LINGUISTIC DETERMINATION OF THE INTELIGIBILITY OF THE SPEECH SOUNDS

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The unsatisfactory results in the phonoauditive correction with patients with impaired hearing from different linguistic areas, having in mind and using results from purely physical analysis of the phonemes isolated or in the word context, at different positions directed us to undertake a more subtle study of the problems of perception of the speech sounds from psychoacoustic and psycholinguistic points of view.

Although the Serbocroat and Macedonian languages acoustically are rather close to each other, and have seemingly close phonetic systems, the perception of the sounds in one language, especially in word and sentence context under the influence of the structural phonological elements, to the population speaking the other language is quite different and the intelligibility is accordingly more difficult. This phenomenon is more emphasized among patients with impaired hearing, therefore the problem came up in the everyday phonoauditive corrective work of our logopedic and audiological clinics.

According to the psychoacoustic analysis of the Macedonian and Serbo-croatian languages the phonemes have the following distribution:

Frequency range	Speech Sounds	
	Macedonian language	Serbo-croatian language
6400—12 800 Hz	*S, C*	*S*
4800—9600 Hz	*Z, DZ*	*Z, C*
3200—6400 Hz	*Č*	*I, Ć*
2400—4800 Hz	*I, Š, K', NJ*	*DJ, J, NJ*
1600—3200 Hz	*E, T, J, G', N*	*E, Š, Č, T, LJ, N*
1200—2400 Hz	*P, F, C*	*Ž, DŽ, D, F, M*
800—1600 Hz	*A, K, Ž, LJ, M*	*A, R, K*
600—1200 Hz	*O, D, R, H, L*	*L, H*
400—800 Hz	*G*	*O, G*
300—600 Hz	*H, B, V*	*V*
200—400 Hz	*U*	*U, B, P*

(After S. Keramitchievsky and Ivo Scarich)

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These analyses are performed using the octave filters SIEMENS, modified in Yugoslavia, semioctave filters ALLISON and tape recorder AMPEX. The ear was the criterion in both analyses. These two analyses were performed and verified individually and in groups in the two languages.

The procedure was that the isolatedly pronounced sound was passed through the filters, seeking the narrowest frequency band at which the sound is best heard i.e. it has the best auditive characteristic for the representatives of that language. At the same time the necessary intensity dynamic, which contributes best to the purity and perception of the sound is provided. In that way the frequency bands and the structural intensity dynamics were established at which the sounds were best heard, spoken and heard by the Macedonian speaking people i.e. Serbo-croat speaking people, regardless of the number and sex if the subjects because the preliminary investigations in this way in both languages showed that these two facts have no essential influence upon the psycholinguistic structure and perception of the sounds, although the results of our experiments in that way are such that female and child pronunciations are higher by 13—15 % than the male pronunciation.

Because at these frequency ranges, with the established intensity dynamic optimal audibility of the sounds is assured and they are called optimal auditive perceptive structures. The results of these analyses have been used for several years in learning Macedonian and Serbocroat languages by foreigners, in logopedic correction and auditive correction and rehabilitation of children and adults with hearing problems in several institutes in Yugoslavia.

The problem of linguistic determination of the intelegibility of the speech sounds appeared in the clinical practice of phonoauditive correction and rehabilitation, using the filter system with patients from the Serbo-Croat linguistic area. While instrumental phonoauditive correction, using the optimal auditive perceptive structures of Macedonian language with Macedonian speaking patients showed excellent results, whereas with the Serbo-Croat speaking patients it was not possible to achieve similar results. On the other hand Serbo-Croat children who had developed hearing loss before they learnt to speak and were rehabilitated in Macedonian institutes found it more difficult to understand even those words which are the same in both languages. Therefore comparative analyses were undertaken using two criteria for both languages: subjects with normal hearing and subjects with linear bilateral symmetric conductive hearing impairment. The experiment was performed in ten subjects of the two languages with normal and impaired hearing, using the same technique and method, which were used in establishing the frequency ranges of optimal audibility in the two languages.

The experiment aimed at establishing the difference in perception of speech sounds with regard to the acoustic and linguistic differences and hearing state. For many reasons we decided to analyse ten speech sounds of each language: five consonants *L*, *Č*, *K'*, *G'* (*Ć*, *DJ*) *Ž* and five vowels — *I*, *E*, *A*, *O*, *U* under the conditions when they are:

1. Pronounced and heard by subjects of the same language. passed through their frequency ranges at the established intensity dynamic for the sounds of that language.
2. Pronounced and heard by subjects of the same language. passed through their frequency ranges, without providing the established intensity dynamic.
3. Pronounced by subjects of the same language and passed through their frequency ranges at the established intensity dynamic for that language and heard by subjects of the other language.
4. Heard by subjects of the same language and passed through their frequency ranges at the established intensity dynamic for that language, and pronounced by subjects of the other language.
5. Heard by subjects of the same language and pronounced by subjects of the other language and passed through the frequency ranges at the established intensity dynamic for the other language.
6. Pronounced by subjects of the same language, and heard by subjects of the other language and passed through the frequency ranges of the same sounds with the intensity dynamic of the other language.

