THE RELATIONSHIP BETWEEN MALOCCLUSIONS AND SPEECH DISORDERS : AN ACOUSTIC STUDY

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ABSTRACT

A corpus of about 100 meaningful Italian words uttered by 36 normoccluded and maloccluded subjects has been analysed spectrographically. The results show that a direct relationship between different classes of malocclusions and speech errors does not exist.

1. INTRODUCTION

One of the questions which has always been and still is outstanding for orthodontists and speech pathologists is whether there is a relationship between dental malocclusions and speech disorders.

By far the greatest difficulty in this kind of research is to find a cause-effect relationship between a single dental anomaly and a particular speech impairment. In fact if on one hand "articulatory defects of speech may exist even though the dental occlusion is normal and, conversely, dental malocclusions may exist in person with normal speech" [3] (p. 921), on the other the greater the seriousness of disgnathic defects cooccurring in the same subject is, the greater his phonetic handicap will be [5] [8]. This is the reason why notwithstanding the great number of studies of the morphological aspects of the different malocclusions, as for instance vertical, anteroposterior and transversal relation ship of the jawbones, interincisal occlusion, overjet, openbite, spacing and crowding of the incisors, the lack of dental elements, the results have often been conflicting [1] [7] [2] [9] [6] [10] [4].

The aim of this research is to verify whether there is a close relationship between dental malocclusions and speech disorders.

Before facing this problem, we should draw some considerations. If dental malocclusions can be easily tested and then classified, the defect of speech is more difficult to identify. It can be recognized only perceptively. In fact the listener is the only one who can say whether a sound is similar to or different from a *normal* sound. His judgement, however, cannot go beyond a personal opinion which can be neither quantified nor experimentally verified, thus originating vague and often inaccurate classifications.

First of all we should say that two different auditory impressions must be the result of two different acoustic signals. However, the opposite is not always true, as two different acoustic signals, generated by different articulatory mechanisms, do not necessarily generate two different auditory impressions. This happens because each speech sound is a complex acoustic signal of which some components are vital, whereas some others, being redundant, can have various characteristics or even lack completely. Suffice it to say that compensatory articulatory movements are able to produce a sound which is perceptively accepted as *normal*.

At the light of what has up to now been said, it is possible to identify a speech sound as faulty only on the basis of the acoustic analysis of the signal. If we skip this step, observing directly the articulatory movements, at the most we will be able, thanks to sophisticate technologies, to reconstruct point by point the mechanism of the individual parts of the speech apparatus, but we will not be able to establish for certain whether such an articulatory mechanism affects the distinctive or the redundant components of the signal. Furthermore it must be borne in mind that the techniques employed nowadays can cause an emotional stress to the speaker that affects negatively the spontaneity of the utterance. This happens because they may be either tissue invasive owing to the attachment of lead pellets, of artificial palates, of electrodes and so on, or biologically unsafe because of radiation exposure.

2. METHOD

From the foregoing, it seems to us that we should start from the acoustic analysis of the signal, which allows to identify faulty sounds as well as to infer the incorrect articulatory movements that produced them. Many are the possibilities given by this method of analysis. In fact on a broad band spectrogram it is possible to deduce the behaviour of the vocal folds from the number and periodicity of the vertical striations and, consequently, to notice the presence of possible anomalies of the glottal pulse. Shiftings on the y-axis of the formants reflect the movements of the articulators and the shapes assumed by the supralaryngeal cavities. Formant frequencies are broad bands of energy represented on the spectrogram by clearly marked darkness areas. According to the different contextual situations, every speech sound has a particular formant pattern : any modification reflects an anomalous posture of articulators involving a change in place and manner of articulation. Nasality is represented on the spectrogram by a loss of energy expecially at the level of the second formant as well as in appearance of one or two extraformants in the low region of frequencies. So the spectrographic analysis allows us to say whether an oral articulation has been realized with an incomplete closure of the velopharyngeal port.

3. MATERIAL

A list of about one hundred meaningful Italian words has been prepared, where dental articulations [t d s z r l n ʦ ʣ] occurred in all phonological contexts. Also bilabials [p b m], labiodentals [f v], palatals [ʃ ʧ ʤ ʎ ɲ] and velars [k g] have been considered.

The list has been read in a silent room by thirty six speakers differently aged (7-9, 12-14, 17-19 years) selected by a clinical test from a total of 228 students. Nine of them were normoccluded subjects and twenty seven represented of the different classes of malocclusion (Class I, Class II, Class III). A structured questionnaire was used to obtain information about age, history of previous speech therapy and orthodontic therapy. All selected subjects had not received any treatment and all of them had normal hearing.

For this research a Nagra IV S recorder, a DSP Sona-Graph 5500 Kay and a computer HP Vectra have been employed. Of each word the broad band spectrogram (from 0 to 8 KHz) and the tracings of Fo, intensity and waveform have been obtained.

4. RESULTS

Subjects without any anomaly have been found in all categories. Table I summarizes the speech anomalies of

TABLE I. Types of articulatory disorders in speech acoustically diagnosed among normoccluded and maloccluded subjects.

