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SEGMENT REDUCTION AND EXPANSION IN FINNISH: A COMPARISON OF READ AND SPONTANEOUS SPEECH

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This study is an investigation of how Finnish speakers adapt the articulation of their phonemes to the task of producing abnormally fast speech. In advance of the study, it was anticipated that the following questions would be relevant to the investigation:
a) Do some sounds (phonemes) consistently speed up more than do others in an attempt at fast speech, and does any such speedup correlate with the articulatory characteristics of the sounds?
b) Is there variation in the rate of phonation from speaker to speaker?
c) Is there a difference between spontaneous speech and reading when speakers attempt to speak faster?
With the collection of observations, the following points were established:
a) The attempt at speedup produced not only faster phonation rates, but also slower phonation rates, with oscillation between the two during the production of the text.
b) No individual phonemes showed consistently greater speedup than other phonemes, nor did any articulatory type consistently show greater speedup. Expected points of greater speedup, such as the superior adroitness of the apex over the dorsum, did not emerge in the actual observations.
c) However, mean phonation rates, both in normal speech and fast speech, were consistently higher when excitation of the cavity was produced by the glottis rather than by a supra-glottal articulator.
d) Speakers varied in the success of their attempt at speedup.

Because of the constraints of space and time in this report, the spontaneous speech data and its comparison with the read material provided here will be saved for presentation at the conference.

1. Subjects

1.1. *Reading task*

Two speakers were chosen for the reading task. The speakers' profiles were similar: middle-aged female residents of Helsinki whose families were originally from Eastern Finland. Both informants received post-graduate education at Helsinki University, and were teachers and researchers.

1.2. Spontaneous *Speech*

Two Finnish narrators were chosen, both ice hockey broadcasters, one from television and one from radio.

2. Material, Equipment, & Procedure

2.1 *Material*

The reading was selected from Appelsiininsiemen of Mika Waltari. This work was chosen because the prose is straightforward and easy to read.

For the spontaneous speech, The Finnish Broadcasting Company (YLE) provided the professional recordings of the 1988 Olympic Ice Hockey coverage, and the radio broadcasts of the 1986 and 1991 Ice Hockey World Championships.

2.2. *Equipment*

For the reading test, a Sony Professional tape recorder was used. The computerized speech analyzer was a combination of the "ISA" (Intelligent Speech Analyzer) program developed by the Finnish engineer Raimo Toivonen, and a Macintosh Plus computer with a Texas Signal Processor and a Sony PCM-coder (A/D and D/A conversion). A Macintosh SE/30 was used to process the visual displays. The voice recordings were digitized, stored in 18.14 second divisions, and then displayed on the screen where individual sounds were measured manually.

2.3. *Procedure*

2.3.1. *The reading test*

The subjects were first instructed to read the passage at a comfortable rate--that is, at a speed they felt to be their "normal" speed. After the first recording, the subjects were then requested to read the same passage as quickly as possible.

2.3.2. *Spontaneous speech*

Samples were taken from these narrators' color commentaries, and from their play-by-play descriptions during threats on the goal. The color commentaries occurred primarily during non-threatening game action, or when game play had stopped, whereas the play-by-play narrations occurred during quick, decisive game moments. Our intent was to select two game contexts that roughly corresponded to the two reading tasks, so that one would elicit normal speech, and the other, fast speech.

3.Results

3.1. *Phoneme durations*

The duration of each successive sound in the text was measured, both for normal and fast speech, and within each the sounds were ranked by duration. The sounds were then grouped into their respective

phonemes, the mean duration of each such phoneme group was calculated, and the groups were ranked by mean duration. The ranking was not found to correlate with articulatory type, such as apical vs. dorsal, or such distinctions as consonant vs. vowel. Rather, the ranked list was observed to divide into two groups: the group with the shorter duration all consisted of sounds (vowels, nasals, r, h, and l) in which the cavity is excited by the glottis; the slower group consisted of p, t, k, and s, in which the oral articulator alone both shapes and excites the cavity. The numbers for Speaker 1 are given in Table 1. below. The mechanism underlying this difference appears to be the following: When the glottis is providing the excitation, the characteristic product of /l/, for example, can be produced by simply passing the apex through the position of /l/ without pause. But if the apex is to provide the excitation, as for the /t/ or /s/, it must remain in position long enough to build up pressure for the explosion of /t/ or direct the air stream for the turbulence of /s/.

/x/ Normal	Mean	Group Mean	/x/Fast	Mean	Group Mean
l	41	Excitation	l	28	Excitation
r	44	by Glottis	i	38	by Glottis
m	55	=58.64	y	38	=46.00
i	55		n	42	
a	56		u	42	
e	59		r	45	
y	60		ä	47	
h	64		e	49	
u	66		a	50	
n	72		m	52	
ä	72		h	75	
t	57	Excitation by	t	56	Excitation by
k	59	Supra-glottal	k	69	Supra-glottal
p	79	Articulator	p	71	Articulator
s	74	=67.25	s	73	=67.25
j	105		j	44	
tt	124		tt	74	

TABLE I. Speaker 1: Phoneme durations grouped by means.

3.2 *Success at Attempts at Fast Speech.*

The speakers were unable to maintain consistent, fast phonation rates for the individual phonemes. In fact, attempts at speedup produced not only faster phonation rates, but also slower phonations, with oscillation between the two during the task. Furthermore, the speakers did not consistently speed up or slow down the same phonemes in their own speech, nor were the points of speedup or

slowdown the same in the two speakers. Figures 1 and 2 depict the performances of the speakers in their attempts to articulate faster.

