TONGUE MOVEMENTS IN MALOCCLUDED SUBJECTS

A. Giannini, M. Pettorino*, G. Savastano**, C. Cimmino**, G. Della Pietra***
** Istituto Universitario Orientale, Fonetica Sperimentale, Napoli, Italia*
*** Università "Federico II", Chirurgia Maxillo-Facciale, Napoli, Italia*

ABSTRACT

The presence of "egressive clicks" due to the mandibular protrusion seems to be a peculiarity of III class malocclused subjects. In this experimental research two methodologies are used to assess the relationship between tongue movements and skeletal discrepancy.

PROCEDURE

The aim of this experimental research is to establish a relationship between abnormal tongue movements and skeletal discrepancy in III class malocclused subjects. In the present work two methods of investigation have been employed: a cephalometric analysis through telecranium in L/L projection and a spectrographic analysis through DSP Sonagraph 5500 KAY.

In the cephalometric analysis not only parameters relative to vertical and sagittal discrepancy were evaluated, but also some parameters indicative of tongue posture. In particular the following parameters were measured: i. the distances of the tongue dorsum from the palatine arch and the vertebral column; ii. the distance between the tip of the tongue and upper and lower incisors; iii. the distances of the hyoid bone from the vertebral column and the mandible.

For spectrographic analysis the Pitch Display program, which monitors both the variations of fundamental frequency by means of a 18.75 Hz bandwidth filter and the formant frequencies of the supralaryngeal cavities by means of a 300 Hz bandwidth filter, was used. The frequency scale has been settled either at 8 KHz or 16 KHz according to the situation.

A corpus of 100 meaningful Italian words and one minute of spontaneous speech have been uttered in a silent room by 12 malocclused subjects as well as by a control group of 8 normoccluded subjects. All speakers were Italian, males and females, aged from 17 to 22 years. The list of words included all Italian phones that, when inserted in the right context, appeared to be relevant to the definition of the relationship between articulatory movements and acoustic signal.

DISCUSSION

In figure 1 all speech anomalies found throughout the experiment are reported.

As far as the voiceless alveolar fricative is concerned, several speech defects can be detected. These can be linked to the following different types of faulty s-sounds: dental, alveolo-coronal and whistled. These three types are compared in figure 2 with the alveolar fricative uttered by a normoccluded subject. For space saving reasons only the important segment is reported. As it is observed the dental fricative exhibits an intense signal at high frequencies around 10-12 KHz (fig. 2, *b*). Therefore the signal portion below 7 KHz, that is perceptively considered more relevant, has been found to be much less intense. This frequency distribution reflects a punctual articulatory constriction between the edges of the upper incisors and the tip of the tongue.

The production of an alveolo-coronal fricative represents one of the peculiarities of III class malocclused subjects. As a matter of fact, in normoccluded subjects the blade of the tongue opposes the postalveolar area so that the formed constriction produces a ʃ-sound. On the contrary in III class malocclused subjects the mandibular protrusion is such that the tongue is in a forward position with respect to the hard palate. As a consequence the blade of the tongue opposes the alveolar area. The acoustic effect of this anomalous contrapposition results in a signal frequency lowering due to a longer articulatory constriction (fig. 2, *c*).

As far as the whistled fricative is concerned the tongue, instead of taking on a convex conformation, flattens down in the middle and arches up on the edges in such a way that it makes a middle channel

FAULTY SPEECH SOUNDS		SPEAKERS 1	2	3	4	5	6	7	8	9	10	11	12
[s]	dental	●									●		
	alv.coron.	●		●		●				●		●	
	whistled			●					●				
[k][g]	fricative	●		●						●			●
[r]	fricative	●					●	●		●		●	
	approximant			●							●		
[f]	whistled				●								●
clicks	bilabial			●	●					●			
	alveolar	●	●	●		●		●		●		●	
	palatal	●	●	●		●		●			●		●
	velar	●	●	●			●	●			●		●

Figure 1. Different speech anomalies of the malocclused sujects.

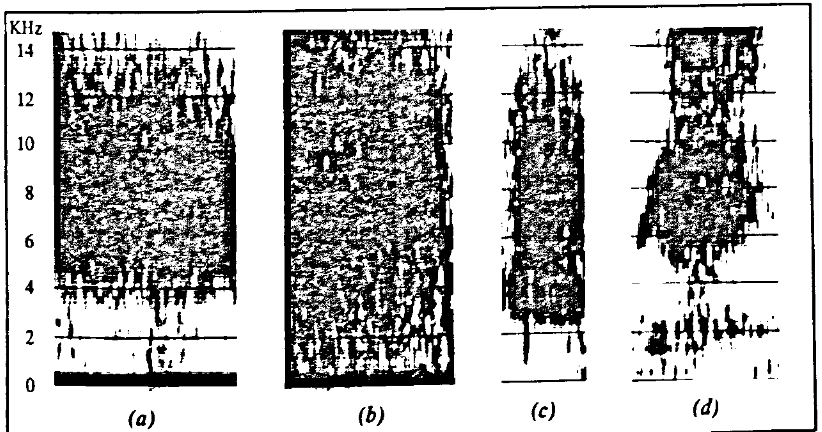

Figure 2. Broad band spectrograms at 16 KHz of s-sounds:
(a) alveolar; (b) dental; (c) alveolo-coronal; (d) whistled.

