SOME PHONETIC CORRELATES OF EMPHATIC STRESS IN SWEDISH

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This paper contributes some information on subglottal pressure, oral pressure, fundamental frequency and segment duration during a Swedish utterance in which emphatic stress is systematically shifted from one word to another. The term "emphatic" is used in the broad sense of "extra" stress in addition to the "normal" word and sentence intonation. It seems unclear to me whether "contrastive" might have been a more appropriate term and whether there are any differences between these two types of stress - emphatic and contrastive - as discussed by Bierwisch (1966). Since it is beyond the scope of this paper to discuss matters of terminology and different degrees and types of stress nothing more will be said about them here, cf. Lehiste (1970), Lieberman (1970), Atkinson (1973) for reviews.

Method

Subglottal pressure was recorded by a no 18 gauge spinal needle inserted through the crico-thyroid membrane; the needle was placed in a specially designed collar which prevented it from entering too far into the subglottic space and also from moving during the recording session. At the insertion the bevel of the needle was placed parallel to the airflow in order to avoid spurious pressure recordings, cf. Hardy (1965). A polyethylene tube, 14.5 in. long and with an inner diameter of 0.118 in., connected the needle to a differential pressure transducer, Statham PM 131 TC $\pm$ 2.5. Oral pressure was sensed by another polyethylene tube, 17.5 in. long and 0.118 in. inner diameter introduced into the pharynx through the nose; the tube was coupled to a second differential pressure transducer of the same type. The different lengths of the tubes were chosen to make the frequency response of the two recording systems as equal as possible since the length of the needle was added to that of the tube for subglottal pressure, cf. Edmonds et al. (1971). The output from the transducers was amplified, low pass filtered at 200 Hz and recorded together with the speech signal on a FM tape recorder, Consolidated Electrodynamics Corp. VR 3300, at a recording speed of 3 3/4 ips.

A separate recording of the speech signal was made through an Electrovoice 664 dynamic microphone on a Scully 280 tape recorder at a recording speed of 7.5 ips.

Throughout the recording session the pressure signals were constantly monitored since the tubes and especially the needle often clogged and had to be cleaned to give a correct pressure signal.

The pressure and F_0 measurements were made on a LINC-8 computer with a program written by Robert Krones. Before the pressure signals were fed to the computer they were low pass filtered once more, oral pressure at 110 Hz and subglottal pressure at 180 Hz, to remove most of the voicing.

For the durational measurements the speech signal was recorded on a Mingograph at a paper speed of 100 mm/sec. and measured by hand.

Material and measurements

The speech material consisted of the utterance "Kvinnor får lättare snuva än män" [ˈkvɪn:ʋɹfɔˈ]ɛt:aɹəˈsnɯ:vaɛnˈmɛn:]

In version 1 it was pronounced with a "normal" intonation pattern for a declarative utterance without any emphasis. In version 2 emphatic stress was placed on the word "kvinnor", in version 3 on "lättare", in version 4 on "snuva" and in version 5 on "män". The different versions were read several times by a native male speaker of Southwestern Swedish (västgötska) and seven repetitions of each version could be used for the analysis.

Subglottal pressure was measured at the points given in Table I. These points are peak subglottal and oral pressure for the voiceless obstruents /k, f, t, s/; the middle of the vocalic segment of the vowels /I, U, ɛ, a, ɯ/; peak subglottal pressure for the final vowel /ə/ in "lättare" which in this case tended to occur towards the end of the vocalic segment; the middle of the nasal consonant /n/ in "kvinnor".

Fundamental frequency was measured at the same points as subglottal pressure during the vowels and the nasal consonant.

