

## CONSONANT SEQUENCES AND LARYNGEAL CONTROL\*

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There are some well-known facts about English phonetics concerning phonetic values of particular consonants that are appreciably dependent on their phonological environments. Thus for example, stop consonants /p, t, k/ in an initial consonant cluster of a stressed syllable are most heavily aspirated before liquids, appreciably aspirated before vowels, and comparatively less aspirated after /s/. Even though there are some problems as to whether we can always uniquely determine the phonetic affiliations of (parts of) consonant clusters to either the preceding or succeeding syllables, and also as to what are the rules that precisely determine the existence and place of any phonetic manifestation of syntactic or morphological "boundary", we often observe cases where such a boundary gives rise to some acoustic correlates, by means of which the listener can detect distinctive differentiation of e. g. "night rate" vs. "nitrate" (in a context like "Give me the \_\_\_ first. "), "I scream" vs. "ice cream" (They say \_\_\_\_\_ for pleasure. "). In those cases where such distinction is actually heard, it is usually not the case that any physical "pause" as such, i. e. silence or weakening constituting a special time segment, characterizes the existence of the boundary mark. In fact, quite often the time course as revealed in spectrograms do not show any local lengthening effect that can be attributed to the insertion of an extra segment corresponding to the boundary. The phonetic values of pertinent consonants, such as the degree of aspiration at the stop release, often seem to characterize the distinction. It is, therefore, a question to be experimentally answered whether there are inherent physical correlates of such boundaries.

There are also cases where such morpheme boundaries give rise to phonological sequences of consonants that are not found within a morpheme.

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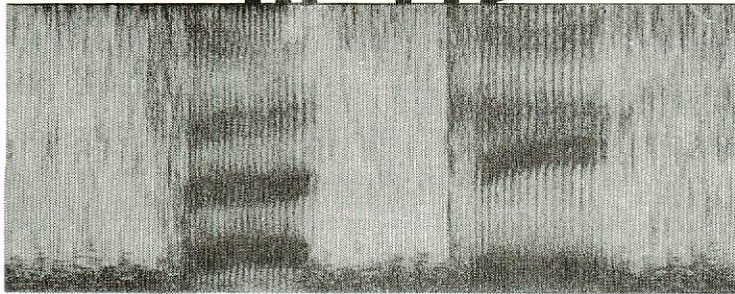
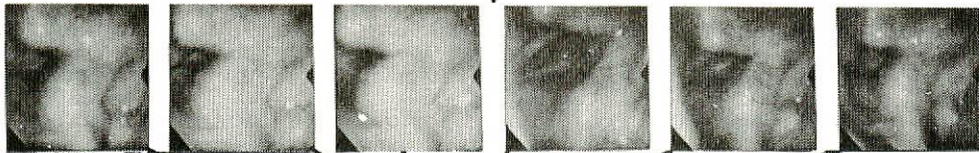
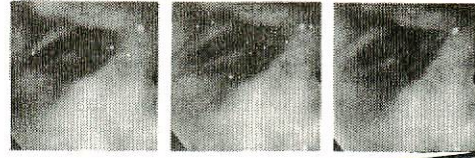
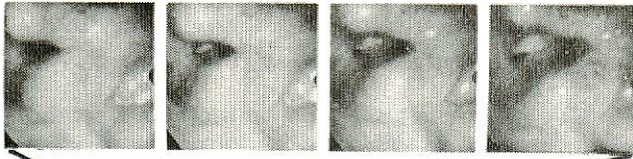
\* Some relevant examples are included in our new 16-mm demonstration film in color entitled "The Larynx in Speech Utterance".

For example, a phrase "bad teeth" contains a consonant sequence /dt/. Also "fat teeth" gives rise to an alveolar stop consonant, which seems to have unique phonetic characteristics. These problems, particularly when they are examined in respect to the articulatory or phonatory control gestures, are of particular interest because some evidence may be found relevant that may suggest or denounce a general hypothesis about syllabification and specific phonetic rules. Acoustic characteristics, however, may not be appropriate for discovering those possible features that can be considered as manifestations of the boundaries.

