Dept. for Speech, Music and Hearing
Quarterly Progress and Status Report

Focal accent and subglottal pressure

Fant, G. and Hertegård, S. and Kruckenberg, A.

journal: TMH-QPSR
volume: 37
number: 2
year: 1996
pages: 029-032

KTH Computer Science and Communication

http://www.speech.kth.se/qpsr

Focal accent and subglottal pressure

Gunnar Fant, Stellan Hertegård and Anita Kruckenberg*
*Dept. of Speech Music and Hearing, KTH, and *Dept. of Logopedics and Phoniatrics, Huddinge University Hospital.*

Abstract

Earlier studies (Fant and Kruckenberg, 1994) of acoustic correlates to prosodic categories in Swedish have shown that focal accent when realized with a local F0 peak may be associated with a minimum in voice excitation amplitude Ee and also in intensity. Meaurements from several speakers indicate that Ee rises with F0 up to a frequency F0r after which Ee decays or stays constant on a plateau. From recordings of subglottal pressure through a tracheal puncturing probe we have found that focal accentuation is generally accompanied by a decay of subglottal pressure starting from a high value at the syllable boundary and decaying within the region of the F0 peak. Our recent recordings also include supraglottal pressure. The relative role of F0, voice intensity, voice source spectral shape, duration and spectral contrasts as correlates of word stress, accent type and focal accent are discussed. Individual variation are large.

Introduction

This is a follow up of an earlier report on stress and word accent in Swedish (Fant & Kruckenberg, 1994). It was concluded that the concept of focal or sentence accent, well defined in test sentences, was more difficult to handle in the analysis of prose reading where a continuous scaling of perceived prominence could provide competing candidates. Our study supported the finding of Bruce (1977) , Gårding (1981), Horne & Johansson (1991) that focal accent is realized with a F0 peak that occurs within the stressed vowel of an accent 1 word and within the secondary syllable of an accent 2 word. Word accents preceding or following the focal region are diluted.

A relevant question is whether focal accentuation and relative prominence are identical in their manifestations or if differences exist. The acoustical correlates of stress and emphasis as discussed and partially quantified in Fant and Kruckenberg (1994) are: duration, F0-modulation, intensity, voice source properties, segmental contrasts. The most consistent stress cue was relative duration. All of these elements could be present in focal accentuation but the dominant feature in our test sentences was the F0-pattern which often could be the main observable feature without any appreciable changes in the durational pattern. The intensity pattern was found to be complex.

Superimposed on a general increase in the focal region a local intensity minimum syncronized with a high F0 peak often appeared, se Fig. 1. This minimum could be related to observed variations of the voice source amplitude Ee with increasing F0 in sustained phonation which shows a rise up to a maximum value at a frequency F0r located in the upper part of the speakers voice register. For F0 rising above F0r, Ee decreases or reaches a limiting value. As a consequence, in a dynamic F0 gesture overshooting F0r, one can expect a minimum of Ee at the maximum F0 and that local maxima appear when F0 passes F0r in the rising and then again in the falling branch.

Intensity, in addition to the Ee proportionality, also increases with F0. One octave increase of F0 provides an emphasis of about 3-4 dB per octave rise in F0. As a consequence the intensity minimum in the F0 peak domain is less apparent than the corresponding Ee minimum.

It was hypothesized by Fant & Kruckenberg (1994) that the shape of the specific intensity or Ee contour in the F0 peak region is dependent on the coordination with subglottal pressure. Our recent experiments have confirmed our hypothesis of a subglottal pressure build up towards the onset of the F0 rise in an early part of the stressed vowel followed by a decaying contour. Without this pressure decay the intensity minimum is lost.

Subglottal pressure and focus

One of the authors, the foniatrics specialist, served as subject for a recording of sub- and supraglottal pressure together with the sound from a microphone placed 10 cm in front of the lips. Subglottal pressure was obtained from a