Results

Figures 1-5 show representative examples of the recorded parameters during the production of each version of the test sentence and the results of the measurements of subglottal pressure, fundamental frequency and

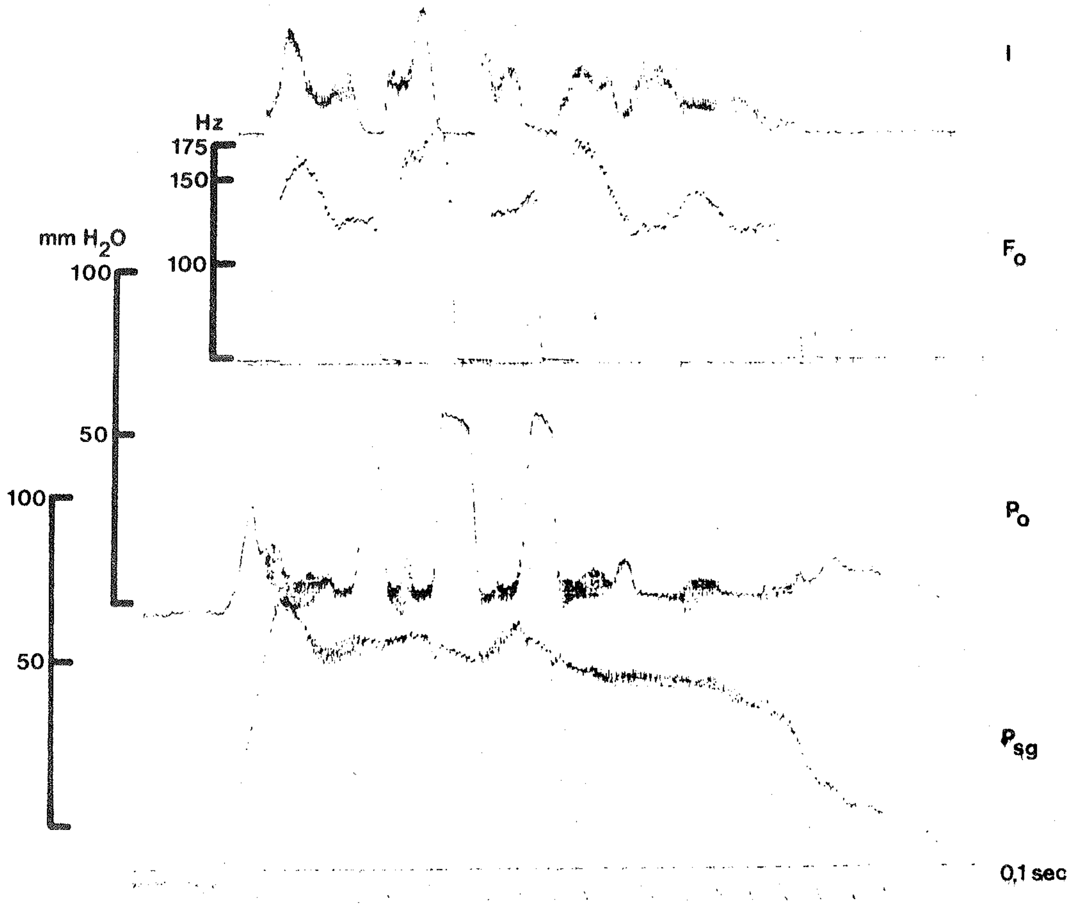

Figure 1. Version 1 of the test utterance - normal intonation. The curves represent from top to bottom: intensity, fundamental frequency, oral pressure, subglottal pressure and time, 0.1 sec.

segment duration are summarized in Tables I-III respectively.

Emphatic stress is associated with an increase in subglottal pressure during the emphasized word. The difference in P_{sg} between words with and without emphatic stress is, however, not the same throughout the utterance but appears to vary according to the position of the word within it; it is greater in the beginning and at the end and slightly less in between. With the exception of the final vowel /ə/ in "lättare" the difference is about the same for the stressed and unstressed vowels in the polysyllabic words although the absolute pressure is higher during the stressed vowels.

For the consonants the difference between the emphatic and non-emphatic versions is greater in prestress than in poststress position.

