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# Final aspiration as a phrase boundary cue in Swedish: the case of *att* 'that'

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## Abstract

*The Swedish word att /at/ is associated with two grammatical functions: a) (part of) a subordinate conjunction and b) an infinitive marker. This pilot study, with 5 short spontaneous discourses from 3 male speakers shows a correlation between pauses after att, and aspiration of /t/ in att, where aspiration can be interpreted as a kind of final lengthening involving the release phase of the stop consonant. We also show a tendency for att with aspiration to be associated with the grammatical function of subordinate conjunction. Further, we are able to show a tendency for the infinitive marker to be unaspirated in the normal case, while the subordinate conjunctions are characterized by final aspiration in 40 % of the cases.*

## 1 Introduction

Previous studies on phrasing have shown how prosodic cues such as pauses and final lengthening serve to signal boundaries in spoken discourse (Bruce et al 1993; Horne et al 1995; Fant & Kruckenberg 1991; Swerts 1997). It has also been observed that even segment-related secondary articulations are often associated with phrase-boundaries (see e.g. Dilly et al 1996 for a discussion of phrase-initial vowel glottalization in English).

### 1.1 Purpose

The goal of this paper is to present pilot data from Swedish that illustrate how segmental strengthening (realized as final aspiration in the subordinate conjunction *att*) can be a useful cue for detecting clause boundaries in speech recognition and parsing algorithms.

### 1.2 Theoretical background

Segmental 'strengthening' and 'weakening' processes are explained by relating their input and output sound categories to a scale of sonority (for a discussion, see Hyman, 1975). According to the sonority scale, vowels are assumed to be the most sonorant segments, whereas aspirated stops and affricates are the least sonorant segments (see Fig. 1.). Consonant strengthening, involving a movement to the left on the sonority scale is often observed for example at the beginning of stressed syllables.

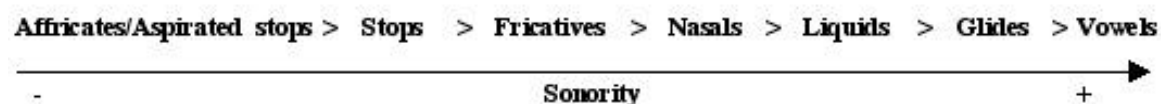
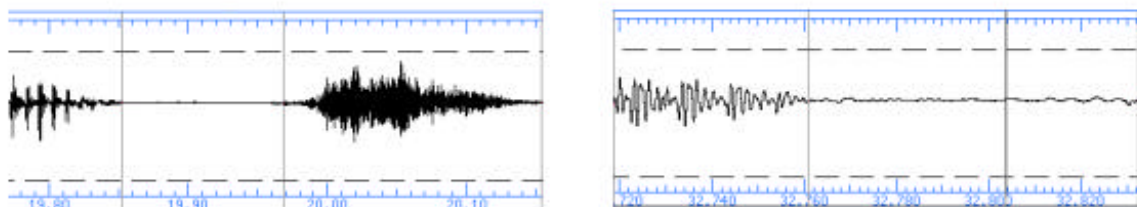


Figure 1. The sonority scale.

In the present study, it will be shown how the strengthening of /t/ in *att* to a strongly aspirated variant occurs in phrase final position in Swedish. This final aspiration can be analysed as signalling the end of a speech fragment which forms part of an uncompleted message.

Aspirated and unaspirated variants of voiceless stops are common in several Germanic languages as contextually conditioned variants. Their distribution is highly predictable in terms of phonetic context. In English, aspirated variants are observed to occur at the be-

ginning of stressed syllables. In Swedish, aspirated stops are also found in this position (Engstrand 1983; Krull 1991), but are even found in "final" (Lindblad, 1998), or "prepausal" (Garlén, 1988) position. Aspirated voiceless stops are characterized by a period of noisy airflow after the burst that lasts for a considerable period of time. For Swedish, the lower boundary for perception of aspiration is about 40 ms (Lindblad, 1998). Below that level, aspiration is not perceived.



