THE GESTURAL ORGANIZATION OF VOWELS AND CONSONANTS: A CINEFLUOROGRAPHIC STUDY OF ARTICULATOR GESTURES IN GREENLANDIC

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ABSTRACT

This poster presents an analysis of speech articulator movements in Greenlandic speech to test the possible universality of results previously obtained from English, Arabic, Swedish and Bulgarian. Greenlandic is particularly interesting in this context because it is completely unrelated to Indo-European languages and because it offers articulations unfamiliar to speakers of European languages, such as uvular consonants and uvularization of vowels.

1. INTRODUCTION

Movements of individual articulators are analysed from an X-ray motion film of speech in order to elucidate principles of gestural organization in vowels and consonants. This is part of an ongoing study of the temporal coordination of articulator gestures in several languages, for which results have so far been presented from Swedish [1,2], Bulgarian [2,3,4] and Greenlandic [5,6,7].

Wood [8] demonstrated from X-ray films of English and Arabic speech that four tongue body gestures are used for vowels (towards the hard palate, soft palate, upper pharynx and lower pharynx), a behaviour that is compatible with the quantal nature of speech [9,10,11]. Continued work on the X-ray films of Swedish, Bulgarian and Greenlandic speech confirmed the four gestures also in these cases.

This work has also provided insights into the temporal organization of articulator gestures. Articulator movements were characterized by an approach phase (when the articulator is moved into position), possibly a hold phase (if it is held there a while), and a withdrawal phase (when it is moved away).

Assimilation (palatalization of alveolar consonants in Bulgarian and Greenlandic, palatalization of velar stops in Swedish, and uvularization of vowels in Greenlandic) was the result of a complete reorganization of gesture timing (compared to unassimilated situations) such that the assimilating gesture was shifted earlier, or delayed, or stretched, and consequently coincided with other activity. This gestural reorganization resulted in coproduction of elements of both phonemes, rather than transformational feature spreading from one to the other.

Explanations for coarticulation generally conform to either the tug-of-war paradigm (competing demands on an articulator resolved at the muscular level) or the gesture-queuing paradigm (re-arrangement of articulator timing at the programming level avoids the conflict). Classic examples of the two approaches are the models of Ohman [12,13] and Kozhevnikov and Chistovich [14] respectively. The handling of gesture conflicts thus offers a test situation for distinguishing central and peripheral activity in coarticulation. Every gesture conflict in the Swedish, Bulgarian and Greenlandic material reported so far (some 20 instances) was resolved according to the gesture-queuing paradigm, indicating that this aspect of coarticulation is preplanned.

The first results from the Greenlandic film have revealed the same principles for gesture organization as were seen in the English, Arabic, Bulgarian and Swedish films. Further material from Greenlandic, comprising additional combinations of vowels and consonants, is examined in the poster in order to consolodate or diversify the preliminary results. This report concludes with background information on analysis procedure and methodology for analysing movement and presenting the data.

2. PROCEDURE

The subject (adult male from Godthaab, representing the central dialect of West Greenlandic) read a series of isolated words at a normal rate of around 5 syllables/sec. Real words were preferred because the polysynthetic word structure of Greenlandic does not lend itself to systematic variation of items and contexts in real contrasting minimal pairs or in specially designed nonsense words.

The X-ray camera speed was 75 frames/sec (13.3 msec/frame) and the radiation was flashed in one 3 msec burst for each frame [8]. A high anode voltage was applied in order to reduce the image contrast between bone and soft tissue. The speech was recorded during the filming session, and pulses (at every tenth film frame) were recorded simultaneously on a second channel for picture synchronization.

3. PRESENTATION OF DATA

The movements were analysed by comparing articulator positions on successive picture frames of the film [1] and presenting them as a sequence of profiles, as in Fig. 1

which shows the movement of the tongue body from a [k] occlusion into a vowel [o]. This is taken from the word /aku/, [ako] (wordfinal Greenlandic /u/ is [o]).

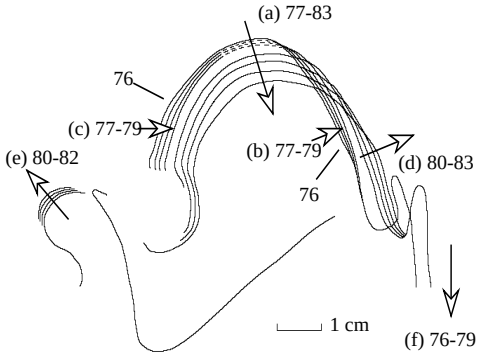

Figure 1. Velar tongue body withdrawal of [k] (frame 76 end of occlusion, frames 77-79 the release) and uvular tongue body approach of [o], during the first part of the vocoid segment of [o]. Taken from the word /aku/, [ako].

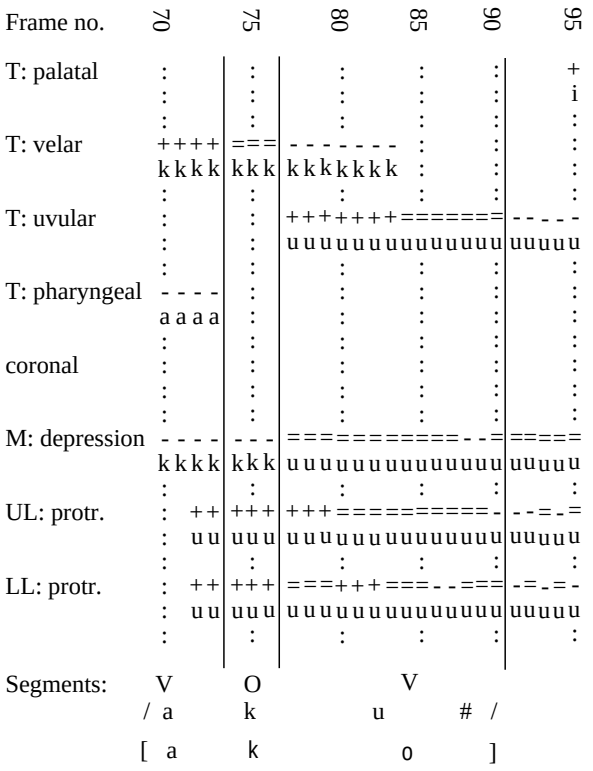

Figure 2. Frame by frame assignment of articulator gestures to the respective frames of the word /aku/, [ako], during frames 72-95 (all activity for /u/). Film frames numbered along the top, articulator gestures listed down the left (T tongue body, M mandible, UL upper lip, LL lower lip). Within the chart, a + sign shows an approach movement, a = sign shows a gesture posture hold, and a - sign shows a withdrawal movement. Below: phonemic and phonetic transcriptions, and phonetic segment type (V vocoid, O occlusion).

The columns of Fig. 2 represent time (each film frame is 13.3 msec). The vertical lines divide the chart into phonetic segments, such that frames 70-73 are the final part of the vocoid segment of /a/, frames 74-76 are the occlusion of /k/, frames 77-90 are the vocoid segment of /u/, and frames 91-95 are in the silent interval after the word. The rows of Fig. 2 represent articulature gestures. For example, UL and LL show lip rounding approach for /u/ commencing in frame 72 towards the end of the /a/ vocoid segment, continuing through the /k/ occlusion and into the /u/ vocoid segment; the lip rounding withdrawal commenced in frame 86 and proceeded intermittently until frame 95 during the silent interval.

4. REFERENCES

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