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SOME CONSIDERATIONS ON PITCH AND TIMING CONTROL IN DEAF CHILDREN

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ABSTRACT

Spontaneus speech (approx.10 hours) produced by ten deaf children (5 males and 5 females, mean age 5 years old, with severe sensory-neural hearing impairment) was recorded during rehabilitation sessions and some selected parts were analyzed by means of a KAY 5500 DSP-Sonagraph. Many phonetic measurements were performed on this speech material (mean vowel formant values, formant transition patterns, power spectrum of stationary unvoiced consonants, prosodic parameters), but particular attention was paid to pitch and timing control. All measurements were compared with an analogous set of data obtained from a control group of ten normal children of the same mean age.

Fundamental frequency and peak intensity values were measured for each period and on this base temporal patterns were drawn and jitter and shimmer histograms were calculated for both groups; furthermore, global word duration, stressed vowel duration, and silent pauses were measured in order to evaluate the performances of deaf children in controlling timing parameters of speech.

The results show that while the vowel production seems to underlie a sort of cathegorization, pitch and timing control definitely need auditory feedback.

1. INTRODUCTION

Speech production in prelingually deaf subjects is only a matter of rehabilitation and integration by means of other sense channels.

Deaf children learn to speak by means of therapies based on articulatory training, hearing and vibrotactile aids, lip-reading, gesture control; but on average they cannot hear what they are saying.

As a consequences the phonic production in these subjects is very poor and has a low intelligibility. Many studies [1,2,3,4,5] have given a valid description of the hearing-impaired speech acoustic qualities. At the same time another question still remains unanswered [6,7,8,9]: which is the role played by the hearing apparatus in speech production and perception? The two questions seem to be strictly correlated, nevertheless they are not often treated together. The present work, to be considered a preliminary report, wants to offer some remarks in order to open a wider discussion on this question.

2. METHOD

Ten deaf children (5 males and 5 females, mean age 6.5 years) affected by severe sensory-neural hearing loss, have been selected for the present study.

250	500	1000	2000	4000	Hz
65	65	70	75	85	dB HTL

Table 1 - Average pure tone hearing loss in the experimental gruop

They are all patients of the section of Audiology in the Department of Human Communication - University of Naples, where hearing aids have been prescribed and fitted for them since an early age (meanly 1.5 year), together with a rehabilitation program. They all were able to read simple phrases and to repeat the name of an object shown to them. About ten hours of conversation between these patients and their therapists were recorded and successively analyzed by means of a KAY 5500 SONAGRAPH. The following parameters were measured:

-formant values for the vowels /a/, /i/, /u/

-initial and final frequency in formant transitions and duration of the transitions in CV sequences, where C is a stop

-spectral shape of fricative consonants

-fundamental frequency and peak intensity values were measured period by period in particularly long vocalic portions; on this base temporal patterns were drawn and jitter and shimmer histograms were calculated for both groups;

-global word duration, stressed vowel duration, and silent pauses within the word;

In a second phase ten normally hearing children of the same mean age as the experimental group one were selected to be used as a control group.

Their speech was recorded for a total time of approximatively 6 hours.

All the parameters above listed were measured in this speech material too.

In this paper I will only report the results about the formant values of vowels, fundamental frequency and peak intensity period by period and timing controls expressed in terms of durational factors.

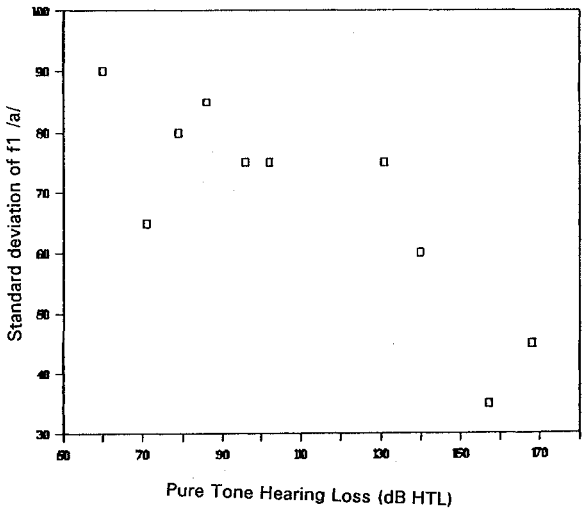
3. RESULTS:

a) formant values for vowels /a/, /i/, /u/

In complete accordance with the results of other authors [1,3,5] the comparison between the data coming from the control group formed by normally hearing subjects and the experimental group formed by deaf children shows that the formant values in hearing-impaired children are considerably altered. This result was the most obvious one, Angelocci et al. [5] early described the loss of intelligibility of vowels uttered by deaf children while Monsen [6] had already shown how the phonological space is widely reduced in this kind of subjects. In the table 1 the mean values for the first three formants for each vowel are reported together with their standard deviations.

	f1 /a/	f2 /a/	f1 /i/	f2 /i/	f1 /u/	f2 /u/
Normal hearing group						
mean	1077	1791	312	2513	330	665
standard deviation	296	691	130	489	104	232
Hearing Impaired group						
mean	1179	2163	396	1900	345	893
standard deviation	109	269	81	370	66	164

