

## VOICELESS AND VOICED CONSONANTS PRODUCED BY ITALIAN DEAF CHILDREN

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**Abstract:** Any evaluating criterion of deaf child's speech is strictly linked to the language system he tries to reproduce. Any single articulatory parameter, in fact, will differently contribute to the speech intelligibility depending on whether it is redundant or distinctive in a certain language. Several papers have so far dealt with the speech production of English children affected by sensorineural hearing loss with the aim of identifying those deficiencies mostly affecting intelligibility. No up to date similar studies appear to exist for the Italian language. To identify which consonants are correctly articulated, which are missed or modified we have decided to carry out a spectrographic analysis on the speech produced by four deaf Italian children.

**Keywords:** deafness, Italian consonants, acoustic analysis.

### 1. INTRODUCTION

Data presented to the International Congress of Audiology held in Bari in June 1996 demonstrate that deafness is ranked fourth among chronic invalidating diseases and comes immediately after rheumatic, cardiovascular and neurological illnesses. Moreover it appears that over a total of 5 million people affected by hearing problems, 40.000 are afflicted by profound deafness. Deafness is classified as *normal* if there is a loss up to 25 dB, *mild* up to 40 dB, *hard* between 40 and 70 dB, *severe* between 70 and 90 dB and *profound* or *sensorineural* more than 90 dB.

If the sensorineural hearing loss occurs in the first 7 months of a child life, an enormous language damage is provoked since in this period the linguistic learning process starts taking place not only

at a phonetic but also at a phonological level. Speech is, in fact, formed of a whole series of lexical, grammatical and syntactic rules that by no means are easy to learn in an abstract way. The problem, therefore, as one can easily guess, depends not only on the acquisition of single phoneme but to a larger extent on the capability of coupling together sounds and meanings. A deaf child, then, will develop its own linguistic system other than normally hearing children and often not clearly intelligible.

Several papers have so far dealt with the speech production of English children affected by sensorineural hearing loss with the aim of identifying those deficiencies mostly affecting intelligibility (Levitt and Stromberg, 1983; Oller and Kelly, 1974; Monsen, 1976; McGarr and Loquist, 1982; Osberger and Levitt, 1979). No up to date similar studies appear to exist for the Italian language and therefore we have decided to carry out a spectrographic analysis on the speech produced by deaf Italian children trying to identify which consonants are correctly articulated, which are missed or modified. The reason for this study is primarily due to the observation that any evaluating criterion of deaf child's speech is strictly linked to the language system he tries to reproduce. Any single articulatory parameter, in fact, will differently contribute to the speech intelligibility depending on whether it is redundant or distinctive in a certain language.

In this paper, which is part of a larger experimental work, we shall concentrate on analysing those data concerning the duration of consonants and their place of articulation. We shall not describe work done on stops already discussed in a separate paper recently submitted to *Acta Acustica*.

## 2. METHODOLOGY

Experiments were carried out with the help of four eight years old male Italian children affected by sensorineural hearing loss (DC=D1, D2, D3, D4) and under treatment since the age of 18 months. To this group another child without hearing impairment was included as normal control subject (NH). A summary of audiometric data for each subject is presented in Table I. As you can see D2 presents absent of hearing to left ear.

A large CVCV type word corpus containing all Italian consonants in intervocalic position was prepared and each consonant was combined with front and back vowels. Recording took place with the assistance of a logopedist who asked each child to say the names of certain pictures representing the selected words. The material was then analysed with a DSP Sona-Graph 5500 Kay. For each consonant the length in ms was measured. The place of articulation was determined by the second formant frequencies for nasals and laterals, by the acoustic signal displacement for fricatives and affricates and by the second formant transitions of neighbour vowels for stops.

