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ON THE PRODUCTION OF THE SWEDISH TJE-SOUND

Per Lindblad[1]

Introduction

The Swedish tje-phoneme in words such as kivas and tjuta have two main variants; being, firstly, an affricated pronunciation that can be written as [tç] and, secondly, a fricative pronunciation usually transcribed as [ç]. Both variants have a certain latitude of pronunciation. The affricate is the normal pronunciation in Fenno-Swedish and is found to some extent in a number of dialects in Sweden. The affricate was the dominant pronunciation in Sweden, even up to the early 1900's, but today nearly all Swedes use the fricative variant.

The phonetic value of the symbol [ç] is exemplified in IPA as the German ich. The normal Swedish tje-phoneme and the typical German [ç] are, however, distinctly different, while the Polish ś and the Swedish tje-phoneme are very similar. The IPA symbol of the Polish ś-sound is [ɕ]. In the following paragraphs I will use the IPA symbol [ɕ] to clearly accentuate the special pronunciation of the Swedish tje-sound and also to establish connections with IPA.

Both [ɕ] and the palato-alveolar [ʂ, ʃ] can be produced, as is known, by different articulatory gestures. It is possible that the specific articulations for [ɕ] also vary with different speakers, perhaps because, just as for [s] and [ʂ, ʃ], the distinctive high frequency components of [ɕ] are determined much more by the dimensions of the front cavity than by the maximum contact area. Since the shape and size of the tongue, tooth ridge, teeth and lips may vary from speaker to speaker, a given size of the front cavity may be obtained by different gestures in different speakers. Another important quality of the sounds

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1) Department of Linguistics, University of Gothenburg, Sweden.

in question, their sharpness, is produced primarily by a concentrated airstream directed by the tongue against the teeth. Speakers with different shapes of the anterior part of their vocal tracts would achieve this effect in different ways.

Despite the variation between different speakers in the pronunciation of [s] and [ʂ, ʃ] it seems reasonable to assume that articulatory gestures can be grouped into a limited number of gesture types, and that a certain gesture type would be the norm for a certain sound within a language, and probably in a number of (or perhaps even most) languages having the sound quality in question. For example, [s] in Swedish is evidently normally pronounced with the tip of the tongue resting against the lower incisors, and with the tongue blade against the alveolar ridge immediately behind the upper teeth (Fritzell 1973, p. 41; Söderpalm Talo 1976, p. 16). A recent investigation (Bladon and Nolan 1977) has shown the same type of gesture to be predominant in English.

The normal articulation for Swedish [ɕ] is probably the one shown in figs. 1 and 2. I have observed this articulation in two X-ray filmed subjects.

Design and Material

Figs. 1 and 2 illustrate the tje-pronunciation of two Southern Swedish male subjects, called hereafter A and B. They were X-ray filmed in profile while uttering the phrase

EBBE SCHISE TJASAR I SODASJO
V_1 V_2 V_3 V_3

and five other versions of that utterance, where the marked vowels were systematically varied while keeping the other sounds constant. Each of the vowels [i:,ɑ:,u:,ɛ:,y:,ɯ:] appeared once in the respective V_1, V_2 and V_3 positions in the six phrases. Thus [ɕ] appears in the following context:

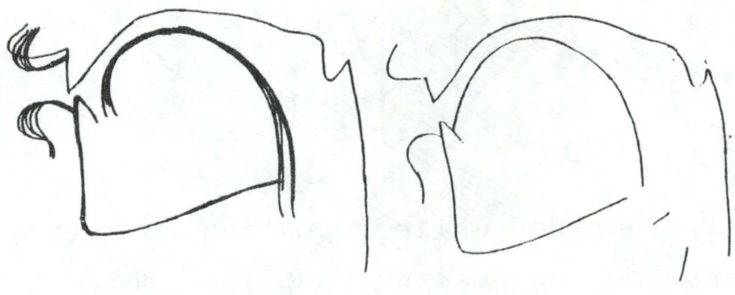

Figure 1

Profile X-ray tracings, speaker A. Left: [ɕ] before [i: ɑ: u: ɛ: y: ɯ:]. Right: the vowel [i:].

