PREASPIRATION IN INTERVOCALIC /k/ VS. /g/ IN NORWEGIAN

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ABSTRACT

This paper investigates the possible contribution of preaspiration to the realization of intervocalic velar stops in Norwegian. A group of 24 native speakers was recorded producing sentence-embedded disyllables containing intervocalic /k/ vs. /g/. Subsequent measurements of segment durations involved the following segments: preconsonantal vowel, breathy part of the vowel (/k/), preaspiration (/k/), consonantal closure, voicing (/g/) and postaspiration (/k/)/consonantal release (/g/). The data collected were used to investigate three different alternatives concerning the realization of preaspiration: (1) Preaspiration is part of the vowel. (2) Preaspiration is part of the consonant. (3) Preaspiration is a segment in its own right. Results of correlation analyses investigating the three hypotheses seemed to rule out alternatives (1) and (2) and to favor the status of preaspiration as an independent segment. It is speculated that preaspiration may be considered to be an additional feature reinforcing the voiced-voiceless distinction.

1. INTRODUCTION

Stop consonants occur in all the known languages of the world and the feature of postaspiration is frequently used to distinguish between different variations of stops [5]. This feature is so common that it is often simply called aspiration. However, in a relatively small number of languages voiceless stops are found to contain preaspiration, i.e. an aspiration phase preceding the oral closure, the probably best-known example being Icelandic [3, 7]. Since the duration of preaspiration in Icelandic normally is much longer than that of postaspiration, Thráinsson [8] argues that the former is not simply the reverse of the latter. In modern Norwegian, preaspiration seems to be a less important feature, which is only present in a limited number of dialects [9, 10]. Investigating this phenomenon for ten speakers of a Trondheim dialect, Moxness [6] found preaspiration to be one of the constituting features in the production of intervocalic voiceless plosives. The present study was designed to investigate whether the trends found in Moxness' study could be verified and extended for an other group of speakers with varying dialectal background. A further aim was to explore the articulatory control mechanism underlying the realization of preaspiration, specifically as far as temporal coordination is concerned (for a discussion of the literature see [10]). There seem to be at least three different possible alternatives: (1) Preaspiration is part of the vowel and is implemented by an early opening of the glottis during the vowel. This hypothesis predicts a negative correlation between vowel duration and preaspiration duration. (2) Preaspiration is part of the consonant and characterized by a delayed closing of the vocal tract for the intervocalic consonant. In this case, a negative correlation between preaspiration and consonantal closure duration is postulated. (3) Preaspiration is a segment in its own right which is inserted between the vowel and the following consonant. This hypothesis predicts a positive relationship between the duration of preaspiration and that from the onset of the vowel to the end of the consonantal closure. These three hypotheses will be tested by means of regression analysis.

2. PROCEDURE

2.1. Recordings

To investigate the realization of the voiceless/voiced distinction, for the present investigation the words 'lake' /ˈla:kə/ ('brine') and 'lage' /ˈla:gə/ ('(to) make') were chosen as speech material. A group of 24 subjects having different dialectal backgrounds served as speakers. They were aged 19-33 years; one speaker was 62 years old. DAT-recordings were made in the sound-proof studio of the Department of Linguistics. 14 different Norwegian words, among them 'lake' and 'lage', were presented as test words on a computer screen five times in a row. For each speaker and each repetition the words were presented in a different randomised order. The speakers were asked to produce the test words in the carrier phrase 'Det var ... jeg sa' ('It was ... I said'). The speech material was stored as Signalyze™ files with a sampling rate of 44.1 kHz and 16 bit resolution.

2.2. Analysis

For the present purposes, only the words 'lake' and 'lage' were analysed. Using Signalyze™ [4] the following segment durations were measured. In 'lake' (Figure 1; SOUND 0127_01.WAV): the /a:/ vowel followed by a breathy part with reduced formant amplitude, preaspiration, consonantal closure and postaspiration. Criterion for the starting point of preaspiration was the presence of clear friction of relatively strong amplitude. In a number of cases, the beginning of the preaspiration phase defined in this way contained a certain amount of voicing. Segments measured in 'lage' were the /a:/ vowel, voicing duration during the /g/ closure, the closure itself and the release burst (Figure 2; SOUND 0127_02.WAV).