SPEECH SOUNDS	DISORDERS			
	NORMOCCLUDED SUBJECTS	MALOCCLUDED SUBJECTS		
		CLASS I	CLASS II	CLASS III
dental stop [t] [d]	retroflex fricative		fricative	fricative affricate
dental fricative [s] [z]	palatal		palatal labiodental interdental whistled	
dental trill [r]	lateral trill		fricative retroflex	fricative
dental lateral [l]	lateral trill		lateral fricative	
labiodental fricative [v]			bilabial stop	
palatal affricate [tʃ] [dʒ]	dental			
palatal lateral [ʎ]				palatal stop
velar stop [k] [g]	fricative		fricative	fricative affricate
oral sounds		nasalized speech	nasalized speech	
voiced sounds		irregular glottal pulses		

normoccluded and maloccluded subjects. As we can see, most anomalies occur with dental articulations, but anomalies in velar stops, nasality and glottal pulses have been also noticed.

Figs. 1 - 4 show the spectrograms relative to the voices of normoccluded and maloccluded subjects.

The spectrogram of the word *sodo* (Fig. 1) uttered by a nornoccluded subject points out two different anomalies, regarding the fricative [s] and the stop [d]. The first one has a dental place of articulation because of a very strong signal starting from 6 kHz. In fact the acoustical signal of a dental fricative shows the highest frequencies and in this case we can see that the signal is cut at the upper edge of the spectrogram. In the meantime we can notice the presence of a strong signal between 3.5 KHz and 4.5 KHz due to a narrowing of the channel at the hard palate. So we can conclude that it is a palatalized dental fricative. As far as the stop is concerned we can say that it is a retroflex, because of an abrupt falling down of F3 and F4 of the adjacent vowels.

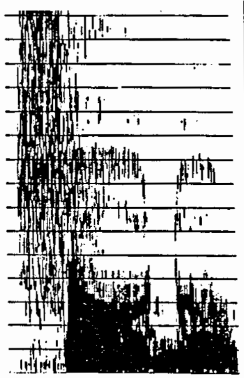

Fig. 1. Spectrogram of the word *sodo*

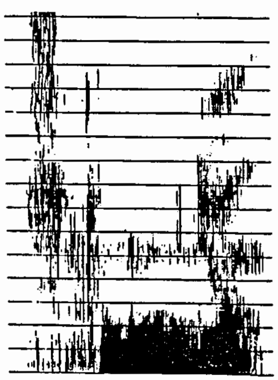

Fig. 2. Spectrogram of the word *studio*

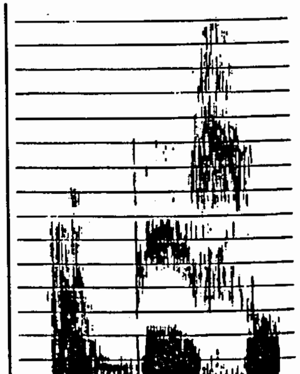

Fig. 3. Spectrogram of the word *avviso*

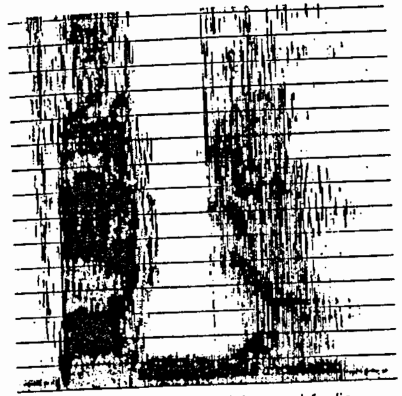

Fig. 4. Spectrogram of the word *foglia*

The spectrogram of the word *studio* (Fig. 2) uttered by a Class I maloccluded subject shows two anomalies, one relative to [s] having the same characteristics already seen in Fig. 1 and the other concerning the whole word, which is completely nasalized, as the presence of an extra formant at 2.5 KHz shows.

The spectrogram of the word *avviso* (Fig. 3) uttered by a Class II maloccluded subject, shows that [v] has been uttered as a stop (absence of signal followed by burst of noise), bilabial because of the F2 deviations of the adjacent vowels and voiced because of the periodical striations. Furthermore [s] shows in addition of the fricative signal, a whistled pure tone at about 4.5 KHz.

In the spectrogram of the word *foglia* (Fig. 4) uttered by a Class III maloccluded subject, both the absence of signal and F2 deviations show that [ʎ] is uttered as a voiced palatal stop [ɟ].

5. CONCLUSIONS

The data gathered in this experimental research point out that a direct relationship between different classes of malocclusions and speech errors does not exist. In fact the same speech sounds can give rise to different kinds of errors, aside from the kind of dental occlusion of the subject. [s] for instance is realized as palatal by a normoccluded subject, as either labiodental or whistled fricative by two Class II maloccluded subjects. Dental trill [r] is realized as a lateral trill by a normoccluded subject, as either fricative or retroflex trill, by two Class II maloccluded subjects.

As regards the different kinds of speech errors our results seem to suggest that fricatives tend to be realized at anomalous places of articulation; stops tend to be realized as affricates or fricatives; laterals and trills tend to be realized as fricatives. Moreover we have to say that the speaker's sex and age do not have any infuence on the occurrence of the different kinds of speech errors.

6. REFERENCES

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