ABSTRACT
This paper is concerned with a systematical investigation of speakers of various southern Swedish dialects, showing that preaspiration is more typical for women's speech. Evidence is found in that preaspiration occurs more frequently for this group of speakers and that its duration is generally longer.

1. INTRODUCTION
Preaspirated voiceless stops have been observed in various Scandinavian languages. It occurs in Icelandic and in some Swedish and Norwegian dialects. Preaspiration seems to be a obligatory/normative phonetic feature for Icelandic but optional/non-normative for Swedish [1]. Preaspiration is not known to be a phonological contrast in any language [2].

It has been shown that for Norwegian the duration of preaspiration is varied between different speaker categories in that older female speakers (age 21-40) produced the longest preaspiration and male speakers of the same age group the shortest. However no clear difference in preaspiration length between gender was found for a younger generation, who produced preaspiration with a length intermediate to the two gender groups of older age [3].

When preparing the speech material for the database of the Swedish project SweDia 2000 [4] (<http://www.swedia.nu/>), it could be observed, that preaspiration not only materialized in northern Swedish dialects but also in southern dialects, which belong to the geographic area of Götaland. The spontaneous impression was that it was mainly women of an older age group who produced preaspirated voiceless stops. Therefore, the frequency of occurence of preaspiration was investigated for different groups of speakers, who belong to two different age categories and different gender.

Furthermore the duration of aspiration was investigated, i.e.: is it longest for older women, so that the spontaneous impression arises that it's they who produce preaspirated stops? A confirmation of this assumption from the data would be coherent with findings from Norwegian [3].

2. THE INVESTIGATION
The investigation consists of two parts. First, the frequency of preaspiration is examined across the complete enquired material and compared between different speaker categories. Secondly, the average of the measured duration of preaspiration is calculated for each word and compared between the different speaker categories.

2.1. Material and Method
The speech material investigated here is part of the speech database of the dialect project SweDia 2000. The selection contains two word pairs, showing quantity contrast. More specifically, the words are tak ([tak], 'roof'), tack ([tak]: 'thanks') and lott ([lott], 'song') and lotl ([lotl], 'share'). These words were elicited by the speaker having to answer a question with the target word (e.g. question: "What do you find on top of a house?", answer: 'roof'; in Swedish it is possible to avoid the indefinite article in such a case) and then repeating it up to five times. Samples were produced by all together 180 speakers. The speakers came from 15 towns scattered all over the south of Sweden (Götaland). For each town 2-4 speakers represented each of the following four groups: older women and older men (55-75 years old), younger women and younger men (20-30 years old). The geographic distribution of the towns is shown in Fig. 1. The recordings were made mainly in the speakers' homes, where care was taken to avoid major acoustic disturbances, like ticking clocks and echo effects.

![Figure 1: Geographic distribution of the towns in the south of Sweden, from where the speech samples originate.](image)

The recordings were made on portable DAT-recorders and later transferred to digital workstations. First, automatic segmentation and labeling of the target words was carried out [5] and then the results had to be adjusted manually. For the manual adjustment a locally developed speech workbench was used (SwediaDbh, [5]). The beginning and end of each word was marked as well as the beginning and end of each vowel and the beginning and end of the occlusion of the word final stop (see Fig. 2, n. b.: all investigated words end with a voiceless stop).
The end of the vowel was set to the point where the formants' intensities decreased abruptly. This place was not always consistent with the beginning of the occlusive phase of the word final stop. In many cases frication noise preceded by a breathy part of the vowel occurred between a modal offset of the vowel and the beginning of the occlusion.

For the purpose of the present investigation the data was analysed as follows:

- To account for the frequency of occurrence of preaspiration the number of labeled preaspirations were counted for each speaker and target word and matched against the absolute number each target word was uttered by each speaker. A comparison of the average frequency of preaspiration between the different speaker categories, i.e. age and gender, was then carried out.

- In addition, the duration of each labeled preaspiration was measured. The average duration for each speaker category was compared for each target word (t-test). For the purpose of normalising speech rate, the ratio of the duration of preaspiration to word length was calculated, too.

