Psycholinguistic meaning of the preformant in the vowel acoustic structure

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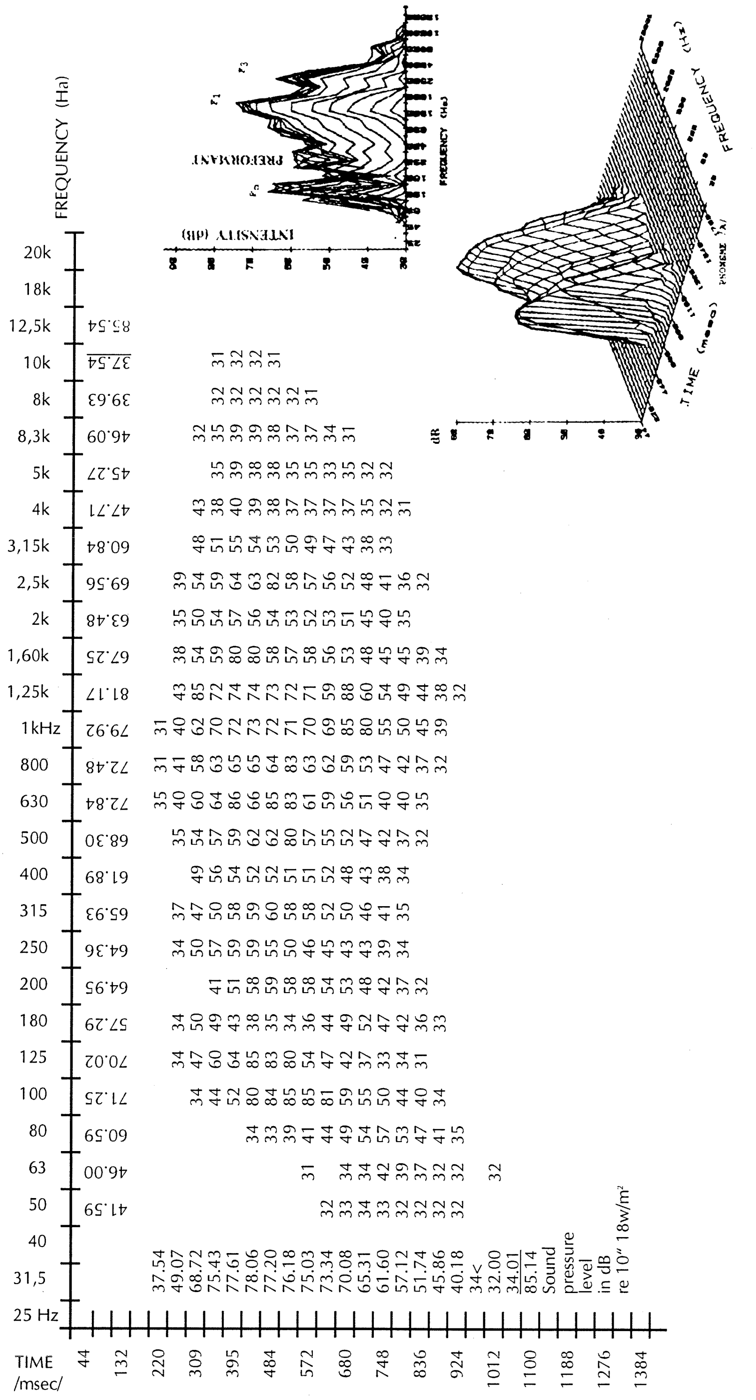
Human speech serves for verbal communication and to reflect (neuro)emotional tension of the individual psycholinguistic state, manifested through voice changes such as intensity, pitch, tremble, colour etc. (Ruiz et *al.* 1990). The latter function does not necessarily coincide with the semantic content and the speaker need not be aware of it. For voice change estimation, the acoustic indicators, like F_0 fluctuation, formant shift, acoustic pattern etc. have been proposed (Simonov, Frolov, 1977). The significance of these acoustic indicators have been confirmed with the application of digital frequencyamplitude analyzer of speech sound, in real time, which enabled their quantification. However, since no data on acoustic structure and psychophysiological meaning of a vowel preformant are available the purpose of the present study was to characterize the possible psycholinguistic role of the vowel preformant. Due to that the spectral position, frequency range, intensity and dynamic acoustic structure of the vowel /A/ preformant were analysed in the subjects at rest, fatigued ones and those under stress.

Method and Materials. The study included 321 healthy human subjects of both sexes ranging from 22 to 64 years of age. Each pronounced all Serbian vowels, altogether 5, one by one, directly into BK analyzer via BK dynamic microphone. During vowel utterance the subjects were sitting in a sound proof chamber. All speech material was analysed by using real time Digital Frequency Analyzer Type 2131 (Bruel and Kjaer, Denmark). The analyzer was connected via interface to the Hewlett Packard Desk Top Calculator 9825B and HP 9872A Plotter. The acoustic vowel structure, produced by each subject, was plotted three-dimensionally, two-dimensionally or numerically by the columns of numbers. Each numerical value represents instantaneous intensity, at the particular frequency and at the given 44 ms interval, during articulation period. When vowel /A/ instantaneous intensities were summed up throughout the spectrum, its overall intensity level or sound pressure level (SPL) is obtained. However, if all instantaneous intensities are summed within any of the one-third octave bands, the overall real time sound intensity of a given band is gained.