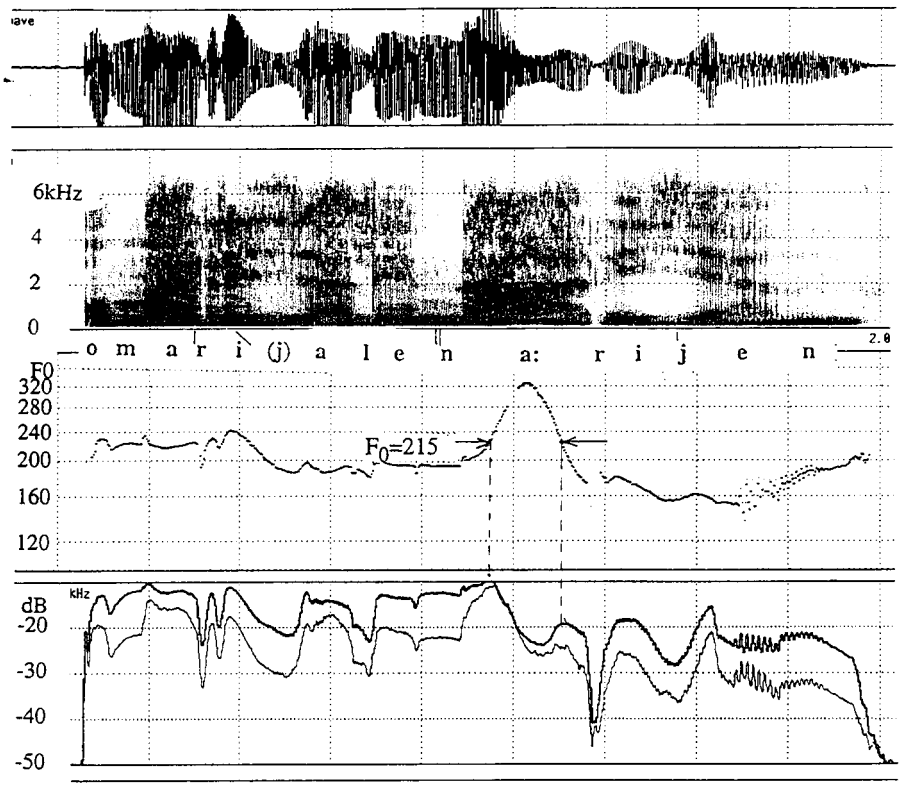

Figure 1. Focal accent on the vowel [a:]. From Fant & Kruckenberg (1994)