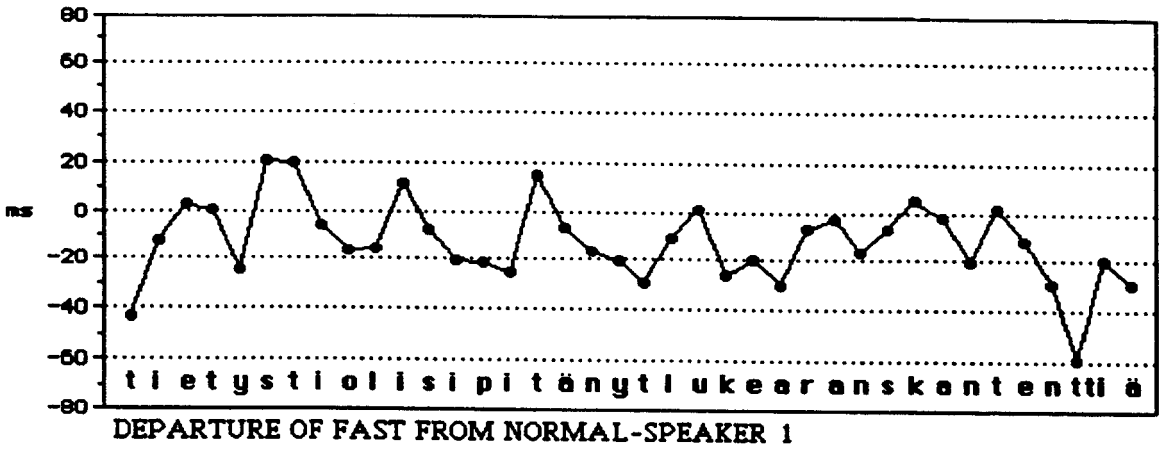

Figure 1. An example of Speaker 1's attempt at fast speech. Normal speed is the horizontal axis at 0. The phonemes are identified below their nodes on the curve. Positive values indicate a slowdown and negative values indicate a speedup.

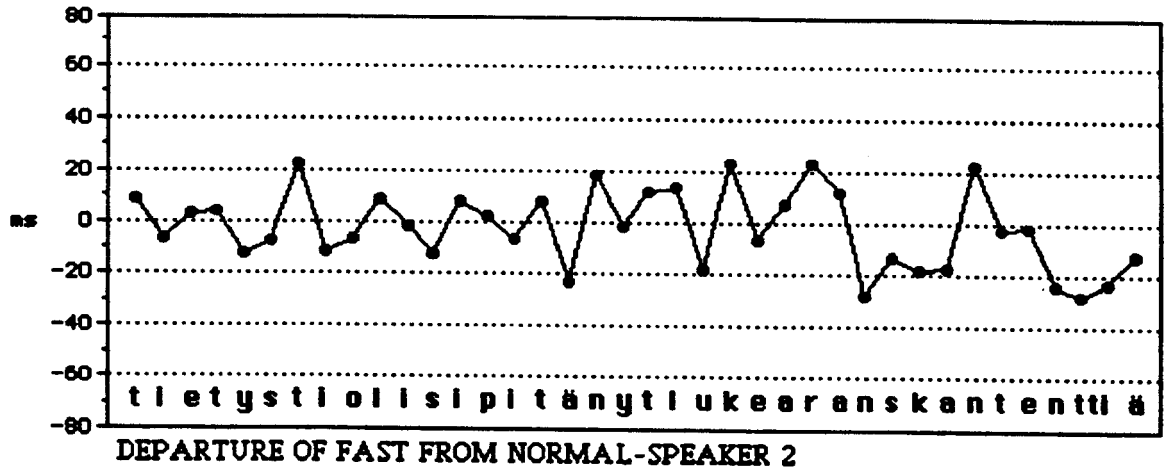

Figure 2. An example of Speaker 2's attempt at fast speech. Positive values indicate slowdowns and negative values, speedups.

3.2.1. *Speaker Variation*

A calculation was made of the number of segments over which the speakers sustained faster rates of articulation, which we termed "bursts". In this manner, it was determined that Speaker 1 was the more consistent of the two in maintaining a faster rate of articulation. For example, Speaker 1 had "bursts" of greater than 3, 4, 5, 5, and 8 segments, whereas Speaker 2 had bursts of 4 and 6 only. In addition, Speaker 1 alternated between slower and faster speech 28 times; Speaker 2, thirty-three times. Similarly, Speaker 1 had a slower

articulation over a maximum of two adjacent segments while Speaker 2 had instances of 5 and 3.

What this suggests is that the results of the attempt at speedup derive more from the person making the attempt, than from the particular identity of the segments. This result is more readily obtained from a laboratory experiment (such as the reading task) than it is from a study of spontaneous speech.

It should be pointed out, however, that the initial speed of the "normal" speed may play a role in the success of the subsequent attempt to speedup. For example, Speaker 2 had a higher speech rate for her "normal" reading, and thus her attempt at increasing her already faster speed may have been compromised by this faster initial speed.

4. Conclusions

In this paper we have examined the effect of abnormally fast speech on the articulation of individual phonemes. We found that the attempt at fast speech often produced slower as well as faster rates of articulation, with oscillation between speedups and slowdowns that were independent of the articulatory characteristics of the individual phonemes. When mean phonation rates were calculated, however, we observed that when the excitation of the cavity was produced by the glottis rather than by a supra-glottal articulator, these phonemes were articulated at a consistently higher rate.
Furthermore, our findings point to considerable speaker variation in consistency and speed of delivery in the normal vs. fast speech tasks. For both speakers, the irregular performance (slowing down as well as speeding up during the attempt at speedup, and this without regard to the particular phoneme being articulated) suggests that the attempt to perform physiologically at an unaccustomed speed led to a "stumbling" effect in the actual speech production.

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