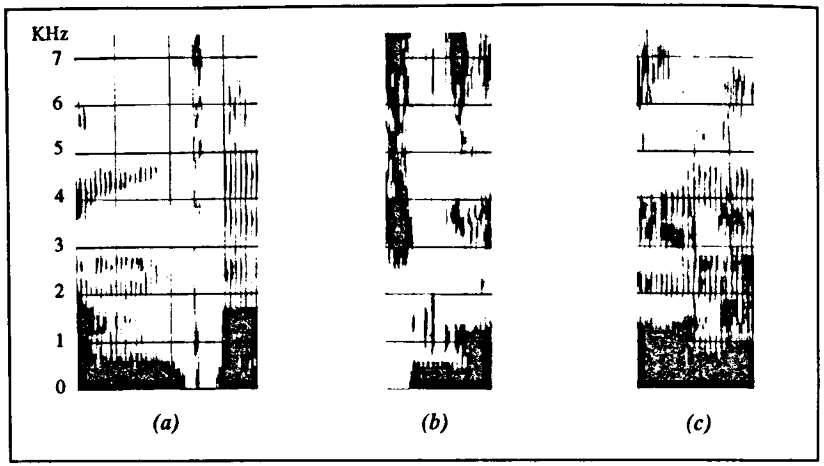

Figure 3. Broad band spectrograms at 8 KHz of different clicks: (a) voiceless; (b) voiced; (c) nasal.

which ends in a constriction between the tip of the tongue and the upper incisors. The resulting acoustic signal is characterized by very high harmonic frequencies (fig. 2, *d*). The same acoustic features are in some cases found also in the labiodental fricatives.

The anomalies found out in the alveolar fricative production were not noticed in the other consonants produced in the same alveolar and postalveolar place of articulation, that is in the alveolar stops and affricates as well as postalveolar affricates. The acoustic signal does not exhibit any anomalous posture as it is to be observed from the behaviour of the F2 transitions of the adjacent vowels. As the silence portion is of capital importance in distinguishing stops and affricates from other consonants, the subject is forced to carry out such closure at alveolar and postalveolar level thus compensating the anomalous tongue forward position with a backward movement of the tip of the tongue. In order to produce such backward movement the subject, in theory, could follow three different articulatory mechanisms: i. draw backward the whole tongue mass toward the pharynx; ii. lift the tongue postdorsum towards the soft palate; iii. flatten and enlarge laterally the tongue dorsum. The first two mechanisms can be excluded since from an acoustic point of view the former would cause an F1 increment and the latter an F2 lowering. Since in none of the cases such behaviour has been found, it is to be concluded that the third mechanism is the likely one.

A confirmatory evidence of such hypothesis comes from the "egressive click" examination (figure 1). With the term "click" we refer to a momentaneous acoustic signal lasting about 10 ms, of strong intensity and variable in frequency depending on the place of articulation where it is generated. This kind of click, from an articulatory point of view, is produced by the formation and rapid release of an occlusion with subsequent air outflow. The release burst is particularly violent and sharp because of the pressure build up behind the occlusion. In fact, most clicks found in the examined subjects, appear in those phones requiring a closure in the oral

cavity. In this case, too, in order to ascertain the site of activation of such mechanism, it is possible to go on by exclusion. A first hypothesis that can be excluded on an experimental basis is that clicks could be produced at glottal level through anomalous openings of the vocal folds. The spectrograms exhibit, in fact, clicks forming both during voiceless phones peculiar of a wide open glottis and during voiced phones (fig. 3 *a*, *b*). In the latter ones one can easily identify clicks that are independent of periodic openings and closings of the vocal folds. A second hypothesis to discard is that correlating the click to a faulty contact between the velum and the naso-pharynx with subsequent air inflow through the nasal cavities. Spectrograms show, in fact, that clicks appear, but with variable intensity, both in nasal phones where the velum is lowered and in the oral ones where no sign of nasalization in the acoustic signal is revealed (fig. 3 *a*, *c*). In three of the examined subjects the presence of clicks during the production of bilabial phones has been detected. In this case the click is due to an anomalous backward movement of the lower lip. This movement causes a

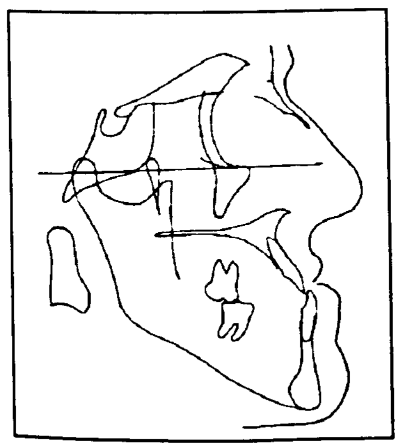

Figure 4. Telecranium of a maloccluded subject.

defective lateral contact quite similar to that occurring when the articulator is the tongue.

The data obtained from cephalometric analysis, comparing I class maloccluded subjects with those belonging to III class, show that, in the latter class, there is a tongue backward posture with interposition in lateral sectors. In figure 4 the telecranium of one of maloccluded subjects is reported.

The results are in full accord with the phonetical conclusions.

CONCLUSIONS

All arguments thus discussed allow the following conclusions as far as the movements of the articulators in III class maloccluded subjects are concerned. When a subject has to realize a closure into the oral cavity he has to withdraw his tongue and this is accomplished through a concerted flattening and a lateral enlargement. Thus the lateral contacts do not occur between the tongue edges and the alveoli but between the tongue edges and the molar teeth. This results in faulty movements that cause trills originating sometimes an almost periodical sequence of two or more clicks.

In addition it must be noticed that in the case of the velar stops, case of particular stress for the speaker, quite often the occlusion is replaced by a constriction. Even the alveolar trill undergoes a change in the manner of articulation since it is sometimes accomplished as a fricative and other times as an approximant.

As for the read and spontaneous speeches it is worth emphasizing that the spontaneous speech is marked by a larger number of defects than the read one which is characterized by compensatory strategies.

The spectrographic data agree quite well with the cephalometric data indicative of a lingual backward posture with interposition in the lateral sectors.