
PERCEPTION OF STRESS BY CZECH LISTENERS

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The purpose of the experiments to be described was to investigate the relation between synthetic speechlike stimuli varying in their physical dimensions and the auditory perception of these stimuli as stressed or unstressed patterns. The evaluation of the examined phenomena is based on listening tests, presented to groups of listeners of Czech nationality.

Irrespective of the function of stress in the Czech language, it may be assumed that Czech listeners are able to discriminate between stressed and unstressed parts of an utterance, one syllable of which is stressed and the other one unstressed. Generally, the results of tests with simplified synthetic speech cannot yield a direct explanation of the relations in natural speech. Nevertheless, they can fairly sensitively indicate the trends existing in natural speech and consequently give rise to reasonable hypotheses.

For the listening test a synthetic combination of two vowels and two consonants was chosen, the order of the sequence being CVCV. This type of sound combination is very frequent in Czech; as a disyllabic word it can occur only with the stress on the first syllable, as a disyllabic rhythmical structure it can have the stress on the first or on the second syllable. The listeners had to decide which of the two synthetic syllables they heard as stressed. It was thus desirable that sounds inserted for the "C" and "V" elements did not form any common Czech word. Accordingly, an "s" was inserted for both C-elements and an "e" for both vowels. The combination "sese" was then used in all items of the listening test, so as to keep the acoustic structure of stimuli — with the exception of variables — constant throughout the whole test. It is supposed that in this connection two further assumptions may be made, *viz.* (1) that no considerably different results could be expected, if other speech sounds were inserted for the V and C and (2) that a different number of syllables in the test items would not yield results fundamentally different from those for disyllabic stimuli. In the present test, three variables were introduced: (1) the sound pressure of the second vowel, resulting in changes in perceived loudness (*I* intensity), (2) the fundamental frequency of the second vowel, giving rise to changes of pitch (*F* —

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frequency) and (3) the duration of the second vowel, perceived as a varying quantity of the vowel (*D* — duration); in several items, only the duration of the second consonant was changed. All variable dimensions were changed on five levels (± 3 and 9 dB, \pm one and three semitones and five logarithmic steps in the range 80—200 ms for the I, F, D dimensions, respectively).

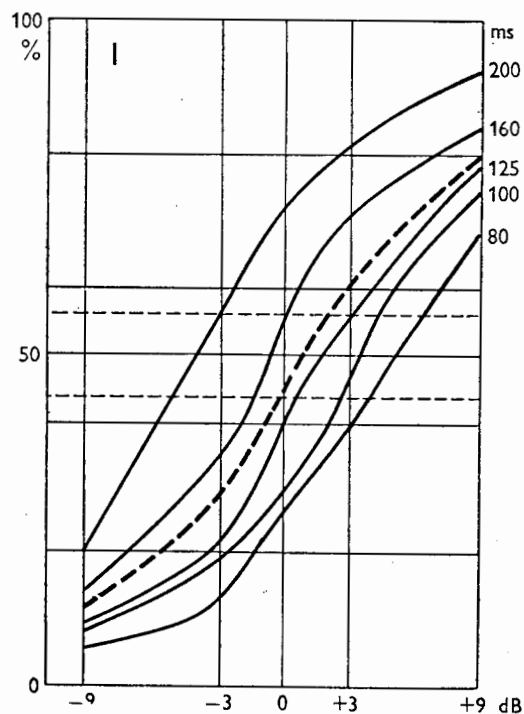


Fig. 1.

The artificial sounds were produced by means of a steady-state synthesizer, consisting of four parallel-connected formant circuits with controllable central frequencies, bandwidths and amplitude levels. The test items (130 in all) were then randomized, stored on tape and presented to 174 subjects who were all young native speakers of Czech. In test evaluations, over 22 000 judgments were subjected to computations. The results were then transferred into tables and graphs, only four of which will be shown here. In the first graph the change of judgments "stressed" is plotted as density function of intensity for respective levels of duration, the remaining dimension (frequency) being kept constant (Fig. 1). In addition, a curve for all duration values averaged is shown. Above and below the 50 % line an "interval of uncertainty" is drawn, computed as the critical difference between chance identifications and identifications required for significance at the 5 % level of confidence. Similarly, the second graph (Fig. 2.) was plotted for changes in duration (on five intensity levels) and in the third graph (Fig. 3.) percentage frequencies of judgments

vs. frequency in cps for five intensity levels is shown. It is apparent that the changes in the frequency dimension influence the judgments of stress with much less weight and consistency than the other two factors involved. The distribution of the points seems to show fairly convincingly that there is a sudden change in judgments between items with both test syllables of equal fundamental frequency and those where the