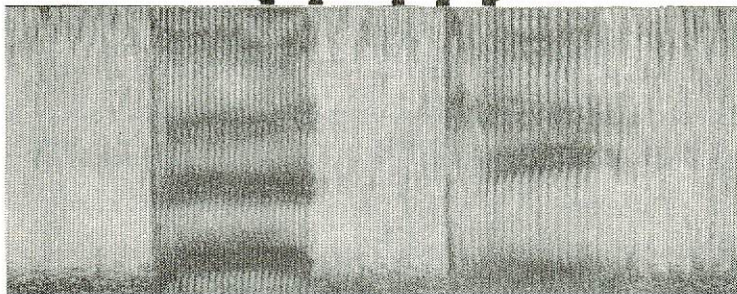
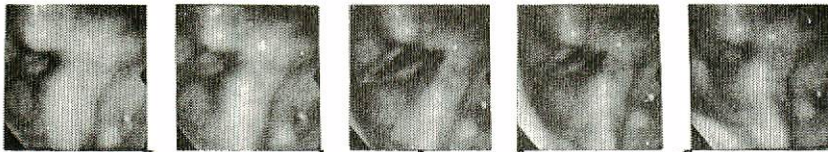
In this preliminary report, we shall examine the problem of stop sequences across a morpheme boundary by use of motion picture frames of the laryngeal images as recorded by a fiberscope. One subject, a native speaker of General American English, uttered sample phrases in isolation. Figure 1 compares utterances of four phrases, "fat teeth", "bad teeth", "fat d's", and "bad d's", in the form of selected frames of 16-mm motion picture film (64 frames/sec.) and sound spectrograms. The time segment in the utterance to which each frame corresponds is indicated by the connecting lines. Representative frames are selected from the first vowel segment, near the implosion to the morpheme final consonant, within the stop closure where the maximum glottal opening is observed when there is any opening, near the explosion of the morpheme initial stop, and within the following vowel segment. In the case of "fat teeth", also consecutive frames between the third and the fourth selected frames are shown to display the change of the glottal configuration during the stop closure. (See the uppermost two rows of pictures.) By visual inspection of these frames, the following points can be concluded for this set of utterances by the speaker. These conclusions hold qualitatively true for other utterances of the same words, and also for a similar set of words ("fat t's", "fat d's", "bad t's", and "bad d's") uttered by the same speaker in several repetitions on a different day.

When the second morpheme starts with /d/ in the sequence /td/, the glottis is nearly closed for the preceding morpheme final /t/. In some samples it was found that the glottis was slightly open only in the cartilaginous portion and closed in the membranous portion. At the same time,

the false vocal cords participate in the articulation of the morpheme final /t/ in /tt/ or /td/. In the sample of "fat teeth" in Figure 1, for example, it can be clearly seen that the false vocal cords approach each other already around the middle of the first vowel /æ/ (the second frame from the left), leaving a narrow view of the closed vocal cords near the arytenoids. Towards the implosion into the t-closure (third frame), the vocal cords are almost completely covered by the false vocal cords. During the closure period for the sequence of two /t/'s, as shown in the uppermost row of frames, the false vocal cords separate again first only at the cartilaginous end of the glottis, and then over the entire length of the glottis, and the vocal cord underneath also starts to show separation in the membranous portion. In about the latter one-half of the closure period, the glottis is seen to be wide open for the morpheme initial /t/. In some utterance samples, the false vocal cords did not show any contact but approached each other and in others, they contacted each other only momentarily; but the tendency for the false vocal cords to participate in a sort of glottalization for the morpheme final [t] in /tt/ or /td/ sequences was consistently observed for this speaker. In the sample of "fat d's" in Figure 1, the same action of the false vocal cords can be clearly observed, to a less extent compared to the case of "fat teeth", and as stated above no clear glottal opening is observed for any portion of the t-closure. One clear difference between /td/ and /dd/ (see the sample of "bad d's" in Fig. 1) is thus, whether the false vocal cords take this special gesture or not. At the same time, it should be mentioned that the appearance of the arytenoids when the false vocal cords show this action, is always brighter and larger compared to the d-articulation in the same environment. (Compare corresponding portions of "fat teeth" vs. "bad teeth", and "fat d's" vs. "bad d's". This reveals that the level of the arytenoids (of the glottis, and the larynx as a whole) was higher at the time this action of the false vocal cords took place. Also, it can be clearly seen in the sound spectrograms that this particular laryngeal gesture was acoustically characterized by a rapid fall of the fundamental frequency of voice near implosion. This kind of pitch fall is not uncommon toward the end of an utterance or so-called breath group. However, a fall of pitch is usually