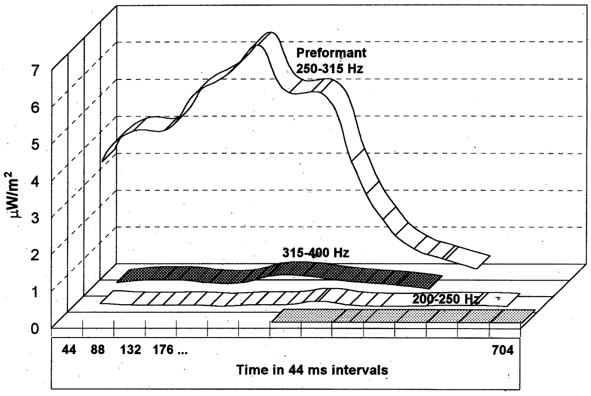
Results. The initial part of the speech sound spectrum, primarily that of vowels, belongs to the so-calld preformant region. It usually extends from 160, 200 to 500 Hz rarely to 600 Hz. A preformant is formed within this region though it can be indistinct or even absent. The vowel preformant is formed in the early childhood, mostly during the third year, and persists for life. Therefore, vowel preformant is a prominent, well defined frequency area, in the lower spectrum part, identified by computerized one-third octave band analysis in real time. In a vowel acoustic structure the preformant is located in front of the first formant i.e., between the upper frequency boundary of the Fo range and the beginning of the first formant. This is why we termed it preformant. In the acoustic structure of a vowel /A/, spoken in isolation, under normal conditions, there

Figure 1. An exemple of the vowel /A/ acoustic structure, identified by one-third octave band analisys, represented by the columns of numbers, as well as two – and three – dimensionally



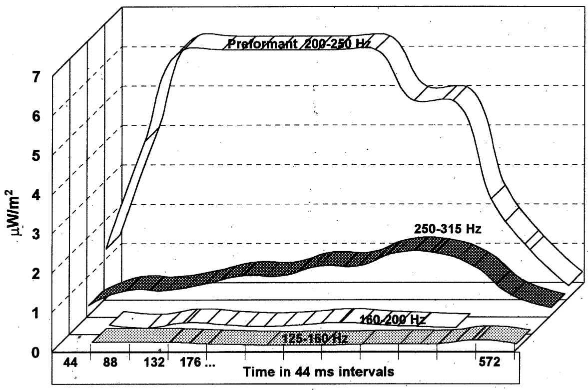
is almost always one preformant though the occurence of the two is possible. If there is only one preformant it is generally located at 315-400 Hz. However, if there are two preformants, one is usually at 160-200 Hz, while another one at 315-400 Hz. They are distinguished by their bandwidth, SPL, peak intensity and acoustic pattern (Fig.1.). The concentration of acoustic energy is higher in the preformant than in the first onethird octave band immediately before, and after the preformant. Each of these two bands contain considerably less acoustic energythan the preformant itself. At rest, during normal utterance of the vowel /A/ its preformant is 1.43 to 37.62 times more intense than the succeeding one. This range was reduced by fatigue, and increased by higher (neuro)emotional tension. The difference is highly significant P < 0.001 (Fig. 2).

Figure 2. Vowel /A/ preformant structure at rest



In the normally produced vowel /A, the preformant minimal instantaneous intensity was chicfly from 31 to 35 dB and maximal one not much higher than 62 dB. Thus, the range of voice intensity within the preformant was about 32 to 630 times. In tired man it is reduced to several tenth of times. But if the fatigue has been accompanied by higher tension, this ratio might be increased. The preformant acoustic pattern i.e. its dynamic structure along with adjacent bands, is characterized by the prominent central portion. It was changed by the fatigue into plateaulike or other types of deformation (Fig. 3.). The SPL has often been very close to

Figure 3. Vowel /A/ preformant structure and neighbouring one-third octave bands at fatigue



that of the wovel *IAI* second formant. The peak within the preformant is considerably higher than that in the preceding andsucceeding 1/3 octave bands. In the preformant it is formed inthe first third of the overall articulation period, but in the neighbouring 1/3 octave bands, this peak appeared before or after this limit.

Discussion. The vowel /A/ preformant has been chosen for detailed acoustic structure analysis, on account of several reasons. First of all, the vowel /A/ was the first or among the first to appear in the human voice system. It seems that it should be more resistent to the stress or any other influence given that it is evolutionary the oldest. Hence, relatively small or moderate mod)fication of its structure wouldreflect considerable changes of speaker's psychophysiological state (through neuroemotional tone variation), as well as certain psycholinguistic individual aspects. Sudden and great variation in the instantaneous intensity, from one to another 44 ms interval, in the course of phonation, along with changeable frequency content causes the considerable structural mod)fication of the vowel /A/. Under normal circumstances the instantaneous intensity of the successive 44 ms intervals, during voice production, chiefly varies from 1 to 4 dB. Variations higher than 4 dB are reliable sign of stress situation. This range is usually smaller at fatigue, and exceeds 10 dB under stress. According to the acoustic structure modification the type and intensity of stress might be judged. Thus, the greater irregularity in the instantaneous intensity variations, the more prominent psychophysiological, i.e. psycholinguistic alterations. In this respect, Williams (1972) drew to the conclusion that the frequency and amplitude of the first two formants, and even that of the third, increase when an individual is subjected to the emotional stress. Furthemore, Simonov and Frolov (1977) pointed out that frequency pattern of the voice energy, identified through one-third octave spectral analysis of isolated words, closely correlated with the emotional stress. Actually, if in the individual with severe hearing loss, the first 200-300 Hz is preserved the interindividual verbal communication is possible. This finding indirectly indicates to the preformant psycholinguistic meaning because this frequency region is the most common preformant location. Besides, at normal state, during speech sound production, the peak intensity of F, – F2 and that of the preformant is reached simultaneously while this is not the case in the adjacent 1/3 octave bands. *Conclusion.* The preformant spectral shift, structural fluctuation and intensity changes correlate with psycholinguistical state of the speaker.

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