Timing of legal and illegal consonant clusters in Swedish

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Abstract

The timing of consonant clusters in Swedish has been studied intensively. However, from a phonological perspective coda-internal timing with regards to quantity has not yet successfully been studied. This study intends to provide more data on the duration of Swedish consonant clusters: (a) sonorant-sonorant clusters and (b) sonorant-obstruent clusters. In addition consonant clusters illegal in Swedish phonology are considered as well to investigate general timing mechanisms underlying coda cluster timing. The results seem to reject a phonological analysis of a long consonant as the first component in VC:C cluster. Rather, articulatory effects of neighboring segments play a role in coda-internal timing.

Introduction

Durational patterns of Swedish sounds have been studied intensively (Czigler, 1998; Bannert and Czigler, 1999). Influencing factors are, among others, stress, quantity, syllable position, neighboring speech segments (Klatt, 1976, for an overview). Phonological as well as phonetic-articulatory factors can be differentiated. While phonological factors such as stress or quantity lengthen or shorten segments to a certain amount in relation to surrounding speech sounds to enhance a phonological contrast, articulatory factors still remain. In other words, in a stressed syllable containing a vowel and voiceless coda plosive the duration of the vowel would be shorter and the closure of the plosive longer than in a comparative syllable with a voiced plosive (Delattre, 1962).

Swedish stressed syllables show complementary quantity of the type /V:C/ – /VC:/ (Elert, 1964; Riad, 1997). The phonological length of a syllable is represented by two morae. According to Riad (1997), long vowels receive two morae, short vowels and long consonants receive one, respectively, and short consonants receive no mora at all.

For consonant clusters, this assumption would predict that the first consonant of a cluster is phonologically long in case of a short vowel (/VC:C/) (Riad, 1997). The coda-internal timing of clusters should reflect this prediction in that the first consonant should be longer than the second. However, consonant duration usually is shortened in clusters as compared to singletons either in onset or coda position (Klatt, 1976). This general tendency has been reported for Swedish as well (Czigler, 1998) and has to be taken into account calculating coda-internal timing.

In Behne and Czigler (1995) syllable codas /k/, /k:/, /k:s/, and /s:k/ were compared in order to provide phonetic evidence for the quantity distinction in Swedish (Elert, 1964) to hold in consonant clusters that the first component of a consonant cluster remains phonologically long. However, the data analysed and discussed there appears to contradict their claims on quantity: the duration of /k/ in a cluster does not vary as a function of position within a cluster. If the claim for quantity in clusters holds, one would expect the phonologically length of the first component to remain also for plosives. For the coronal fricative the data in Behne and Czigler (1995) support the phonological analysis.

The aim of this study is to extend the study of Behne and Czigler (1995). To their investigated speech materials we add certain consonant clusters in order to find out whether other clusters support the quantity distinction or not. In addition, we use illegal consonant clusters of Swedish to investigate whether articulatory constraints might underlie the coda-internal timing.

Methods

Subjects

Seven speakers of Stockholm Swedish (two female and five male) participated in this experiment. All speakers are native speakers of Swedish and reported no speech or hearing impairments.

Materials and Recordings

The recordings were conducted in the recording studio of the Department of Linguistics and Phonetics at Lund university. Speech data were digitized at a samplings rate of 48 kHz with a 16 bit resolution. Subjects were instructed to read the sentences as natural as possible. Since the target words of the present investigation are nonsense words speakers were instructed to read through the sentences to familiarize themselves. They were explicitly instructed to take care of the target words since the consonant clusters varied only minimally, and since illegal consonant clusters of Swedish had to be read. The sentences were given on a paper.

The materials consisted of six different coda types and two quantity distinctions. Four tokens per item have been constructed and each sentence contained two target items. Thus, each subject read 24 sentences ((6 x 2 x 4) / 2) resulting in total of 168 sentence (24 sentences x 7 speakers). In total 336 tokens have been analysed.

The cluster patterns used are given in Table 1. The target items have been inserted in carrier phrases like *På torget kan man köpa den nya sillosten med tuckandelar.* 'At the market you can get Sill cheese with took pieces in it.'.

	[-voice]		[+voice]	
Singleton	/ V:k/	/ Vk: /	/ V:l /	/ Vl: /
Cluster 1	/ V:ks /	/ Vk:s /	/ V:lm /	/ Vl:m /
Cluster 2	/ V:sk /	/ Vs:k /	/ V:lt /	/ Vl:t /

Table 1: Consonant clusters used in the production study

Compared to Behne and Czigler (1995) eight additional clusters are used. Six of these contain a liquid as singelton or as the first part of a cluster. The remaining two, /V:ks/, /V:sk/, are added to compare the initial part of the cluster which should be phonologically short with the corresponding consonant when occurring as a singleton or as a phonologically long cluster consonant.