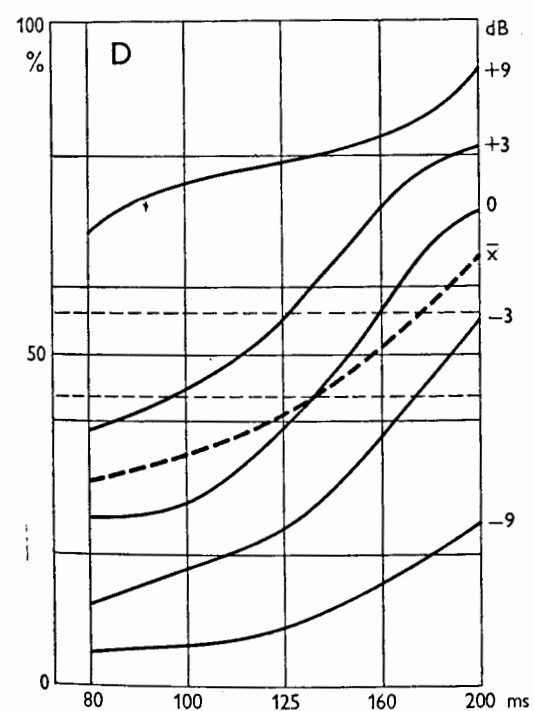


Fig. 2.

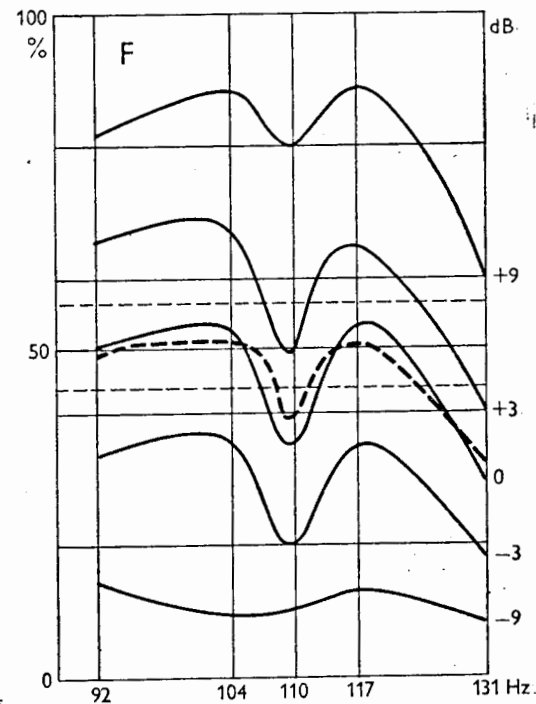


Fig. 3.

fundamental frequency was changed slightly. Slight changes (one semitone) are associated with an increase of judgments in the direction "stressed". By introducing somewhat greater changes of fundamental frequency, a reversed effect is evoked, and the number of test syllables rated as stressed diminishes in both cases.

In the last graph shown here (Fig. 4.) data of judgments changing simultaneously and in the same direction in two and three physical dimensions are given. The total mean value of all judgments is included in the form of a horizontal line. Its position below the 50 % line shows that in borderline cases Czech listeners more often perceive the stress on the first syllable. In combined plots of the graph shown, the expected effect of a simultaneous change in two or three dimensions is obvious: the central portion of both curves is very steep and even the minor effect of frequency changes adds to the abrupt swing between the "stressed" and "unstressed" areas.

