WHAT CAUSES THE VOICED-VOICELESS DISTINCTION?

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The difference between voiced (v) and voiceless (vl) consonants (C), in linguistics characterized by one distinctive feature, proves to be carried by a number of acoustical and perceptual attributes. They are: 1a) C_{vl} are longer than C_v. 1b) A vowel (V) adjoining a C_{vl} is shorter than one next to a C_v (with preceding [V-] more than with following [-V] vowels). Measurements of the duration of pairs of isolated Dutch words, differing in voice character only, yield no significant difference in mean duration; consequently it seems justified to assume that differences in duration of the C are compensated by differences in the -V- (fig. 1). 2) Both V- and -V seem to have longer

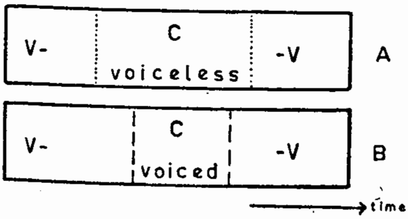

Fig. 1. Schematic build-up of VCV combinations with a voiceless [A] and a voiced [B] consonant.

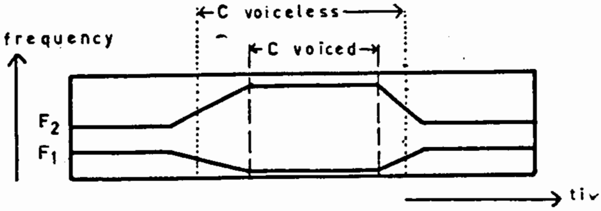

Fig. 2. Schematic combinations as in fig. 1 with addition of identical non-interrupted formant transitions.

formant transitions with C_v than those next to C_{vl} (duration as well as frequency range). By drawing identical formant transitions in fig. 1, we see that parts of the transitions, in the v-situation belonging to V, correspond to the initial and final parts of C in the vl-situation (fig. 2). 3) During C_v a sound generated by vibration of the vocal cords is usually detectable; although, due to a damping of the higher frequencies, the F_2 will acoustically be absent, a low continuation of F_1 remains detectable (fig. 3B). During the C_{vl} this sound is absent (fig. 3A). 4) The sound level of the friction noise is higher in C_{vl} than in C_v. 5) The sound level of -V- next to C_{vl} is lower than that of those next to C_v (in -V more than in V-). 6) The F_0 contour of -V following C_{vl} starts high and declines during -V, whereas after C_v a rise of F_0 occurs in the initial

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part of -V followed by a fall after 50—100 ms. The top of the F_0 contour tends to higher values after and, to a lesser extent, before C_v than with C_{vl}.

Each of the attributes is perceptually detectable, although more attributes, rather than a single one, have to cooperate to obtain a change in voice character. To get a better understanding how these attributes are connected, an articulatory model will be developed. Differences in the physiological aspect of the *v/vl*-distinction as found in the literature are: 1. With C_{vl}, the larynx tends to a higher position than with C_v.

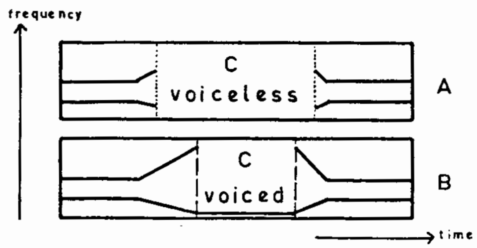

Fig. 3. Schematic build-up of VCV combinations as in fig. 1 and 2; the F_2 is interrupted during the consonants and F_1 is removed in the voiceless situation.

2. With C_v the pharynx seems to be wider than with C_{vl}. 3. The glottis is in vibration action during C_v while during C_{vl} it is slightly opened and not vibrating. 4. The intraoral pressure (P_{io}) is higher with C_{vl} than with C_v. 5. With C_{vl} a stronger airflow occurs than with C_v.

The effect of a high larynx position and a narrow pharynx (C_{vl}), is a small volume of the pharynx; if the larynx is low and the pharynx wide (C_v) a large volume results. The resistance (R_{gl}) for the upward airstream is lower in the case of C_{vl} (open glottis) than in the case of C_v (vibrating glottis). The small volume and the low R_{gl} together can be held responsible for a quick build-up of the P_{io} with C_{vl}; contrary to this the large volume and high R_{gl} with C_v prevent a quick build-up, so that P_{io} may not reach the value obtained with C_{vl}. Assuming that the suglottal-P is independent of the voice character of C, differences in P_{io} will cause differences in P-drop across the glottis (increase of P_{io} causes decrease of P-drop). The main reason of the cessation of voice with C_{vl} lies probably in too low a P-drop causing too weak an airstream to sustain vocal vibration.

