ANALOGS OF TAHLTAN CONSONANT HARMONY IN ENGLISH CVC SYLLABLES

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ABSTRACT

Tahltan is an Athapaskan language with perhaps the world's only three-way consonant harmony system (dental, alveolar, and alveopalatal). Although most explanations have depended on feature analysis, Gafos [1] proposed that differences in tongue grooving could account for the pattern. Here, we use ultrasound to examine the initial plausibility of this argument by determining whether a language without consonant harmony, American English, also shows such groove patterns. Finding such a pattern would support its possible existence in the precursors to Tahltan, from which the harmony system could arise. Coronal sections of the anterior portion of the tongue of three speakers of English uttering CVC syllables were collected via ultrasound and the depths of the groove measured. The data are consistent with Gafos's predictions, with three groove depths differing for the three classes of consonants. This pattern supports the possibility that the consonant harmony derives from this ancillary feature of consonant production.

Keywords: Tahltan, Athapaskan, ultrasound, consonant, harmony

1. INTRODUCTION

Tahltan is an Athapaskan language with very few remaining speakers dispersed across the three small communities of Iskut, Dease Lake, and Telegraph Creek in northern British Columbia. It is the only documented case of a three-way harmony system for consonant place [7]. Briefly, the coronal harmony exhibits right-to-left directionality, where the rightmost affricate or fricative of one of three phonologically contrastive series –dental /t^{θ} t’$^{\theta}$ $d^{ð}$ 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 /ƛƛ’ λ ɬ l/ are non-triggers and are transparent to the harmony. Many examples are given in Shaw [7].

Although the phenomenon has been the focus of analysis from various theoretical perspectives, most authors [1, 2, 6] have relied exclusively on the data transcriptions and descriptions in Hardwick [3] and Shaw [7], both of which are based on unpublished fieldwork documentation and audio recordings made by Shaw from 1981-1983. Affirmation of the harmony process is found in Nater [5], but no additional data are presented.

The principal issue to be addressed here is whether the configuration of the tongue groove proposed by Gafos [1] occurs and, if so, whether it is sufficient to explain the harmony process. The first consideration is that the tongue shapes posited by Gafos are not completely consistent with those found in 3D reconstructions from ultrasound images for English sounds [8]. His proposed flat configuration for the interdental fricative is not in accord with the ultrasound results; instead, it is somewhat less grooved than that for the alveolar fricative. The palatal fricative has a flat or even a domed shape anteriorly and a sizable groove posteriorly. The alveolar is deeply grooved, as claimed. Thus there are, indeed, differences among the three fricatives that can be seen in the tongue shape.

For the present study, tongue grooving was measured at the midpoint of the fricative noise and of the vocalic segment. Although the groove can be expected to differ between the C and the V, as a result of the vowel articulation itself, the grooving at vowel midpoint could still be consistent with that of the fricative; each of the three fricative environments could result in different shapes during the vowel, as was tested here via ultrasound.

2. EXPERIMENT

We performed an experiment with three speakers of English to determine whether a language such as English, without the Tahltan harmony process nonetheless maintains the tongue grooving differences across vowels. If such an unrelated language has an analog to the proposed mechanism for Tahltan, it would indicate that direct measurements of Tahltan would be informative.

2.1. Method

We took coronal ultrasound images at a relatively anterior portion of the tongue during the production of nonsense CVCs.

2.1.1. Stimuli

The CVC syllables combined the fricatives /θ s š/ (both Cs were the same) and four vowels /i ɑ æ u/. Four repetitions of each syllable were measured for Speaker 1, eight for the others.

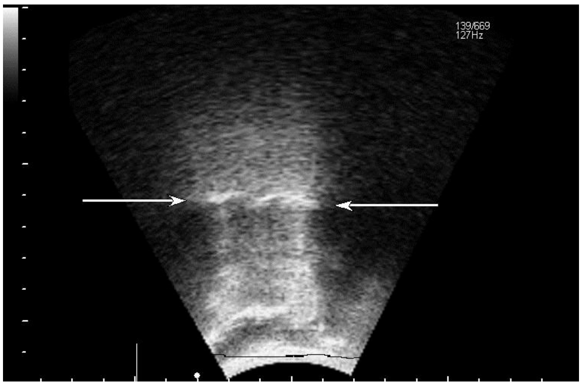
2.1.2. Speakers

Three speakers of North American English were recorded. Two were female, one (Speaker 1) male.

2.1.3. Procedure

An Aloka SSD5000, a Titan Sonosite or an Aloka SSD1000 ultrasound machine was used (for Speakers 1, 2 and 3 respectively). The transducer was placed under the jaw so that coronal sections could be obtained at a relatively anterior position of the tongue (see Fig. 1). This portion of the tongue is maximally different for the consonants [8]. The transducer was not fixed in place, so there is some variation in location of the section.

Figure 1: A coronal section of the anterior portion of the tongue (Speaker 1, midpoint of initial /s/ of /sɑs/). The tongue surface appears in the middle of the image at the lower edge of the white line between the two arrows.



