Postvocalic Consonant Clusters and Timing Effects in Swedish

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ABSTRACT

Previous research has provided a general picture of effects on syllable-internal timing, and offered a preliminary description of consonant clusters in Swedish. The goal of this project is to investigate the extent to which consonant duration varies in consonant clusters. Is the phonological distinction between C and C: evident in consonant duration within a consonant cluster? How does a consonant cluster in the coda affect the timing of other components of the syllable? The project currently underway aims to address these points.

INTRODUCTION

Articulatory timing and its ensuing acoustic signal are affected by a broad range of factors. Although vocalic portions of speech are believed to be more elastic than portions corresponding to consonants (Kozhevnikov and Chistovich 1965, Lehiste 1960) and have been the principle focus of timing research, the timing of consonants can also be affected (Behne and Nygaard 1991b, Gay 1978, Kozhevnikov and Chistovich 1965).

Previous research on syllable-internal timing has illustrated a variety of factors affecting consonant duration. Although speaking rate can be realized via different strategies, consonant duration tends to be shorter in fast speech than in slow speech (Behne and Nygaard 1991b, Gay, Ushijima, Hirose, and Cooper, 1974, Gay 1978, Pickett and Decker, 1960). Consonants typically are longer in stressed syllables than in nonstressed syllables (Lehiste 1960, Klatt 1974, 1976, Umeda 1975, Oller 1973). Consonant duration can also be affected by sentence position. Along with the nucleus, postvocalic consonants of a syllable are typically longer in final sentence position than in non-final sentence position (Oller 1973, Klatt 1975, Edwards and Beckman 1988). And in Swedish, the duration of a postvocalic consonant can be affected by the distinctive length of the preceding vowel. Phonologically long vowels tend to be followed by short consonants whereas phonologically short vowels typically are followed by long consonants (Elert 1964).

The duration of a single consonant is also known to differ from the duration of the same consonant in a cluster. In an early investigation of consonant clusters in Swedish, Lindblom, Lyberg and Holmgren (1976) found that consonant duration is shorter when the consonant is part of a consonant cluster than when it is a single consonant. Similarly, the overall syllable duration increases as the number of consonants increases. Fant & Kruckenberg (1989) observed that the duration of a syllable increases about 60 ms for each additional phoneme.

More recent findings (Czigler 1993a) indicate that focal accent results in a 40 ms increase of duration for a single consonant and for a consonant cluster, suggesting that focal accent has a greater effect on the relative duration of a single consonant than of a consonant cluster.

Czigler (1993b) has shown that the absolute duration of a phonologically long first consonant in an inter-vocalic consonant cluster and a phonologically short single consonant are similar. However, in terms of C/V-ratio (consonant /vowel durations), the C/V-values for the phonologically long consonants are greater than one, whereas the C/V-values for the phonologically short consonants are less than one. This finding

suggests that the phonological dichotomy "long-short" does not correspond directly with the duration of consonant segments.

Previous research has provided the base for a more extensive examination of the nature of timing and consonant clusters. For example, is the phonological distinction between C and C: evident in consonant duration within a consonant cluster or does the shortening of consonants observed by Lindblom (1976) lead to comparable durations? How does speaking rate affect the relative durations? Is there only a certain amount of relative syllable time allocated to the coda? If so, how is the relative timing of components in consonant clusters like C:C and CC affected? The goal of the present study is to investigate the extent to which consonant duration varies in consonant clusters. With that aim, in the current project we chose to focus on consonants in the coda of the syllable and to analyse the effects of five factors on consonant duration: coda type (C, C:, Cs, sC), place of articulation of the C in the coda (labial, dental, velar), speaking rate (fast, medium, slow), quality of a preceding vowel (/i/, /a/), and type of following segment (vowel, consonant).

METHOD

Subjects

Twelve subjects will be asked to participate in the study. All participants will be native speakers of standard Swedish with no history of speech or hearing impairment. Participants will be between 20 and 40 years old. To date three subjects have participated in the project.