Figure 2

Profile X-ray tracings, speaker B. Left: [ɕ] before [i: ɑ: u: ɛ: y: ɯ:]. Right: the vowel [i:].

$$\text{ə ɕ} \begin{Bmatrix} \text{ι:} \\ \text{ɑ:} \\ \text{u:} \\ \text{ɛ:} \\ \text{y:} \\ \text{ɯ:} \end{Bmatrix}$$

Both speakers were recorded while repeating the six phrases twice, which gives the two series I and II. The diagrams in this article are based on series I. Series II showed essentially the same tendencies as series I.

The X-ray films were taken at the X-ray department of Lund hospital.[1] The film speed was 75 frames/sec. Tape recordings were made at the same time. Representatives of every case of [ɕ] have been taken from the frame where the tje-gesture shows maximum contact. This point usually occurs immediately after the midpoint of the fricative sound. On the basis of these frames the most important contour lines of the articulatory organs were drawn in profile diagrams. Figs. 1 and 2 show the contour lines for [ɕ] preceding the six different vowels in series I. As a contrast is shown each subject's articulatory position for the pronunciation of [i:].

Results

The following features of [ɕ] are strikingly constant for both subjects despite the varying vowel context and, besides, alike for the two speakers:

I. Angle between the lower and upper jaw, which was very small.

II. Position of the body of the tongue, which was raised and advanced as for [i:].

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1) For helping with the X-ray photography I take this opportunity to thank Sidney Wood and Gunilla Holje, Rolf Schoener and Gudmund Swahn from the X-ray department of Lund Hospital.

III. Position of the <u>front of the tongue</u>, which differs from that of the [iː] articulation. Figs. 1 and 2 show how the blade of the tongue for both subjects is withdrawn from the lower front teeth for [ɕ] (about 10 mm) but not for [iː]; subject B had a rather sharp edge. The surface of the tongue below this edge points steeply downwards. In subject A the bending is somewhat more gradual. Thus a cavity is formed between the surface of the tongue and the lower front teeth. This cavity is about 15 mm deep. Observe that this front tongue position means that the cross-section of the vocal tract is widened abruptly in front of the displacement for [ɕ].

These features seem to be essential for the production of the normal Swedish tje-sound. To this can be added another two features which, as far as can be seen, are also essential to the production of [ɕ] but which cannot be illustrated with the help of profile diagrams:

IV. The blade of the tongue forms, just by the marked forward edge, a maximum constriction against the alveolar ridge. The cross-section area of this constriction is of the same order of magnitude as that of [s], and it is, as in [s], groove-shaped rather than slit-shaped. At the constriction the air-stream generates turbulence, so here is a sound source.

V. The concentrated <u>air stream</u> which is formed at the constriction is directed <u>against</u> the edge of the lower front teeth, so that turbulence is also generated here. The sound associated with [ɕ] is, then, produced both at the narrow constriction and at the teeth.

I have obtained information concerning IV by direct observation of subjects A and B, and also a number of other speakers. For those who are not satisfied with this direct method, there is the possibility of proving the hypothesis instrumentally, using X-ray sections or palatography. I plan to experiment along these lines.

The assumption of V, that the teeth's effect upon the air stream is an important source of sound, is reinforced by two different factors: Firstly, that [ɕ] is changed radically even by a slight lowering of the jaw while the tongue is held constant relative to the upper jaw. Secondly, subject B who has protruding front teeth pushes his lower jaw forward about 4 mm for his pronunciation of [ɕ]. This causes the teeth to get into the air stream. With other sounds, however, his lower jaw moves little in a horizontal direction from its position of rest. See fig. 3.

In contrast to the features already discussed, the lip articulation for [ɕ] varies considerably in the different vowel contexts, especially with subject A. See figs. 1 and 2. All of these lip gestures are, however, variants of a non-rounded gesture. This can be observed when, for example, the sound is pronounced isolated. The basic lip articulation for [ɕ] is, then, the same as for [i:] and [j].

The contrast [ɕ] - [i:, j]

The tongue and lip articulations for [ɕ] and [i:, j] are, as we have seen, very similar. But they are not completely so. See figs. 1 and 2. What basically differentiates them is, partly, that the lip articulation for [ɕ] seems to be more likely to vary, and partly that the front of the tongue makes a specific articulation in [ɕ] which obviously implies a complication when contrasted with [i:, j].