**Figure 2:** To the left: waveform of [at˥˥] with final aspiration. To the right: Waveform of [at˥] without final aspiration.

In Swedish, the sound string /at/ (graphically *att*) is ambiguous. It can be associated with two grammatical functions: 1) infinitive marker corresponding to English 'to' as in *att se* 'to see' and 2) subordinate conjunction corresponding to 'that' as in *Anna sa att Maria var sjuk* 'Anna said that Maria was sick'. In its second function, *att* is also part of several, more complex subordinate conjunctions, e.g., *så att* 'so that'.

In spontaneous speech, *att* as an infinitive marker is often pronounced as [o:] whereas *att* as a conjunction is never reduced to [o:]. There are no clear rules that predict when the infinitive *att* is reduced, such as, e.g., infinitive *att* is not reduced when it is emphasized. As a conjunction, *att* can be reduced to [at˥] with an unreleased /t/ (see Fig. 2). However, it is very often realized [at˥˥] (see Fig. 2), or even [at˥˥˥] - a strongly aspirated or affricated long consonant in this function. Since this aspiration is an easily identifiable acoustic cue, it could be used in algorithms for speech recognition and understanding. The degree of aspiration is observed to vary, however, and we speculate that this variation can be related to the degree of speech planning.

Although *att* is analyzed syntactically as a conjunction introducing a subordinate clause, it is often realized phonetically at the end of the preceding clause in disfluency contexts. Thus, for speech parsing purposes, *att* signals that the message is incomplete and that a new clause is being planned. We further speculate that the degree of aspiration/affrication can possibly reflect the degree of complexity of the new item being processed.

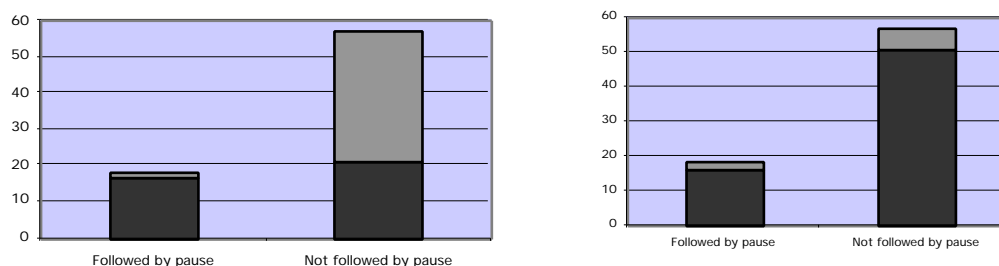
*Att* is one of the absolute most frequent words in Swedish (Johansson 1999), and both of its associated grammatical functions occur often. Since the subordinate conjunction *att* would normally trigger a more complex construction (i.e., a subordinate clause) than the infinitive marker *att* (normally initiating a simple infinitive construction), one could expect more features of planning to be associated with the former form of *att*. Such planning features would be pauses following *att*, and consonant strengthening in the form of final aspirated /t/.

## 2 Method

The material for this pilot study was collected within the Spencer Project on Developing Literacy in Different Contexts and Different Languages (Berman & Strömqvist, 1999). The data consist of five spontaneously spoken discourses from three Swedish males, 25-30 years of age. The recordings were made in a sound studio.

Prosodic analyses were carried out using the ESPS/waves environment. The duration of every occurrence of *att* was measured. Length of aspiration and length of [t] were measured, as well as the duration of pauses and filled pauses following *att*. In doing this, we were able to compare length of aspiration a) as part of the whole word [at˥˥], and b) as part of the segment [t˥˥], in *att* as a subordinate clause and *att* as an infinitive marker. This would enable us to look for a correlation between duration of aspiration and duration of (filled)

pauses. Following Lindblad (1998) aspiration phases shorter than 35 ms were classified as having no aspiration.