### 2.2. Frequency of occurrence: results

Preaspiration did not occur equally often for the different target words, as can be seen in Fig. 3. On average the speakers preaspirated most frequently the final stop in the word *lott* (58%, 81%), less frequently in *låt* (51%, 68%), even less in *tack* (30%, 38%), and least frequently in the word *tak* (17%, 20%). It can also be seen in Fig. 3 that women produced more preaspiration on average than men for all words. However, the difference was stronger for the words, which were produced generally more frequently with preaspiration: 23% for *lott*, 17% for *låt*, 8% for *tack*, but only 3% for *tak*.

A comparison concerned with the age of the speakers showed that younger speakers produced preaspiration clearly more frequently than the older speakers in those words which show more preaspiration in general, which are *låt* (19%) and *lott* (20%). The difference between age groups was not that apparent for the word *tack* (4%). For the word *tak* the reverse showed: speakers of the older age group preaspirated the stop more frequently, although with a minor difference only (3%).

**Figure 3:** The average frequency of produced preaspiration for female (w) and male (m) speakers and for each word.

**Figure 4:** The average frequency of produced preaspiration for older (o) and younger (y) speakers and for each word.

**Figure 5:** The average frequency of produced preaspiration for older and younger, female and male speakers and for each word.

A closer look at the frequency of occurrence in each particular speaker category shows the that the word *tak* is most frequently produced with a preaspirated stop by older women (ow, 23%), slightly less frequently by younger women (yw,
19%) and equally least frequently by older and younger men (om & ym, 17%). However, there is only little difference between all the four categories.

The word *tack* is most frequently produced with a preaspirated stop by younger women (yw, 40%) and only slightly less frequently by older women (ow, 37%). Male speakers showed preaspiration to a lesser extent, in that the younger men (ym) preaspirated stops in 32% and the older men in 26%.

The word *låt* was most frequently produced with a preaspirated stop by younger women (yw, 76%), followed by the younger men (ym, 63%). Almost the same frequency of preaspiration can be found for the older women (ow, 60%), but older men show a lower percentage of preaspiration (om, 39%).

The word *lott* is also most frequently produced with a preaspirated stop by younger women (yw, 91%). Older women preaspirate stops less frequently (ow, 70%), which is slightly more often than young men (ym, 68%). Older men show the lowest frequency of preaspirated stops (49%).

### 2.3 Frequency of occurrence: summary and discussion

A general tendency in this part of the investigation is found in that women and younger speakers produced preaspirated stops more frequently, which leads to the assumption that it is young women who produce them most often. This was clearly the case for the words *låt* and *lott*, as can be seen in Figure 5. For those words, no major difference is found in the frequency of occurrence of preaspiration between older women and younger men. However, older men produced preaspiration clearly less frequently in these words.

For the other words (*tak* and *tack*) different patterns were found. *Tak* was produced with a preaspirated stop marginally more often by older women than by speakers in the other categories. And for *tack* the female speakers of both age groups produced preaspirated stops equally more often than male speakers of both age groups.

Only the results for the word *tak* support the initial assumption of this investigation, which was the subjective impression that it seemed to be older women, who mainly preaspirated word final stops. For the other words, speakers of the younger generation show a relatively stronger presence of preaspiration. Compared to the frequency of occurrence for the older women, the stronger presence for the younger generation when divided by gender, shows an equally high frequency of occurrence for the younger men, and even higher frequency of occurrence for the younger women.

In the following section a closer look at the duration of preaspiration is taken, to get a grip on the initial assumption from a more qualitative perspective.

### 2.4 Duration: results

A clear difference in the duration of the preaspiration section in each word can be observed between female and male speakers in that the female speakers produce a longer preaspiration (Fig. 6). A minor range of duration variation for the female speakers occurs between the four words, where the shortest preaspiration is present for *tack* (45ms) and the longest duration is present for *lott* (50ms). The values for the other two words lie in between (46ms). For the male speakers a similarly minor range of duration variation between the different words is found, which stretches from 30ms for *låt* to 34ms for *tak*. The values for the other two words are 31ms.

A t-test carried out for preaspiration length for each word showed that the duration difference between the female and the male speakers is highly significant for all four words (p < 0.001).

