NEW OBSERVATIONS OF CERTAIN CV AND VC TRANSITIONS

ANTTI SOVIJÄRVI

1.

In Finnish, there is a combinatory variant of /h/ which is entirely voiced and appears in medial positions between vowels and after voiced consonants, e.g., *vaha* [vaɦa] 'wax', *sihinä* [siɦinæ] 'hiss', *puhua* [puɦua] 'speak, talk', *vanha* [vanɦa] 'old'. The accurate definition of this allophone is: fully voiced soft (lenis) glottal fricative.

In my synthetic experiments in the Phonetics Department of Edinburgh University I investigated the following interjections spoken by a deep bass with the fundamental of 100 c/s: *ahaa* [aˈɦa:], *ihii* [iˈɦi:], and *uhuu* [uˈɦu:]. The same words have been analysed from cineradiographs taken at the Central Hospital of Helsinki University with the same male subject. In these films shot at a speed of 200 frames/sec., and in lateral view no changes of the vocal tract cavities can be observed. Consequently only the movements in the glottal area are characteristic.

In this connection I have to mention that the unvoiced allophone of the /h/ is articulated with slight dorsal and velar movements, constricting some varying parts of the vocal tract a little. The following frame diagrams (Figure 1) have been schematized from the film. They illustrate the transition from [i] to [h] in the word *hihnat* [hihnat] 'bands'.

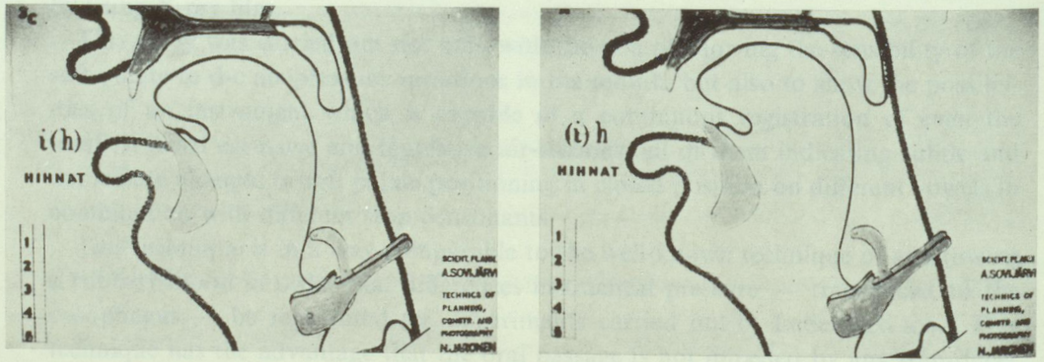

Fig. 1a-b. The end of the [i] and the beginning of the unvoiced [h] in the word *hihnat*.

In describing the transitions of the type VɦV on the basis of synthesized words, we have to consider the curve form of the resonance bars of *F*1, *F*2 and *F*3. The transitional segments including the on-glide, off-glide transitions and the voiced [ɦ] between them represent the following curve forms: (1) in the segment of [a] transitions, *F*1 and *F*3 have a convex curve form but *F*2 has a concave one, (2) in the segment of [i] transitions, *F*1 is concave but *F*2 and *F*3 are convex, and (3) in the segment of [u] transitions *F*1 and *F*2 have a concave form, but *F*3 is convex. The duration of both the on- and off-glides is 20 to 30 msec., the length of the medial consonant varies between 80 and 110 msec.

The accurate regulation of the amplitude of 'Hiss through Formants', which is parameter 8 in the system of the PAT synthesizer, seems to be very important from the point of view of obtaining satisfactory auditory naturalness. During the experiments one could observe that in the [a]- and [i]-coloured [ɦ] sounds, naturalness was only achieved when the height of the amplitude curve concerned was reduced to about 2 mm and in the [u]-coloured one to about 6 mm from an initial height of about 15 mm. The physiological cause of this phenomenon is obviously a very slight enlargement of the glottal air passage, when the voiced [ɦ] is pronounced, as shown by the investigations carried out by Äimä (1924) with a laryngo-endoscope.

2.

In the analysis of the VC and CV transitions of certain dentals I have used radiography and sound spectrography. Attention has been paid mainly to the resonatory role which the sub-lingual cavity has in the formant pattern. During my experiments in the University of Wisconsin, Madison, impression compound material (Kerr perfection red compound) was placed in the cavity between the raised apex, the incisors and the floor of the front part of the mouth.

Two types of appliance were moulded into the shape of this space of the subject: (1) the 'total' impression appliance filled the space entirely when the [n] and [l] sounds were pronounced (Figure 2); (2) the smaller 'partial' impression, trimmed horizontally about 1 mm below the edge of the lower incisors to allow free air flow, was placed in the lower part of this cavity, when the sounds [s], [ʃ], [r], [z], [t] and [d] were pronounced (Figure 3). The radio-opacity of some of these pieces was improved by covering them with zinc-containing foil.