**Figure 3a (left):** Distribution of *att* followed by a pause and/or with final aspirated /t/ in absolute numbers. To the left: cases where *att* is followed by a pause; to the right: cases where *att* is not followed by a pause. The upper, lighter layer shows the cases where the final /t/ is not aspirated, whereas the lower, darker layer shows the cases where /t/ is aspirated. **3b (right):** Distribution of *att* followed by a pause collapsed over *att* as infinitive marker and *att* as a subordinate conjunction. To the left: cases where *att* is followed by a pause; to the right: cases where *att* is not followed by a pause. The upper, lighter layer shows the number of cases of *att* as an infinitive marker, whereas the lower, darker layer shows the number of cases of *att* as a subordinate conjunction.

### 3 Results

In the five discourses studied, *att* occurs 99 times. Of these, *att* functions as a subordinate conjunction in 67 cases, as an infinitive marker in 8 cases, and as part of other, more complex subordinate conjunctions in 24 cases. Thus, *att* as a subordinate conjunction is more frequent than *att* as an infinitive marker. (It should be pointed out that an additional 17 cases of the infinitive marker occurred in the data in the reduced form [ɔ̃].) In what follows, we will only look at the 75 cases where *att* occurs as a single subordinate conjunction or before an infinitive.

Fig. 3a shows that 18 of the 75 investigated cases of *att* were followed by a pause. 17 of these cases also had an aspirated /t/, which makes a strong implication, i.e. that pauses are connected with aspiration. However, from a comparison of Fig. 3a and 3b we find that the opposite is not true; of the 57 cases where *att* was not followed by a pause, 21 of the cases showed final aspiration. Thus, the implication that aspiration automatically leads to a pause following *att* is not true.

### 4 Discussion and conclusion

Many studies have claimed that pauses are used for planning, and that pauses therefore are often found at clause boundaries (see e.g., Chafe 1979; Beattie 1980). Other studies have shown that final lengthening signals boundaries in spoken languages (Bruce et al 1993; Horne et al 1995). Aspiration could be considered to be one kind of final lengthening involving the release phase of the final stop consonant. This would lead us to look for a correlation between pauses and final aspiration, i.e. that an *att* followed by a pause should also have an aspirated /t/. Indeed, this is what has been observed in this pilot study.

Finding this, we can conclude that there is a correlation between pauses and final aspiration. When looking at the distribution of the two types of *atts* followed by a pause, we find that most of these cases involve *att* as a subordinate conjunction. Although it is not possible to prove it statistically, since the number of infinitive *atts* is so low, we would still like to suggest that *att* as a subordinate conjunction is more likely to be followed by a pause.

The question is what happens if we take away the cases where *att* is followed by a pause and see if we can observe any differences in aspiration between *att* as a subordinate conjunction and *att* as an infinitive marker.

What we find, however, is that 0 % (0 of 6) of the realizations of infinitive *att* have final aspiration, while 40 % (21 of 51) of the realizations of *att* as a subordinate conjunction have final aspiration. Although the low number of cases with *att* as an infinitive marker makes it impossible to run statistics on this result, it is worth stressing the fact that when the cases followed by pause were excluded, none of the infinitive *atts* had final aspiration, while 40 % of the *atts* as subordinate conjunction had final aspiration.

In this study, we have tried to show a correlation between aspirated /t/ in the frequently occurring homonym *att* in Swedish, and its function as a subordinate conjunction. Although this is only a pilot study, it nevertheless suggests that aspiration of final /t/ in *att* could be a useful cue in, e.g., developing algorithms for speech recognition and parsing. If *att* has final aspiration and is followed by a pause it is more likely that we are dealing with the realization of *att* as a subordinate conjunction, rather than the realization of *att* as an infinitive marker.

The tendencies we have found so far show that it would be fruitful to carry out a larger investigation, preferably with more cases of *att* as an infinitive marker.

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