /f/ [4]. Lexical tone was relatively robust as a feature (87% accuracy). Cantonese has 3 level tones (high,

mid and low level) and 3 contour tones (high rising, low rising, low falling). Leveling of contour tones was the most common tone error pattern observed.

Single-word intelligibility was investigated in the same group of Cantonese speakers [5], using a test based on one developed for English speakers with dysarthria [6]. Both tests aimed to determine which perceptual-phonetic contrasts contribute most to reductions in single-word intelligibility. The Cantonese test included 17 contrasts known to be problematic in Cantonese speakers with dysarthria [2]. The findings for the Cantonese speakers again largely confirmed findings of previous studies of English speakers with cerebral palsy [7, 8]. For example, the most problematic contrasts involved laryngeal control, fine motor control of the articulators, and velopharyngeal control. 'Tone level' was the second most problematic contrast for this group of speakers. However, when the 6 most problematic variables were entered into a predictive analysis of single-word intelligibility, tone level made little contribution. The reason for this was that tone level was impaired relatively equally across speakers, and thus did not differentiate between speakers of different intelligibility levels.

A similar study was conducted with 20 Mandarin-speaking young men with cerebral palsy [9]. Six phonetic contrasts were employed in the perceptual study. The results were broadly in line with those previously found for English speakers with cerebral palsy. For example, vowels were more intelligible than consonants, and the speakers demonstrated difficulties with the contrast between aspirated and unaspirated consonants (similar to the voicing contrast in English). The study also involved acoustic analysis of 7 parameters, and determination of the contribution of these acoustic contrasts to intelligibility. Extensive variance was found for the speakers with cerebral palsy. Most of the speakers appeared to demonstrate contrasts, although these were not always produced in the same ways as those produced by age-matched controls. There was good correspondence between the acoustic and perceptual findings. The findings were broadly consistent with those of a similar study with English speakers with cerebral palsy [7]. The results suggested that, as for English speakers with cerebral palsy, the Mandarin speakers had impaired temporal and spatial control of the articulators. The authors concluded that the differences observed between the 2 studies (an apparent lesser involvement of vowel contrasts in intelligibility and a larger involvement of the aspiration contrast in Mandarin) needed further investigation before it could be concluded that these were language-specific.

The authors called for further exploration of other variables which impact on intelligibility, including suprasegmental variables.

Based on the finding that Cantonese speakers with cerebral palsy had difficulty producing tone level contrasts [5], the 3 level tones were analyzed acoustically [10]. Only 3 of the 19 speakers had what could be characterized as a contrastive system for the 3 tones. Common error patterns included a higher F_0 than control speakers, an extreme falling pattern for the level tones, and lowering of the high level tone. Excessive variability in performance was also found (a feature which appears to be language-universal in dysarthria).

The F_0 patterns of target level tones produced by 4 of the Cantonese speakers with cerebral palsy and 1 non-dysarthric control subject were compared with the perception of these tones by healthy listeners [11]. The speakers with cerebral palsy showed errors in either F_0 level or F_0 contour or both. There was frequent confusion among the level tones and also level tones were perceived as contour tones. This study showed the impact that disordered F_0 control can have on the intelligibility of single words in Cantonese.

The 3 Cantonese contour tones were also investigated in the larger group of speakers with cerebral palsy [12]. Again, the speakers with cerebral palsy had a higher F_0 than the control speakers. Most of the speakers with dysarthria showed a falling contour for rising tones. Other abnormal patterns observed were a rising contour for falling tones, and reduced as well as excessive F_0 ranges. Nevertheless, about half of the speakers with dysarthria appeared to have contrastive systems.

Lexical tones were studied in Mandarin-speaking young adults with cerebral palsy (with spastic, athetoid, and mixed types), using both perceptual and acoustic analyses [13]. Many of the findings were similar to those for Cantonese speakers, as reported above. For example, reductions in tone accuracy were noted in single-word productions, although tones were more accurate than consonants produced by the same speakers. The authors hypothesized that the relative robustness of tones might be due to the lower number of contrasts in the tonal system, relative to the contrasts required for consonants. However, a physiological explanation was also offered, relating to the relatively easier control for tone (involving predominantly control of F_0) versus the control mechanisms necessary for consonant contrasts. Tone accuracy appeared somewhat lower for this group of Mandarin speakers than previously reported for Cantonese speakers with cerebral palsy [2]. While this may have been due

to differences in the tonal systems of Cantonese and Mandarin, it was considered to be more likely due to differing overall severity levels between the 2 groups of speakers. Acoustic analysis of the F_0 patterns for tone productions in this group of Mandarin speakers revealed variable productions, atypical patterns, flattening of the rising final portion (for tone 3), but preservation of many contrasts. The authors called for further investigations of the relationship between F_0 patterns at the syllable level (for tones) and F_0 intonation patterns at the sentence level.

The control of F_0 at the connected speech level was investigated for Cantonese speakers with spastic- and athetoid-type cerebral palsy and healthy controls [14]. Both groups of speakers with cerebral palsy had significantly higher F_0 in connected speech than the control speakers; the speakers with spastic cerebral palsy had lower SDFO (standard deviation of fundamental frequency), indicating monotone speech, whereas the speakers with athetoid cerebral palsy had highly variable SDFO. These findings were broadly in line with those of previous findings in English speakers with cerebral palsy. The authors did not investigate F_0 for lexical tone in this study. However, they concluded that 'it would be of interest to investigate further the relationship between flattened or excessive F_0 contours at the sentence level and tonal disruption at the single word level' [14, p. 231].

