

A STUDY ON THE SPEECH OF DOWN'S SYNDROME SUBJECTS USING THE ACOUSTIC MODELS

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ABSTRACT

Down's Syndrome subjects are known to possess certain speech quality characteristics besides their physical features. In this paper some of speech qualities are tested. By using X-ray technique the dimensions of the vocal tract for down and normal subjects are determined and used to get correlation between articulatory acoustic aspects, i.e. the way in which the formant frequencies (F1, F2 and F3) are related to the configuration of the vocal tract as a whole. This is achieved by using the mathematical tube models. Comparing the values with those obtained for the normal subjects, the reason for the characterized Down's Syndrome's speech is clarified.

INTRODUCTION

Down's Syndrome is one of the best known clinical types of mental maldevelopment. Review of the literature /1/, /2/, /3/ indicated a markedly high incidence of speech defects among mentally retarded especially Down's Syndrome. Other reviews /4/, /5/ related speech problems to anatomical deviations. These studies showed a universal agreement that articulatory problems constitute a major part of their communicative problems.

The objective aim of this paper is to correlate some of the acoustic parameters of the incidence of speech quality (F1, F2, & F3) to the anatomical anomalies of Down's Syndrome. This is done by using different experiments; spectrographic analysis, models for hard palate and X-ray investigations. The obtained results from these experiments are used to calculate F1, F2 and F3 by using the mathematical acoustic tube models of the vocal tract.

EXPERIMENTAL ANALYSIS

The above mentioned experiments are performed on 5 Down's and 5 normal subjects. Their ages ranged from 10 to 15 years with mean average of 12 years. They are institutionalized. Concerning the test data, there are eight different and unfamiliar words which are:

| | | | |
|----------|-------------|----------|-------------|
| /qaziiz/ | dear | /ʃidiid/ | strong |
| /saliil/ | descendant | /siniin/ | years |
| /razaaz/ | sprinkle | /widaad/ | proper name |
| /dalaal/ | proper name | /sinaan/ | teeth |

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Most of the speech sounds used are voiced. The choice was based on different points and manners of the articulation. They constitute a natural class of sounds. The selection is also based on the choice of dental area. Each subject was instructed to repeat a series of test words presented in a random order to avoid an order effect.

All the test samples were analyzed by using the sona-graph. The first three formants for each vowel are measured at their center using wide-band analysis.

From the palatal model for each subject the dimensions of the oral cavity are obtained.

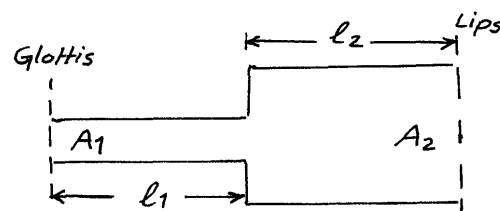
By using X-ray technique for the vocal tract, we can deduce the dimension of the pharyngeal cavity which extends from the 2nd cervical vertebra to the end of the 6th cervical one in two different postures ; open and closed mouth.

ACOUSTICAL MODELS

Dunn /6/, Fant /7/ and Flanagan /8/ stated that the vocal tract could be simulated by two tuned circuits, these are the analogy of the approximated two tube model. This simulation is valid for the vowels /i/ and /æ/. For the vowel /u/, Fant and Flanagan suggested that the simulation is made better by using more and shorter tube sections.

From /9/, if we represent the vocal tract by only two tube model during the phonation of /æ/ and /i/, then we can determine the formant frequencies graphically or iteratively from the relation :

$$\frac{A_1}{A_2} \tan(\omega \tau_1) = \cot(\omega \tau_2)$$



Where A1 is the cross-sectional area of the first tube which has a length =l1 and represents the pharyngeal cavity. A2 and l2 are those for the second tube which represents the oral cavity . $\tau_1 = l_1/c$ and $\tau_2 = l_2/c$, c is the speed of sound.

RESULTS

Table (1) shows the obtained results of the average values of the formant frequencies in Hz for the vowels /i/ and /æ/ by using the spectrographic analysis for both groups.

Table (2) indicates the average values of l1 ,A1 , l2 and A2 for both groups (l in cm and A in cm²) . These are based on the results obtained from the dimensions of the palatal model, the X-ray postures and the two tube model given by Flanagan.

| Vowels | F1 | | F2 | | F3 | |
|--------|-----|-----|------|------|------|------|
| | N | D | N | D | N | D |
| /i/ | 389 | 439 | 3135 | 2691 | 4746 | 4082 |
| /æ/ | 811 | 644 | 2448 | 2105 | 3285 | 3216 |

Table (1)

| Subject | /i/ | | | | /æ/ | | | |
|------------|------|------|------|------|------|------|-------|------|
| | l1 | A1 | l2 | A2 | l1 | A1 | l2 | A2 |
| Normal (N) | 8.08 | 8.00 | 4.48 | 1.00 | 3.50 | 1.00 | 11.43 | 8.00 |
| Down (D) | 9.03 | 9.33 | 3.90 | 0.75 | 3.66 | 1.08 | 11.90 | 6.00 |

Table (2)

Table (3) shows the values of the calculated formant frequencies in Hz for the vowels /i/ and /æ/ by using the two tube model.

| Vowels | F1 | | F2 | | F3 | |
|--------|-----|-----|------|------|------|------|
| | N | D | N | D | N | D |
| /i/ | 312 | 256 | 2151 | 1949 | 3763 | 3748 |
| /æ/ | 734 | 675 | 2083 | 1951 | 2689 | 2661 |

Table (3)

DISCUSSION AND CONCLUSION

- 1- From table (1) we can observe that the average values of all formant frequencies of vowels /i/ and /æ/ for the Down's subjects are lower than those for the normal subjects except for the first formant for the vowel /i/.
- 2- From table (3) we can see that the calculated values of the formant frequencies using the two tube acoustic model for the Down's subjects are lower than those for the normal subjects. The obtained values for both groups are lower than the measured values in table (1).
- 3- The first formant of the vowel /i/ for the Down's group reported higher measured values than the normal group. This is due to the enlarged tongue which prevents the maximum or the minimum constriction in the oral cavity. From the acoustical model this effect is not taken accurately into consideration and therefore, the value of this formant frequency is following the same tendency

of the other formant frequencies, i.e. it has a lower value than that of the normal group.

- 4- By using the acoustical models , we can estimate any acoustic deviations and their tendency related to certain anatomical structures concerning the configuration of the vocal tract.

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