Another tendency which can be noted is that subglottal pressure during the non-emphasized words in an utterance where one word carries emphatic

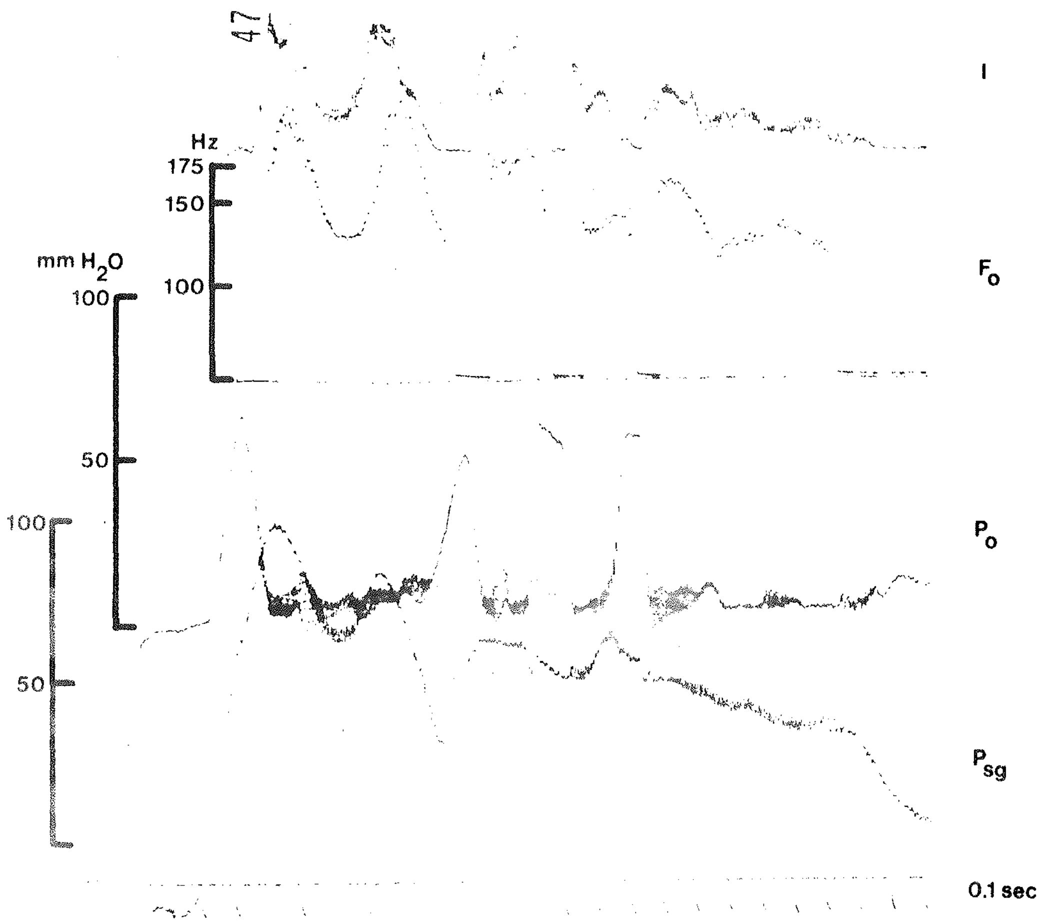

Figure 2. Version 2 – emphasis on "[illegible]".

