Title: A comparison of midsagittal tongue shapes during clarinet performance and vowel production using ultrasound

Joshua Gardner a,1, Maureen Stone b

a Arizona State University, School of Music, Tempe, AZ 85287, USA, b Department of Neural and Pain Sciences and Department of Orthodontics, University of Maryland Dental School

Similar to the acoustical function of tongue motion during speech, the shape of the tongue has important implications during clarinet performance. In speech, the shape of the tongue alters the acoustical properties of the vocal tract, acting as a filter for the sound source—the vocal folds. This is seen in particular during vowel production, where altering the shape of the tongue has the audible effect of changing vowels, such as between /i/ and /u/. Researchers have noted distinct tongue motion patterns during clarinet performance since the 1960’s, with cinefluoroscopic and endoscopic imaging techniques. Such findings suggest that tongue behavior may be linked to the pitch being performed. Several theories have emerged, including the role of vocal tract resonances and impedances. A recent saxophone study suggests the vocal tract is capable of producing strong upstream resonances that can override the resonance system of the instrument, thus overriding control of the reed’s vibrations. Weak downstream resonances occur at higher frequencies; therefore vocal tract influence is more prominent in the higher registers.

Of potential value to researchers and pedagogues alike is a quantification of tongue shapes during performance. Although tongue motion has been observed with cinefluoroscopy and endoscopy, neither has presented the opportunity to measure tongue shape and motion within a single plane. Ultrasound offers this opportunity because it images an approximately 2mm slice of tissue within a given plane and it can be stabilized, ensuring the measurement of tongue motion only. In this paper, midsagittal tongue contours will be examined from ultrasound images taken during clarinet performance. The performance context is a chromatic scale from D3 to Bb6, thus encompassing nearly the entire range of the instrument. Midsagittal contours will be extracted from the ultrasound images using EdgeTrak, a semi-automatic edge detection program developed by the Vocal Tract Visualization Laboratory. A map of tongue shapes will be created, displaying the observed two-dimensional midsagittal tongue shape at each pitch. In addition, the relationships between these tongue shapes and the tongue shapes of selected vowels are of great interest. The tongue contours extracted from the chromatic scale will be compared to tongue contours extracted from pedagogical speech articulation exercises. The articulation exercises are designed to approximate the perceived tongue motion during the multiple articulation technique and are found commonly in multiple articulation methods for clarinet. The data for these exercises were collected at the same session as the clarinet data and include four vowels: /a, i, u, e/, each of which are in a CVC context with unvoiced linguadental and lingua-velar consonants. These vowels have been suggested in pedagogical literature. To compare the performance tongue contours to the vowel tongue contours, root-mean-square (RMS) differences will be calculated between each pitch and each vowel contour using a nearest neighbor point comparison. This value will represent the global difference between tongue contours. Correlational analysis may reveal a relationship between vowel and performance tongue shapes as a function of the pitch being performed. Such a link would enhance and facilitate clarinet pedagogy.