The outcome of the experiment was as follows; the scoring is expresed in per cents:

Conditions	Subjects with normal hearing		Subjects with impaired hearing	
	Mac. language	S.-Cr. language	Mac. language.	S.-Cr. language
1	100	100	86	84
2	87	86	84	82
3	42	40	35	32
4	84	80	79	80
5	40	39	36	35
6	38	40	34	31

At the first condition, besides the conductive impairment of hearing of the subjects from the control group, the percentages the highest, and taking in to consideration the impairment of hearing the difference between subjects with normal and subjects with impaired hearing is minimal. As the reduction of hearing among all subjects was linear and stood at the level of 35—45 db, the emission was amplified in every case with impairment at the level of detection. The sounds the optimal frequency ranges of which were at the spectral range from 1000 Hz to 6000 Hz did not require high amplification from that one they got linearly, and the established intensity dynamic which is characteristic for the perception of those sounds by the normal ear. The optimals above and below this range required additional linear or dynamic amplification of 8—15 db. When the optimal was established in every case according to the impairment, together with the additional amplification it increased to 92 per cent.

This fact on the one hand undoubtedly shows that the optimals are standard as psychoacoustic structural form and psycholinguistic perceptive norm for every language individually. On the other hand it shows that besides the specific perception of the speech sounds by the pathological ear, which has its own system of perception is again based on the phonoauditive structure of the phonemes of the mother language.

In the modified conditions the percentage is highest when the sounds are pronounced and heard by the subjects of the same language and passed through the frequency ranges which are the optimals for the same sound of the other language. The percentage is almost the same in the two criteria. The percentage is high too, when the sounds are heard by the subjects of one language and passed through their own optimal frequency ranges with specific intensity dynamic, but pronounced by the subjects of the other language. But the percentages are much lower when these sounds are passed through their specific frequency ranges with the characteristic intensity dynamic. In that case that decreases to 40 and 30 per cent.

In the third, fifth and sixth conditions the percentage is the lqwest i.e. that perception is the worst.

According to the nature of the conditions and the height of the percentage it can be easily seen that every speech sound has its defined critical frequency range and intensity dynamic, and that its psycholinguistic structure articulatively and auditively is conditioned and interdependant according to the pecularity of the language.

Contrary to the statements that for the distinction and perception of the vowels the movement of the first and second formants is essentialy important and for the consonants the width and intensity of concentrations of the acoustic energy, our previous and this experiment show it cannot be generalized, for it depends on the nature of the phoneme and circumstances. It is true that for some vowels in our language the movement of the first and second formants is more important (*O*). while for others the second and third (*U*), the third fourth and fifth as it for (*I*) etc. And the intensity of the acoustic concentration is not always important. A great number of consonants are phonologicaly characterized by the spectrum of the areas which physically are not the strongest. Therefore the phenomenon of perception should be sought in the phonological system of the language and not simply in the purely physical dimensions of the sounds. The structure of the physical parameters of auditive perception of the speech sounds is involved in and based on the phonological structure of the language, therefore it differs in every language even for the same or similar speech sounds in close languages. And it reflects the specific phonology and originality of the language.

Without diving into the neurophysiological, physical and psychological aspects of the problem, because in these case only the psycholinguistic phenomenon of perception of the speech sounds is taken in consideration, it can be concluded once more that the perception of the speech sounds does not depend only on the physical laws and psychophysiological conditions but it is also linguisticaly determined too.

DISCUSSION

Sovijärvi:

1. Did you use in all your experiments the same filter bands not varying the frequency areas? Your investigations concerning the psycho-linguistic patterns in related languages are very impressive. The continuation of your studies is important.

2. In Finnish there are 8 vowel phonemes. Therefore it would be difficult to use your filter system to distinguish the oppositions i/y, e/ö, and ä/a.

Keramitchieva—Keramitchievsky:

In our psycho-linguistic analysis we use a number of different filters capable of combining the frequency areas in the whole speech spectrum requiring the necessary intensity dynamics. They enable the adjustment of the electronic transmission according to the specific dimensional structure of every phoneme separately. In that case, and in connection with the first part of the question put by Mr. Sovijärvi my answer would be as follows: we use different filter bands covering all the areas capable of widening and narrowing the speech spectrum and at the same time capable of regulating (adjusting) the dimensional interrelation.

In regard to the question whether these filters can satisfy the needs for an adequate analysis of phonemes in Finnish: I am quite sure that there is no difficulty because the development of the filter technique enables us to get even more subtle results than the ordinary technique, for instance to establish opposition in the Finnish vocal system.