MULTIPLE EFFECTS ON SYLLABLE-INTERNAL TIMING IN NORWEGIAN

Dawn M. Behne and Bente H. Moxness
University of Trondheim, N-7055 Dragvoll, Norway

ABSTRACT

This study examines the concurrent effects of rate, stress, postvocalic voicing and distinctive length on timing in Norwegian C_1VC_2s. Findings suggest that the similar timing patterns associated with postvocalic voicing and phonological length may be distinguished by the timing of C_1. A consistent pattern of results was observed for focal and nonfocal conditions across speaking rates.

INTRODUCTION

The duration of phonetic segments is known to be affected by a variety of factors. When this occurs, the duration and relative timing of other components within a syllable can also be affected. Four factors which are known to affect segment durations in languages are speaking rate, focal stress, postvocalic voicing, and distinctive length. These factors all occur in Norwegian and constitute the basis for this investigation.

Background

Speaking Rate. For many languages, research has shown that segment durations within a syllable are affected by speaking rate. Although speakers may use different strategies to vary speaking rate, both vowels and consonants within syllables produced at a slow rate tend to be longer in duration than those produced at a fast speaking rate (e.g., [1]). Effects of speaking rate on segment durations specific to Norwegian have not been reported, but the general pattern of results observed for other languages is expected.

Stress. The duration of a segments within a syllable can also be affected by stress. Research on the effects of stress on segment duration in Norwegian and other languages has shown that vowels in stressed syllables are typically longer than those in nonstressed syllables and that the duration of consonants within the syllable may be similarly affected (e.g., [2][3]).

Postvocalic Voicing. Vowel duration can also be affected by the voicing of a following consonant. Vowels preceding a voiced consonant are typically longer than those preceding a voiceless consonant (e.g., [4]). This pattern has been observed in Norwegian words such as *takk* [tɑk:] "thanks" versus *tagg* [tɑ:g:] "thorn" [2][5]. Cooccurring with the effect on vowel duration, for many languages, including Norwegian, a postvocalic voiceless consonant has generally been found to be longer than a postvocalic voiced consonant (e.g., [2]).

Distinctive Length. Phonological distinctions can also be realized by means of segment durations within the syllable rhyme. Norwegian has traditionally been described as having a phonological distinction between short and long vowels. Accompanying this vowel length distinction is a difference in postvocalic consonant length. The phonotactics of Norwegian are such that, in a closed syllable, a distinctively long vowel tends to be followed by a short consonant, and a distinctively short vowel typically is followed by a long consonant. For example, the word "takk" [tɑk:] *thanks* has a distinctively short vowel followed by a long consonant compared to "tak" [tɑ:k] *hold* which has a distinctively long vowelfollowed by a short consonant. This quantity distinction of Norwegian vowels [2][6] and consonants[2] is also realized acoustically.

Current Investigation

Previous research suggests that speaking rate and stress have a relatively global affect on the duration of segments within a syllable, whereas postvocalic voicing and distinctive length principally affect segment durations within the rhyme, with an inverse relationship between the duration of a vowel and postvocalic consonant.

Recent findings suggest that in Norwegian [6] effects of postvocalic voicing and distinctive length might not be limited to the rhyme, and that prevocalic consonant duration may also be affected. In Norwegian, the of a prevocalic consonant duration was found to decrease with increased vowel duration due to postvocalic voicing, whereas the duration of a prevocalic consonant increased immediately preceding a phonologically long vowel. These timing patterns have been observed in both focal and non-focal conditions in Norwegian [2] and suggest that the duration of a prevocalic consonant may assist in distinguishing the similar timing patterns within the rhyme associated with postvocalic voicing and distinctive length.

In fluent speech segment durations reflect the concurrent influence of speaking rate, focal stress, postvocalic voicing and distinctive length. The present study extends previous research and investigates whether the timing patterns observed for postvocalic voicing and distinctive length in non-focal and focal conditions are affected by the relatively robust affects of speaking rate.

METHOD

Stimuli

Twelve target words were used in the investigation. All target words were real CVCs containing /i,ɔ,ɑ/ or /i:,ɔ:,ɑ:/ and a postvocalic /k/ or /g/. The initial consonant was either a stop or a fricative.

Brief dialogues were developed for each target word. Each conversation consisted of a question and a response. For each target word the set of conversations was balanced to include the target word as focused and nonfocused in both initial and final sentence position.

Subjects

The subjects were 9 native speakers of Norwegian between 20 and 30 years old with no history of speech or hearing impairment.