3. RESULTS

3.1. Pooled data

The discussion in this section will focus on the pooled data for the whole group of 24 subjects. The corresponding means for the segment durations in 'lake' based on 120 observations are presented in Table 1. From the data it can be seen that for the present group of speakers preaspiration is an important component in the realization of the voiceless medial plosive. On an average, the last 23 ms portion of the vowel has a breathy quality while the duration of the actual preaspiration phase amounts to 32 ms. Thus, a signal portion of 55 ms in total shows the laryngeal setting that is typical for the articulation under scrutiny.

It should be noted that individual speakers showed rather strongly varying behavior. For example, the shortest mean breathy vowel portion measured for one of the speakers was merely 10 ms, whereas the longest mean amounted to 59 ms. Similarly, the mean durations for preaspiration varied between 13

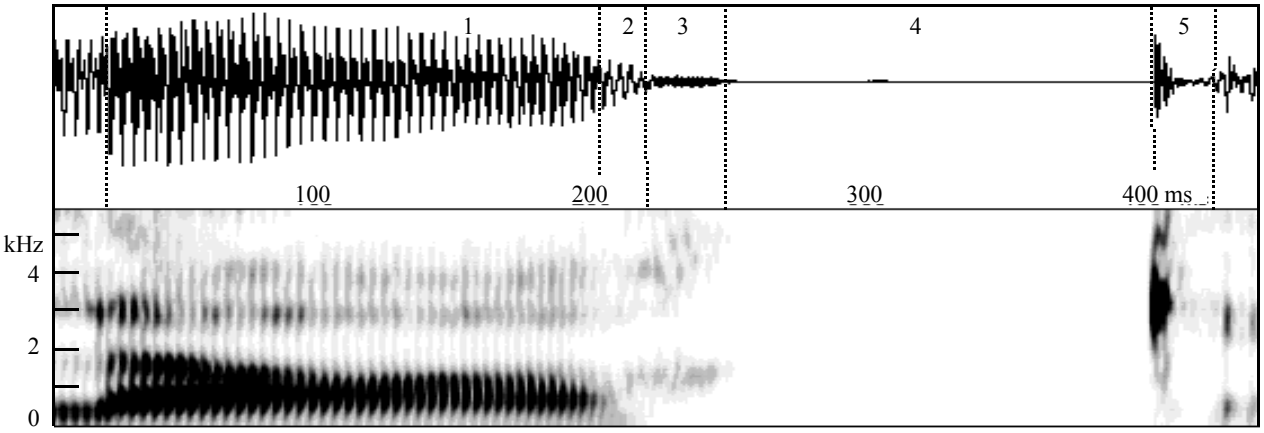

Figure 1. Waveform and spectrogram (filter bandwidth 200Hz) of 'lake' produced by a female speaker. Segments indicated are: (1) vowel; (2) breathy part of the vowel; (3) preaspiration; (4) closure; (5) postaspiration.

