An acoustic study of affricates in the Songyuan dialect of Mandarin Chinese

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Introduction

•An affricate is a compound sound consisting of a stop (like /t/ in "tea") followed by a fricative (like /s/ in "see") made at the same place in the mouth.

•Since they are complex, affricates are late-acquired across languages.

•Mandarin affricates are particularly interesting because there are six that contrast by place of articulation, tongue posture, and presence or absence of aspiration. This study examines the three unaspirated affricates (see Table 1).

Table 1.

IPA	Place	Posture
[ts]	dental	laminal
[tɕ]	alveolopalatal	bunched
[tʂ]	retroflex	apical

•Few studies of affricates have been done. Peter Ladefoged and Zhongji Wu (1984) did study Mandarin Chinese affricates, but reported electropalatographic findings rather than the finer acoustic details.

•Fricatives as non-compound single sounds have been studied before in many different languages, including Catalan Spanish (Recasens & Espinosa 2007), and English (Jongman et al. 2000, Nissen & Fox 2005).

Goals

•To adapt acoustic measures that have been developed for fricatives to look at the fricative portion of the affricates.

•To define each of the affricates so that they can be compared and contrasted with one another across place of articulation and across gender.

•In future work, to understand how children acquire these difficult affricate sounds.

Methodology

•Each of the affricates was elicited at the beginning of at least 2 words, using a picture-prompted repetition task.

•Audio recordings of 8 Mandarin Chinese speaking men were analyzed using Praat signal analysis software.

•For each affricate token, the following points were marked:

burst (beginning of frication): the release of the stop closure

fricEnd: end of high frequency energy; sometimes coincides with voicing onset

vOnset: onset of F2

•Burst and fricEnd were used to calculate fricative duration and to extract a 20 ms window (Fig. 1 left panel) to calculate a spectrum.

•vOnset was used to extract the second formant value.

•Centroid, standard deviation, skewness, and kurtosis were calculated from the spectrum (Fig. 1 right panel).

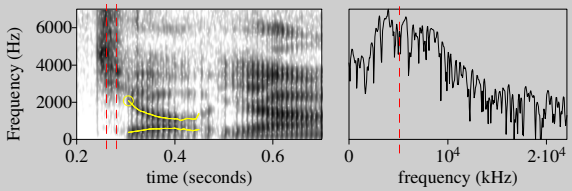

Figure 1. Spectrogram (left panel) of *jiao3 ya1* 'foot' showing 1st and 2nd formants (yellow traces), onset F2 value (yellow circle), and 20-ms window (red cursors on left) for extracting spectrum (right panel) in order to calculate centroid (red cursor on right).

Results to date

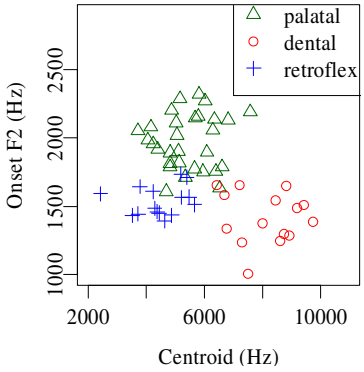

Figure 2. Relationship between centroid and onset F2

•In Figure 1, the distributions of the tokens of the three sounds barely overlap, showing that centroid and onset F2 together distinguish the men's affricates robustly.

•The centroid for [ts] is highest, in keeping with its dental place of articulation.

•The onset F2 value for [tɕ] is highest, in keeping with its palatal bunching posture.

All of the above findings parallel those obtained in a study of the corresponding Mandarin fricatives (Li 2008).

•Skewness is lowest for [ts], which means that it has the highest frequency energy.

•Kurtosis is highest for the unaspirated retroflex affricate [tʂ]. This means that its spectrum has very clearly defined peaks.

Table 2. Mean value for each of the spectral moments and duration by place of articulation

Place of articulation	Centroid (Hz)	Standard deviation (Hz)	Skewness	Kurtosis	Duration (ms)
tɕ	5438	2245	1.2718	2.4555	58
ts	8120	2007	0.3009	2.0359	45
tʂ	4486	1995	1.8594	8.0669	25

•Nissen and Fox (2005) obtained similar results in their study of fricatives produced by English-speaking adults. They found that alveolopalatal sounds produce peakier spectra than the dental/alveolar sounds.

•Duration is longest for [tɕ] and shortest for [tʂ]. A repeated measures ANOVA with duration as a within-subjects factor showed a significant effect of affricate place ($F(2,6)=120$, $p<0.001$).

•Duration differences may reflect posture differences among affricates, since it is easier to move the tongue tip (as in [tʂ]) than the tongue body (as in [tɕ]).

Future work

•Further statistical analyses will be done to refine our understanding of the differences between the three unaspirated affricates.

•The same measurements will be made for the three aspirated affricates.

•The same analyses will be done on utterances from ten adult female speakers. Mandarin-speaking women and men have several articulation differences.

  •We are interested to see the age at which children acquire these differences.

•Beginning in Autumn 2008, the same analyses will be done on utterances from 80 children aged 2-5 years.

Acknowledgments:

This project is part of the paidologos project, funded by NIDCD grant 02932 to Jan Edwards and Mary Beckman

Thanks to Fangfang Li for sharing her Praat scripts and helping in the acoustic analysis, and to Oxana Skorniakova for sharing the work of tagging the files.

For a copy of this poster and a list of references, see http://www.ling.ohio-state.edu/~edwards