That [ɕ] is a "difficult" sound is shown by the facts that a child learns the sound late in life, and that adult foreigners often fail to master its idiomatic pronunciation. [ɕ] is also a very unusual sound in the languages of the world. The difficulty of the sound seems to lie both in its production and perception. In contrast to this, [i:] and [j] are learnt at an early stage by the child, and are very common among the languages of the world. [i:] and [j] can be said to be both easy to produce and to perceive.

<u>The contrast [ɕ] - [ç]</u>

The typical German [ç] should normally be produced with the same tongue body and lip position as [i:], [j] and [ɕ] but, unlike [ɕ], with the tip of the tongue against the lower teeth or the bottom of the mouth as in normal [i] and [j] (see fig. 4). The maximum constriction in [ç] is formed further back than in [ɕ], with the back of the tongue against the hard palate. The cross-section of the point of constriction seems to be slit-shaped, while it is groove-shaped for [ɕ]. Unlike [ɕ], the cross-section of the vocal tract area increases gradually anterior to the point of constriction in [ç]. Variation in the angle between the lower and upper jaw in [ç], or the tongue tip's position (between the bottom of the mouth and the lower teeth), only produces a slight acoustic-perceptual effect, also unlike [ɕ]. Furthermore, [ç] sounds more or less the same, whether it is pronounced with inhalatory or exhalatory air stream, while [ɕ] is radically changed by inhalation. Two factors of production are eliminated in [ɕ] by inhalation: Firstly, there is no longer an air stream directed against the teeth and, secondly, there is no steep increase of the cross-section area at the air stream's outlet from the constriction. There are, however, no such production factors for [ç] producing a difference in inhalation and exhalation.

In the same way as [ɕ], [s], [ʂ] and [ʃ] also change their character when pronounced with an inhalatory air stream. The sibilant character of the sounds disappear; they are no longer sharp and strident. It seems obvious that [ɕ], just like these other sounds, is a sibilant. The most important articulatory condition for sibilance seems to be the perturbation of a concentrated stream of air at the teeth. It seems also that the

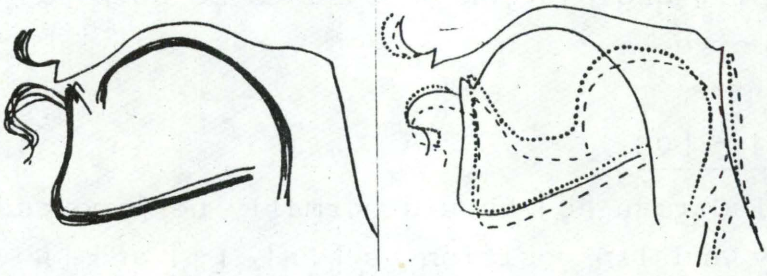

Figure 3

Profile X-ray tracings, speaker B. Left: [ɕ] before [i: ɑ: u: ɛ: y: ɯ:]. Right: the vowels [i](unbroken line), [ɑ:] (broken line) and [u:] (dotted line).

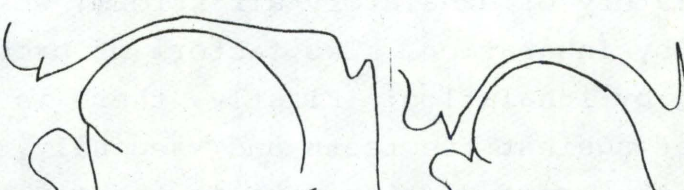

Figure 4

Profile X-ray tracings of [ç]. Left: speaker B; [ç] was spoken in isolation, a following [ɛ:] being intended. Right: [ç] as reproduced in Wängler (1958).

steep increase in cross-section area anterior to the constriction contributes to the efficiency of the sound source as far as sibilance is concerned.

Thus, [ɕ] is a sibilant, whereas [ç] is not. However, with regard to auditory brightness, the sounds resemble each other and both contrast with the brighter [s] and the darker [ʂ]. Fig. 5 shows the typical acoustic differences and similarities between [ɕ] and [ç], as pronounced by speaker B, who does not, however, use [ç] as a natural sound. Their spectra have approximately the same energy distribution, weak energy at the lower frequencies but from about 3 kHz and upwards a strong, wide energy band without very noticeable formant peaks. This acoustic similarity probably explains the similarity of their auditory colour.