Procedure

Recordings were made of each subject producing the full set of conversations with an experimenter in a sound attenuated room. For each conversation the experimenter asked the question and the subject read the response. The full set of conversations was produced by each subject at a self-selected slow, medium and fast speaking rate. Subjects were encouraged to speak as if participating in a natural conversation.

Measurements

Three measurements were made within target C_1VC_2 from subjects' responses in each conversation: (1) frication/closure duration of C_1, (2) vowel duration, and (3) closure duration of C_2. Frication was measured from the beginning to the end of the aperiodic energy. Closure durations were measured from the start of the closure to the beginning of the release. Vowel duration was measured from the onset to the end of periodic energy.

RESULTS

For each of the three measures, a four way analysis of variance was calculated with speaking rate (fast, medium, slow), focus (nonfocal, focal), postvocalic voicing (voiceless C_2, voiced C_2), and distinctive length (short vowel, long vowel) as independent variables. Main effects were observed for all three measures.

Speaking Rate

Effects of speaking rate on segment durations are illustrated across panel columns in Figures 1 and 2. Speaking rate was found to affect the durations of C_1 [$F=109.30$, $p<.0001$], V [$F=241.75$, $p<.0001$], and C_2 [$F=214.24$, $p<.0001$]. For all three segments durations were reliably shorter at the fast rate than at the medium rate [F of $C_1=77.30$, $p<.0001$; F of $V=97.82$, $p<.0001$; F of $C_2=195.74$, $p<.0001$], which in turn were shorter than at the slow rate [F of $C_1=34.79$, $p<.0001$; F of $V=145.79$, $p<.0001$; F of $C_2=38.64$, $p<.0001$]. These findings are consistent with previous research showing that speaking rate has a relatively global affect on segment durations within a syllable, affecting both vowel and consonant durations.

Focal Stress

Main effects of focal stress was also observed for all three segment durations. As a comparison of the panel rows in Figures 1 and 2 illustrates, C_1 [$F=121.79$, $p<.0001$], V [$F=118.63$, $p<.0001$], and C_2 [$F=92.82$, $p<.0001$] durations were longer in the focal condition than the nonfocal condition.

Data were further analyzed to determine whether focus affected segment durations at each of the speaking rates. Reliable differences due to focus were observed for all three segment measures at the fast [F of $C_1=49.18$, $p<.0001$; F of $V=51.32$, $p<.0001$; F of $C_2=21.28$, $p<.0001$], medium [F of $C_1=51.42$ $p<.0001$; F of $V=43.66$, $p<.0001$; F of $C_2=51.78$, $p<.0001$],

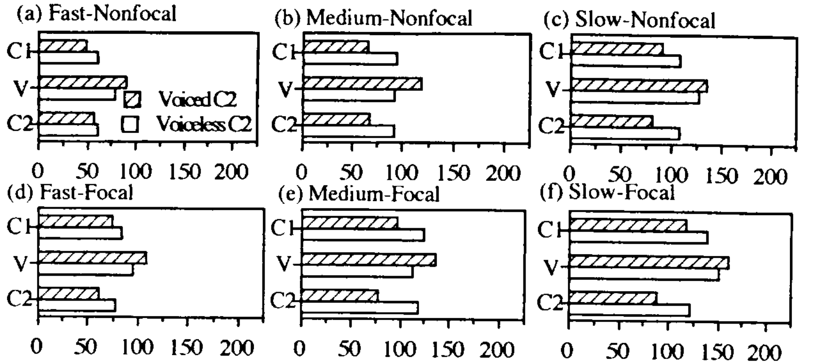

Figure 1. Mean segment durations with postvocalic voiced and voiceless consonants in nonfocal (top row) and focal conditions (bottom row) at fast (left column), medium (center column), and slow (right column) speaking rates.

and slow [F of C_1=29.87, p<.0001; F of C_2=35.99, p<.0001; F of V=22.81, p<.0001] speaking rates. These results support previous findings showing that focal stress tends to have a general effect on segment durations within a syllable [2].

<u>Postvocalic Voicing</u>. Main effects show that postvocalic voicing affected the duration of C_1, V, and C_2. As is demonstrated in Figure 1, the duration of C_1 is shorter when the postvocalic consonant is voiced than when it is voiceless [F=58.44, p<.0001]. Vowel duration is longer before a voiced consonant than before a voiceless consonant [F=69.47, p<.0001]. In addition, C_2 is shorter when it is voiced than when it is voiceless [F=293.93, p<.001]. As the results summarized in Table 1 and the means in Figure 1 show, this same pattern of results was observed for nonfocal and focal conditions at all three speaking rates. However, in some cases differences were not statistically reliable. Most notably, vowel duration was not affected by postvocalic voicing in either the nonfocal or focal condition at the slow speaking rate. Comparable results have been reported for English in conditions when multiple linguistic factors lead to increased segment duration [7], tentatively suggesting a vague upper limit on the duration of segments within a syllable. Similarly, at the fast speaking rate, although the expected pattern of results was obtained, no reliable difference was