Depth of tongue groove was measured by placing a straight line across the two highest points of the tongue; this line was often not parallel to the bottom of the ultrasound image (see Fig. 2). The depth then was measured as the distance from the deepest point of the groove up to the surface line (with the line being perpendicular to the surface line). When the tongue was domed rather than grooved, the endpoints of the straight line were placed at the outermost edges of the tongue surface image, and the perpendicular line was extended upwards to the highest point of the tongue surface.

Figure 2: Expanded view of the tongue surface from Fig. 1. Tongue surface is traced in the grey solid line. Tongue groove is measured by connecting the two highest points of the tongue and then taking the perpendicular depth from there (solid black lines, which are slightly displaced for greater visibility).

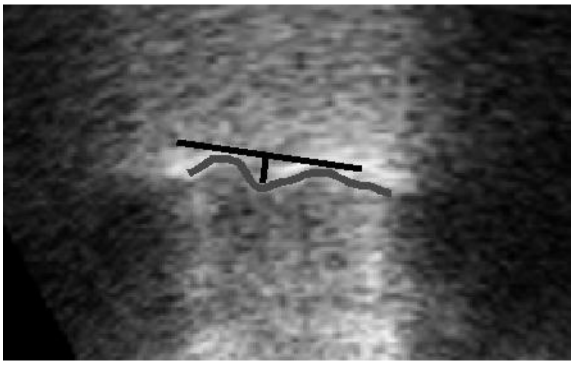


Figure 3 shows samples from all positions and all consonants with /ɑ/ for Speaker 1.

3. RESULTS

Overall for Speaker 1, [ʃ] was slightly domed, [s] was grooved and [θ] was somewhat more grooved (see Table 1 for all speakers). This is in accordance with Stone and Lundberg [8]. Overall, [u] was slightly domed, [i] was fairly flat, [ɑ] was grooved and [æ] was deeply grooved. Again this was in accordance with Stone and Lundberg [8].

For Speaker 2, two files (for [si] and [su]) were corrupted and could not be measured. All fricatives were grooved (no token had a dome pattern), and the groove was maintained (indeed, deepened) in the middle of the vowel. The order of the fricatives was different, with [θ] the least grooved, followed by [ʃ] and then [s]. [u] was the least grooved, [i] was grooved, while [ɑ] and [æ] were deeply grooved.

For Speaker 3, all fricatives were grooved (though two tokens of [ʃ] had a dome pattern), and the groove was maintained (if anything, deepened) in the middle of the vowel, except for the [u] vowel with [θ]; because the other three vowels patterned together, we excluded the [θ] from the [u] context for this speaker. The order of the fricatives was the same as Speaker 1: [ʃ] the least grooved, then [s] then [θ]. The differences between each pair were similar in magnitude. The vowels patterned similarly to Speaker 2.

Figure 3: Coronal ultrasound images of the tongue for each syllabic position for each consonant type, Speaker 1. The tongue surface is at the bottom of the uppermost white line in each image (this is about in the middle of each frame, as in Fig. 1).

