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CORRECTING PRONUNCIATION DISORDERS IN INDIVIDUALS WITH HEARING IMPAIRMENT BY USING SOFTWARE FOR SPECTRAL ANALYSIS OF SPEECH

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ABSTRACT. In the present study are presented some aspects of a broader study aimed at developing aspects of verbal auditory function in individuals with hearing loss wearing digital hearing prosthesis and individuals with cochlear implants. By viewing the acoustic features of speech, using Cool Edit Pro program and the program Praat increase the effectiveness of intervention to correct pronunciation in people with hearing loss.

Keywords: *visualization of the pronunciation, spectrograms, formants, resonant chambers, co-articulation; pronunciation disorders, auditory-verbal training.*

ABSTRAKT. In dieser Arbeit werden einiger Aspekte aus einer reichlicherer Arbeit präsentiert über die Entwicklung der hör- mündliche Funktion bei Personen mit Hypoakusie, wenn sie über eine analogische und digitale Hörprothese verfügen und Personen die Cochleaimplantat
bekommen. Durch Sichtbarmachung der akustischen Besonderheiten der Sprache, durch Benutzung des Programms COOL Edit Pro und Praat, bei den Personen mit Hypoakusie, die Wirksamkeit der Ausspracheverbesserung wird größer.

Stichwörter. *die Sichtbarmachung der Aussprache; Spektogrammen; Formanten, Resonanzzimmer, Koartikulation; Aussprachestörung; hör- mündliche Übungen.*

1. Theoretical framework

1.1. Acoustic features of verbal productions in people with hearing impairment

The main concern related to hearing loss refers to the implications for speech perception. The audiologist tests give us a summary of the acoustic properties of a signal. This summary note on a particular type of audiogram which contains an area marked for various categories of spoken sound. This "map" has particularly informative value; it provides an insight into the components of the "auditory space" pronunciation which are involved in vowel contrasts and in decisions such manner/place.

Spectrographic analysis of verbal productions in people with hearing impairment allows finer highlight of the way in which the contrasts above mentioned undergo changes expressed including formants view. Theories of speech perception will, in different ways, follow the examples that detect the relationship between perception and articulation and co-articulation issues.

In light of motor theory regarding speech perception is sustained the link between speech production and speech perception. For example, when a stop occurs in different vocalic contexts there is no sound evidence to support its constant perception, this being due to coarticulation (Liberman and Cooper, quoted Lepot-Froment, 1999).

When it comes to articulation invariance for place on explosive consonants, researchers take into account the possibility that it could be included in the acoustic signal. This is the theory of acoustic invariance. One aspect that supports this theory, but on the perception of vowels, is that the ear is able to extract format based on Fourier analysis. Around the same way should work ear and consonant perception (Ryalls, 1997).

During the speech, due to changes in size and shape of the larynx, there will be changes in intensity and frequency, which will lead to increase of harmonics and suppress others one. Consonants generally have a shorter duration being strongly influenced by neighboring vowels (Fraser, 1995).

In our country there is concern for visualizing acoustic features of speech both parts of phoneticians and psychopedagogists, especially those studying aspects of verbal language development in people with hearing impairment.

One of the Romanian researchers was Florin Constantinescu, who contributed to this field, has developed lists of verbal material (logatoms, words, sentences), specifically for the Romanian language, intended to vocal audiometrics, material that is also extremely useful in auditory-verbal training and has been used in this study. A reference work for phonics and phonology field, with consistent treatment/ handling of acoustic aspects of speech specific to Romanian language is that one of Rosetti and Lăzăroiu (1982) in which are presented and analyzed the spectral representations of phonemes of the Romanian language and some logatoms. This study is part of the current concerns of psycho-pedagogical related to auditory-verbal training in people with hearing impairment, including through computer programs that allow the analysis and visualization of acoustic characteristics of speech and pronunciation (Anca, Hațegan, 2008).

