SWEDISH CONSONANT CLUSTERS IN SPONTANEOUS SPEECH: PRELIMINARY ACOUSTIC-PHONETIC OBSERVATIONS

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ABSTRACT

Compared to other parts of the Swedish phonological system, consonant clusters have not been studied sufficiently. This is especially true of the phonetic aspects. Therefore, the research programme "Variations within consonant clusters in spoken Swedish (VaKoS)" was launched, aiming at highlighting their occurrence and distribution in spontaneous speech, their temporal variations and the phonological processes operating on them. Preliminary data from the spontaneous speech of one female Standard Swedish speaker is presented.

INTRODUCTION

From a typological and universal point of view, Swedish is characterized by a relatively complex syllable structure. Within a morpheme, the syllable nucleus may be preceded and followed by three consonants, e.g. *straff* (penalty), *växt* (plant). Within the syllable as the phonotactic domain, five consonants may follow, e.g. *skälm+sk+t* (inflected form of roguish). Consonant clusters of eight consonants, at least in the canonical forms, can arise across word boundaries, e.g. *skälmskt skratt* (roguish laughter). However, in fluent speech, some consonants are normally deleted. The prosodic feature of quantity intersects in an intriguing way with consonant clusters in morphemes and syllables. Shedding light on this important area of Swedish phonology that has not yet received due attention, is the goal of the project "Variations within consonant clusters in spoken Swedish (VaKoS)".

The project aims at describing the occurrence, distribution and temporal variation of consonant clusters in phonetically controlled and spontaneous Standard Swedish speech. Phonological processes operating on these clusters will also be studied. Speech samples of one hour's length of five male and five female Standard Swedish speakers of similar background will be collected in the data base DUKoS (Databasen i Umeå för svenska konsonantgrupper). The investigation will also include perceptual experiments.

BACKGROUND

Phonotactic aspects of consonant clusters are treated in [1]. The domain of analysis is the word and a generative programme for possible consonant clusters in Swedish is developed. Compared to the morpheme as the domain of analysis, this approach yields larger clusters.

In a classic work [2], an attempt to write rules for phonological processes operating on consonant clusters was made. In contrast to [1], spontaneous speech was the goal of that investigation. It also treated clusters that arise across word boundaries.

Variations within consonant clusters from a phonological point of view are treated in [3]. Typical processes are deletion, assimilations and retroflexation. However, experimental studies concerning spontaneous speech and quantitative aspects of consonant clusters including phonological processes have not been conducted.

Experimental data concerning the temporal pattern of variation of consonant clusters consisting of /s, t, k/ in initial, medial and final morpheme position in phonetically controlled utterances were presented by [4]. A linear increase of consonant and cluster durations of about 40 ms due to focus accent applies to all positions.

GOAL

The goal of the present study is to collect preliminary acoustic-phonetic data on Swedish consonant clusters in spontaneous speech. Three main aspects are dealt with: first, the frequency of occurrence of consonant clusters with respect to word and morpheme boundaries. Second, the distribution of phonological processes effecting consonant clusters and their phonetic manifestations. Third, the segmental composition of the clusters.

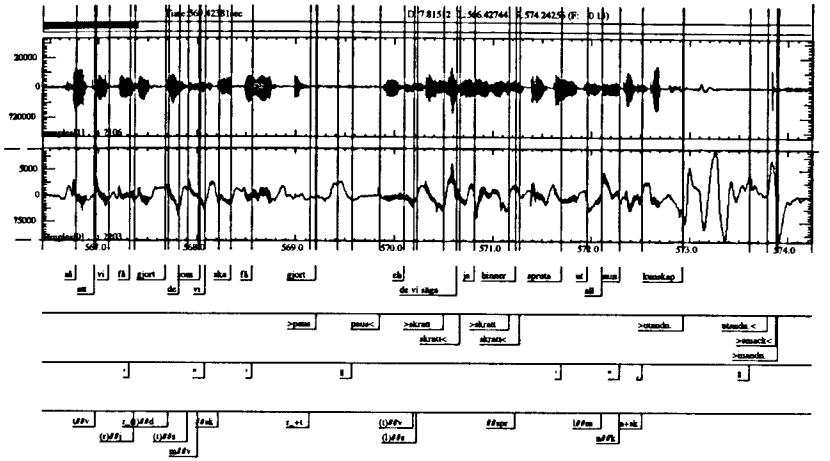

Figure 1. Illustration of processing the speech material. From top: speech wave, laryngograph signal, four levels of labelling.

