ON THE PRODUCTION OF LOW TONGUE TIP /s/: A CASE REPORT

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X-ray motion pictures and electromyography were combined to record tongue movement and tongue muscle activity of a normal speaker during /s/ production. The /s/ was in /i/, /ɑ/, and /u/ vowel environments and in two and three consonant clusters. Lead pellets attached to the tongue tip and dorsum were tracked by frame-by-frame analysis of the X-ray film. Recordings from the tongue muscles were graphed and compared with the movement data. Results demonstrate that this subject produces /s/ with the tongue tip down behind the lower incisors and the blade elevated toward the alveolar ridge. EMG data from the tongue shows that the tongue tip depression is not passive but is an active part of the motor strategy used by this subject to elevate the tongue body. These findings suggest that speech pathologists might well include the tip-down strategy of /s/ production in the therapeutic process as an alternative to the tip-up /s/.

Introduction

The voiceless alveolar fricative /s/ may require a precision of articulation that surpasses that of most other speech sounds. Evidence for this generalization arises from the difficulties people often have with this speech sound when speaking under adverse circumstances such as when intoxicated, anesthetized for dental repair (Scott and Ringel, 1971; Borden et al., 1973), or after some change in the anterior part of the mouth, such as with the insertion of an oral prothesis (Hamlet et al., 1976). The /s/ sound leads the list of defective phonemes in dysarthric speech (Schuell et al., 1964) and is not only one of the most troublesome sounds for children (Templin, 1957), as might be expected with the loss of deciduous teeth, but it also ranks high among articulation errors found among college freshmen (Hall, 1938).

Variations in the Tongue-Alveolar Ridge Construction for /s/

Phoneticians have traditionally described normal production of /s/ to involve, among other adjustments, the formation of a constriction at the alveolar ridge by elevation of the tongue tip and blade. An alternative method for producing the constriction is usually described as a variant used by some individuals (Kantner

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and West, 1946; Heffner, 1949; Bronstein, 1960). Kantner and West (1946), for example, describe the variant method as follows:

> "One common variation existing in many individuals and apparently unrelated to any anomaly of teeth formation might well be mentioned. These individuals place the tip of the tongue against the inner borders of the lower teeth, while the blade is rolled upward, making about the same contacts as those described above."

Anecdotal evidence suggests that this variant /s/ may be more common than is generally supposed. Subtelny et al. (1964) report that a tongue tip down /s/ was used by one-third of 30 speakers. In a sample of 26 students enrolled in an undergraduate phonetics class at C.C.N.Y., 50% reported the tongue tip to be behind the upper incisors during continuous /s/ production, 27% reported a middle position, and 23% reported the tip to be behind the lower incisors. Thirty-five percent of the students were inconsistent, altering the /s/ position in various contexts. For example, there were eight or nine reports of low tongue tip position for /sk/ and /sɑ/, but only five and four reports for /si/ and /st/, respectively.

Speaker reports of tongue location are always suspect, as many speakers find it difficult to sense and describe the shapes that their tongues are taking. Pinching the tongue tip with the fingers before each utterance, however, was found to facilitate feedback of movement and position.

Clinical Methods for /s/ Production

In view of the difficulty many speakers have in acquiring an acceptable /s/ sound, and in view of the availability of two common methods of /s/ articulation, it is surprising that the *tip-up* model is so favored in speech pathology. Two methods suggested for shaping the tongue for /s/ are to direct the speaker to withdraw the tongue from a /θ/ position while elevating the tip or to depress the tongue tip slightly from a /t/ position. In both methods, the elevation of the tongue tip is emphasized (Van Riper, 1963). Elevation of the tongue blade by depressing the tongue tip is not usually presented as an alternate method in speech pathology textbooks.

If we knew more about the differences between *tip-up* and *tip-down* positions, we might know better how to present the alternatives to clients who lisp. The purpose of this article is to report some findings from a combined X-ray motion picture and electromyographic (EMG) study of a speaker with a perceptually normal tongue tip down /s/ and to suggest how these findings might relate to clinical procedures. This study is part of a larger scale combined EMG and X-ray investigation of the temporal and positional aspects of fricative consonant production.