If two consonants follow a vowel, the vowel is generally phonologically short (Bannert, 1974; Elert, 1991). However, in the above clusters a phonologically long vowel followed by a consonant cluster might be analysed as a stem morpheme with an inflectional mopheme, e.g. a neuter 't' in /se:l + t/, thus a legal cluster in Swedish. The cluster containing a long vowel and the 'sk'-cluster is illegal in Swedish (cf. Sigurd, 1965). A rarely occurring pattern is /V:lm/ which surfaces with a coronal nasal as in *moln* 'cloud'.

Analysis

The speech data was processed in Praat (Boersma and Weenink, 2005). Target syllables were labelled. Durational measurements were obtained for (i) syllable duration, (ii) vowel duration, (iii) coda duration, (iv) coda consonant duration C1, and C2 in case of a consonant cluster. Stops were labelled from the beginning of the closure to the end of the release friction, fricatives from the beginning to the end of the aperiodic energy, vowels and sonorants from the onset to the offset of periodic energy.

Results

Vowel duration

The ratio of short/long vowel duration reveals that short vowels last approximately 65% of the duration of long vowels independent of if they are followed by a single consonant or a cluster. This holds for vowels followed by voiced codas. For vowels prior to unvoiced codas the ratio is about 10% less. A one-way ANOVA results in reliable differences between short vowels before unvoiced and voiced singeltons or clusters ($F = 8.44, p < 0,005$), but not before voiced codas ($p > 0.05$).

	before [-voice] (n=28)	before [+voice] (n=56)
Singleton	56,4	64,5
Cluster	52,7	63,3

Table 2: Ratio of short/long vowel duration before unvoiced (left) and voiced (right) codas divided by singleton and cluster codas in percent.

Singleton vs. cluster codas

Comparing the duration of the velar stop with that of the liquid we observe a general tendency for the liquid being longer than the stop (cf. Figure 1). However, this difference is not significant for all comparisons as the confidence intervals in Figure 1 show. We further observe that the duration of a consonant in a cluster lasts about 60% than that of a singleton consonant. Comparing the velar stop and the liquid in a cluster, respectively, we observe no significant difference for both /k/ and /l/ between the two clusters ($p > 0.05$).

Coda-internal timing

In Figure 2, the duration of the first consonant in a cluster is compared with the duration of the second one in the same cluster. The first consonant is considered to be a phonological long consonant. Comparing the duration of all four first

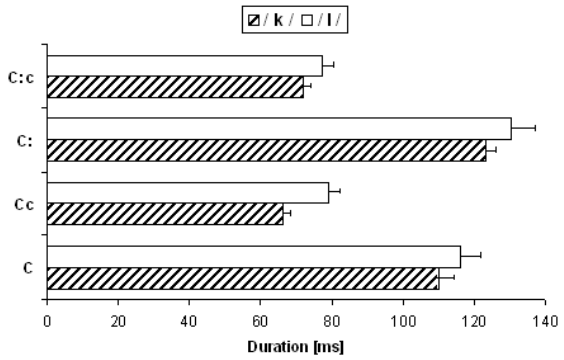

Figure 1: Mean duration of the velar stop and the liquid as singleton as well as first consonant in a cluster after short and long vowel.

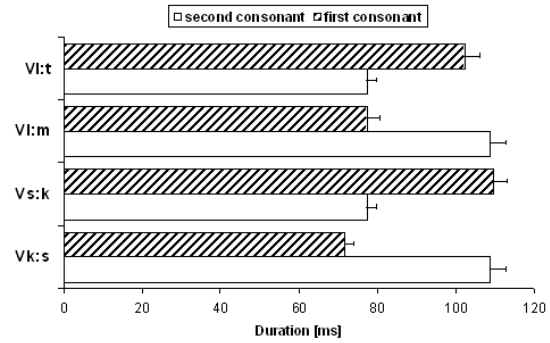

Figure 2: Mean duration of first and second consonant in consonant clusters with phonologically short vowel.

consonants with each other in Figure 2, we observe that a consonant before a stop (cluster /lt/ and /sk/) is longer than before a nasal or fricative (cluster /lm/ and /ks/) (cf. Figure 2). Conversely, the second consonant is longer if it is preceded by a liquid or stop. The same holds for consonant clusters following phonologically long vowels as shown in Figure 3.

Syllable and rime duration

Figure 4 displays mean syllable duration for all clusters contrasting clusters with phonologically long and short vowels. Generally, a syllable containing a phonologically long vowel is longer than containing a short vowel ($F = 10.104, p < 0.005$ for /ks/; $F = 7,729, p < 0.01$ for /sk/; $F = 11.437, p < 0.005$ for /lm/; $F = 8.085, p < 0.01$ for /lt/).

Considering the duration of the rime which is shown in Figure 5 no uniform picture arises. Generally, cluster duration is longer than singleton duration. However, not all vowel-cluster durations are equally long. For instance, the rime /V:k/ is longer than that of /Vk:s/.

