Title: A motion vector analysis of tongue motion in SENĆOŦEN /qV/ and /Vq/ sequences

Sonya Bird, Janet Leonard and Scott Moisik
University of Victoria

This study examines the speed and trajectory of the tongue in /q-vowel/ vs. /vowel-q/ sequences, as pronounced by two speakers of SENĆOŦEN, a dialect of North Straits Salish.

Several studies have indicated that articulatory sequences in which the tongue moves backward in the oral cavity behave in systematically different ways from those in which the tongue moves forward. For example, Gick & Wilson (2006) investigate ways in which /iq/ and /qi/ sequences are pronounced across a range of unrelated languages, and find very little evidence for symmetrical strategies: they find no languages at all in which an epenthetic vowel is inserted both before and after a uvular stop (i.e. [i³q] and [q³i]); in addition, they mention that if Skye Scots Gaelic is indeed a language in which vowel compromise occurs both preceding and following uvulars (i.e. [i]q and [qi]; they have no primary data on this), it “constitutes the only known case of symmetric responses to this conflict” (p. 654).

To gain a fuller understanding of why sequences involving forward vs. backward tongue movement behave in asymmetrical ways (e.g. is it because of articulatory limitations?), it would be beneficial to have a precise understanding not only of the articulations themselves, but also of the **speed** with which they are made. To this end, we consider SENĆOŦEN, a dialect of North Straits Salish spoken on the Saanich Penninsula, Vancouver Island, B.C. Previous acoustic work (Bird & Leonard, 2009) has shown that SENĆOŦEN /iq/ is realized with an epenthetic element, whereas /qi/ is realized with vowel compromise. Here, we use ultrasound to ask the question: Does the tongue move more slowly in /iq/ sequences (with a transitional element) than /qi/ sequences (without a transitional element) and, if so, is this also the case for other vowel-uvular sequences? To answer this question, we record two fluent SENĆOŦEN speakers reading lists of words containing /Vq/ /qV /Vk/ and /kV/ sequences. Resulting ultrasound videos are quantified using a motion vector analysis. This highly automated technique allows for assessing frame-to-frame changes in video data, and therefore provides a means to evaluate the speed and direction of movement of various parts of the tongue (see Figure 1).

Preliminary findings indicate that the tongue may move more slowly during /Vq/ sequences than /qV/; velar articulations (/Vk/ and /kV/) do not show the same kind of kinematic asymmetry. Findings support the previous acoustic evidence that /Vq/ sequences are more ‘drawn out’ than /qV/ sequences: /Vq/ sequences take longer to produce than /qV/ sequences; it is likely this extra length that gives rise to the perception of a transitional element.

This study contributes to the growing body of data on the asymmetrical realization of articulatory sequences in which the tongue moves forward vs. backward. It also introduces an innovative tool for quantifying ultrasound data: motion vector analysis, which is used here to quantify the speed with which the tongue moves in addition to the direction it moves in.
Figure 1. An illustration of ultrasound video image analysis using motion vectors: a pair of consecutive frames during the transition between /i/ and /q/ in a /iq/ sequence (top) are analyzed by an automated algorithm, which breaks the image down into a set of analysis blocks sized to capture the maximum movement recorded across all of the video frames. The sample motion vector plot (bottom) shows the movement that occurred between the two frames. Notably, the tongue dorsum (dashed region) shows the posterior movement associated with the uvular articulation. The motion vectors can be statistically assessed to obtain an approximation of the velocity (both magnitude and direction) of various portions of the tongue during the articulation.