Proceedings of Meetings on Acoustics

Volume 19, 2013 http://acousticalsociety.org/

ICA 2013 Montreal
Montreal, Canada
2 - 7 June 2013

Speech Communication
Session 5aSCb: Production and Perception II: The Speech Segment (Poster Session)

5aSCb47. A comparative cross-linguistic study of vocal tract shaping in sibilant fricatives in English, Serbian and Mandarin using real-time magnetic resonance imaging

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An articulatory study of sibilant fricatives is described, with the goal of describing variability in lingual articulation across languages. Real-time Magnetic Resonance Imaging (rtMRI) data were collected from three speakers each of English and Mandarin and two speakers of Serbian and reconstructed at a rate of 22.4 frames per second. Parallel acoustic data were also collected and subsequently denoised. Subjects spoke the segments /s/ and /S/ in symmetrical vowel contexts (e.g. 'pa sap' for English and 'asa' for Mandarin). Articulation was analyzed using a semi-polar grid overlaid on the image plane and midsagittal distance functions were obtained by measuring cross distances at ~0.5 cm intervals from the glottis to the lips. Analysis shows that place of articulation for /s/ is more anterior compared to /S/ across languages. Apical articulation is observed for /s/ across languages, while /S/ is produced laminally in English and apically in Serbian and Mandarin. Patterns of tongue shaping variability differ, as well, across languages. For instance, higher standard deviation is observed anterior to the place of articulation for /S/ in Mandarin, compared to Serbian and English. [Work supported by NIH]

Published by the Acoustical Society of America through the American Institute of Physics

 [DOI: 10.1121/1.4800257]
Received 22 Jan 2013; published 2 Jun 2013

1. INTRODUCTION

An articulatory study of sibilant fricatives is described, with the goal of describing variability in lingual articulation across languages. Real-time Magnetic Resonance Imaging (rtMRI) data were collected from three speakers each of English and Mandarin and two speakers of Serbian. The Chinese and Serbian subjects were born in different parts of China and Serbia respectively and all have some proficiency in English as their second or third language. Data were reconstructed at a rate of 22.4 frames per second using a sliding window technique [1]. Parallel acoustic data were also collected and subsequently denoised [2]. Subjects produced the sibilant fricatives /s/ and /ʃ/ in symmetrical vowel contexts (e.g. 'pa sap' for English and 'asa' for Mandarin). Articulation was analyzed using a semi-polar grid overlaid on the image plane and midsagittal distance functions were obtained by measuring cross distances at approximately 0.5 cm intervals from the glottis to the lips.

2. RESULTS

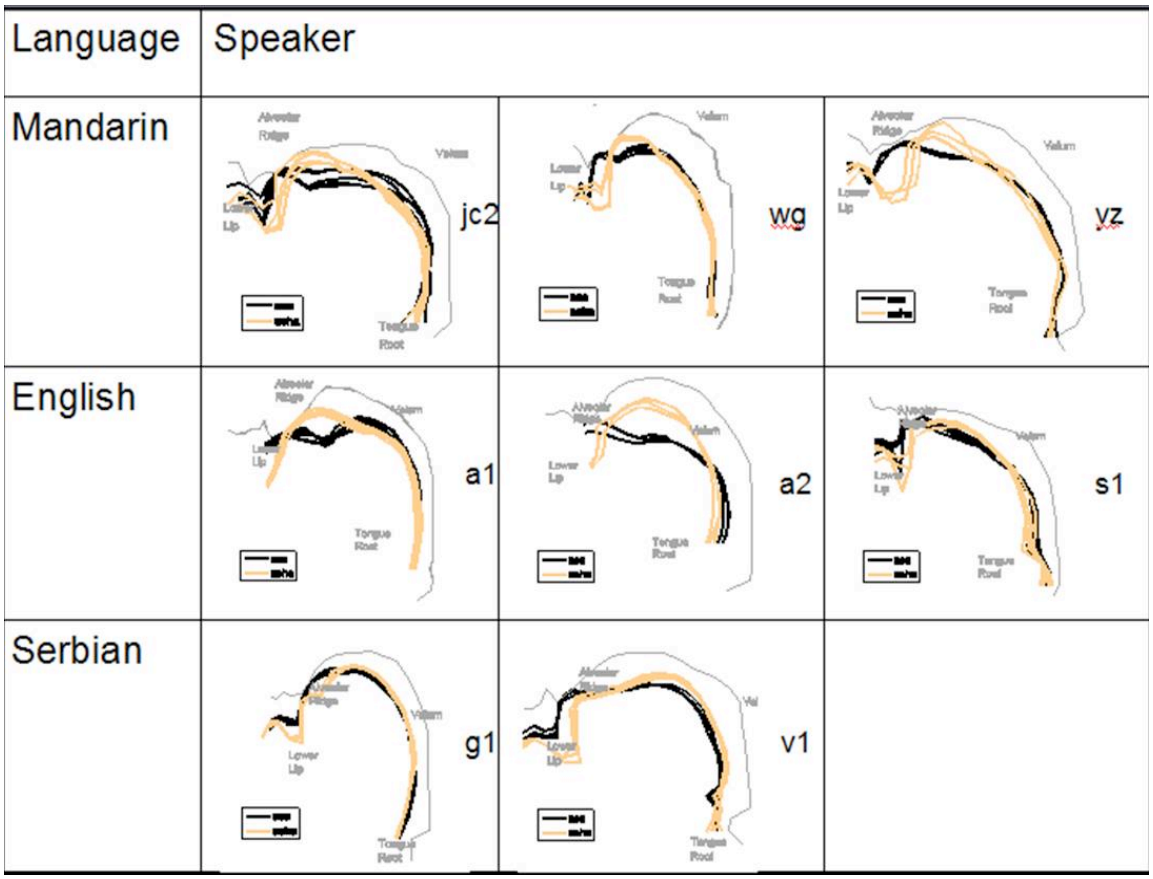

FIGURE 1: Mid-consonantal articulatory targets for Mandarin, English and Serbian sibilant fricatives. Lingual postures are captured at the point of maximal coronal constriction, and lingual outlines show mean posture calculated over three frames centered on the mid-consonantal frame of interest.

