

# Acoustic Aspects of the Speech of Children\*

RASHMI, M.

Speech is a neuromuscular activity. In other words, the output of this activity is the acoustic signals, which are used for communication—as speech. The acoustic characteristics of speech have been found to vary with age. These acoustic features on various aspects of speech production indicate that the accuracy of motor control improves with age until adult-like performance is achieved at about 11 or 12 years, somewhat after the age at which speech sound acquisition is usually judged to be complete.

"Today we are able to measure the acoustic or audible aspects of voice with sophisticated equipment. The voice print analyzer, sonograph, airflow meter, pressure recorder and computerized models of the vocal tract enable investigators to confirm earlier empirical findings and unearth new aspects of vowel sound characterization. The physiological aspects of sound production such as breathing patterns, vocal attack, vocal fold vibration and some resonance qualities can be revealed by acoustic means."

"The past two decades have been witness to an increasing application of acoustic analysis to the study of speech development in children."

---

\* Master's Dissertation, University of Mysore, 1985.

The acoustic analysis to study the speech development in children has been found to be useful, as such studies reflect :

- (1) The adjustment of phonatory apparatus.
- (2) The shaping of the vocal tract, and
- (3) The timing and co-ordination of articulation and thus provide evidence regarding the anatomical and neuromuscular maturation of the speech mechanism. This information is of importance in early identification, diagnosis and treatment of various speech and language disorders.

Some acoustic analyses have been considered to be useful in knowing more about the developmental disorders and thus in the treatment of developmental disorder of speech.

The present investigation was therefore undertaken to study certain acoustic and aerodynamic parameters, recommended by Hirano (1981), namely :

1. Maximum phonation duration of vowels.
2. Maximum duration of [ s ] and [ z ] and the s/z ratio.
3. Fundamental frequency of phonation.
4. Speaking fundamental frequency.

5. Fluctuations in the frequency of phonation.
6. Fluctuations in the intensity of phonation.
7. Frequency range in phonation and speech.
8. Intensity range in phonation and speech.
9. Intensities at harmonics.
10. Rise and fall time of phonation.
11. Vowel duration.

These parameters were studied in a sample of two hundred and twenty children, both males and females, ranging in age from four years to fifteen years, who were normal in terms of their speech, language and hearing.

Data on the maximum duration of [ a ] [ i ], [ u ], [ s ] and [ z ] and the repetition of the three Kannada sentences "idu papu". "idu ko:ti" and "idu kempu banna" were recorded. Each child was given three trials. One of these samples from each of the three trials was used for analysis.

The duration of the vowels and the fricatives was measured using a stopwatch, the longest of which was considered as the maximum phonation.

This sample was then fed to the Pitch Analyzer (PM 100) to obtain to fundamental frequency of phonation, fluctuations in frequency and intensity, in the initial medial and final segments of phonation, the frequency and intensity range in phonation and the rise and fall time of phonation. The three stimulus sentences were then fed to the Pitch Analyzer and the speaking

fundamental frequency, frequency range in speech and intensity range in speech were obtained for each subject.

To measure the vowel duration and the harmonics, the word "idu" was fed to the High Resolution Signal Analyzer. The duration of the vowel [ i ] and the harmonics occurring in it were measured for all the two hundred and twenty children.

The data thus obtained was subjected to statistical analysis, in order to determine the mean, standard deviation and the significance of difference.

### **Conclusions**

After the statistical treatment, the following conclusions were drawn :

#### **I. Maximum Duration of Phonation**

- (1) The MPT of vowels increases as a function of age in both males and females.
- (2) There is no significant difference in the MPT of vowels, between males and females, across the age range studied.
- (3) The MPT of [ i ] is the greatest followed by [ u ] and finally [ a ].

#### **II. Maximum Duration of Sustained [s] and [z]**

- (1) The maximum duration of sustained [ s ] and [ z ] is found to increase as a function of age.
- (2) The maximum duration of sustained [ z ] is greater than that of sustained [ s ], indicating a s/z ratio that is less than one.
- (3) There is no significant difference in the maximum duration [ s ], [ z ] and s/z ratio, between males and females.

### **III. Fundamental Frequency of Phonation**

- (1) In males, there is a lowering of fundamental frequency with advancing age upto the age of 14 years, after which there is a marked decrease in the fundamental frequency.
- (2) In females, the gradual decrease in fundamental frequency with increase in age is seen across the entire age range (4-15 years) studied.
- (3) A significant difference between males and females is observed only in the 14-15 year old age.
- (4) The fundamental frequency of [ a ] is the lowest, followed by [ i ] and finally, [ u ], which has the highest fundamental frequency of the three vowels studied.