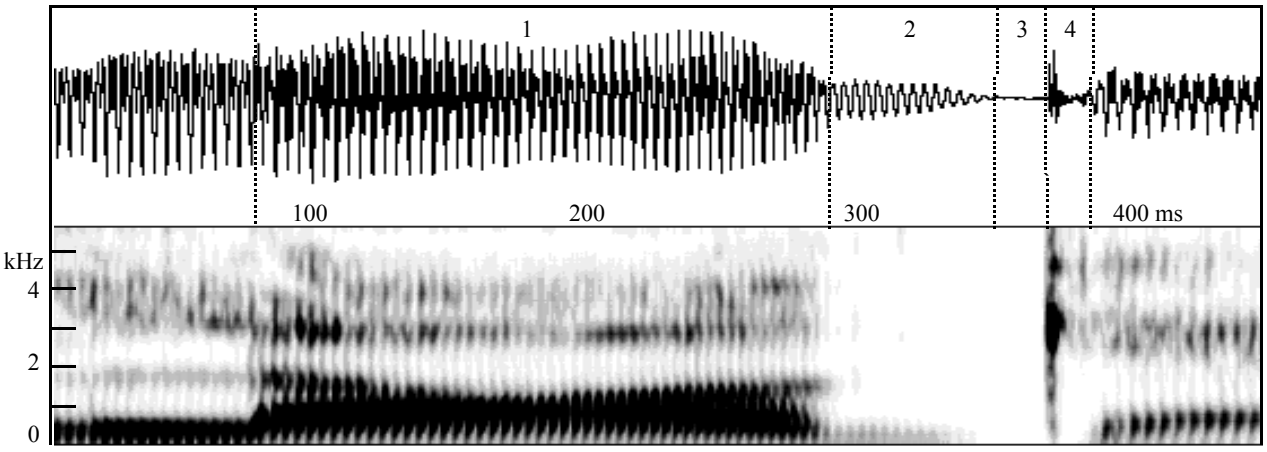

Figure 2. Waveform and spectrogram (filter bandwidth 200Hz) of 'lage' produced by a female speaker. Segments indicated are: (1) vowel; (2) voicing during closure; (2+3) closure; (4) release burst.

ms and 87 ms. In the next section it will be shown that these inter-subject differences are dialect-related rather than idiosyncratic.

As is shown by the data for the whole group of speakers presented in Table 2, the realizations of 'lage' show a temporal structure that is quite different from that found for 'lake': With a mean duration of 222ms the vowel is significantly longer ($t(238)= -13.70$; $p< .0001$), while closure duration is shorter ($t(238)= 11.68$; $p< .0001$). Different from the voiceless stop, the voiced velar does not contain any preaspiration but is filled with approximately 81% voicing.

3.2. Dialectal differences

In the following discussion the group of 24 subjects will be divided into two subgroups containing 5 and 19 subjects, respectively. Subjects belonging to the former group were speaking dialects that are traditionally regarded to have preaspiration as one of the typical characteristics (Rogaland and Stavanger: 2 subjects each; Northern Gudbrandsdal: 1 subject). This group is indicated as the "preasp" group in Tables 1 and 2. Twelve out of the 19 speakers from the second subgroup had a Trøndelag background, while the seven remaining speakers spoke dialects from regions south of Trondheim. Since the preaspiration duration measured for the latter seven speakers did not differ significantly from that for the twelve subjects from Trøndelag, the data for these groups were pooled (indicated as "remaining" in Tables 1 and 2).

Moxness [6] reported a mean value of 20 ms for preaspiration in /pVkə/ words, where V= /i:/, /a:/ or /u:/. In comparison, the present value of 32 ms could seem to be rather high. However, the seeming discrepancy can be explained by the following two considerations. First, from Moxness' description it can be deduced that preaspiration was found to be longer following the vowel /a:/ than following /i:/ or /u:/ (separate values for /a:/ are not given). A second, more important factor is the influence of the dialectal background of the speakers. Whereas Moxness used a homogeneous group of subjects speaking a Trøndelag variant, the inclusion of the present five speakers of "preaspiration" dialects appeared to have a substantial influence on the mean realization of preaspiration. Inspection of the data for those five speakers revealed that they had a mean preaspiration duration of 58 ms, which is

Subjects	n	vowel	breathy part of vowel	preaspiration	closure	postaspiration
all	120	166 (31)	23 (12)	32 (20)	119 (26)	23 (8)
preasp	25	177 (30)	22 (10)	58 (28)	126 (19)	26 (11)
remaining	95	163 (30)	23 (13)	25 (10)	117 (27)	22 (7)

Table 1. Segment durations (mean and standard deviation) in ms in context-embedded 'lake' for all the 24 subjects, 5 speakers from a "preaspiration" dialect (preasp) and the remaining speakers. The segments correspond to parts (1)-(5) in Figure 1.

Subjects	n	vowel	voicing	closure	release
all	120	222 (33)	68 (24)	84 (21)	12 (8)
preasp	25	243 (37)	55 (37)	107 (20)	17 (7)
remaining	95	217 (30)	71 (18)	78 (16)	11 (8)

Table 2. Segment durations (mean and standard deviation) in ms in context-embedded 'lage' for the same groups as indicated in Table 1. The segments correspond to parts (1)-(4) in Figure 2.

significantly longer than the duration of 25 ms measured for the remaining 19 subjects ($t(118)= 9.34$; $p< .0001$). The latter value seems to harmonise pretty well with the one found by Moxness.