Sound spectra were obtained as three informants (a Finnish speaking female, an American-English speaking male and a Swedish male subject) pronounced words containing dentals with the filling appliance in position and without it. When these sound spectra are compared, it is observed that an additional resonance area is significantly dependent on the emptiness of the sub-lingual cavity. This formant is called *FS*. For instance, in the alveolar sounds [l] and [n] pronounced after the vowels [a] and [e] the FS-peak is found between about 1400 and 1900 c/s, and its

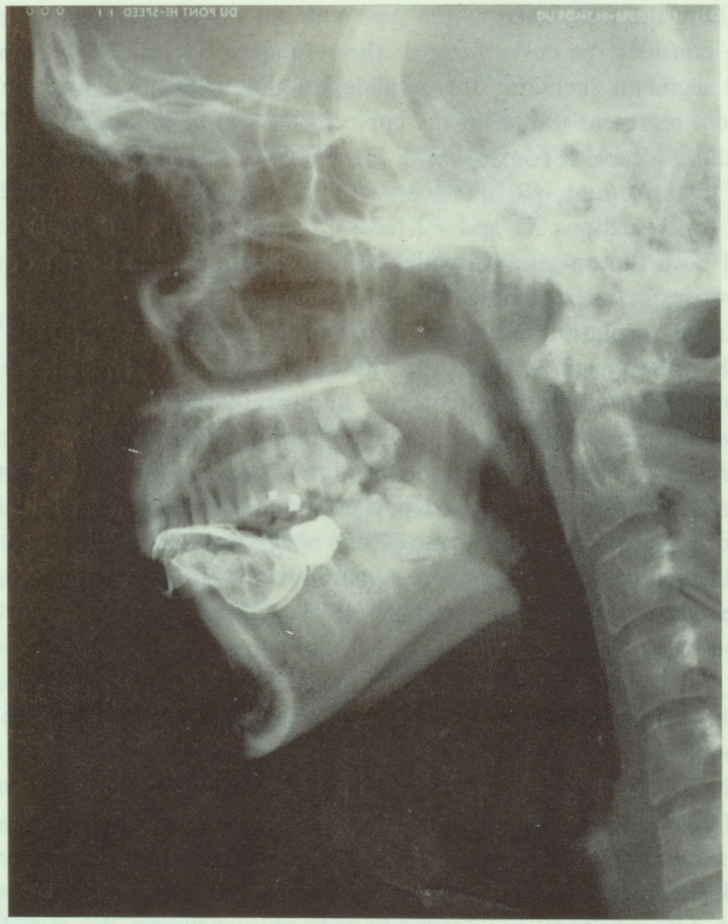

Fig. 2. The total impression placed in the sub-lingual space when *n* of the word *Anna* was pronounced.

relative intensity, in comparison with the cases damped with filling appliances varies from 9 to 24 dB.

In the spectrum of the alveolar variants of the [s] pronounced after the vowel [a] a decrease of intensity (about 5-10 dB) of the *FS* is found between 1100 and 1500 c/s during the damping experiments.

It would be interesting to perform research with subjects in whom the tip of the tongue has a very tight frenum, and to compare their dental sound spectra with those of the control population. Very probably the *FS* is lacking in the former group.

There is one typical example of the transitions between vowels and dentals investigated so far which I want to explain: the transition [a(s)] with special reference to the appearance of the assumed sub-lingual formant *FS*. The trial word was *Vaasa* spoken by a male subject in the Finnish phrase '*Kuningas Vaasa*' [kuniŋŋas va:sa] 'King