### **IV. Speaking Fundamental Frequency**

- (1) There is very little change in speaking fundamental frequency as a function of age in males, upto the age of 14 years, at which age a sudden decrease in the speaking fundamental frequency is observed.
- (2) There is very little change in the speaking fundamental frequency in females with increase in age.
- (3) The speaking fundamental frequency of males and females is not significantly different in the younger age groups upto 14 years. A significantly lower speaking fundamental frequency is present in the males of the 14 to 15 year age group compared to the females.

### **V. Fluctuations in Frequency of Phonation**

- (1) The fluctuations in frequency of the initial and final segments of the

phonation of [ a ], [ i ] and [ u ] show a decreasing trend with age in males. The 14 to 15 year old group shows an increase in the range of fluctuations for all the vowels.

- (2) In females a decrease in the range of fluctuations in frequency of the initial and medial segments is observed upto the age of 9 years. There is an increase in the range of fluctuations in the 9 to 11 year old females, which again drops down till the age of 15 years.
- (3) The medial segment in phonation for both males and females is quite steady, and the range of fluctuations as a function of age does not show much difference.
- (4) No difference in the range of fluctuations in frequency between males and females is observed in the younger age groups. The males consistently show greater fluctuations in frequency in the phonation of [ a ], [ i ] and [ u ] than females in the 14 to 15 year old group.

### **VI. Fluctuations in Intensity of Phonation**

- (1) The fluctuations in intensity in the initial and final segments of phonation for all the three vowels is greater than the fluctuations in the medial segment, for both males and females.
- (2) The fluctuations in intensity of the initial and final segments of phonation do not show a systematic trend for any of the vowels, in both males and females. However, the initial segment of phonation shows significantly larger fluctuations in intensity in the age groups above 12 years in males, for all the three vowels.

- (3) The medial segment of phonation shows no difference in the range of intensity fluctuations as a function of age.
- (4) The older age groups of males (above 12 years) show a significantly higher range of fluctuations in the initial segment of phonation than the females of the same age group. The younger age groups do not show much difference in the range of fluctuations in intensity between males and females.

### **VII. Frequency Range in Phonation**

- (1) The frequency range in phonation decreases as a function of age in both males and females.
- (2) A sex difference in the frequency range of phonation is inconsistent.

### **VIII. Frequency Range in Speech**

- (1) The males show a decreasing trend in the frequency range of speech with increase in age.
- (2) The females also exhibit a reduction in the range of frequencies used in speech as a function of increasing age.
- (3) There is no significant difference in the range of frequencies used in speech by males and females.

### **IX. Intensity Range in Phonation**

- (1) The intensity range in the phonation of vowels decreases as a function of age in males.
- (2) The intensity range in the phonation of vowels show no difference as a function of age in females.

- (3) A significant difference between males and females in the range of intensity used in the phonation of the vowels is seen in the younger age groups, up to about 10 years, after which the difference is no longer significant.

### **X. Intensity Range in Speech**

- (1) There is a significant difference in the intensity range utilized in speech by males and females as a function of age below 6 years and above 14 years which shows a greater range of intensities for the sentence 'idu pa:pu'. For the sentences 'idu ko:ti' and 'idu kempu banna', the difference is inconsistent.
- (2) In females, the 9 to 11 year old children use a greater intensity range, though inconsistent.
- (3) The difference in the intensity range of speech between males and females at particular age levels is inconsistent.

### **XI. Harmonics**

- (1) The energy level above 1000 Hz is less than the energy level below 1000 Hz.
- (2) The a-parameter decreases between 9 to 14 years in females and 9 to 15 years in males.
- (3) There is no significant difference in the a-parameter between males and females in the age range of 4 years to 15 years.

### **XII. Rise Time of Phonation**

- (1) There is a gradual decrease in the rise time of phonation of all vowels

with increasing age in both males and females.

- (2) A slight increase in the rise time is seen in the 9 to 10 year old group of males and 10 to 11 year old group of females.
- (3) There is no difference in the rise time of phonation between males and females in all the age groups studied.

### **XIII. *Fall Time of Phonation***

- (1) Contrary to the decreasing trend of the rise time of phonation, as a function of age, the fall time shows an increasing trend in both males and females.
- (2) There is no significant difference in the fall time of phonation between males and females.

### **XIV. *Vowel Duration***

- (1) The males and females show a consistent decrease in the vowel duration as a function of age.
- (2) The females have a longer vowel duration compared to the males, across the entire age range studied.

### **Recommendations**

- (1) The study may be carried out with a larger sample in each age group.
- (2) The analysis could be extended to other vowels.
- (3) The speech samples using the mother-tongue of the subjects can be studied.
- (4) The same parameters can be studied in a clinical population of children to explore the clinical utility of this information.