The mean durations of the other segments in 'lake' spoken by the subgroup of five speakers did not differ substantially from those found for the other speakers. The difference found for vowel duration (177 ms vs 163 ms), though statistically significant ($t(118)=2.16$; $p= .033$), seems to be of only marginal importance. Further, the differences for the durations of the breathy part of the vowel (22 ms vs 23 ms) and closure duration (126 ms vs 117 ms) are statistically nonsignificant ($t(118)= -.64$; $p= .521$ and $t(118)= 1.43$; $p= .156$, respectively). Finally, the five subjects speaking "preaspiration" dialects produced a marginally longer postaspiration (26 ms vs 22 ms; $t(118)= 2.08$; $p= .040$).

Drawing a tentative conclusion from these comparisons it can be stated that the main acoustic manifestation of the feature "preaspiration" is the signal portion in 'lake' that has been defined as such in the present investigation: It is this phase that distinguishes the realizations of the present two subgroups. In contrast, the breathy part of the vowel does not seem to play a constituting role since its duration was the same for the two groups. Presumably, the breathy part can be considered to be merely the articulatory preparation of the following preaspiration which does not play a distinguishing role in itself.

Together with the results for 'lake' the mean segment durations in 'lage' spoken by each of the two subgroups seem to suggest different strategies for the realization of the voiced-voiceless distinction. The "preaspiration" group has a relatively long /g/ closure (C/V-ratio= .44) that is only partly filled with voicing (51%). In contrast, the remaining speakers' /g/ closure is shorter (C/V-ratio= .36) and largely filled with voicing (91%).

3.3. Sex-specific differences

Previous studies have pointed out that the manifestation of preaspiration is, among other things, affected by speaker sex [1, 2]. Especially, the glottal abduction during the final part of the vowel resulting in breathiness has been found to be more marked for female voices. It seems reasonable to assume that this is due to anatomical differences between the female and the male larynx. It was investigated whether sex-related differences in the production of preaspiration can be found in the present data. To that aim, the five speakers of a "preaspiration" dialect (four females, one male) were excluded from the data. Among the remaining 19 subjects there were merely four men so that our conclusions can only be of a preliminary character.

Inspection of the data showed that the duration of the preaspiration phase was the same for the two sexes (25 ms for the females vs 24 ms for the males; $t(93)= -.523$; $p= .602$). However, for the female voices the breathy part of the vowel in 'lake' was found to be longer than for the males (25 ms vs 17 ms). This difference, though not large, turned out to be statistically significant ($t(93)= -2.47$; $p= .015$).

3.4. Regression analyses

The aim of this section is to find a preliminary answer to the question whether preaspiration must be regarded to be an inherent part of other segments or has the status of a segment in its own right. In order to investigate the three different hypotheses formulated in the introduction, three regression analyses were performed to establish the relations between the durations of the following segments in 'lake':

(a) preaspiration and vowel,
(b) preaspiration and closure,
(c) preaspiration and the part from the onset of the vowel to the end of the consonantal closure.

vowel	closure	vpacl
$r= .055$	$r= -.040$	$r= .391$
$p< .552$	$p< .666$	$p< .0001$

Table 3. Correlation coefficients (r) and statistical probabilities (p) for durational correlations between preaspiration and vowel, closure and the total of vowel, preaspiration plus closure (vpacl). n= 120.

Table 3 presents the product-moment correlation coefficients that resulted from the regression analyses for the variables indicated above. From the table it appears that the correlations between preaspiration and vowel duration as well as between preaspiration and closure duration are very weak and far from statistically significant. Therefore, the type of the correlations as positive and negative, respectively, can safely be said to be irrelevant.

In contrast with these results the third correlation turned out to be statistically highly significant. The relationship between preaspiration duration and the total duration of vowel, preaspiration plus closure is positive (Figure 3). This kind of relationship can be expected for a correlation between the

duration of an independent segment and the duration of that segment plus one or more adjacent segments.