1.2. Pronunciation of vowels and consonants features in people with hearing impairment

Classic literature on the hearing impaired shows a dependence of the defect pronunciation of phonemes to the degree and type of hearing deficit. Vowels are pronounced more easily and also the vowel pronunciation habits are formed more easily than consonants. After Mare (1993, quoted by Anca, 2006) defects of pronunciation of

vowels are present in the speech of people with profound hearing loss in more than 50% and of the consonants and the proportion of 70-75%; in severe hearing loss only 25% of vowels deviated from the norm while 40% of consonants shows defects, 10% of vowels are affected in moderate hearing loss and 30% of the consonants; and in mild hearing loss, the proportion of vowel pronunciation disorders is much lower, while the consonants are affected in proportion of 11-12%. Disorders are caused by incorrect position of tongue in the articulation process. There is a tendency to blur the extreme positions of the tongue in vowel emission. At the deaf, the isolated vowel pronunciation, tongue often occupies a central position (minimum effort law) resulting in several categories of flaws (defects):

Neutralization is the most common defect emission and pronunciation of vowels. In Romanian, the position of tongue is neutral to the vowel "ă" (medium vocal and semi-closed). At the deaf, most vowels acted as the vowel "ă".

Substitution is the replacement of vowel with other vowel, the defect occurs in 30%. For example, “a” is pronounced as “ă”, “e” as “i”, “o” as "u".

Diphthongalization refers to splitting vowels: “iecran”. It occurs at a rate of 7-10%.

Vowel *nasalization* occurs due to a quantity of air flow on nasal route.

Disorders in pronunciation of consonants are more frequent and severe than those encountered in isolated vowel pronunciation. Of these we mention a few:

- *desonorization* occurs when in the consonant sound emission; the vocal chords vibration is omitted. For example: the occlusive “b”, “d”, are transformed into “p”, “t”; the fricatives “z”, “j” transform into “s”, “ş”. Is one of the most common disorders of consonants pronunciation. Affricate “ğ” turns into “č”;

-*substitution* is of two kinds: when consonants are replaced by other sounds similar according to manner of articulation criterion. Example: “b” with “d” or “p” with “t”. Another type of defect is to replace a consonant with another which has different manner of articulation as occlusive are replaced with fricatives, example: “t” with “f” or inversely.

Speech intelligibility depends not only on the pronunciation of phonemes but also on the particularity pronunciation of words, that is why it is important to consider several variables related to the coarticulation field.

Depending on the variables related to the coarticulation it must: adapt methods and procedures used in deaf demutization; adapt methods and procedures applied in correct pronunciation and speech disorders in people with hearing loss and selection of verbal material used in auditory verbal training.

2. Methodology of research

With the aim to improve the inteligibility of speech, two individuals with hearing impairment beneficiated, during one semester, of speech training with the support of two computerised programmes: Cool Edit Pro programme and Praat programme. In the present study some aspects of a wider study are presented, aspects that aim the development of verbal auditory function at hard of hearing individuals

in the context of fitting with digital and analogical hearing aids, but also individuals with cochlear implant.

Objective: visualizing the particularities of the pronounciation of individuals with congenital profound hearing impairment with the use of computerised programme Praat programme with the aim to identify articulation and coarticulation difficulties and their correction.

Hypothesis of the study: the spectographic visualisation contributes to a decrease of the deficitary aspects of the pronounciation at individuals with hearing impairment in the conditions of specific training.

Specific hypothesis: in the case of coarticulation the formants are dependent on the way in which the sound is filtered by the active and passive organs in the articulation, but also by the particularities of the pronounciation of the individuals with hearing imapirment.

Participants to the study:

- one adult with profound congenital hearing impairment, who learned to speak through traditional methods, predominant visual and tactile-kinesthesic.
- one adult with profound congenital hearing impairment with bilateral fitting, with digital aids, who learned to speak also by the good use of auditory channel.

Both participants, users of the specialised computerised programmes, designed for the the visualization of speech are motivated to increase the level of inteligibility of speech for a better professional and social inclusion.

The development of research

The linguistic material that was used was diverse. The two participants in the study beneficiated of trainings in which recordings of the isolated pronounciation of phonemes of the Romanian language were realised, of the monosyllables and bisyllables, words (selected for a higher diversity of coarticulation contexts), but also sentences with a different level of complexity. With the help of logatomes we can observe the level of pronounciation of different phonemens, in coarticulation contexts, and with the verbal material with signifficance we can evaluate speech.