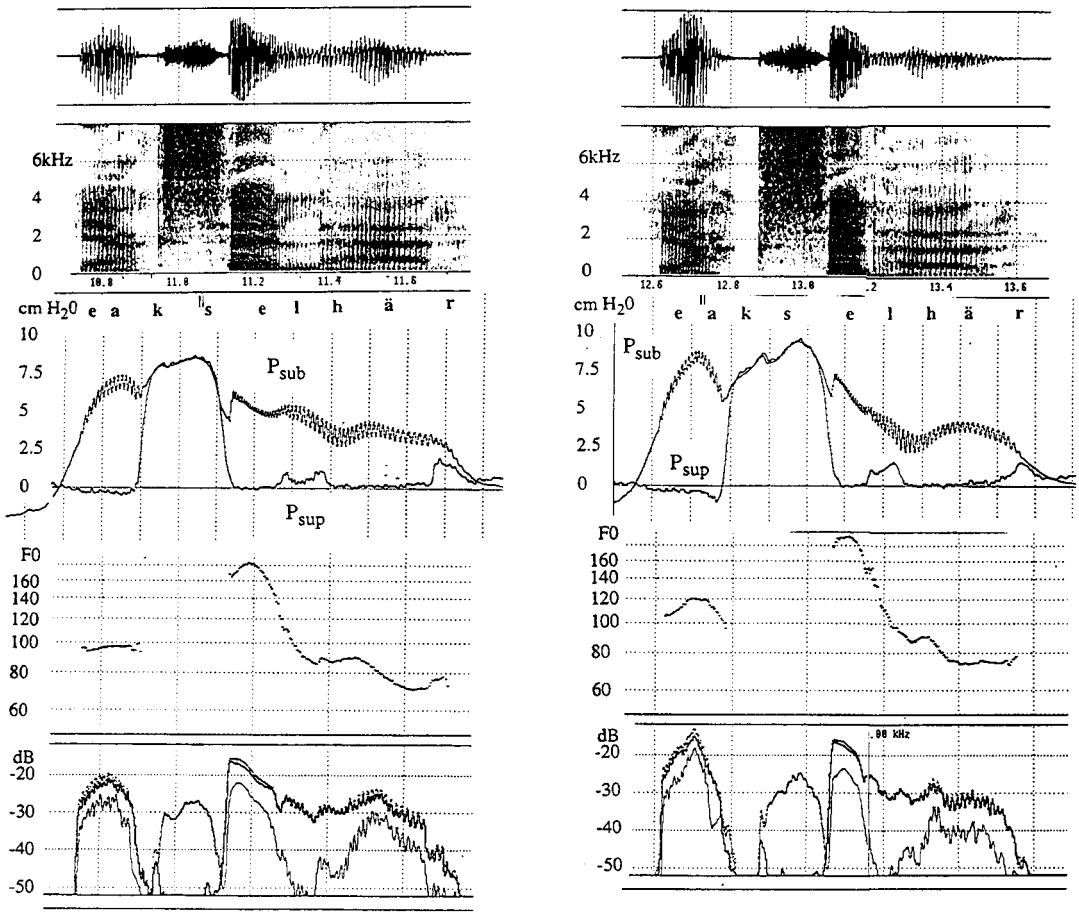

Figure 2. Sub- and supraglottal pressures added to a spectrum, F0 and intensity display. Focal accentuation of the test words [ak"sel] and ["aksel]

needle probe inserted externally into the trachea. Supraglottal pressure, just above the larynx, was obtained from a flexible probe inserted through the nose.

Examples of sub- and supraglottal pressure recordings added to our standard display of oscillogram, spectrogram, F0 contour and intensity curves are shown in Fig. 2 pertaining to two utterances, "E *Aksell* här?" and "E *Axel* här?" contrasting in the location of stress in the accent 1 test words [ak"sel] versus ["aksel], both pronounced in focus. Sub- and supraglottal pressures display the expected covariation with a maximum of pressure build up in occlusive segments and a rise of supraglottal pressure in the [l]and the [r] segments.

The local fall of subglottal pressure towards the end of the[a] in ["aksel] reflects a pressure loss due to the pre-occlusion abduction gesture. Comparing the two utterances, we note rather modest differences in subglottal pressure and intensity favouring the primary stressed syllable. The upper intensity contour represents low pass 1000 Hz prefiltering and the lower represents SPL with high frequency preemphasis. Given a specific context the difference between the two curves can be interpreted as an inverse measure of the voice source high frequency gain. A relative increase of high frequency content is a common stress correlate in focal positions. A moderate effect is to bee seen in Fig. 2.

Figure 3 illustrates the focal and nonfocal realization of the accent 2 word [lè:nar] and the contrasting accent 1 focal realizations [le"n*a*:r] versus ["le:nar] within a carrier phrase.

The same tendency of a falling intensity during the focal rise of F0 in [a:] as was observed for subject AK in Fig. 1 can also bee seen in Fig. 3 but the minimum is less apparent. A turning point at F0r=140 Hz for maximum intensity typical for a male voice was observed. F0r for the female subject of Fig.1 was 215 Hz.

A general impression of all accentuation's including non-focal realizations is that a subglottal pressure fall is timed to start somewhat earlier than a following intonation peak. If prominent, the fall may signal the end of a prosodic phrase.

Subjects may differ considerably in the realization of the F0 contour within an utterance. Our subject in Fig. 3 showed rather shallow F0 modulations in the absence of focal accentuation. Subject AK, on the other hand, displayed nonfocal accentuation's with the accent 1 HL* prototype of Bruce, i.e. a distinct fall in F0 from a preceding unstressed syllable to the stressed syllable. In focus the contour was quite reversed, i.e. the HL* fall of F0 was eliminated and the following focal F0 peak dominated the entire utterance.

A common finding for all subjects was the by now well established patterns of focal realization with a single peak for accent 1 and two peaks for accent 2 of which the second gains more in height than the first with increasing emphasis.

This has been but a brief report on a limited part of our quite recent experimental material involving subglottal pressure.

Acknowledgments

This work has been financed by grants from the Bank of Sweden Tercentenary Foundation, the Carl Trygger Foundation and support from the Telia Promotor AB The authors are indebted to Kjell Gustafson and to Johan Liljencrants for assistance with the recording and processing of data

References

Bruce G (1977). Swedish Word Accents in a Sentence Perspective, CWK Gleerup, Lund.

Fant G & Kruckenberg A (1994). Notes on stress and word accent in Swedish, Proc. Int. Symp. on Prosody, Sept. 18 1994, Yokohama. Also published in STL-QPSR 2-3 1994, 125-144.