It could be speculated that a longer preaspiration duration is a consequence of a generally slower speech rate. However, the nonsignificant correlations between preaspiration and vowel/closure duration indicate that this is not the case. This conclusion is underpinned by the nonsignificant correlation between preaspiration and the total duration of the vowel plus the consonantal closure excluding preaspiration (r= -.017; p= .854).

The joint results from the regression analyses allow the conclusion that preaspiration is neither a part of the vowel nor belongs to the medial plosive in 'lake'. Rather, it has to be ascribed the status of an independent segment.

4. CONCLUSION

The results of the present investigation suggest that preaspiration of intervocalic stops in Norwegian is a relatively common phenomenon. Especially marked preaspiration was found four five speakers of dialects that traditionally are considered to have preaspiration as one of their characteristic features. It seems reasonable to distinguish two different stages in the acoustic manifestation of the feature "preaspiration". The first stage is characterized by a glottal abduction during the last part of the preconsonantal vowel giving rise to a breathy quality. The present data indicate that the duration of this breathy part varies with speaker sex, female voices showing more marked breathiness. The second stage involves a mainly voiceless glottal friction. For the present purposes, this phase was defined as preaspiration. It was the duration of this part of the speech signal that distinguished between the speakers of the "preaspiration" dialects and the others.

The data showed that the group of speakers with strong preaspiration also differed from the other subjects with regard to the realization of the intervocalic voiced stop. This seems to allow the conclusion that preaspiration is one of the constituting factors involved in the realization of the voiced/voiceless opposition in their dialects.

Finally, from regression analyses it appeared that preaspiration underlyingly belongs to neither the preconsonantal vowel nor the stop consonant itself but rather can be regarded to be an independent segment which is inserted between these two segments.

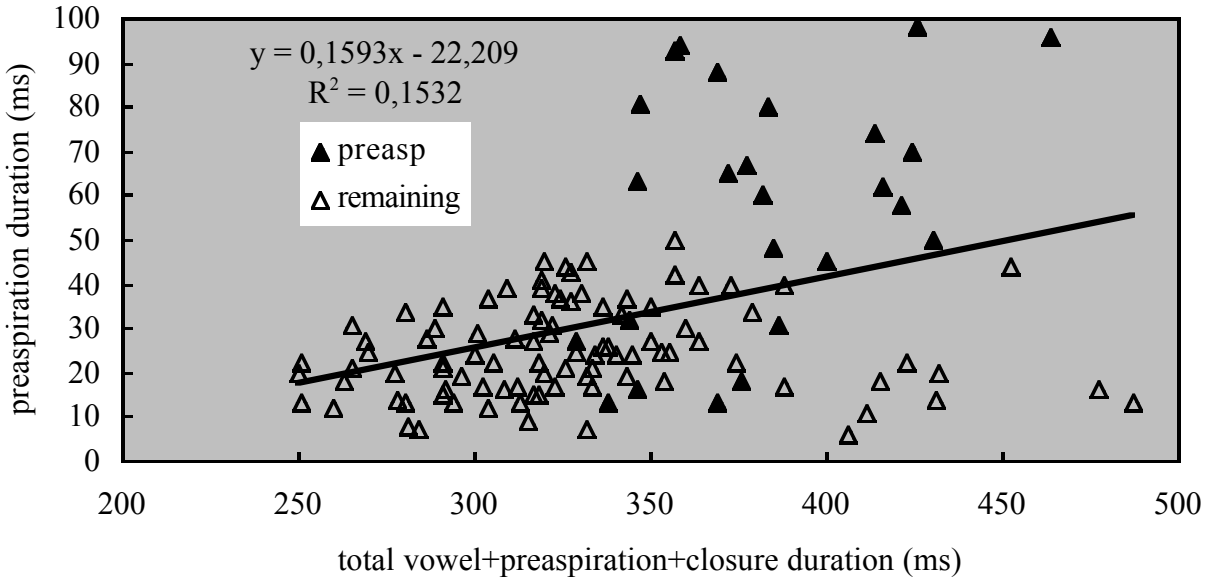

Figure 3. Preaspiration duration plotted against total vowel+preaspiration+closure duration in 'lake'. Indicated is the regression line for the data pooled across the speakers of "preaspiration" dialects and the remaining speakers (cf. Table 1).

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