Testing predispositions in consonant harmony

English evidence for Tahltan patterns

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Background: Consonant harmony is relatively rare in the world's languages, and a three-way contrast is even rarer. One case that has attracted attention is that of Tahltan [ISO 639-3 code: tht]. Briefly, its coronal harmony exhibits right-to-left directionality, where the rightmost affricate or fricative of one of three phonologically contrastive series – dental /$t^{θ}$ $t'^{θ}$ $d^{ð}$ θ ð/, alveolar /t^{s} t'^{s} d^{z} s z/, or alveopalatal /$t^{š}$ $t'^{š}$ $d^{ž}$ š ž/ – triggers PLACE agreement in other members of these sets that precede it. Notably, two other series of coronal obstruents, /t t' d/ and the laterals / ƛ ƛ' λ ɬ l/ are non-triggers and are transparent to the harmony (Shaw, 1991). Gafos (1996) proposed that differences in tongue tip shape (which could be preserved across intervening consonants) could account for the pattern. Taking tongue groove as an index of tongues shape, Tahltan was found to show such a pattern (Whalen, Shaw, Noiray, & Antony, 2011). That result, however, could have been due to the harmony itself; we need a language without the harmony but with the three distinctive places of articulation to see whether the foundation for the harmony exists elsewhere. English provides such a case and is investigated here.

Methods: Tongue groove is measured from biplanar (simultaneous sagittal and coronal) images during running speech, using the algorithm of Whalen et al. (2011): first, a line connecting the two peaks of the coronal tongue shape are found (Fig. 1a). A perpendicular line is then formed connecting that line to the groove bottom, and the length of that perpendicular is the groove depth. This method is relatively insensitive to changes in probe orientation, and it does not assume that the vertical dimension (to either the lower or the higher of the two high points of the tongue) is the true depth. Dome shapes are the inverse of that measurement (Fig. 1b), but the magnitude is not as reliable given the difference in reference endpoints.

a) b)

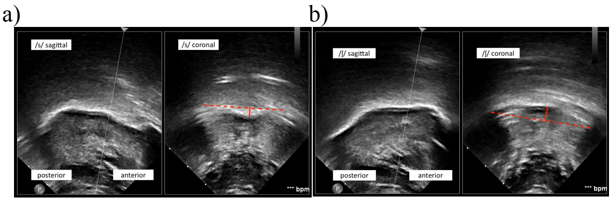

Figure 1: *Samples of biplanar imaging. The dotted line in the sagittal image shows the orientation of the coronal image. The perpendicular solid lines in the coronal sections represent the measurement strategy (depth) for the groove (a) or dome (b).*

Native American English speakers read $C_1VC_2VC_1$ stimuli from a computer screen. C_1 was one of the consonants of English that correspond to similar consonants in Tahltan: /s ʃ θ/, and C_2 was one of the consonants of English that correspond to transparent consonants in Tahltan: /t k/ or one of the competing consonants (e.g. /s/ as C_2 and /ʃ/ as C_1). V was one of /ɑ æ i u/. The stimuli were presented on in modified English orthography, with the vowel qualities explained ("a" for / ɑ/, "ae" for / æ/, "i" for /i/, "u" for /u/) and the voiceless nature of "th" emphasized.

Ultrasound imaging was performed using a Philips EPIQ 7 ultrasound machine with an X6-1 xMatrix array transducer. Only biplanar sections were obtained (rather than full volumetric) so that the frame rate could be fast enough to capture all the segments. Two separate runs were done for the entire list, one with a relatively anterior cross-section (as in Fig. 1) and one with a more posterior one; grooves are expected to vary by anteriority. Key frames were identified from the synchronized audio signal. Measurements were made at the midpoint of fricatives but just after release of the stops. It was assumed that the complete closure of the stops would deform the tongue to the extent that the grooving would be uninformative. We plan to have analyzed data from 6 speakers by the time of the conference.

We plan also to collect simultaneous electromagnetic articulography (EMA) data (Fig 2). This will provide some additional indication of tongue tip shape via the angular orientation of the most anterior receiver. We will also examine the angle of an off-midline receiver as another indication of tongue depth at that one position. Our anterior coronal plane will be near that location, and will be indexed by using EMA sensors on the probe to relate its position to the EMA tongue sensors.

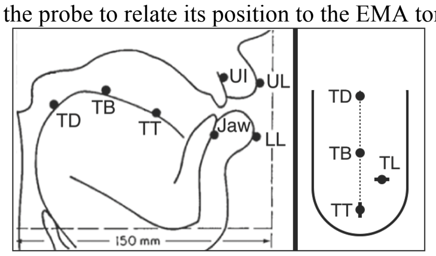

Figure 2: *EMA Sensor Layout: midsagittal profile and transverse tongue. Tongue Tip (TT) and parasagittal Tongue Left (TL) bars show axes determining sensor orientation angles.*

Results and discussion: Preliminary results from one speaker of American English indicate that groove depth differences for the three places of articulation are distinct. Further, the differences are maintained through intervening consonants.

The pilot results indicate that English has the kind of predisposition for three-way consonant harmony that appears in Tahltan. It is thus likely that every language with a three-way contrast allows the tongue shape to persevere over intervening consonants. If that is so, it is not clear why Tahltan enhanced this tendency into a phonological process. It is conceivable that the much larger inventory of consonants in Tahltan put pressure on the language to simplify in some other way, and thus this predisposition was emphasized. It would be of interest to examine other languages, especially those related to Tahltan, to see if larger inventories result in larger groove differences. For now, we can only conclude that Gafos's conjecture is plausible.

References

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