

SOME OBSERVATIONS ON THE PERCEPTION OF STRESS IN CZECH

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Considerable attention has been paid to the problems of the perception of stress during the last three decades. Generally speaking, the results of the various experiments have largely coincided in showing that there is no one-to-one correlation between judgments of stress and any single physical feature of the speech signal.

In an earlier experiment we tried to determine the influence of three physical dimensions - intensity, fundamental frequency, and duration - on the perception of stress in Czech; the sound material consisted of synthetic disyllabic items. In listening tests of this kind, the listeners' judgments are based, generally speaking, on two complexes of phenomena, which may be labelled as, firstly, acoustic properties of the speech signal and, secondly, contextual cues. The relation between the two complex factors can vary within considerable limits in natural utterances; in experimental conditions it is possible, however, to suppress, to a certain extent, the part played by one of the factors. We also treated the selection of a suitable test word as important. In the experiments we used throughout combinations of the syllable 'se': the word 'sese', meaning 'session', does exist in Czech, though it is quite rare - this means, it is less likely to evoke the association of a word with first syllable stressed, and even less likely in the light of the fact that an actual sequence of syllables se-se is very common in Czech.

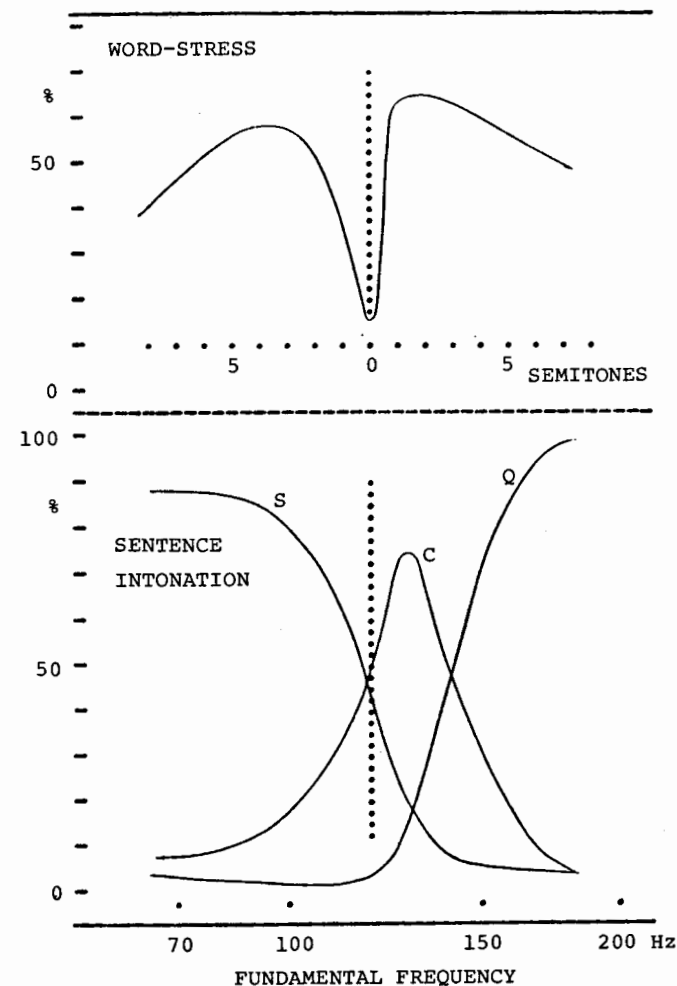
In the instructions to the test, the listeners were invited to mark stressed syllables; in English terminology the term 'prominence' would perhaps be more fitting, but the corresponding term does not exist in Czech phonetic literature. In the last edition of the standard handbook of Czech orthoepy (Hála 1967, 65) it is stated: 'By stress we usually understand the phonetic emphasis of one syllable with respect to others; within a single word this emphasis is called word-stress.' The task of the listeners was then to mark this 'phonetic emphasis', prominence. The test stimuli were produced by means of a simple synthesizer of our own construction, recorded on tape in random order and presented to 170 Czech

listeners. The results of the test can be summarized as follows: increasing intensity of the stimulus leads to an increase in the number of 'stressed syllable' judgments; increased duration has a similar effect. With changes of the fundamental frequency the relationship was found to be somewhat different. Relatively small changes - a semitone up or down - led to a conspicuous increase in the number of judgments 'stressed syllable', while a further raising or lowering of the fundamental frequency did not lead to any further increase in the number of 'stressed' judgments, but on the contrary led to a decrease.

In the evaluation of the results of this experiment we were aware that they were valid for the experimental conditions of the test and for the synthetic material used. However, we have left as an open question the unexpected influence of frequency changes on stress evaluations, i.e. the stronger effect of small changes of the fundamental frequency and the similar effect of both the increase and decrease of the fundamental frequency on the number of judgments 'stressed'. One hypothesis here was that more marked changes of tonal pitch are evaluated rather as sentence melody. Besides, a possible influence of the synthesizer had to be taken into consideration.