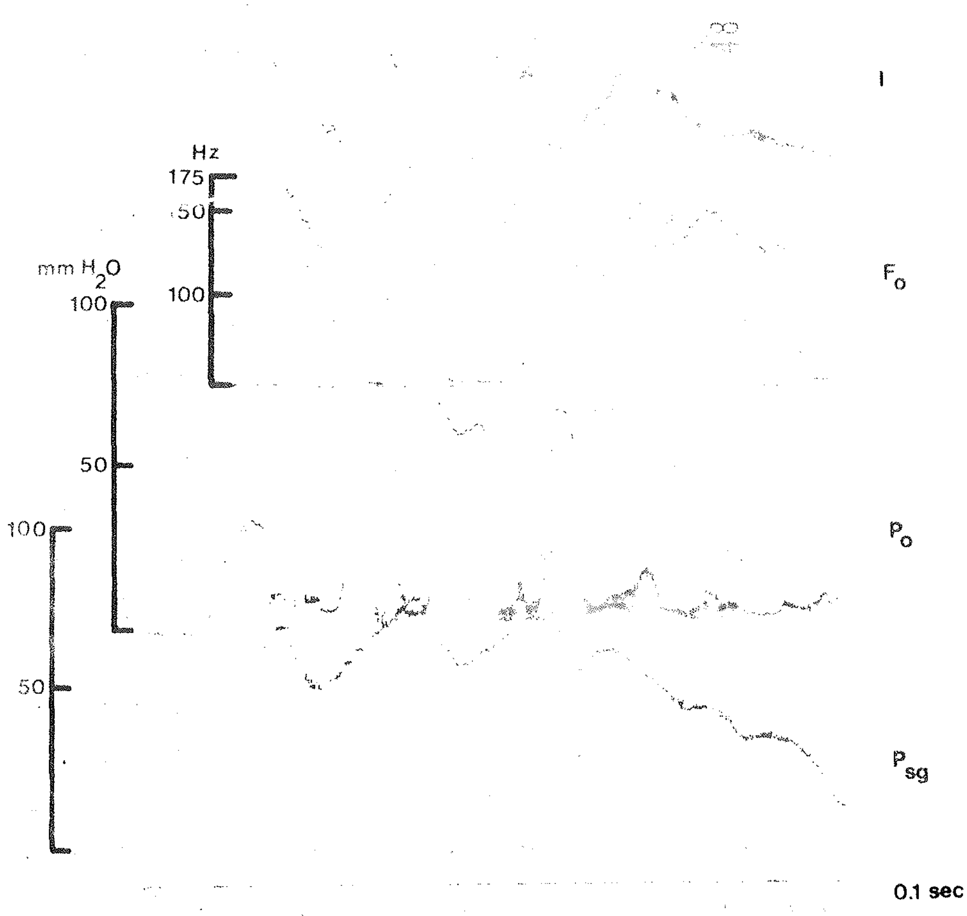

Figure 3. Version 3 – emphasis on "lättare".