Method

The speaker was one of the authors (GJB), a native speaker of American English. The speech material consisted of nonsense syllables in which /s/ was in initial and final syllable positions, in /i/, /ɑ/, and /u/ contexts, and in /sp/, /st/, /sk/, /spr/, /str/, and /skr/ consonant clusters. The utterances were produced at a comfortable speaking rate.

Electromyography

Hooked-wire electodes were inserted into the following muscles: the genioglossus,[1] the superior longitudinal, the inferior longitudinal, and for reference the orbicularis oris muscle of the upper lip (see Hirose, 1971, for insertion details).

EMG data were collected simultaneously with X-ray motion pictures. A more extended EMG run followed the X-ray filming of the subject. In this second run, 10 tokens of each of the 48 utterances were spoken from a random-order list. All of the EMG signals were recorded on magnetic instrumentation tape along with the acoustic signal and a sequence of code pulses. A digital computer later averaged the integrated EMG signals for each electrode position. For details of the computer averaging system see Kewley-Port (1973). The EMG run recorded during the X-ray filming was analyzed separately in order to compare EMG and X-ray data for each utterance.

Cinefluorography

A 16-mm cine camera recorded X-ray film at a rate of 60 frames per second. The X-ray generator delivered X-ray pulses to a 6-inch image intensifier tube. Barium sulphate paste was used as a contrast medium along the tongue dorsum and several 2.5-mm-diameter lead pellets were attached to the tongue in order to quantitatively track tongue movement. The pellets were attached by means of a cyanoacrylate adhesive to the tip of the tongue and at a position two-thirds of the distance between the tip and the foramen caecum with the tongue extended. Other pellets were attached to the tongue but fell off during the experiment. The X-ray films were analyzed by hand tracings of each frame using a Perceptoscope Film Analyzer. The movements of the lead pellets were tracked by marking their

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[1]Genioglossus m.—Primary muscle of the tongue. The fibers which run posteriorly are active for /i/ as the tongue is fronted and elevated.

Superior Longitudinal m.—Intrinsic muscle of the tongue; courses along the dorsum and its contraction curls the tongue tip up.

Inferior Longitudinal m.—Intrinsic muscle of the tongue; courses along the underside of the tongue body and its contraction curls the tongue tip down.

positions at each frame on templates using the maxillary bone and fixed X-Y coordinates as references. Measurements were made between each pellet and the coordinates, and the extent of elevation and fronting of each pellet was graphed for each utterance. Finally, the integrated EMG plots for each muscle were compared to the X-ray data for each utterance with lip closure for /p/ used as the temporal line-up point.

Results

Figure 1 shows the usual position of the pellets during /s/ production for this subject. The tip of the tongue was behind the lower incisors and the dorsum bunched up toward the alveolar ridge. The lips were flared outward. This figure may be contrasted with that for the tip up /s/ shown by Perkell (1969, p. 80). The movement data showed remarkably little variation of the /s/ constriction across contexts. The tip of the tongue remained behind the lower teeth for /s/ in all contexts. It was further backed by approximately 3 mm for the /s/ in /stu/ than for /sti/ and was in all vowel contexts further back for /sk/ than for /sp/ and /st/. The elevation of the tip also never varied more than 3 mm. In general, the tip was lower for /sk/ than for /sp/ or /st/ and lower in the context of /u/ than /i/ or /ɑ/. The more elevated and backed tongue positions (as for /k/ and /u/) produced a more depressed and backed tongue tip position. The dorsal pellet also showed few contextual variations, with the pellet 2-3 mm higher for /i/ than for the /u/ and /ɑ/ contexts, but no difference seen in the /s/ positon of the /sp/, /st/, and /sk/ clusters.

The movement data of this study showed that this subject produces /s/ with a low tongue tip position irrespective of adjacent vowel or consonant cluster environment. More interesting, however, is the question of whether this is a passive or active gesture. Is the tip merely left behind upon blade elevation or is the tip actively depressed to facilitate the dorsal elevation? This question, of course, can be explored by reference to the EMG data. If the inferior longitudinal muscle, which is responsible for tongue tip depression, is active through /s/ production,

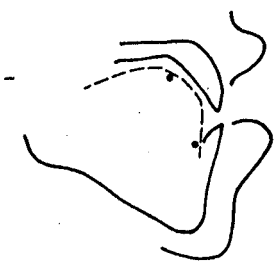

Fig. 1. Tracing from a lateral X-ray motion picture showing pellet positions typical for /s/ production by this subject.

then we can speculate that the tip-down position reflects a deliberate motor strategy for the gesture.