Midsagittal tongue postures comparing mid-consonantal articulatory targets for the both sibilants across all subjects are illustrated in Fig. 1. Lingual outlines show mean tongue edges calculated over a three-frame window centered on the mid-fricative frame. Differences amongst languages, but also within a language can be clearly observed though broad patterns of articulation are also observed.

Articulation of /s/ is apical articulation across languages. This fricative produced is also produced with a more anterior location of the critical constriction formed between the tip of the tongue and the dental or post-dental passive articulators.

The fricative /ʃ/ shows more variation in production across languages, and also across different speakers of the same language. While it is produced laminally in English, it is produced apically in Serbian and Mandarin. Also, while subject WG of Mandarin produces it as a palato-alveolar, subject YZ produces it as a retroflex.

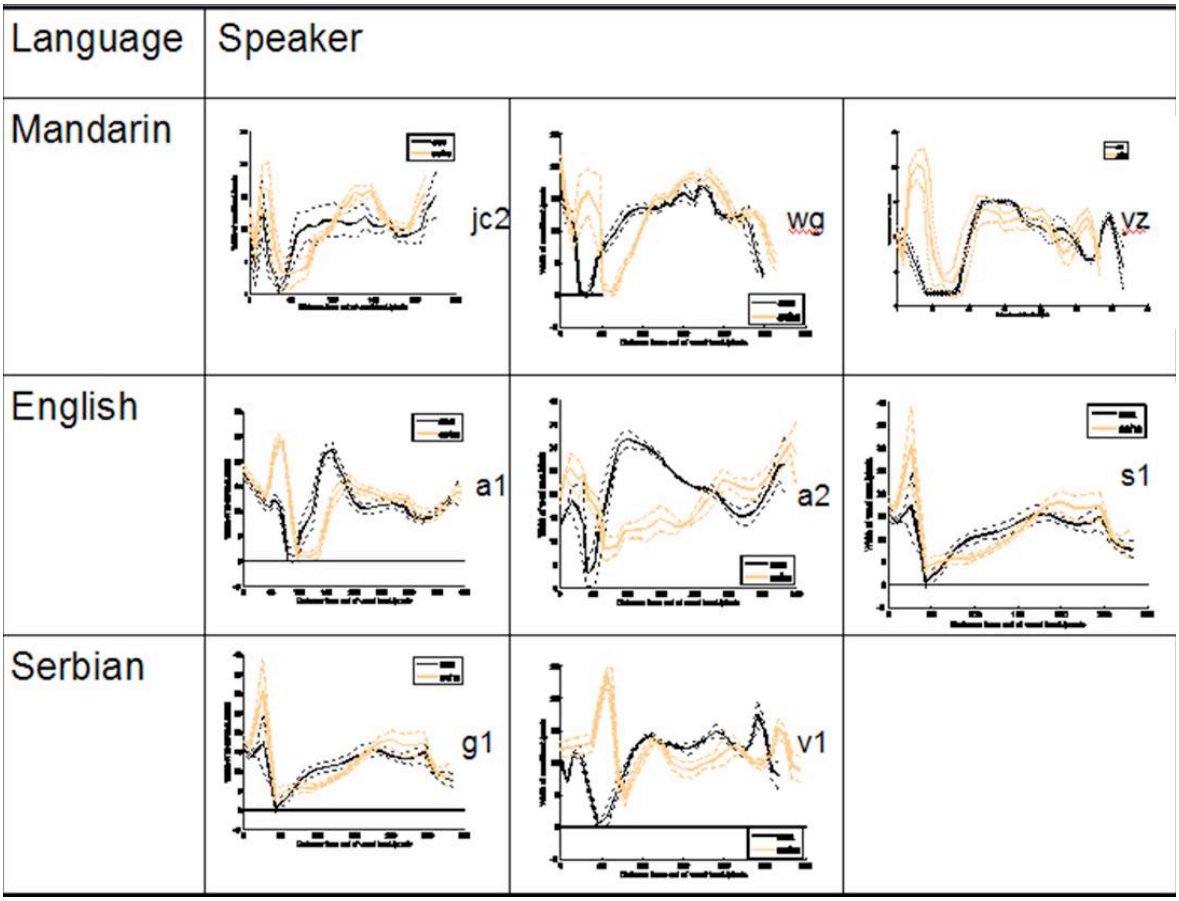

FIGURE 2: Area functions for Mandarin, English and Serbian sibilant fricatives. Distance from the roof of the mouth to the tongue is obtained and plotted from the top of the vocal tract to the glottis. The middle line is the mean while the lines above and below show one standard deviation above and below the mean.

The area functions comparing the width of constriction between the roof of the mouth and the tongue across the vocal tract are illustrated in Fig. 2. Lingual outlines show mean width calculated over a three-frame window centered on the mid-fricative frame, while the dotted lines above and below the mean line shows one standard deviation above and below the mean. The plot shows similar information as that displayed in Fig. 1, but also shows more clearly the magnitude and location of the variation of the individual fricative for the same speaker.

Within speakers of each language, /s/ is produced with little variation across the vocal tract, with the lines of standard deviation following very close to the mean line. /ʃ/, however, shows greater variation, especially around the place of articulation, and this is evident for all three languages.

ACKNOWLEDGMENTS

Research supported by NIH Grant DC007124.

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