## 3. DATA

Fig. 1 presents average values of durations and F2 relative to nasals and laterals produced by NH

**Table I: Audiometric data for deaf subjects**

Subject	Pure-Tone Thresholds					
	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
D1 R Hear	75 dB	80 dB	95 dB	100dB	115 dB	
D1 L Hear	75	80	90	95	120	
D2 R Hear	95	100	95	90		80
D2 L Hear						
D3 R Hear	75	115				
D3 L Hear	80	120				
D4 R Hear	80	95	105			
D4 L Hear	80	100	105	40		

subject and by the four DC. It is observed that DC generally tend to lengthen consonantal durations. This trend is particularly evident in D1. In addition it is remarked that the difference in duration is less relevant for palatals. Such consonants that are always produced with a long duration in the Italian language, appear to be well established in the phonological system of deaf children. As far as F2 is concerned, the analysis shows that places of articulation are correctly produced. There is, in fact, a gradual raising of such formant from the bilabial place for [m] to the alveolar place for [n, l] and to the palatal place for [ŋ, ɿ].

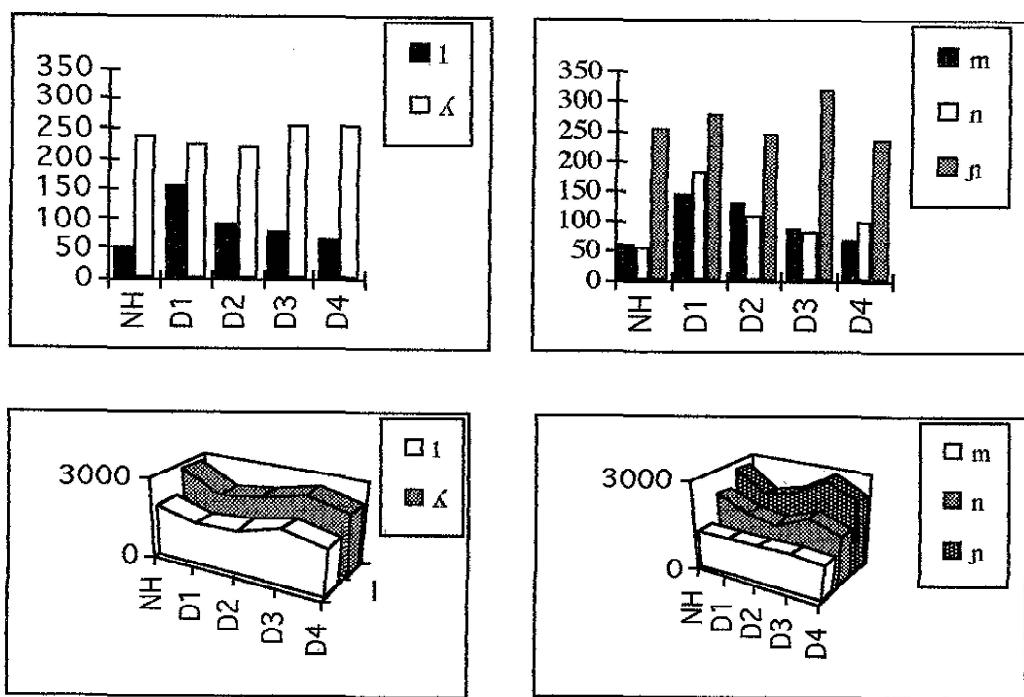


Fig. 1 Average duration and F2 of laterals and nasals

Bilabial nasal appears to be better produced while, in the case of alveolar and palatal consonants, the articulatory target does not seem to be hit since the respective values as compared to NH subject are always lower but for D3. In addition, no error was found for manner of articulation and fundamental frequency while occasional substitutions were revealed for the place of articulation of palatals produced instead as alveolars (18% for nasals and 12% for laterals). Occasional are those substitutions not exceeding 25%.

Several substitutions both in manner and place were found, on the contrary, for alveolar trill production. Data demonstrate that in 60% of the cases such consonant is produced as lateral or fricative and in the remaining 40% as an uvular trill. These data, however, cannot be considered as typical of deafness since the alveolar trill is often mistaken even from NH children.

In fig. 2 average durations of voiceless fricatives [f, s, ſ] and affricates [ts, tʃ] are reported.