As the vocal cords are attached to the larynx it seems probable that a difference in its position results in a difference in the condition of the vocal cords. This may explain the differences in F_0 and sound level within *-V-*; a high larynx position causes an unfavourable vibration condition of the vocal cords, manifesting itself in an abduction of the vocal cords. This condition results in a high F_0 and a low sound level (C_{vl}). The airflow depends directly on the P-drop across the oral constriction. A high P_{io} leads to a high P-drop which causes a strong airstream (C_{vl}). This strong airstream accounts for the high sound level of C_{vl}.

Measurements of the total duration of word pairs, differing in voice character only, yield no significant difference in mean duration. However, words with fricatives proved to be significantly longer than those with plosives and words with dentals proved to be longer than those with labials. These results show that if the mode of operation of muscles, controlling the open-close movement as well, changes, its consequences manifest themselves in a difference of duration. As a difference in voice character is not coupled to one in duration it seems justified to assume that the *v/vl*-distinction is controlled by muscles operating independently of the closing musculature. The pharyngeal constrictor muscle seems likely, since: 1. It does not interfere with the closing movement of the mouth. 2. It influences position and condition of the larynx. 3. In constituting the back wall of the pharynx, it will exert influence on the width of the pharynx.

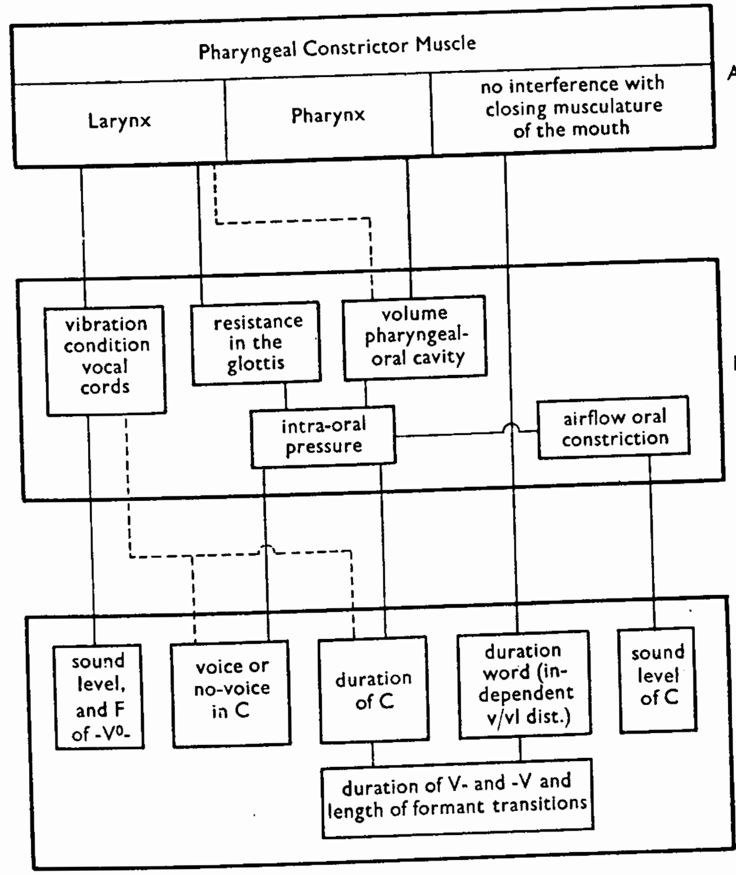

Fig. 4. Model accounting for the voiced-voiceless distinction, relating: the physiological factors [*A*], their physical effects [*B*] and the acoustical realisations [*C*].

These three physiological factors form the basis of the measurable attributes. A schematic view of these causal relations is represented in fig. 4 through the articulatory model.

MacCarthy:

Request for information on several points:

1. Were the categorical statements made by the speaker based on linguistic evidence from Dutch speakers?

2. How would the speaker deal with the fact that in different languages (e.g. English v. German, or Southern v. Northern English) there are different tendencies to shorten e.g. vowels before voiceless consonants? Would he say that the physiological tendencies are always operating, but that one language (dialect) gives way to or alternatively resists the tendency more than another?

Smith:

What is the background for your statement, that the larynx is raised by the activity of the constrictors and thus favours the unvoiced position?

When you only have this from literature I think, that X-ray film studies would be interesting. This may—or may not—support your statement.

Slis:

Ad MacCarthy: As an answer to your first question I can say that the acoustic attributes as mentioned are based on a series of isolated words spoken by Dutch speakers. The physiological attributes are partly based on material obtained with Dutch speakers and partly on material, found in the literature of speakers of other languages. The answer to the second question is: that it is quite possible that besides the actions described in the model other actions take place; e.g. that the command for a vowel preceding a voiceless consonant is different from one preceding a voiced one in certain dialects or languages.

Ad Smith: First of all I want to state that I made a model and that I do not pretend to make statements. Secondly that the part of the model under discussion is based on Literature only indeed.