MATERIAL

Two adult speakers, two males and two females, aged between 30 and 40, from the Stockholm area were recorded. The spontaneous speech of each speaker, approximately 60 minutes each, was organized into four different topics with the duration of about 15 minutes each. The topics included summer holiday, cooking, literature and body language. Recordings of the speech wave and the electro-laryngograph signal were made simultaneously. This signal makes it possible to clearly observe the actions of the glottis during consonant production. The preliminary data presented here comprises one topic about body language by the female speaker. A passage at the beginning of the text is shown:

"... å för mej blir de allså väldit väldit jobbit att försöka dels hålla tråden *så att vi få gjort de som vi ska få gjort eh de vill säga ja hinner spruta ut all min kunskap* å dels att ja hinner avläsa inte bara på dom som sitter längst fram ..."

The text is represented in a simplified orthography expressing the way of pronunciation in this spontaneous speaking style. The following prosodic markers are inserted:

Phrase boundaries:
‖ strong phrase boundary
| weak phrase boundary
Prominence levels:
"CV focus accent
'CV primary stress (word accent)
,CV secondary stress

ANALYSES

In a preparatory phase, the material was labelled on a SUN Sparc2 station using ESPS/waves+. Four levels of labelling were selected: (1) an orthographic representation as close as possible to actual pronunciation, (2) non-verbal behaviour like laughter, clicks, in- and exhalations, (3) prosodic features of phrase boundaries and four levels of prominence (see above) and (4) consonant clusters. For the first level, we found methodological inspiration in the work of the Gothenburg linguists [5]. Figure 1 gives an illustration of a short passage contained in the text sample given in italics above.

When specifying the consonant clusters in the speech sample, we started out from the underlying or canonical word form. Retroflex consonants in morphemes are analysed as single segments (phonemes). Thus 'bord' (table) contains an initial and only one final consonant. Retroflex consonants, however, arise as the result of the phonological process of retroflexation across morpheme and word

boundaries, e.g. 'smor+d' (greased), 'spar+sam' (economical), 'vår#dag' (spring day).

Together with the segmental composition of the clusters, morpheme and word boundaries are indicated. We found it necessary to differentiate between a simple word boundary within a compound word (mat#sal, 'dining-room') and a double word boundary delimiting words (##fönster##, 'window'). Sometimes it was difficult to decide the morphological status of word elements. Numerals like 'sexti' (sixty), words like 'månda' (Monday) and 'därför' (because) were treated as one morpheme. The reason for this decision is phonological and morphological: these words have the acute accent and for the language user of today these words cannot be divided into meaningful parts.

RESULTS

The preliminary results of this introductory study are presented in three groups: (1) occurrence of the consonant clusters expressed as their frequency, (2) the phonological processes, (3) their segmental composition.

Occurrence and frequencies

The speech sample studied had the length of about 12 minutes. It contained 1.000 consonant clusters. The ten most frequent consonant clusters are given under three conditions: (1) total in Table 1, (2) in morphemes (initially, medially, finally) in Table 2, (3) across word boundaries in Table 3. The first column in each table givs the frequency of occurrence, the second the consonant cluster in IPA notation and the third an example context. Segments in parentheses are deleted in the speech signal.

Table 1. Overall occurrences of consonant cluster. Total: 1.100.