A comparison of the average duration values reveals that in all subjects [f] is longer than for NH, [s] is similar and [ſ] retains the long duration parameter typical of the Italian language as already observed for [λ, ɲ]. Sole exception is D3 who exhibits the same duration for all three phones.

The voiceless labiodental fricative is best reproduced among these consonants. No mistake has been detected in its production while occasional manner of articulation substitutions have been detected for the alveolar and postalveolar, the former produced as stop (10%) and affricate (10%), the latter as affricate (25%). In the case of voiced [z] it appears realized as voiceless in all cases, [v] presents a longer duration when compared to NH and it is occasionally produced as [m].

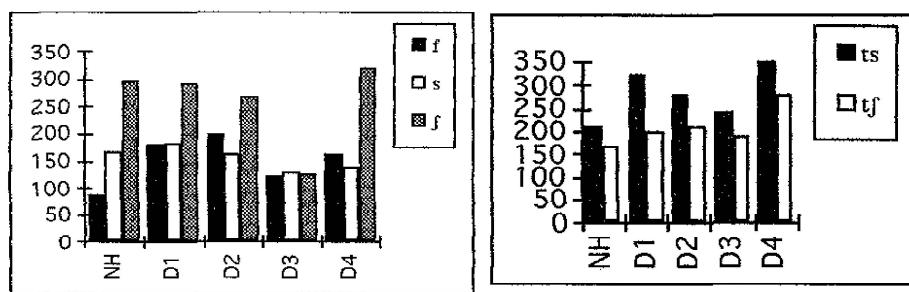


Fig. 2 Average duration of voiceless fricatives and affricates

In affricates, too, duration in deaf children appears longer. The longer [ts] duration is correlated also to the Italian language where a phonemic distinction between short and long [ts] does not exist being [ts] produced always as long. Occasional manner substitutions for alveolar affricates produced as fricatives were detected as well as manner and place substitutions for postalveolar produced as alveolar fricative. Values relative to [dz] and [tʃ] are not reported here because these consonants are substituted in 95% and 94% of cases respectively with the corresponding voiceless phones.

Table II shows all the consonants substitutions made by our subjects.

Table II: Consonant substitutions

PHONES	SUBSTITUTIONS							
	[n]	[l]	[r]	[s]	[m]	[ts]	[f]	[t]
[p]	18%							
[λ]		12%						
[r]			31% 40% 29%					
[v]				20%				
[z]					100%			
[s]						10%	10%	
[ʃ]							25%	
[ts]				22%				
[dʒ]						95%		
[tʃ]				19%				
[dʒ]						94%		

#### 4.CONCLUSIONS

It has been often asserted that a generalization about production behaviour of deaf children cannot be proposed as yet because each subject, in the absence of any hearing feed back, constructs its own language system. Still, however, the amount of data collected in this research permits to draw useful conclusions about production mistakes in the case of the Italian language.

As far as the place of articulation is concerned, the lower F2 values reveal (as already stated by Oller and Kelly, 1974) that a forward of the place of articulation occurs but the different displacement in frequency furthermore reveals that all consonants but [r] have been classified and retained. The observed substitutions can be considered as occasional given their low occurrence. Even in the case of the manner of articulation it is possible to conclude that the phonological system in our subjects is well established since the few observed substitutions again are to be considered occasional despite the only exception for [r] which, by the way, is most substituted consonant even in normal subjects.

Experimental data about durations reveal a general consonantal lengthening. Since the Italian language is characterized by long and short consonantical opposition, a longer duration in the consonantal segment might affect dramatically the speech intelligibility. Yet, however, data for palatal nasal and lateral, for voiceless postalveolar fricative and for voiceless alveolar affricate allow us to state that, anyhow, distinction between short and long consonants is present in deaf children.

Sonority is present in those consonants characterized during the steady state by an outflow of air through the nasal or oral cavity, while it looks absent when an oral closure is predicted. It appears, then, rather clear that, despite the logopedic rehabilitation, synchronism between laryngeal and epilaryngeal movements essential to realizing the fundamental frequency in the production process, is hardly made automatic. For this reason voiced affricates and stops among consonants appear to be the most penalized.

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