According to traditional views on "dynamic accent" in Czech, the intensity factor was often presented as the fundamental one and the influence of durational changes

denied. Experiments in the perception of stress in various languages, some of them using also synthetic material, show, in a majority of cases, the outstanding perceptual importance of fundamental frequency changes. This was shown e.g. by Mol and Uhlenbeck, Fry, Strevens, Bolinger, Lieberman, Malmberg, Rigault, Jassem, Isačenko and Schädlich and others. In the present experiment no such prevailing impor-

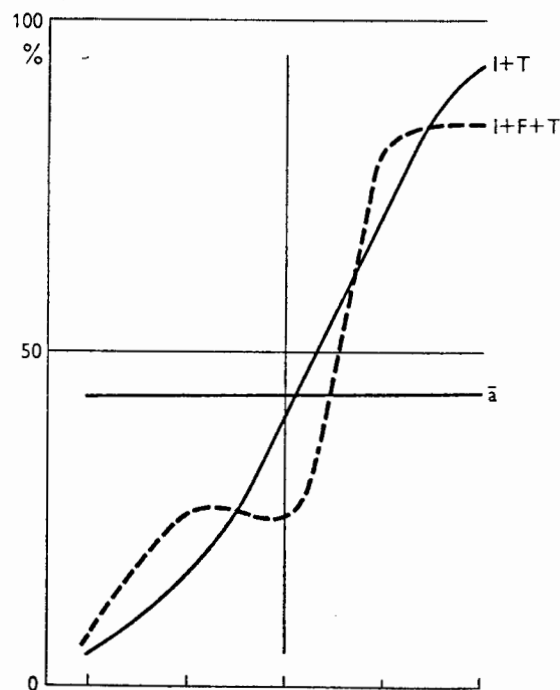


Fig. 4.

tance of fundamental frequency changes was experienced by Czech listeners. (By detailed statistical analysis it has been demonstrated that this trend was apparent in a group of Czech students of French.) A limited investigation into the relative effect of durational changes of the fricative sound used as a C-element in test items shows that a decrease in duration of the consonant causes a slight increase in the number of "stressed" judgments and an increase in duration a more pronounced one. In both cases the effect is weaker than the influence of changes in the vocalic element. The effect of sequence in pairs of adjoining stimuli is statistically significant, i.e. an influence of the immediately preceding item on the following one was stated, working in the direction of contrast. A possible equivalent of this effect in natural speech signal cannot be excluded from consideration. It is hoped that the results reported may contribute to a better knowledge of the auditory evaluation of stress in Czech.

DISCUSSION

Fischer-Jørgensen:

a) As Czech has phonologically relevant vowel length also in unstressed syllables, one should expect duration to be less important for the perception of stress than in other languages. Has such a comparison been possible? b) Does the amount of increase in frequency, duration and intensity required for perceiving one syllable as more stressed than be neighboring syllable differ for first and second syllable?

Rischel:

I wish to ask whether the segments constituting the test stimuli were entirely steady-state sounds switched on and off abruptly. One might consider the possible relevance of the type of onset and offglide for the judgment of stress placement.

Sivertsen:

Were your listeners linguistically trained or naive? What instructions were given to them they were asked to identify the stressed syllable? What did your listeners mean by 'stress'?

Janota:

Ad Fischer-Jørgensen: Principally, a comparison of listening tests presented to native speakers of various languages would be possible and quite useful. In that case, however, the test material would have to fulfil comparable conditions of acceptability for both or all languages investigated. As yet, a similar effect in the frequency domain could be demonstrated indirectly on results of the test presented to Czech students of French. In this group, a greater relative importance of fundamental frequency changes for the perception of stress was apparent.

In our test, the amount of increase in frequency, duration and intensity required for perceiving one syllable as more stressed than the neighbouring one does not differ for the first and second syllable of the test items used, except for the fact that the total mean value of all measurements shows a slight shift in the direction to judgments of 'stress on the first syllable'. (Cf. Fig. 4.)

Ad Rischel: The segments constituting the test items were not switched on and off abruptly; besides, all the stimuli were stored on tape. Two identical test tapes were used for all the tests.

Ad Sivertsen: The groups of listeners consisted mainly of first year students of the philosophical faculties in Prague and in Brno, so that they were not completely linguistically naive, though they were not specially trained for the test. The instructions to the test were recorded on the test tape so as to exclude a possible influence of a non-uniform formulation of the task on the results of the experiment; the listeners were asked to underline the stressed syllables of all items. No explicit explanation was given as to what was meant by stress (rather, we expected the answer from the listeners), though the listeners' linguistic knowledge could not, of course, be eliminated. It was expressly mentioned in the test instructions that the test items were synthetic, but the purpose and composition of the test was not explained.