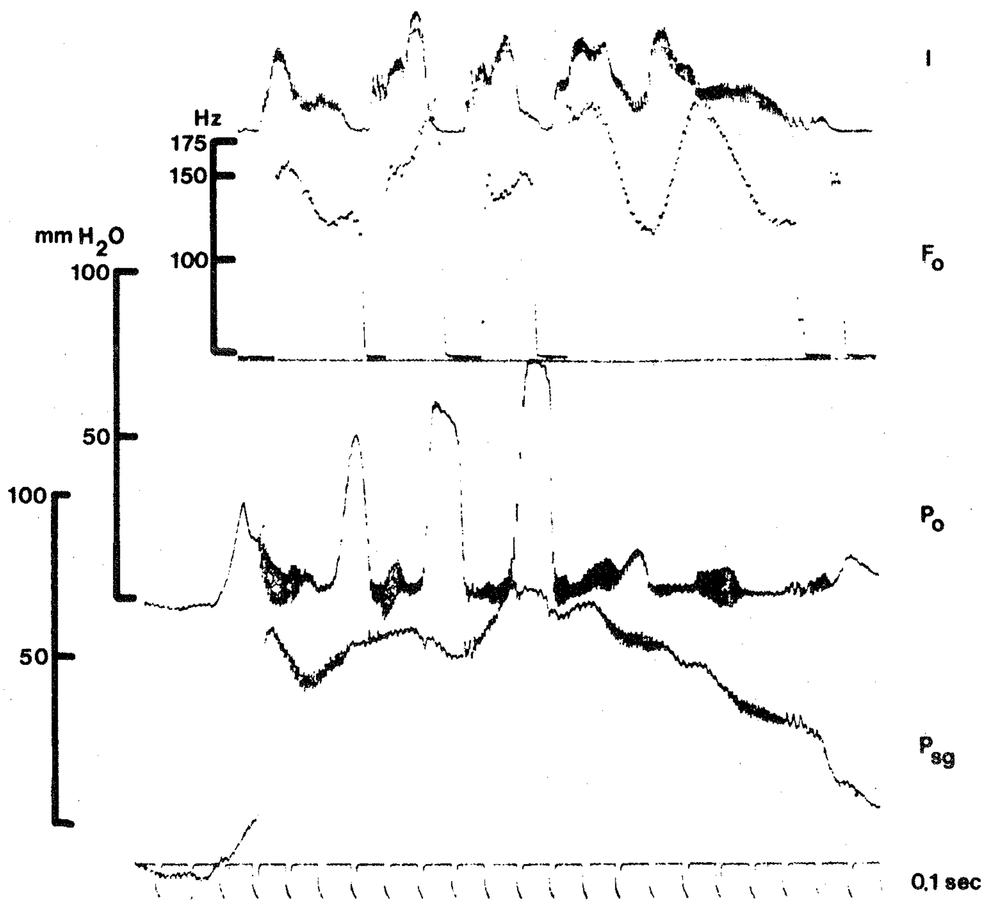

Figure 4. Version 4 – emphasis on "snuva".

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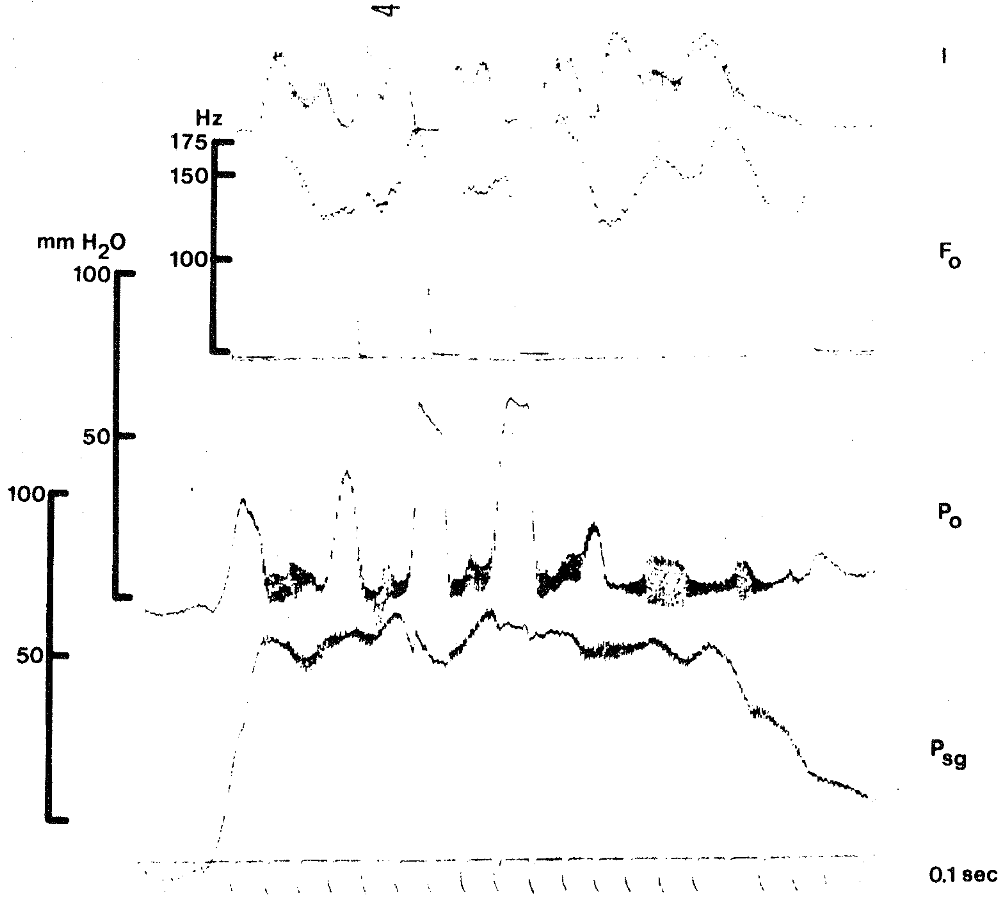