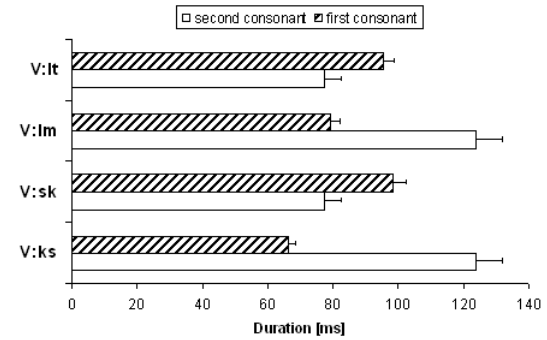

Figure 3: Mean duration of first and second consonant in consonant clusters with phonologically long vowel.

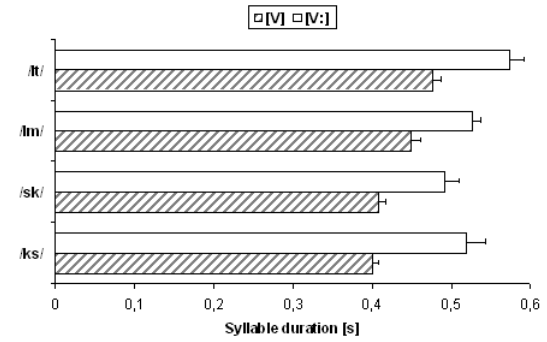

Figure 4: Mean syllable duration contrasting clusters with phonologically long and short.

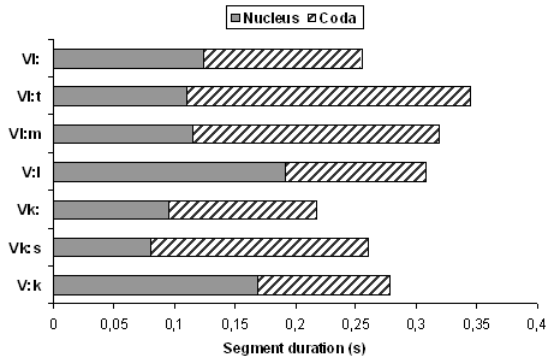

Figure 5: Mean rime duration across clusters divided by mean nucleus and coda duration.

Discussion

The durational patterns analysed in this study are in line with previous research: Concerning vowel duration our data confirm that phonologically long vowels are longer in duration than their phonologically short counterparts as shown in Table 2. This seems also to be the reason that overall syllable duration is longer for syllables containing a long vowel than for syllables with short vowels (cf. Figure 4). The ratio for short vowels before voiced codas is about 65% and corresponds to that reported in Elert (1991, 128). In addition, our data support the general tendency for vowels being relatively shorter before unvoiced codas than before voiced ones (cf. Delattre, 1962).

Comparing our data to that of Behne and Czigler (1995) we observe similar results for /k:s/ and /s:k/ clusters (cf. Figure 2) as well as for a comparison of the duration of /k/ as a singleton or as a first consonant in cluster (cf. Figure 1). This means that our data are comparable to that of Behne and Czigler.

A deviation from previous findings is the duration of /s/ before a stop in consonant clusters: According to (Klatt, 1974, 58) an /s/ as the first component of a cluster ending in a stop is shorter than in any other phonetic environment. Our data as well as the results of Behne and Czigler (1995) show an increase in /s/ duration before stops (cf. Figure 2). One could argue that this is due to the phonological length of the /s/ in this particular position (Vs:k). However, our data of an illegal cluster in Swedish (V:sk) show the same lengthening effect (cf. Figure 3). The question remains whether this lengthening effect is a language-specific effect in Swedish.

Behne and Czigler (1995) concluded from their data on /sk/ and /ks/ clusters that the first consonant of a cluster is longer than the second one and that the timing differences reflect the phonological structure, i.e. after a short vowel the first component of a consonant cluster is phonologically long (VC:C) (cf. Riad, 1997). Considering our data however shows that this is not uniformly the case. Given that we observe a timing difference for the liquid in different clusters (i.e., /lt/ and /lm/, cf. Figures 2 and 3), we conclude that the timing patterns in the cluster analysed rather reflect an articulatory constraint than a phonological one: we observe longer consonant durations before stops, a fact that explains also the findings of Behne and Czigler. Recall that they only found a significant difference for /s/, not for /k/ as the first component of a cluster. According to our conclusion the difference for /s/ is due to the fact that a stop, i.e. /k/, follows in the cluster.

From the presented timing data in Swedish we can conclude that the phonological claim a first consonant within a cluster might be phonological long in case of a preceding short vowel is not supported by phonetic evidence. Rather the data seems to provide evidence that coda-internal timing is constrained by articulatory cues. The individual consonants have an impact on the duration pattern of neighboring consonants. Therefore, the question remains whether there might be other phonetic evidence for a VC:C structure, or whether the claim of a VC:C structure might be maintained. At least, phonological quantity in Swedish is reflected by overall syllable duration (cf. Figure 4) as well as for singleton coda consonants (cf. Figure 1).

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