The EMG data revealed that for the /s/ portion of all the utterances, consistent activity (above 200 μV) appeared for the inferior longitudinal muscle (IL). The genioglossus muscle (GG) was active for /i/ for this subject but not for /ɑ/ or /u/. Figure 2 shows the interaction of the IL and GG during the utterances /pis/ and /pɑs/. Note the reciprocity between the activity envelopes of the two muscles: GG for the vowel and IL for the consonant. [The superior longitudinal muscle (SL) which was low in activity except in the /st/ or /r/ cluster contexts is not shown]. Figure 3 shows unaveraged EMG signals for /spɑpə/, /stɑpə/, and skɑpə/ utterances. The EMG data support the movement data in that the depressed tongue tip is accompanied by muscle activity from the IL which seemingly aids in bunching and elevating the dorsum of the tongue. Both sets of data, movement and EMG, show that this subject produces /s/ with a tongue tip-down gesture and that this gesture is an active one produced by the contraction of the IL muscle rather than the tip being passively left behind as the blade elevates.

Discussion

The clinical question is whether it is better to differentiate between the two /s/ gestures on the basis of which part of the tongue (tip or blade) produces the constriction or whether it is better to focus on the placement of the tip alone. Is it the case that for the tongue tip up /s/ the *tip* is actively elevated whereas for the

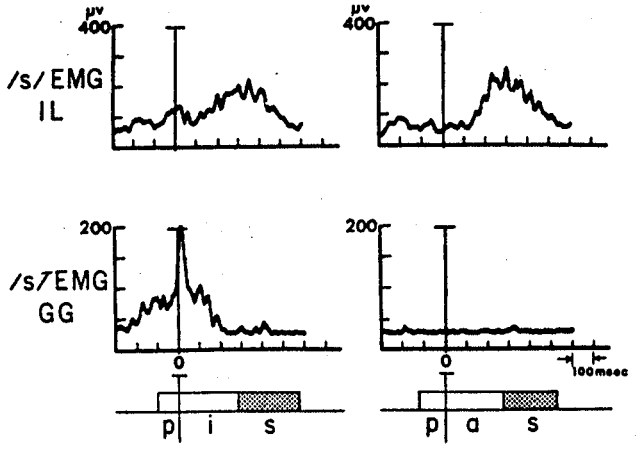

Fig. 2. Averaged EMG from the inferior longitudinal muscle (IL), which is active for /s/, and from the genioglossus muscle (GG), which peaks for /i/.

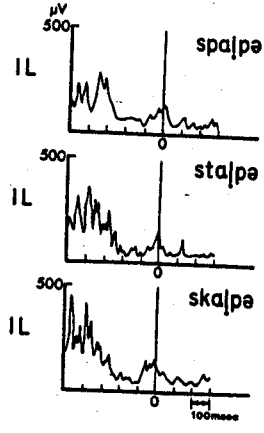

Fig. 3. Unaveraged EMG data from the inferior longitudinal muscle (IL) for the utterances /spɑpə/, /stɑpə/, and /skɑpə/.

tongue tip down /s/ the *blade* is actively elevated leaving the tip behind? The other possibility is that the tongue tip is active in both cases. In the tongue tip-up case, the tip is actively elevated along with the blade to form an anterior blade-alveolar ridge constriction. In the tongue tip-down case, the tongue tip is actively depressed which aids in bunching the dorsum of the tongue up, thus forming a constriction with a more posterior portion of the blade.

Our X-ray and EMG findings suggest that the second difference is the critical one. For at least one normal tongue tip-down /s/ speaker, active depression of the tongue tip accompanies the elevation of the tongue blade to form the necessary constriction between tongue and palate. In speech pathology, the suggested techniques for /s/ articulation might well be modified to include instructions to tuck the tongue tip down behind the lower teeth, especially in cases where the clients have shown strong resistance to traditional tongue tip-up therapy.

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