In the following tests we concentrated specially on these problems. Firstly, a test was prepared in collaboration with J. Liljencrants at the Speech Transmission Laboratory of the Royal Institute of Technology in Stockholm and this time, the OVE III synthesizer was used. 42 test sentences 'byla to sese' - meaning 'it was/was it a session' - were prefabricated, in which the fundamental frequency values of the last vowel were systematically changed with much closer graduations than in the earlier test. The changes in the fundamental frequency corresponded to 0, $\frac{1}{2}$, 1, 2, 4, 6, and 8 semitones in each direction away from the fundamental frequency of the previous syllable; in addition, the intensity of the last vowel was changed at 3 levels. This material was then prepared for a new listening test with other groups of listeners: firstly, the isolated stimuli 'sese' were extracted from the recording and again the listeners' task was to mark the syllables they thought stressed; in the second test, the whole synthetic sentences were used and the listeners' task was to indicate with each item, whether they felt the sentence to be

statement, question or continuative sentences. A total of 100 listeners took part in the test, and the results are presented in the following graph:



Upper part of the graph: percentages of judgments 'stress on the second syllable'

Lower part of the graph: percentages of judgments S-statement, Q-question, C-continuative sentence

Scale in semitones: difference in pitch of the second syllable of the test word

It can be seen from the graph that the evaluation of stress accords well with the previous experiment: a steep rise from a dip of the curve in the middle with a slow decrease in percentages 'stressed' farther away from the center line. The graph also very clearly shows that in the area of fundamental frequency changes where the number of judgments 'stressed' begins to fall, there is a marked distinction of sentence melody - in the lower part of the graph - when it comes to evaluating the 'sentence' stimulus. By and large, these results corroborate the hypothesis that smaller changes of the fundamental frequency contribute more to the perception of stress, while greater intervals are more at play in the domain of sentence intonation.

In this test again the listeners responded readily and within narrow limits to signals of identical fundamental frequency; these stimuli with no or only a very small difference between the first and the second syllable were, however, not only identified, but the judgment 'first syllable stressed' was ascribed to them quite consistently. A possible interpretation of this finding is that the listeners evaluated both the rise and fall in frequency as a deviation from a pitch level of the first syllable in the test word, held constant throughout the whole test. This would be in agreement with findings from analyses of running speech, where departures from the basic contour of intonation in the direction up or down both are used in Czech to express prominence of a part of an utterance.

Two different tests were then prepared to investigate this hypothesis: in one test an attempt was made to keep the characteristics of the test similar to those of the previous experiment with the exception of the fundamental frequency of the first syllable of the test word: this was changed in a random order within an octave interval. The test items were prepared by means of the synthesizer HO 2, constructed by Maláč et al. (1975), and the listening tests were finished and evaluated in August 1978. In another test again the sequence 'sese' was used, but this time as a natural speech signal. In view of the high occurrence rate of 'se', even in iteration, in Czech texts it was easy to prepare a continuous text, a short story, which contained within its two pages a total of 116 repetitions of the syllable 'se' with the stress assumed to fall variously on the first or on the second

syllable of the sequence se-se. A professional speaker read the story and the tape recording was then used to prepare test tapes containing copies of all the sese combinations cut out of the master tape. A total of 50 listeners then heard the isolated items; their task was as with the earlier tests.

The results of the perception tests with both synthetic and natural items in isolation compare well with those of the earlier tests with synthetic stimuli, with a very clear difference, however, in the perception of changes of pitch: in the present experiments the effect of a change, i.e. the influence of pitch rise on an increase of judgments 'stressed', is manifest primarily towards the upper pitch levels. Clearly, this difference is not due to any difference inherent in the use of synthetic or natural speech signals, but to the different way in which the experiment was organized. In the first two experiments the fundamental frequency level of the first syllable of the test word was constant and hence probably provided a reference level comparable with a basic contour of sentence intonation. - In short, the results of the experiment with the isolated items of natural speech can be described as follows: the syllables marked 'stressed' had a higher fundamental frequency than those marked 'unstressed' in 93% of the cases, a higher peak intensity in 79%, and a longer duration in 44% of the cases.

Conclusions

By means of listening tests using disyllabic items, the influence of changes in intensity, fundamental frequency, and duration on the perception of stress in Czech can be shown.

In general, it can be demonstrated that an increase of any of these parameters leads to an increase of the number of judgments 'stressed'.

With changes of the fundamental frequency, however, the growth of the judgments 'stressed' is distinctly non-linear: slight changes of approximately a semitone lead to a considerable increase in the number of judgments 'stressed', while larger changes have a lesser effect on the evaluation of stress in a group of Czech listeners.

Results of a test with identical synthetic stimuli once in isolation and then in a simple sentence context corroborate the hypothesis that small changes of fundamental frequency have a

stronger effect on word-stress evaluations, whereas more marked changes have a noticeable effect on evaluations of sentence intonation.

The influence of context may be strong even in tests with isolated items: in tests with a constant pitch of the first syllable of disyllabic test items, deviations - both up and down - from this constant level are found to increase the number of syllables marked as stressed. In tests without the constant pitch level of the first syllable, only increase in fundamental frequency is found to add to the number of judgments 'stressed'.

Listening tests with isolated items only have been referred to in the present paper; it is obvious that even here there is a strong tendency of the listeners to evaluate the items as parts of a broader context.

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