![Figure 6: The average duration (in [ms]) and standard deviation of preaspiration for female (w) and male (m) speakers and for each word.](image)

When including age difference (Fig. 7), it can be seen that older and younger male speakers do not show much deviation in the duration of preaspiration for the words *tak* (34ms, p > 0.5) and *tack* (31ms, p > 0.5; n. b.: a t-test was applied). For the word *låt* a significant difference is found (om: 27ms, ym: 32ms; p < 0.01), and for the word *lott* the significance of duration difference is very high (om: 27ms, ym: 34ms; p < 0.001). In the cases of a significant duration difference old men always produced a shorter variant.

Female speakers did not show a duration difference according to age category for the same words as the male speakers. No significant duration difference is found for the words *låt* (ow: 45ms, yw: 46ms; p > 0.1), *lott* (ow: 51ms, yw: 49ms; p > 0.1) and *tak* (ow: 45ms, yw: 48ms; p > 0.01). On the other hand a high significance of duration difference was found for the word *tack*, where the older women produced the longer preaspiration (ow: 51ms yw: 40ms; p < 0.01).

![Figure 7: The average duration and standard deviation of preaspiration for female and male, older and younger speakers for each word.](image)
The difference between preaspiration duration of younger speakers of both genders was highly significant for each word ($p < 0.001$). For the older speakers the level of significance for duration difference is not quite as high as for the younger speakers for the word *tak* ($p < 0.01$). However, for the other words the duration difference is equally great as for the younger speakers ($p < 0.001$). In both age groups female speakers show longer preaspiration for all words than male speakers.

### 2.4.1. Ratio of preaspiration in the word

In this section a closer look is taken at the length of preaspiration in relation to word length. This step was taken to normalise for speech rate, so that it can be shown that differences in duration between speaker categories is not based on a variation in speech rapidity. Fig. 8 shows that preaspiration takes up more time in all the target words produced by female speakers than it does for male speakers. It can therefore be assumed that the results above, showing that female speakers produced longer preaspiration than male speakers is not based on different speech rate.

![Figure 8: Average ratio of the preaspiration section in a word for female and male speakers and all words.](image)

### 2.5. Duration: summary and discussion

In this part of the investigation it was shown that female speakers produced longer preaspiration prior to stops than male speakers did. The difference was highly significant for all four target words and varies from 12-15ms between the two groups of speakers. Within each speaker group a fairly constant duration is maintained across all words.

Since the preassumption to this study was that it is rather the older female speakers who produce preaspirated stops, a closer look was taken at the influence of age on the duration of preaspiration. It could be shown that female speakers, no matter what age group they belonged to always presented a longer phase of preaspiration than male speakers. The duration difference between age groups within the same gender did not vary. No significant duration variation was found between the groups of male speakers of different age. But this was the case for the female speakers for one word, which was *tack*.

The results are not coherent with Norwegian [4], where female speakers of an older age group produced longer preaspiration compared to all other groups, whereas no difference in duration was found between male and female speakers of a younger age.

The findings from the inquiry on the ratio of preaspiration in a word which shows that it takes up more time in the case of female speakers, consolidate the results from the duration measurements above in that variation in the duration of preaspiration is not based on speech rate, but a feature of speech.

This part of the investigation did thus not confirm the preassumption that primarily female speakers of an older age group produce preaspirated stops in southern Swedish, which can be based on a longer duration of the preaspirated section so that its occurrence would be more apparent to the listener. Instead, female speakers of a younger age also show a similarly long preaspiration. Furthermore younger male speakers show similarly short preaspiration as older male speakers. It can thus be concluded that the factor of age does not have any influence on the duration of preaspiration. The factor that constitutes the difference is gender.

### 3. CONCLUSIONS

This study shows that preaspirated voiceless stops are produced by both, female and male speakers of Southern Swedish. However, female speakers tend to realise preaspiration more frequently than male speakers do in the words under investigation. The influence of age did not show the expected results, which were that older women produced preaspiration more often than younger women. Preaspiration is thus typical for female speakers irrespective of age.

What was shown from the frequency of occurrence of preaspiration can be confirmed by the duration measurements. Female speakers of both age groups tended to produce longer preaspiration than male speakers, i.e. preaspiration is more substantial for female speakers.

It can thus be concluded that preaspiration is a more apparent feature of female speech in southern Swedish, irrespective of age group. Preaspiration does not seem to become extinct in the future, since younger speakers tend to make use of it more frequently than older speakers.

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### 4. REFERENCES