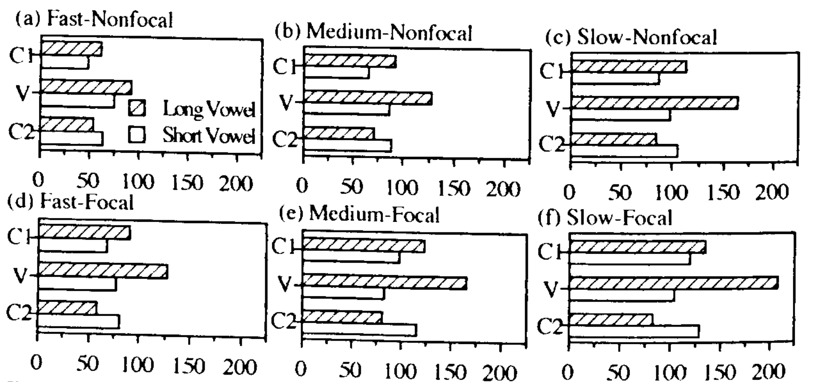

Figure 2. Mean segment durations (in ms) for distinctively short and long vowels in nonfocal (top row) and focal conditions (bottom row) at fast (left column), medium (center column), and slow (right column) speaking rates.

Table 1. F-values and probabilities for C_1, V, and C_2 for postvocalic voicing and distinctive length within the nonfocal and focal conditions at fast, medium and slow speaking rates.

Timing Factors		Postvocalic Voicing			Distinctive Length		
		C_1	V	C_2	C_1	V	C_2
FAST RATE	Nonfocal	F=6.57 p<.0111	F=19.14 p<.0001	F=2.64 n.s.	F=7.09 p<.0084	F=40.25 p<.0001	F=7.095 p<.0083
	Focal	F=3.70 n.s.	F=13.26 p<.0003	F=32.01 p<.0111	F=19.49 p<.0001	F=172.93 p<.0001	F=44.18 p<.0111
MEDIUM RATE	Nonfocal	F=24.85 p<.0001	F=59.27 p<.0001	F=45.50 p<.0001	F=20.63 p<.0001	F=146.86 p<.0001	F=16.36 p<.0001
	Focal	F=16.50 p<.0001	F=26.79 p<.0001	F=123.94 p<.0001	F=14.65 p<.0002	F=349.27 p<.0001	F=95.12 p<.0111
SLOW RATE	Nonfocal	F=5.04 p<.0257	F=1.90 n.s.	F=47.86 p<.0001	F=10.98 p<.0001	F=133.99 p<.0001	F=30.95 p<.0001
	Focal	F=9.44 p<.0024	F=2.32 n.s.	F=93.23 p<.0001	F=4.97 p<.0268	F=283.08 p<.0001	F=175.95 p<.0001

observed for duration of C_1 in the focal condition or C_2 in the nonfocal condition.

Overall, findings for postvocalic voicing show the expected inverse relationship between the vowel and postvocalic consonant durations and. results for C_1 suggest that it may also assist in cuing postvocalic voicing.

<u>Distinctive Vowel Length</u>. Results for distinctive length show that the duration of C_1 is longer before distinctively long vowels than before distinctively short vowels [F=69.84,p<.0001]. The mean duration of distinctively long vowels is longer than the duration of distinctively short vowels [F=1050.63, p<.001] and C_2 is shorter following distinctively long vowels than following distinctively short vowels [F=287.18, p<.001]. As Figure 2 and the right side of Table 1 illustrate, this timing pattern was reliably observed in nonfocal and focal conditions at the fast, medium, and slow speaking rates. These findings suggest that distinctive length is reflected in the acoustic signal by the duration of the vowel, by the inverse relationship between the V and C_2 duration, and by the duration of C_1.

CONCLUSIONS

The results indicate that speaking rate and focal stress has a global affect on syllable-internal timing. The effects of distinctive vowel length and postvocalic voicing have an inverse effect on the duration of a vowel and postvocalic consonant within the rhyme. However, despite their similar effects on rhyme-internal timing, postvocalic voicing and distinctive vowel length have different effects on the duration of the prevocalic consonant. This pattern was observed in nonfocal and focal conditions across speaking rates. The robust nature of the timing patterns for the prevocalic consonant suggest that it may assist in distinquishing the similiar timing patterns of the rhyme associated with postvocalic voicing and distinctive length.

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