Figure 5. Version 5 – emphasis on "män".

stress is lower than when no emphatic stress occurs in the same utterance. For some reason subglottal pressure during the word "snuva" appears to be an exception to this.

The F_0 data in Table II go in the same direction as the pressure data in that emphatic stress is correlated with an increase in fundamental frequency. In general the increase in F_0 accompanying emphatic stress is much greater during the unstressed than during the stressed vowels. The only exception to this generalization is the vowel in "män" but this word is monosyllabic and also occurs in utterance final position. During the nasal consonant /n/ in "kvinnor" fundamental frequency is actually somewhat lower in the emphatic than in the non-emphatic version of this word. The F_0 variations during the non-emphasized words in an utterance where one word has emphatic stress seem to be the same as when no emphatic stress occurs in the same utterance.

Increased segment duration is another correlate of emphatic stress. This increase is especially large for the phonologically long segments of a word, i.e. the consonants /n, t, n/ in "kvinnor", "lättare" and "män" as well as the vowel /ʉ/ in "snuva".

Discussion

The function of emphatic stress seems to be to make the emphasized segment stand out against the rest of the utterance and the importance of fundamental frequency, duration and intensity for the perception of both normal and emphatic stress has been shown for several languages, Lehiste (1970); F_0 has often been claimed to be the most important factor whereas intensity would be of minor importance. One of the conclusions arrived at in the study of the intonation of Southern Swedish by Hadding-Koch (1961) is that "Tonal features are probably the chief indicators of contrastive stress, i.e. pointing to one of two or more possibilities, usually by means of a marked rise or rise-fall. In Accent-2 words this contrastive pointing may be realized by the unstressed syllable instead", (Hadding-Koch, 1961, p. 190).

Substituting the term "emphatic" for "contrastive" we see that the present results are in agreement with this statement. First, the fundamental frequency curve spans a much larger range of frequencies when a word has emphatic stress than otherwise. This is illustrated by the word

Table I. Subglottal pressure at selected points of the utterance, mm of water.

Sentence version	k	(v)	i	nn	o	(r)	f	(år l)	ä	tt	a	(r)	e	s	(n)	u	(v)	a	(än m)	ä	(n)
1	39		69	56	63		64		63	58	57		66	61		54		49		43	
2	53		86	56	78		50		59	51	51		60	56		52		43		37	
3	38		66	55	57		63		73	62	67		70	62		58		47		36	
4	39		62	50	55		60		61	57	54		66	70		64		56		39	
5	31		61	51	54		59		61	55	53		62	58		57		52		55	
with emphasis	53		86	56	78				73	62	67		70	70		64		56		55	
without emphasis	39		69	56	63				63	58	57		66	61		54		49		43	
difference abs	14		17	±0	15				10	4	10		4	9		10		7		12	
difference %	36		25	±0	24				16	7	18		6	15		19		14		28	

Table II. Fundamental frequency at selected points of the utterance, Hz.

Sentence version	(kv)	i	nn	o	(r får l)	ä	(tt)	a	(r)	e	(sn)	u	(v)	a	(än m)	ä	(n)
1.		167	130	127		185		129		143		171		122		127	
2		186	122	193		177		127		137		163		121		119	
3		159	130	121		191		152		193		187		125		118	
4		157	126	121		184		127		144		189		163		122	
5		159	130	124		176		135		147		178		125		169	
with emphasis		186	122	193		191		152		193		189		163		169	
without emphasis		167	130	127		185		129		143		171		122		127	
difference abs		19	–8	66		6		23		50		18		41		42	
difference %		11	–6	52		3		18		35		11		34		33	

Table III. Duration of selected segments of the utterance, msec.