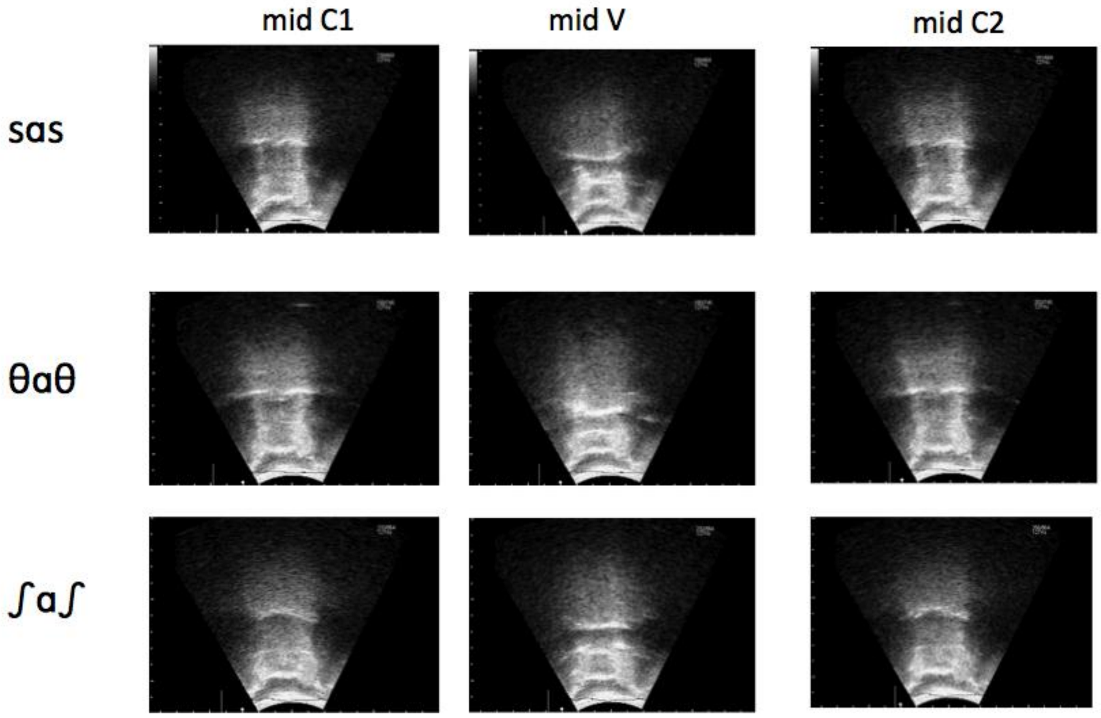


Table 1: Tongue groove measurements, in mm, for Speakers 1, 2, and 3 (respectively). Negative numbers indicate grooves; positive numbers indicate domed shapes. ("NM" is "not measured.")

C	V	Depth (C and V)	Depth (V only)
ʃ	i	3.31, -4.63, -2.82	2.21, -4.92, -3.90
	ɑ	1.57, -3.61, -3.61	0.69, -4.05, -4.70
	æ	-0.83, -4.73, -2.82	-1.79, -4.45, -5.34
	u	4.05, -1.96, -2.46	4.42, -2.14, -2.39
s	i	-1.38, NM, -3.49	-1.52, NM, -3.88
	ɑ	-1.38, -4.39, -3.46	-0.97, -5.07, -4.37
	æ	-2.9, -3.69, -4.58	-3.17, -3.82, -5.85
	u	-0.92, NM, -2.88	-0.97, NM, -3.05
θ	i	-2.02, -3.26, -4.31	-2.21, -3.12, -4.61
	ɑ	-1.98, -4.12, -3.73	-0.69, -5.57, -4.22
	æ	-3.27, -4.26, -4.84	-4.14, -4.20, -5.83
	u	-1.74, -2.20, -2.05	-1.24, -2.19, -0.17

Importantly, the pattern held at the vowel midpoint (see Table 1). In a separate Analysis of Variance for each speaker with the factors Fricative (s/ʃ/θ), Vowel (i/ɑ/æ/u) and Position (mid initial fricative, mid vowel, mid final fricative), there were significant effects of Fricative, Vowel, F*V, and V*P. Crucially, F*P was not significant for Speakers 1 and 2, indicating that there was no detectable difference in the depth of grooving across all three syllable positions (middle of the two Cs and middle of the V). For Speaker 3, the mid-vowel [ɑ] was grooved only as much as the fricatives from that syllable. However, the other vowel contexts showed a similar size of groove in the three locations. Thus the vowel production was just as grooved as the consonant despite the small differences in magnitude between them.

4. DISCUSSION

The difference in tongue grooving that is seen during fricative production is maintained to a large extent through the vowel. This is in accordance with the predictions of Gafos [1]. Having this difference persist through the vowel is consistent with basing the Tahltan consonant harmony on a tongue configuration that can act “at a distance.” The tongue groove was as different across the three segment types in the middle of the vowel as it was in the middle of the consonant.

Coarticulation has been found throughout the speech signal, so it is not completely unexpected that consonants would influence a vowel throughout. However, tongue grooving is difficult to observe and thus is seldom reported. Although English has not exploited this feature to control harmony the way that Tahltan has, the fact that it maintains such a configuration makes it promising to look for such a configuration in Tahltan itself. We are planning a trip to the Tahltan community to measure the tongue grooving directly. We expect to find results similar to those presented here.

Although such a patterning in tongue grooving helps us understand how a three-way consonant harmony system can function, it does not immediately suggest how Tahltan came to rely on this feature phonologically. If all languages have such groove differences, why are harmony systems that rely on it not more common? Among Athapaskan languages, two-way consonant harmony systems are relatively common, including in languages like Navajo, which lacks the third (dental) series of consonants (and thus could not have a three-way distinction). Could an Athapaskan language with all three series of consonants have a two-way contrast rather than a three-way one? Further study is needed. The domain that has been studied in Tahltan, in addition, includes only the so-called "conjunct" prefixes, which are more closely related to the verb. The “disjunct” prefixes need to be studied to see whether they exhibit the same pattern.

It may be that, in the phonologization process, Tahltan has emphasized the differences in tongue grooving, in which case they might be of greater magnitude than those found for English. This is often the case for (partly) phonologized patterns that derive from coarticulation. An example is the greater length difference in vowels before voiced or voiceless consonants found in English relative to other languages [4]. Alternatively, if the groove depth is, instead, similar in magnitude to that found in English, it might suggest that this feature of articulation is not what has been phonologized after all. The predisposition toward this pattern would then exist in the tongue shapes, but the pattern itself might depend on other features. We will have to await the results from the Tahltan speakers to draw further inferences.

5. ACKNOWLEDGMENTS

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