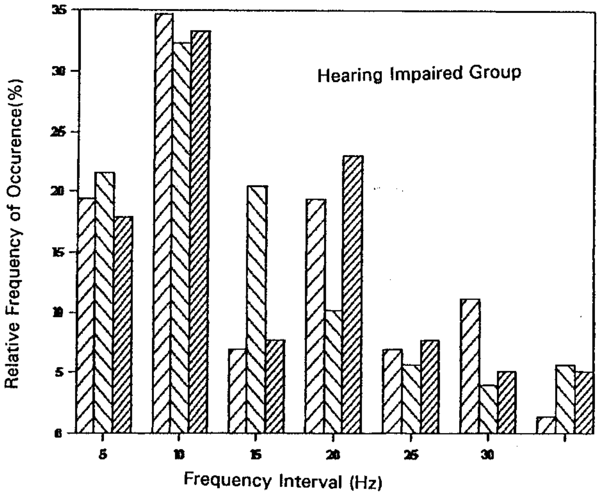
One can observe, behind the differences in the mean values, how the standard deviation values in deaf subjects are systematically lower than the corresponding values in the control group. Another relevant information can be driven by the study of the correlation between the values of variance in frequency for a particular formant in different subjects and their mean pure tone hearing loss at 500,1000, and 2000 Hz.

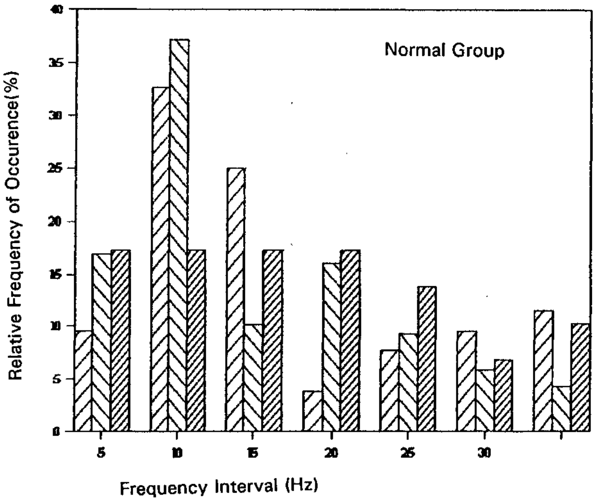


The trend of the correlation is clearly negative and represents an inverse proportionality between the two parameters.

b) Jimmer histograms

An amount of about 1500 periods taken from stationary vowel pronounced by three hearing impaired children and a similar sample taken from the utterances of three normal hearing children was segmented and analyzed according to [13]. In figure 3 and 4 normalized frequency jitter histograms are respectively shown for both groups. As one can see, no relevant differences seem to exist between the two groups.





This result indicates that it does not exist any abnormal pitch perturbation in deaf children's phonic production.

This statement implies that, when any irregular behaviour in the fundamental frequency in the speech of deaf patients is noticed, it cannot be due to an abnormal larynx performance but it can only depend on the lack of auditory feedback.

By the way, many authors have described such irregularities [11,12].

c) timing control
the most impressive differences between data from the two groups arise just when one evaluates the parameters deriving from temporal performances in the speech of deaf subjects.
As an example, the next table is based on the analysis of the Italian trisyllable [far'fal:a] ("butterfly") repeated by four deaf children (7 repetitions complexively) and two normal children (4 repetitions). It resumes some comparison of timing performances between the two groups. Some data are normalized using the length of each observed word as a reference.
Word duration is longer in deaf subjects. Both unstressed syllables are longer in deaf subjects than in normal ones. The stressed syllable is longer in normal subjects than in deaf ones, but in the latter it still is the longest syllable in the word. The average phone duration is 125 ms in deaf subjects and 115 ms in normal ones, but, if we take into account the frequent absence of the initial [f] in the realizations of the deaf subjects, the average goes up to 146 ms in this group.

Table 3.1 Syllable duration

	syl.1	syl.2	syl.3
Norm.gr.	27%	48%	27%
Hear.Imp.	35%	39%	26%

Table 3.2

dur.(ms)		word dur.(ms)	avg.phone
	Norm.gr.	877	125
	Hear.Imp.	807	115

4. DISCUSSION

The reduction in variability of formant values when the hearing loss increases seems to indicate the presence of a sort of cathegorization: being unable to hear his own vowels, the deaf speaker learns to produce these sounds by rehabilitation and not by a natural learning; as a consequence he repeats them always with the same articulatory position and with just a slight effect of coarticulation. For this reason all temporal factors get altered.

The absence of any difference within the two groups in frequency perturbation parameters indicates that it does not exist any abnormality in glottal functions in deaf subject: , the alteration in controls of prosodic performances can not only be attributed to a lack of auditory feedback but to interaction effects between temporal and coarticulatory factors as well[14,15].

A natural development of this study , will be the analysis of postlingually deaf subjects [16]. The lost of hearing ability after the aqcquisition of language has interesting symptoms in degeneration of speech performances. These symptoms could give us further informations in the direction of describing the role of auditory apparatus in speech production and perception.

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