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ON THE CONTROL OF ASPIRATION IN SWEDISH*

Anders Löfqvist

Swedish voiceless stops are aspirated in prestress and unaspirated in poststress position. (Aspiration will in the following be taken as the interval from stop release to the onset of glottal vibrations for a following segment.) This difference within the set of unvoiced stops is, however, not phonemic in Swedish but when it occurs aspiration serves as one of the cues for the distinction between voiced and voiceless stops since the former are always unaspirated.

Studies of subglottal pressure during the production of Swedish stops, Löfqvist (1975), reveal no difference in this parameter related to aspiration and the results are in agreement with a model of respiratory activity in speech which assumes that the respiratory system, ceteris paribus, generates a constant subglottal pressure irrespective of the presence or absence of aspiration after the stop release.

The control of aspiration would thus seem to depend on the coordination of glottal and supraglottal articulations. In this connection we can note that the difference in closure duration between Swedish voiced and voiceless stops is rather small except in those positions where the latter are unaspirated, Karlsson and Nord (1970), Löfqvist (1973); this is mainly due to an increase in closure duration for the voiceless set in these positions. From this we might hypothesize that the presence or absence of aspiration for the voiceless stops in Swedish is related to the duration of the oral closure.

This hypothesis is strengthened by the data given in Figure

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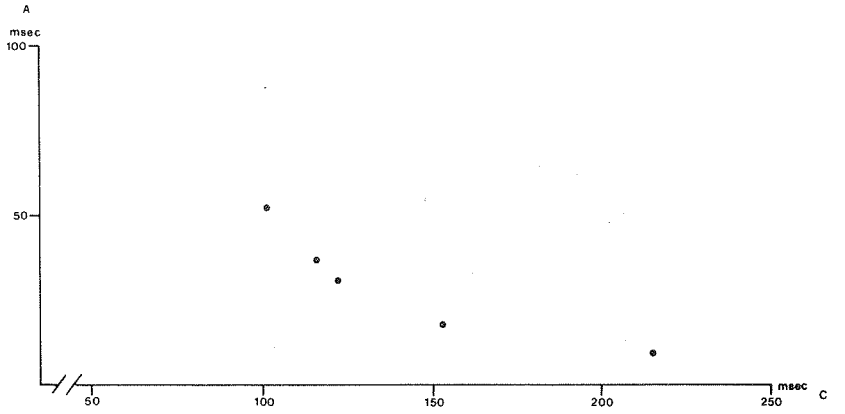

Figure 1. Aspiration (A) plotted against closure duration (C) for voiceless stops in various positions and under different stress conditions in bisyllabic words.

1, which shows the duration of the period of aspiration (A) plotted against the duration of the occlusion (C) for voiceless stops in various positions and under different stress conditions in bisyllabic words; each point represents the mean of 35 tokens and a negative correlation is apparent between aspiration and closure duration ($r = -0.9$). A simple model for the control of aspiration in Swedish voiceless stops based on these results would assume that the glottal gestures are invariant and that the duration of the oral closure controls the amount of aspiration. If the release occurs while the glottis is still open the stop will be aspirated, if it occurs when the glottis is already closed the stop is unaspirated and the degree of aspiration depends on when the release occurs in relation to the glottal gesture.

To get a picture of the glottal activity photoglottographic recordings were made during the production of the same test material, an example of which is shown in Figure 2. Let us for the moment concentrate on the timing of the glottal movements in relation to the supraglottal events and return later to the size of the glottal opening. The transillumination technique does not give an adequate measure of the degree of glottal opening since the amplitude of the signal depends, inter alia, on the relative positions of light source and light sensor and these positions change during the recording session; the temporal relationships in the curve appear, however, to remain stable irrespective of such changes. For the facts to be compatible with the model outlined above we would expect among other things that the interval from implosion to peak glottal opening remains stable across different positions. A plot of aspiration (A) versus the interval from implosion to peak glottal opening (T), Figure 3, shows no correlation ($r = 0.04$) and thus seems to be in agreement with the model as far as timing in bisyllabic words are concerned; a fair agreement can also be found with the material presented in Lindqvist (1972).

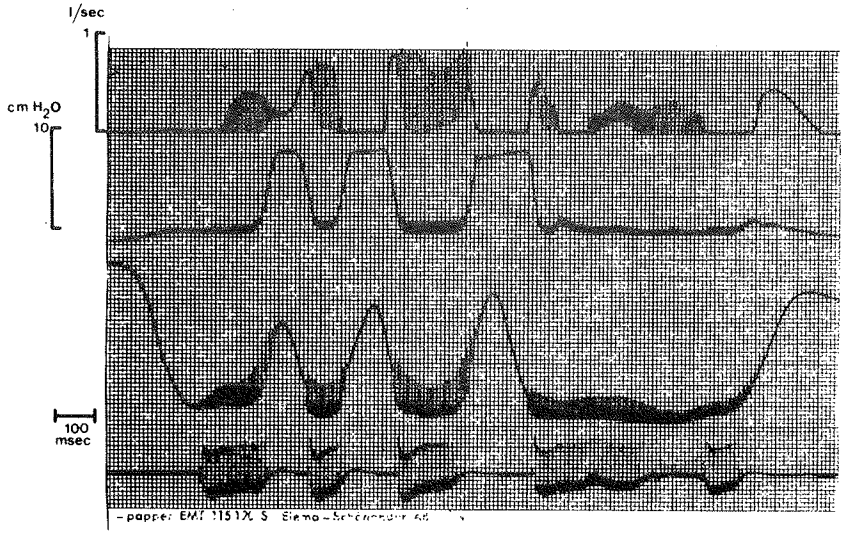

Figure 2. Record of the utterance "Men se 'teten igen". The curves represent from top to bottom, oral air flow, oral air pressure, photoglottogram and signal from larynx microphone.