One final study of Cantonese speakers with cerebral palsy involved children with severe dysarthria who communicated primarily by augmentative and assistive communication [15]. The aim of the study was to determine the extent to which the children could communicate intent to a familiar conversational partner using only prosodic cues. Using an interactive computer game, mothers guessed which vocalization target their child was attempting; the targets varied by duration, pitch level and pitch contour. Although it was not designed as a cross-language comparison study, there was some evidence to suggest that Cantonese-speaking mothers might be better than English-speaking mothers at interpreting pitch-based cues, due to their experience with a lexical tone language. The authors called for a more systematic investigation of this hypothesis.

We turn now to studies of Chinese speakers with hypokinetic dysarthria associated with PD. The perceptual characteristics of Cantonese speakers with hypokinetic dysarthria were determined [16] using procedures based on the classic Mayo Clinic study [17, 18]. The perceptual profile for Cantonese was largely similar to profiles for English [17, 18] and Japanese [19] speakers with PD. For

example, the most severely affected dimensions were those relating to voice quality, reduced pitch and loudness variation, and imprecise consonants. Tone distortion (a dimension added for this study) was relatively robust – ranked 20th in severity of the 21 dimensions included. This was possibly related to the task (rating scale, as opposed to phonetic transcription). However, the contrast in findings for lexical tone and intonation (‘monotone’) suggested a possible differential control for these 2 functions. Differential control for tone and intonation had been previously proposed by Vance [20], who hypothesized that intonation might predominantly involve changes in subglottal pressure, whereas tone might predominantly involve changes in laryngeal maneuver. However, no direct evidence was provided to support this hypothesis.

Wong and Diehl [21] found that tones produced by a Cantonese speaker with PD were identified less accurately by listeners than those produced by a control speaker. The speaker with PD had a more restricted tonal space (as defined by the pitch range of all 6 tones) as well as a more restricted range at the phrase level than the non-impaired speaker. The study lent support to a tone normalization theory termed ‘context-target pitch distance’, where listeners use the pitch distance between the target tone and the preceding syllables to identify tones [22]. Although this study involved a single subject with PD and a single target syllable (/si/), it provided insight regarding impairments in tone and intonation in Chinese PD, and how listeners comprehend the tones produced by speakers with PD.

Lee Silverman Voice Treatment (LSVT®) is a well-established method for improving the speech of individuals with PD [23]. A pilot study was conducted with 4 Cantonese speakers with PD, using treatment based on the principles of LSVT® [24]. As expected, all 4 speakers showed improvements in vocal intensity, increased mean pitch and increased pitch range, as previously reported for English speakers undergoing this treatment approach [23]. However, although improvement was noted in intonation for all 4 speakers (that is, the speakers became less monotone), there was no significant improvement in the accuracy of lexical tones. This was possibly related to the relative mild pre-treatment impairment in tones. However, the authors also again discussed the possibility of differential physiological control for lexical tone and intonation, as hypothesized by Vance [20]. It should be noted here that Dromey and colleagues [25, 26] found that LSVT led to both increases in subglottal pressure and improvements in laryngeal control, although the studies

(conducted with English speakers) did not specifically investigate lexical tone.

An extension study, using LSVT® with 12 Cantonese speakers with PD, reported similar findings [27]. Significant decreases in monotonicity were noted for the group. However, there were no significant improvements in tone accuracy, as determined both perceptually and acoustically. Those speakers who had relatively flattened contour tones before treatment showed little improvement after treatment. Again, pre-treatment tone accuracy was relatively high, which may have influenced the results.

The relationship between tone and intonation in non-impaired Cantonese speakers has been investigated, using both perceptual and acoustic analyses [28]. More recently, this relationship was systematically investigated in Cantonese speakers with PD, using acoustic analysis [29]. The PD speakers contrasted tones similarly to control speakers in varying contexts. However, lower F_0 values were found for tones at the final positions of questions, in contrast to the rising tones found in normal speakers [28]. That is, intonation had a smaller influence on the production of lexical tones by PD speakers than for control speakers.

Conclusions

This review of studies of Chinese speakers with dysarthria was restricted to publications in English, and focused on only 2 clinical populations: individuals with cerebral palsy and those with PD. Nevertheless, it has highlighted the advantages of the study of dysarthria in languages other than (the most-heavily reported) English. Several of the studies provided tools and information which will enhance clinical practice with Chinese speakers with dysarthria. The studies also offer an enhanced theoretical understanding of dysarthria. One general conclusion is that Chinese speakers with dysarthria show many of the same patterns of speech errors as English-speaking individuals with dysarthria. This reflects the ‘language universal’ component of dysarthria, and the universality of neurophysiological impairment on human speech production systems. Several ‘language-specific’ features also have been documented in Chinese speakers with dysarthria. These, in contrast, illustrate the interplay between neurophysiological damage and the specific phonologies of a language (e.g. Cantonese, Mandarin). For example, differences in fricative systems or phonotactic structures may result in different manifestations of dysarthria. One of the most obvious differences

between English and Chinese is the tonal nature of Chinese. This feature has attracted a lot of attention from scholars investigating dysarthria in Chinese speakers. Dysarthria of course affects not only segmental features of speech but also suprasegmental and prosodic. This raises the obvious question of the relationship between

tone and intonation in speakers with dysarthria. Further investigation is needed, but it appears that there are complex if not independent relationships between tone and intonation, which may further inform and challenge models of dysarthria based primarily on English, a non-tonal language.

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