39	(t)##d	att de
37	nt	inte
24	(r)##m	här med
23	nd	andan
17	st	fäste
17	n##s	den som
16	t##m	att medge
15	(t)##v	det var
14	(t)##s	det som
13	(r)##j	menar jag

Table 2. Consonant clusters in morphemes. Initial: total 57

10	st	stora
9	sk	skola
8	spr	språk
5	gr	grand
3	kr	kroppen
3	bl	blev
2	skr	skrift
2	pr	producera
2	fr	från
1	tr	tror

Medial: total 214

37	nt	inte
25	nd	andan
17	st	fastnat
8	rj	börja
8	ntr	intresse
8	ŋk	tanken
7	ld	ålder
6	ntl	egentligen
6	ndr	andra
5	kt	kt

Final: total 19

5	sk	grammatiska
4	st	bästa
2	ʂt	första
2	nt	instrumenten
2	nd	band
1	rk	starka
1	rb	verb
1	nt	instrumenten
1	ns	minns
1	kt	dialekt

The number of clusters within morphemes varies greatly between positions. The largest number is to be found in medial position, the smallest in final.

Table 3. Consonant clusters across word boundaries. Total: 620

39	(t)##d	att de
24	(r)##m	där med
17	n##s	kan se
16	t##m	att man
15	(t)##v	det var
14	(t)##s	det som
13	(r)##j	försöker ge
12	(r)##d	är det
12	n##m	kan många
11	m##d	dom där

The frequency distribution of the consonant clusters in the three contextual categories above is rather similar. While 252 clusters appear only once in the speech sample, 64 clusters only twice, 35 clusters only three times, etc., one cluster is to be found 37 times and the most frequent one 39 times (cf. Table 1).

Phonological processes

By far the most frequent phonological process observed is consonant deletion, in total 360 instances. Final /t, r/ are deleted most frequently. Table 4 gives all the deletions found in the speech sample.

Table 4. Consonant deletions and their frequency. n = 360.

t	126	h	6	k	2
r	104	l	6	p	1
g	44	j	5	ɖ	1
d	36	gt	5	lt	1
n	9	m	3	sk	1
v	7	s	3		

Segmental composition

Consonant clusters within morphemes will be used in order to illustrate their segmental composition. Table 5 gives an overview showing 2- and 3-consonant clusters, grouped according to the features obstruent, nasal and liquid.

Table 5. Segmental composition of 290 morpheme internal consonant clusters. Two and three segments.

Initial		Medial		Final	
2	3	2	3	2	3
	spr				
st		st		st	
sk	skr			sk	
pr					
kr				kt	
gr					
		nt	ntr	ʂt	
		nd	ndr	nt	
		ŋk		nd	
		nʃ		ns	
bl		ld	ntl	rk	
		rj		rb	

Three consonant clusters are only found in initial and medial position. In initial position, combinations of obstruents and /r/ dominate, while medially most clusters contain a nasal. In final position, pure obstruent clusters and combinations of nasal or /r/ followed by an obstruent appear as well.

CONCLUSIONS

We have developed a method and procedure that ensure a quantitative and qualitative processing of spoken Standard Swedish with respect to the analysis and phonetic description of consonant clusters. The largest difficulty encountered is morphological segmentation. We decided to give priority to the synchronic aspect and to disregard the diachronic perspective. The preliminary results of our project work are promising. The data on the occurrence and frequency distribution of the consonant clusters, the distribution of the various phonological processes and the specification of their segmental composition will contribute substantially to our knowledge of the phonotactic structure of Standard Swedish. Our results will also deepen our insights into the typological dimension of consonant clusters. Furthermore, this is of great interest to experimental phonology. One side-effect of our work, due to excellent computer facilities, will be a corpus of spontaneous speech labelled for prominence, morpheme, phrase and word boundaries, consonant clusters and even non-verbal signals. At the end, it will be available on CD-ROM. We plan also to publish the first frequency word list of spontaneous Swedish, sorted forward and backward, based on five hours' recording of five male and five female adult speakers.

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