If we try to extend the model to stops in words with more syllables it turns out, however, that the situation is not that neat. A plot of aspiration versus closure duration for stops in words with 2, 3 and 4 syllables, Figure 4, shows the same negative correlation ($r = -0.5$) but several cases can be seen where this relation does not hold. Furthermore, aspiration appears not to decrease beyond a certain limit and when this limit is reached a further increase in closure duration has no effect. At the same time the plot of aspiration against the interval from implosion to peak glottal opening for the same material, Figure 5, reveals a positive correlation ($r = 0.7$) indicating that peak glottal opening tends to occur earlier during the occlusion for the unaspirated and less aspirated stops.

The results obtained thus far suggest that several strategies can be used in the production of voiceless stops for the control of aspiration. One is to change the length of the closure period; in the unaspirated case an increase means that the glottis gets time to return to a position suitable for voicing to occur prior to the release of the oral closure. Another is to vary the moment at which glottal abduction and adduction occur and perhaps also the speed of the glottal movements. If peak glottal opening occurs late during the occlusion this ensures that the glottis is open at the release in the aspirated case and if it occurs early the glottis will be closed at the release in the unaspirated case; for the unaspirated stops the abduction may start during the preceding segment and thus cause the stop to be preaspirated. These two strategies seem to be combined in the production of Swedish voiceless unaspirated stops. A third strategy involves variations in the magnitude of the glottal opening; a reduction of peak glottal opening tends to occur in those positions where the stress pattern of the word makes the closure duration of the aspirated stops quite short.

As was mentioned above the transillumination technique can

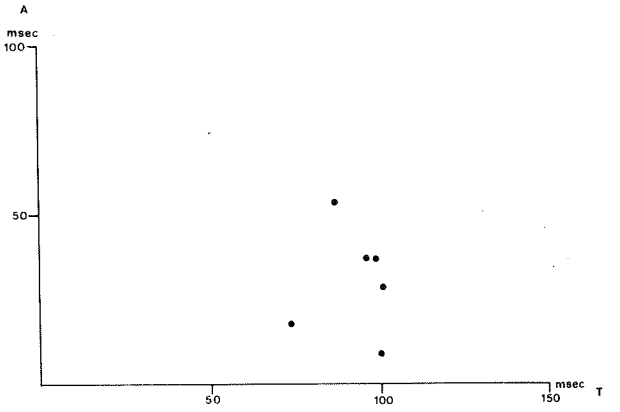

Figure 3. Aspiration (A) plotted against the interval from implosion to peak glottal opening (T) for voiceless stops in various positions and under different stress conditions in bisyllabic words.

not give a quantitative picture of the degree of glottal opening. Inspection of the records and comparisons of glottal opening for stops within the same test word do, however, suggest two general tendencies. Peak glottal opening is related to closure duration and increases with it. Glottal opening at the moment of release, suggested by Kim (1970) to be the determining factor for aspiration, is related to aspiration and tends to be larger the longer the period of aspiration. At the same time it should be noted that counterexamples to both these generalizations can be found.

The material discussed above suggests a framework for studying the relations between closure duration, voicing and aspiration in stop production and various strategies used for the control of aspiration in various languages.

References

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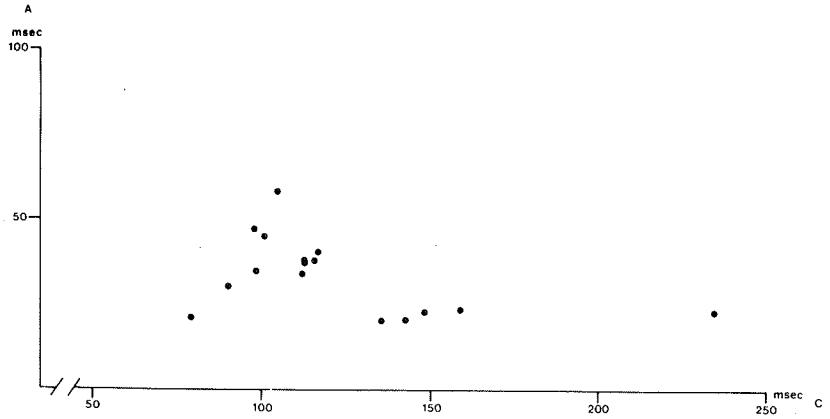

Figure 4. Aspiration (A) plotted against closure duration (C) for voiceless stops in various positions and under different stress conditions in words with 2, 3 and 4 syllables.

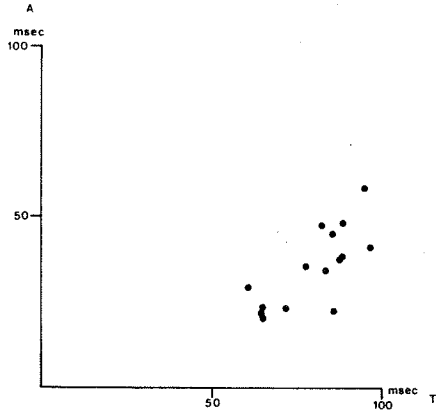

Figure 5. Aspiration (A) plotted against the interval from implosion to peak glottal opening (T) for voiceless stops in various positions and under different stress conditions in words with 2, 3 and 4 syllables.