Gårding E (1981) Contrastive prosody: A model and its application, Studia linguistica. Vol 35, No 1-2, 146-165.

Horne M & Johansson C (1991) Structure and Accenting in English and Swedish Texts, Working Papers 38, Lund University Dept. of Linguistics, 97-114.

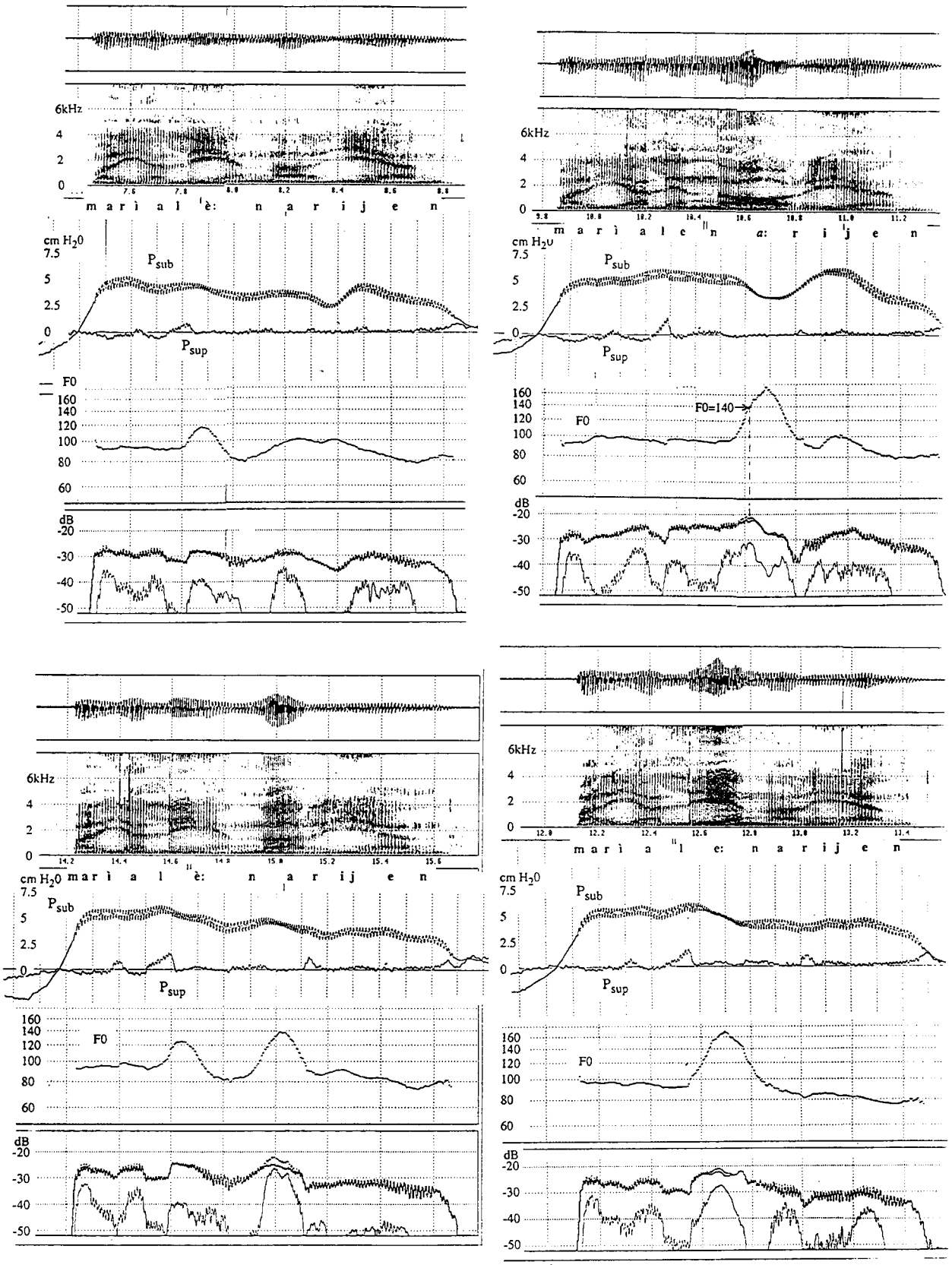

Figure 3. Left column accent 2 test words [lè:nar]; above non-focal, below focal accentuation. Right column focal accentuation of accent 1 words, [le"na:r] above and ["le:nar] below.