Materials

Stimulus materials have been developed using bisyllabic, compound target words which have the form '___ost' ('___cheese') or '___host' ('___cough'). As is illustrated in Table 1, the first syllable of target words was selected based on the coda of the first syllable. In the first syllable of the target words, the coda has one of four forms: C, C:, Cs, or sC. A labial, dental and velar C was used for each type of coda. The C:, sC and Cs codas each occurred with short vowels /a/ and /i/ as the nucleus, and each C coda occurred with the corresponding long vowels. In all cases the onset of the first syllable of the target word was an oral stop.

Table 1. *Sample target words. Examples are given of the target words used for a velar stop in the consonant cluster of the coda.*

	'__ost'		'__host'	
C	tikost	takost	tikhost	takhost
C:	tickost	tackost	tickhost	tackhost
Cs	ticsost	taxost	ticshost	taxhost
sC	diskost	taskost	diskhost	taskhost

Each target word was used in a brief conversation with a statement and question produced by a laboratory assistant and a response given by the subject:

Lab Assistant: En av de nya ostarna/hostdiagnoserna heter ___.
Vad var det för ord jag sa?
(The name of a new cheese/cough-diagnosis is ___.
What was the word I said?)
Subject: Du sa ___.
(You said ___.)

Five occurrences of each target conversation were used. Intermixed with the randomized target conversations are fillers conversations, with an open question allowing a free response from the subject.

Procedure

Each subject will be asked to produce the full set of conversations seated with a laboratory assistant in a sound-attenuated, recording room. For each conversation the assistant will produce the first part of each conversation and the subject will provide the response. The subjects will be asked to respond to each question as if participating in a natural conversation.

The full set of conversations will be produced by each subject at a self-selected slow, medium, and fast speaking rate. The order of speaking rates will be counterbalanced across speakers.

The conversations will be recorded using a DAT recorder. The duration measurements summarized in Table 2 will be extracted from the last sentence of each conversation (i.e. the subjects response) using SoundScope. These measurements include the overall duration of the utterance produced by the subject, the duration of the target word, the duration of each syllable of the target word, and more detailed duration measurements within each syllable (see Table 2).

Table 2. *The measured sequences and segments. The given duration measurements were made for each target. Parentheses mark measurements which do not pertain to target words in all conditions.*

Utterance: "Du sa [target word]"	
Target Word	
Syllable 1	**Syllable 2**
Duration of:	*Duration of:*
(a) Prevocalic obstruent	(a) Fricative /h/ alt. pause
i. Closure	(b) Vowel /o/
ii. Burst/aspiration	(c) Fricative /s/
(b) Vowel	(d) Closure /t/
(c) (Fricative /s/)	(e) Burst/aspiration /t/
(d) Postvocalic obstruent	
i. Preocclusion aspiration	
ii. Closure	
iii. Burst/aspiration	
(e) (Fricative /s/)	

ANALYSIS AND DISCUSSION

A five-way analysis of variance will be calculated for each measurement with coda type (C, C:, Cs, sC), place of articulation of the C in the coda (labial, dental, velar), speaking rate (fast, medium, slow), vowel quality (/i/, /a/), and type of following segment (V of 'ost', C of 'host') as independent variables. Based on this analysis and further comparisons, two questions will be addressed. First, is the phonological distinction between C and C: evident from consonant durations within a consonant cluster? If so, the duration of consonants in C and C: codas should differ. And second, is there only a certain amount of relative syllable time allocated to the coda? If there is, we would expect that speaking rate would have a different affect on the duration of consonants in C: codas than those in the Cs or sC codas, however no difference would be expected between the durations of consonants in the Cs and sC codas. In particular, based on Behne and Nygaard (1993) it is expected that with increased speaking rate the duration of consonants with Cs and sC codas will reach an upper limit whereas the shorter C and C: will not.

Research on English (Behne and Nygaard 1991a, 1991b, 1993) and preliminary findings for Norwegian (Behne and Moxness 1994) suggest relative upper and lower limits on the duration of the rhyme. This pattern has been particularly evident when several factors affecting segment duration co-occur. Based on the postvocalic consonant clusters in the current project we also plan to examine whether comparable limits may pertain to the segmental components of the coda (i.e. the components of a consonant cluster), and/or to a level comparable to the phonological notions of a nucleus and coda.

In summary, results from the project currently under way are expected to lead to a fuller characterization of the timing within consonant clusters and concurrent affects on timing within the syllable as a whole.

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