Sentence version	(kv)	i	nn	o	(r får l)	ä	tt	a	r	e	s	n	u	v	a	(än m)	ä	n
1		98	78	93		88	129	47	18	78	106	42	136	56	78		145	141
2		121	176	158		93	124	54	16	81	109	44	126	58	84		129	132
3		76	70	89		106	193	86	19	86	119	39	145	59	88		138	141
4		85	73	91		95	120	58	22	75	134	41	201	76	118		150	155
5		74	71	84		91	119	51	18	84	116	40	132	61	91		155	224
with emphasis		121	176	158		106	193	86	19	86	134	41	201	76	118		155	224
without emphasis		98	78	93		88	129	47	18	78	106	42	136	56	78		145	141
difference abs		23	98	65		18	64	39	1	8	28	−1	55	20	30		10	83
difference %		23	126	70		20	50	83	6	11	26	−2	40	36	38		7	59

"kvinnor"; not only are the F_o maxima higher during this word in version 2 of the utterance but the minimum is also slightly lower, cf. Table II and Figs. 1-2.

Second, the unstressed vowels in the words "kvinnor", "lättare" and "snuva" show a much greater increase in F_o as a result of emphatic stress than do the stressed vowels in the same words. These words all have tonal accent 2 and the emphatic stress thus seems to be carried by the unstressed syllables in this case.

The patterns of P_{sg} variations found in the present study are in accordance with those reported in other investigations of the same parameter, cf. the references given below. During a declarative utterance with normal intonation subglottal pressure is highest at the beginning and then drops during the utterance to reach its minimal value towards its end. Overlaid on this pattern there are peaks occurring during the syllables carrying sentence stress. When emphatic stress is placed on a word higher peaks occur for it. We note on the other hand that when the emphasized word is at the end of the utterance there is an increase in P_{sg} but this is not necessarily the peak subglottal pressure of the utterance which it tends to be in other positions. The increase in subglottal pressure for emphatic stress is thus relative rather than absolute and the variations can probably in part be accounted for by reference to the pressure-volume relationship of the lung, Rahn et al. (1946).

The expiratory force of the relaxation pressure increases with increasing lung volume and it is thus greater at the beginning than at the end of an utterance since the volume of air in the lungs has decreased during the utterance. Assuming the net addition of expiratory effort for emphatic stress to be the same all over the utterance one would expect the difference between the emphasized and non-emphasized syllables to be the same irrespective of their position but that absolute pressure is higher in the beginning and successively lower the closer we get to the end of the utterance. Although the scarcity of the material makes it unwise to draw any far reaching conclusions it appears that the latter part of the assumption is true whereas the former is not since the increase in pressure for emphatic stress tends to be greater in the beginning and at the end of the utterance, cf. Table I. This can hardly be due to any mechanical factors but are independently controlled manifestations and the reduction of subglottal pressure during the non-emphasized words in an utterance where one word has emphatic stress would seem to be of the same kind.

From Figs. 1–5 it is evident that the F_o and P_{sg} curves follow each other rather closely, especially during the words with emphatic stress – perhaps with the exception of the vowel /a/ in "snuva". It is well known that, other factors being equal, an increase in subglottal pressure causes fundamental frequency to rise. The magnitude of this influence appears, however, rarely to exceed 5 Hz per cm of water, Öhman and Lindqvist (1965), Ohala (1970), Hixon et al. (1971). Increasing F_o is, on the other hand, usually accompanied by increasing glottal resistance, Broad (1968), Perkins and Yanagihara (1968), Shipp and McGlone (1971), which in itself would cause subglottal pressure to rise. Since the activity of the laryngeal muscles was not studied in the present investigation nothing can be said about the specific contribution of respiratory and laryngeal mechanisms to F_o control nor about the influence of glottal resistance on P_{sg}.

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