We illustrate with the help of spectograms based on the recording of a logatome with the use of Praat programme, the particular aspects of the pronounciation of the two participants and the analysis of these particularities.

Analysing the spectral representation of the logatome “aibd” pronounced by the person with hearing impairment with a hearing aid we can notice the fact that there is no real process of coarticulation. Each sound is pronounced separately, the glotal blockage being identified after each pronounciation of a phoneme.

The isolated pronunciation of the sounds emphasizes the articulation abilities superior to coarticulation, the voice disorders are reduced, the nasalization is identified only in small proportion. The increase in the tone of voice is still present, especially concerning the third formant, an underlined aspect in the spectral representation of the pronunciation of the sound “i”.

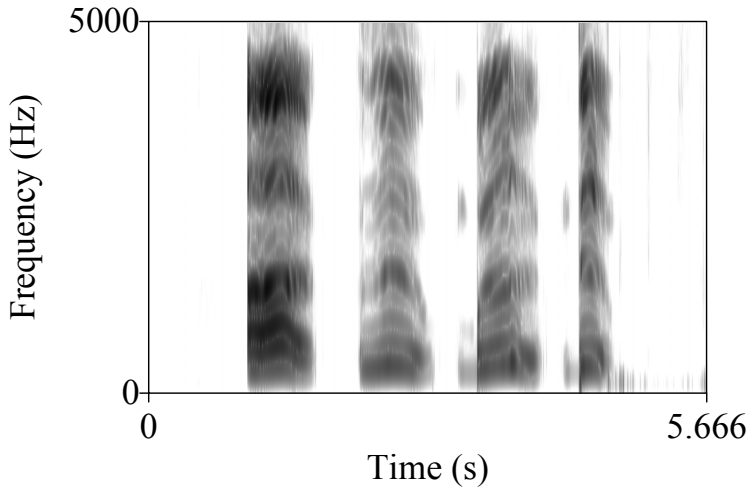

Fig.1. Spectrogram for logatom (non-word) "aibd"- hearing impaired pearson with auditory prosthesis

After Rosetti, Lăzăroiu, (1982), the vowels are identified through the three formants (F1, F2 and F3). The third formant plays an important role in the discrimination of vowels, only because those who have F2 and F3 are really close, these being the anterior vowels („e" and „i"). When F2 and F3 are close, their perception is equivelent with the perception of a single formant whose frequency is intermediar to them.

We specify that in the case of this participant there is an oral cavity with a hard palate that presents an ogival vault, that reflects in the dimensions of the resonance cavities and directly in the quality of sounds as it follows: the more the resonance cavity is bigger, the lower frequency of the sound, and the smaller the resonance cavity, the higher the sound. Ryalls (1997) shows the way in which the two chambers separated by the tongue in the oral cavity influences the sound produced by the larynx. The resonance of the sound in each cavity generates a formant dependent on the frequency of the size of the cavity. So the form of the vocal tract acts like a filter, with an accent of some of the harmonics of the fundamental. The cavity behind the tongue is responsible for the first formant, and the anteror cavity for the second.

The difference between the intensity of the pronunciation of the sound "a' is easily identified in comparison with the intensity of the other logatomes that compound the logatome in case. The pronounciation of the sound "a" with an incresed intensity emphasizes the position of the accent at the level of this sound, bringing a plus of ampliffication to some frequencies that don't belong to the formants, due to the forced expiratory flow, with an inadequate dose.

In the case of the vowels, the sound produced by the vibration of vocal cords is filtered by the form of the oral track, especially buy position of tongue. The particular form of the articulation organs specific to each vowel acts like a filter for the sound produced by the larynx. The fundamental of the voice is not equal, especially for the pronounciation of the explosive „d", which even if it is resonant, loses from the intensity because it is aspired postconsonant. The aspiration of the consonant leads to the reduction of time allocated to its pronounciation, from all of the pronounced sounds these being presented in the shortest period.