f æ t t i θ



b æ d t i θ



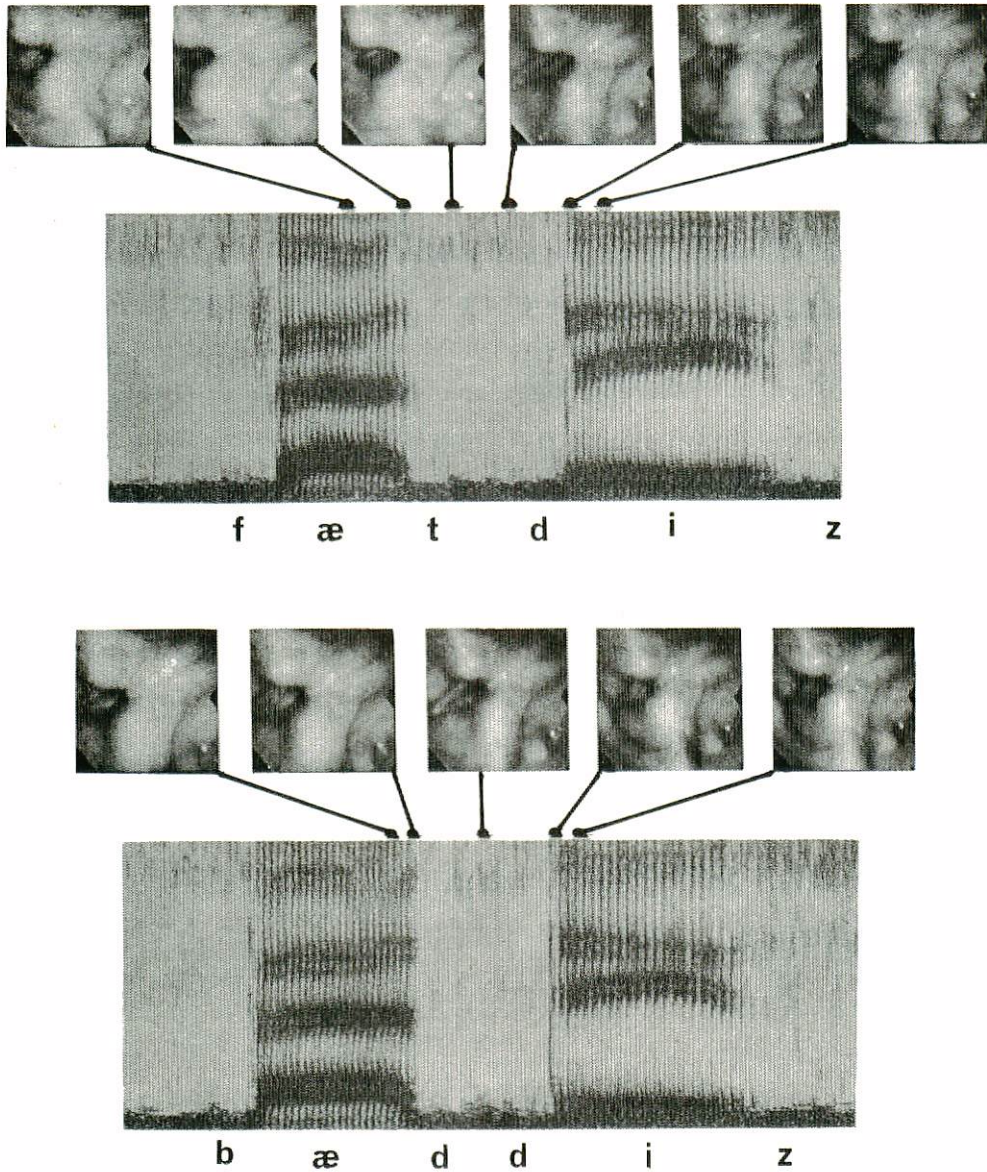


Figure 1. Selected frames of 16-mm movie film of the laryngeal images taken by use of a fiberscope and spectrograms of the utterances of phrases "fat teeth", "bad teeth", "fat d's", and "bad d's", in isolation, by a native speaker of General American English.

associated with a marked lowering of the larynx.\*

Morpheme final /t/ when followed for example by a morpheme initial /r/ does not seem to show this peculiar characteristic of laryngeal control in this subject. Thus he uttered the phrase pair "gay tray" and "hate ray" in clear distinction, for example, but his morpheme final [t] in the latter (with less aspiration than in the former) shows the normal open glottis. Some samples of his conversational speech\*\* revealed also that the false vocal cord gesture took place in the stop sequence /tt/ in e. g. "Yes, we should tape it, too.", but not (in several utterances we examined) in /tp/ in "Tape it please.". Also, one utterance of the sentence final /p/ in "Here, this is good tape." showed a clear closure of the false vocal cords, and in another a close constriction of the same. Some closer examinations are underway.

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\* This effect also can be seen in the demonstration film cited in the previous footnote.

\*\* ibid.