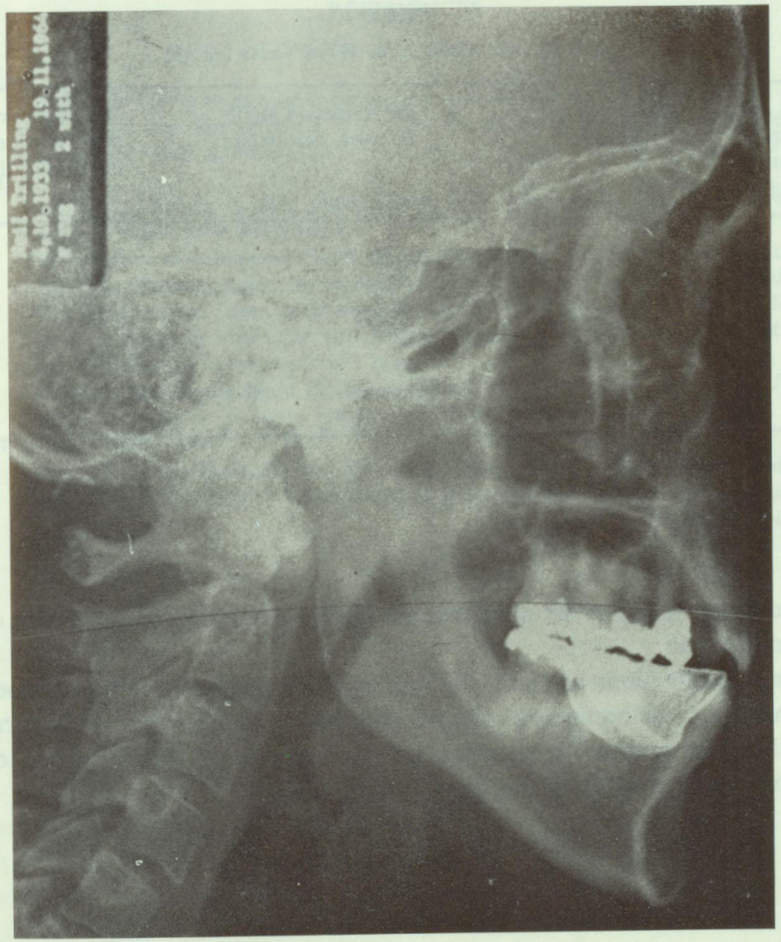

Fig. 3. The partial impression placed in the space concerned when the American-English [-ɹ-] of the word *rug* was pronounced.

Vasa'. About 30 msec. before the beginning of the unvoiced [s]-sound, the *FS* appears suddenly between the formants *F*2 and *F*3, measured from the sonagram of frequency vs time. The corresponding parts of the *F* pattern in the segments concerned have been analysed on the basis of time-point spectra (sections) registered by means of the narrow filter (45 c/s). See Table 1.

We can consider that in the last phase the frequency of *FS* is a little higher than in the former phase. The same phenomenon appears during the two corresponding phases of the test words *ruusu* 'rose' and *viisi* 'five', because the *FS* rises from 1300 to 1650 in *ruusu* and from 1650 to 2150 c/s in *viisi*. In the transition [u(s)] this formant is situated below the *F*3 (1700 c/s) and in the transition [i(s)] below the *F*2 (1950 c/s). The frequency level of *FS* depends not only on the individual size and form of the

TABLE 1.

The Transition a(s) *in the Word* Vaasa [va:sa]

Formants or Components with dB and p/s values	The target of the long [a:]		The transition [a(s)] 20 msec. before [s]		The beginning phase of [s] 40 msec. after the former timepoint	
*F*1	750	36	600	35	550	25
*F*2	1100	37	1350	39	1450	22
FS[a]	(doesn't exist)		1650	20	1750	19
*F*3	1800	35	1950	30	—	—
CA[b]	—	—	3000	23	2650	21
CI[c]	—	—	3700-7350	20-7	3200-4200	15-12

[a] the sub-lingual formant.
[b] the noise-component of the alveolar arch.
[c] the noise-component of the incisors.

sub-lingual cavity, but at the same time on the varying places and manners of apico-dental articulation.

Further investigations primarily by means of synthetic and auditory experiments, will be needed to determine the relative importance of the rather weak formant *FS* among the other auditory cues which are characteristic of the transitions of dental sounds pronounced with a raised apex.

3.

In a comparison of the (unaspirated) Finnish [ka], [ki] transitions (analysed by the Voiceprint spectrograph of Helsinki University), the following preliminary results have been obtained. The [ka] transition is characterized by a decrease of the distance between *F*1 and *F*2 during release frication period of about 20 msec. until the onset of the vowel, whereas the [ki] transition is characterized by a diminution of the distance between *F*2 and *F*3. No essential differences between the transitions in stressed and unstressed positions are noticeable. According to the measurements made so far, the diminutions of these distances vary in the [ka] transition between about 150 and 250 c/s, corresponding to 3-4 halftones, and in the [ki] transition between about 250 and 700 c/s, corresponding to 2-4 half-tones. The distances between the formants generally start increasing from the onset of the vowel onwards. The material analysed concerns two test subjects (a female adult and a 10-year old boy). The next step in my investigations will be to verify these results by means of synthetic and auditory experiments.

REFERENCES

Äimä, F.
1824 "Vorläufige Versuche zur Endoskopie der Kehlkopfartikulation der labiale Verschlusslaute sowie der Spiranten *h, s, f*", in *Festskrift tillägnad Hugo Pipping på hans sextioårsdag* (Helsingfors).

Sovijärvi, A.
1964 "Tarkkuusmittauksia suomen yleiskielen /s/:n ja /š/:n äänikirjoista", *Suomen logopedis-foniatrisen yhdistyksen julkaisuja* 1.
1965 "The Influence of Sublingual Cavity on the Acoustical Structure of Dental Sounds (X-Ray Film)", in *International Association of Logopedics and Phoniatrics, Proceedings of the XIIIth International Congress* (Vienna, Verlag der Wiener Medizinischen Akademie).
1969 "Der Lautübergang im Lichte von Röntgenfilmen und Spektrogrammen", *Annales Academiae Scientiarum Fennicae*, B:153.3.
1970 "On Transition in the Light of X-Ray Films", in *Proceedings of the VIth International Congress of Phonetic Sciences*, Prague 1967 (Prague, Academia) pp. 851-855.

Sovijärvi, A. and Aune Ylppö
1962 "Sonagraphic and Palatographic Studies of Full Denture, Half Denture and Edentulous Cases", *Acta Odontologica Scandinavica* 20.