The pronunciation of the sound "b" is marked by a strong explosion, especially at low frequencies, that distinguishes a base of posterior articulation in the pronunciation of this phoneme. The posterior articulation offers the sound a low tonality in the first part of the articulation sequence, and in the second part due to the very accentuated parasite sound "î", the tone is higher with periodical and aperiodical combined oscillations on high frequencies. This is interpreted by Ryalls (1996) as follows: when the tongue is positioned anterior for the vowel *''î''*, the cavity that is formed in front of the tongue, responsible for F2 is very small, that explains the high frequency of the second formant, while the first one is situated at a very low frequency.

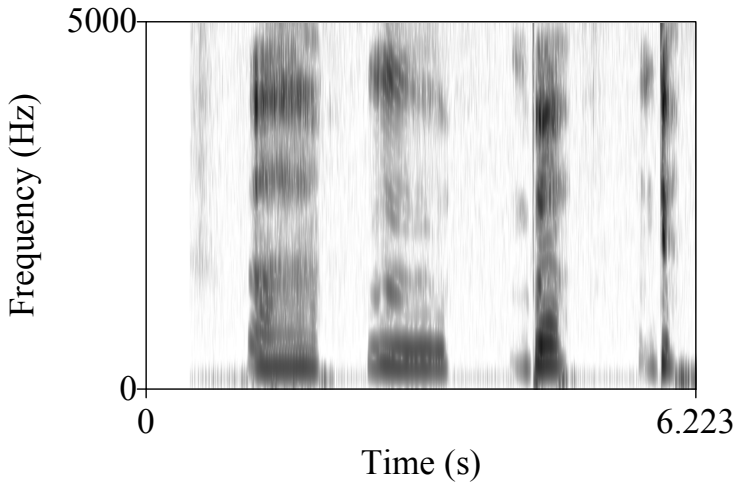

Fig. 2. Spectrogram for logatom (non-word) "aibd"- hearing impaired pearson without auditory prosthesis

In the case of the individual with hearing impairment, not fitted, we can notice the significant dilution of the logatome "aibd". In this case too the articulation of the logatome is marked by pauses; the sounds are not coarticulated, but pronounced in isolation.

Even if all the component sounds of the logatome are sounds with voice, the fundamental of the voice is not regular which indicates an inadequate activity of the larynx, especially for the pronunciation of the explosive consonants. In the case of the consonants, the acoustic information changes faster than for the vowels, as it shows (Ryalls, 1996): while the vowels are determined by the relative stability of the frequeny on the formants, many consonants are characterised by the change of the frequency of formants → the transition of formants. At this participant with hearing impairment there is an aspired explosive character of the sounds, the aspiration showing the presence of some noises due to the friction of the walls of the expired air, when the articulation of the low frequencies, deep and inadequate, the voice increasing inadequately in the second part of the resonance rate through the focusing on the articulation of the support sound. These characteristics in articulation mark the phenomenon of the neutralisation of the pronounciation, with signifficant implications at the level of inteligibility.

In the pronunciation of the sound "i" we can notice the weakening of the sound, so that this cannot be even received, the spectrum of the pronunciation of this sound being marked by aperiodical oscillation in the nasopharyngeal activity. The intesity of the first format is an imporant proof fod the nasalisation of the sound. This phenomenon that is frequently observed in French, can be produced in our language only by the association of the vowel with a nasal consonant, or in the case of this logatome all the sounds are oral.

The pronunciation of the sound "a" is less altered which underlines the fact that the high level of openness of the sound facilitates the articulation process even in the situation of a profound hearing loss that is not compensated technically. But the articulation of the sound is realised on higher frequencies than normally, the inadequate dose of the expiratory flow being visible due to the presence of the cvasiperiodical oscillation, specially on high frequencies, that support the presence of a parasite nasal pronounciation of a participant.

Conclusions

Generally we can observe that by the use of logatomes we can distinguish differences between the spectral representations in the speech of the two participants to the research, these being determined by the constitution of the articulation organs, by the particularities of the pronunciation of the individuals with hearing impairment, but also by the presence/ absence of hearing control (auditory fitting).

The lack of the auditory and semantic control emphasizes the differences in the pronunciation of the two participants. This aspect emphasizes the importance of individualised speech therapy interventions, realised both through traditional modalities and with the help of computerised programmes that allow the visualization of the different parameters of pronunciation and speech.

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