The typical difference between the spectra of the sounds as pronounced by speaker B is the degree of steepness of the energy decline at lower frequencies. The lower limit at about 3 kHz is steep for [ɕ] and more drawn out for [ç]. This difference may be a general acoustic cue to the auditory difference between [ɕ] and [ç], a hypothesis which I intend to investigate further.

<u>[s], [ɕ] and [s]</u>

The contrast between [ç] and [ɕ] in fig. 5 probably illustrates the most important acoustic correlate of sibilance. This correlate should be comprised of a strong, broad energy band without very marked formant peaks which goes abruptly down at the lower frequency limit. This observation is strengthened by the spectra of [s], [ɕ] and [ʂ]. See fig. 6 which shows typical spectra of these sounds. Observe that their energy patterns are, in their main features, similar to what was observed for [ɕ]. The frequency positions for steep/abrupt lower limit of the patterns vary, however, systematically between the sounds. [ɕ] takes up the position between [s] and [ʂ].

The relation between the frequency position for the lower limit (and thereby the sound's lowest effective resonance), the

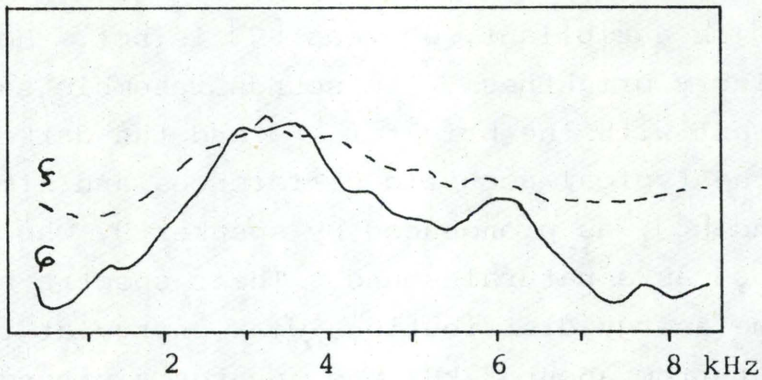

Figure 5

Typical [ç] and [ɕ] spectra, spoken in isolation by speaker B.

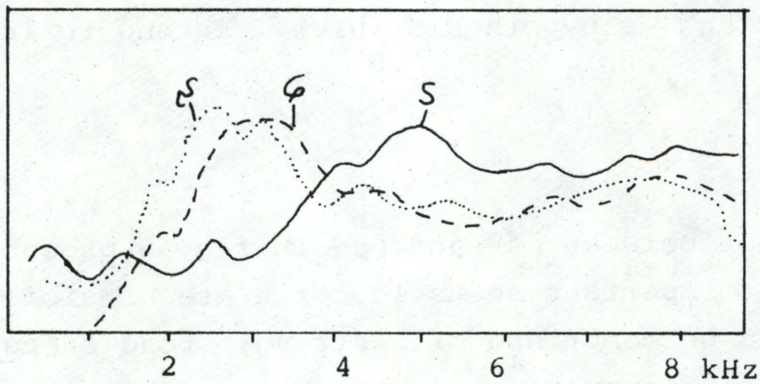

Figure 6

Typical [s], [ɕ], and [ʂ] spectra, spoken in isolation by speaker B.

relative size of the front cavity, and the auditory impression of brightness for these sounds is noticeable. The smaller the front cavity, the higher the frequency, and the brighter the quality. [ɕ] takes here a position between [s] and [ʂ]. The contrasts are not very great.

In several Swedish dialects that have all of these three sounds, there is to be found a crowded sibilant dimension. The [ɕ]-articulation is, as mentioned above, difficult to accomplish per se. The degree of difficulty of this articulation is further increased because of the small differences between [ɕ] and the two other sibilants.

Conclusion

The front cavity of the sibilant sounds should be given great attention. The position of the body and front of the tongue in [s], [ɕ], [ʂ] and [ʃ] should be studied with special reference to their influence on the dimensions of the cavity between the tongue and the lower teeth. Because this cavity (the most important resonator) is small, even slight changes in its size (just as for the vestibule between the teeth and lips) give rise to great acoustic-perceptual effects in these sounds.

In Linell, Svensson and Öhman (1971, p. 97), the Swedish tje-sound is classified as [-coronal] and [-strident]. From the above it should be clear that this is incorrect, and that the normal tje-pronunciation should, on the contrary, be [+strident] and [+coronal].

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