

LISTENER IDENTIFICATION OF SPEAKER SEX IN CHILDREN FROM THREE TO NINE

by

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ABSTRACT

The speaking fundamental frequency of 24 three, five, seven, and nine-year old children was analyzed using conversational speech samples. Results indicated that speaking fundamental frequency decreases with age for both males and females with the males in the two younger age groups demonstrating higher fundamentals than the females. An analysis of listeners' abilities to identify the sex of the subjects based only upon their speech samples revealed an overall correct identification rate of 77.5%. The results indicate that such judgements are not based upon the speaker's fundamental frequency characteristics. An additional factor which may influence this identification ability is discussed.

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INTRODUCTION

The fundamental frequency characteristics of the pre-adolescent child have been a concern of various authors including Fairbanks et al (1949a, 1949b), Hollien et al (1965, 1967), McGlone (1966), Weinberg and Bennett (1971) and McGlone and McGlone (1972). These studies encompass children aged 12 months to 10 years. Examination of these data, however, reveals a need for further study. Specific deficiency areas exist, i.e. no information is available concerning the fundamental frequency characteristics of the three to five year old child. Additionally, the data that are provided for older children seem somewhat inconclusive. A comparison of the results from the Weinberg and Bennett study with those of Fairbanks et al reveals the unlikely conclusion that fundamental frequency increases approximately 45 Hz between the ages of five and eight years for both males and females. These findings led to the development of the present study with the purpose of further analyzing the fundamental frequency characteristics of pre-adolescent children, particularly the three to five year age group.

Using the data thus provided, a second area of study was also considered, that of the ability of listeners to identify the sex of a speaker based on a speech sample. A search of the literature revealed reports from several investigators who have studied the area, including Schwartz (1968a), Schwartz (1968b), Ingemann (1968), Coleman (1971), Weinberg and Bennett (1971), Murry et al (1974) and Lass et al (1976). Once again, however, the results appear somewhat inconclusive in establishing factors which allow a listener to make an accurate judgment of speaker sex. Lass et al indicate that fundamental frequency is the primary characteristic upon which this judgment is based while Weinberg and Bennett suggest that fundamental frequency information does not provide the distinction. They speculate that differences in vocal tract resonances comprise the distinctive quality. Therefore, this study also examined the ability of a

listener to identify the sex of a young child based only upon recordings of his conversational speech and considered the vocal characteristics upon which listeners make such judgments.

FUNDAMENTAL FREQUENCY ANALYSIS

Methodology

Sixteen children aged three, five, seven, and nine years (± two months) with no observable voice abnormalities were utilized as subjects. They were equally divided into the above four age groups each containing two males and two females. Conversational speech samples were obtained from each subject with all but 2 children recorded in a sound-treated booth using a Tandberg stereo recorder and a standard set of pictures and questions for stimulation. The remaining two subjects were recorded using the same instrumentation in a small, reasonably quiet, speech clinic room at their school. Each sample was subjected to an analysis of speaking fundamental frequency using a Honeywell 1508 Visicorder Oscillograph, with a paper speed of 100 cm/sec. A minimum of 20, .1 second time frames were analysed for each subject, averaging approximately five seconds of running speech.

Results and Discussion

The results of the fundamental frequency analysis are presented in Table 1. As the table indicates, mean fundamental frequency generally decreased with age for both males and females with the males decreasing a mean total of 84.22 Hz and the females decreasing 34.49 Hz. The male mean fundamental was consistently higher than the female at all ages, with differences of 55.89 Hz at three years, 24.52 Hz at five years, 7.4 Hz at seven years and 6.16 Hz at nine years.

	Hz	Hz	Hz	Hz
Male	322.88	272.59	261.55	238.66
Female	266.99	248.07	254.15	232.50
	3	5	7	9
	Age in Years			

Table 1. Mean Fundamental Frequency of Male and Female Speakers for Each Age Group

As indicated above, these results suggest, contrary to comparisons of earlier data, that fundamental frequency decreases with age for both males and females. While the data are in opposition to Fairbanks, who reported higher fundamental frequencies for both sexes, they are relatively consistent with the findings of Weinberg and Bennett. A rather unexpected finding in the present study was that, for the two youngest age groups and the three year olds in particular, the male speaking fundamental was considerably higher than the female. Because no other information is available concerning the three year old child, it is impossible to check the consistency of this finding with previous data. This sex difference decreases for the five year olds and becomes negligible for the seven and nine year olds.

SEX IDENTIFICATION ANALYSIS

Methodology

Two types of samples were utilized for the listener's sex identification of the speakers. In the first, all possible male-female pairings were made within each age group for a total of 32 pairings. These were presented to the listeners in a randomized, counterbalanced design. The listeners, 20 third year speech pathology students, were instructed to identify the male in each pairing and indicate their response on an answer sheet. The listeners were individually presented the samples via Sony DR5A stereo earphones and a Sony Stereo Tape recorder. In the second design, the listeners were presented only one sample at a time, 16 in all, and instructed to identify the sex of the speaker. Method of sample presentation was the same as above.

Results and Discussion

For both designs, the listeners were generally able to correctly identify the sex of the speaker. Overall, the paired comparison task yielded an accuracy rate of 77.5%. The single subject task appeared to be more difficult and resulted in a correct identification rate of 65%. The former task is in close agreement with Weinberg and Bennett who reported a 74.5% accuracy in identification using five and six year old subjects.

Because it could have been possible that the listeners were basing their judgments of speaker sex upon what was said rather than the acoustic features, an analysis of the verbal content of each sample was made. Written transcripts of the samples were prepared and given to 10 third and fourth year speech pathology students who were instructed to identify the sex of the speaker based upon the transcriptions. Their average correct identification rate was 53%, indicating that they were essentially at a chance level of identification. It was determined therefore, that the listeners in the study were not making accurate judgments of speaker sex as a function of the sample content. Some other cue in the sample appeared to account for these identifications.

It appeared in the present study that the listeners' judgments were facilitated when they could make a comparison between two voices in identifying speaker sex. As had been suggested in earlier research, it appeared fairly obvious that the fundamental frequency characteristics of the speaker were not the cues relied upon in making these judgments, since the listeners had little difficulty differentiating speaker sex even when the males and females had virtually identical fundamental frequencies. In the present study there was at times a wide discrepancy in fundamental between a male-female pairing; however, the listeners did not appear to be internally assigning a particular pitch to a particular sex. If the listeners had held a preconceived set for one sex having a higher or lower pitch than the other, it seems reasonable that this would have been reflected in their judgments. They would perhaps have demonstrated some consistency in assigning sex as a function of pitch. This did not appear to occur. Regardless of differences in fundamental within any given pairing or which sex demonstrated the higher pitch, the listeners made relatively accurate judgments. They did not consistently mistake a high pitched male for a female or vice versa. It was determined, therefore, that some speculation could perhaps be made into the acoustic characteristics which allowed for these distinctions in sex identification to be made. Weinberg and Bennett had suggested that vocal tract resonances could account for the differences. The present study thus initiated a very limited probe into the format frequency characteristics of the samples.

Because an accurate spectrographic analysis required relatively identical samples from each subject and the tapes used in the previous areas of the study were conversational in nature, only a very limited number of samples could be utilized. Five of the original 16 samples proved to have wording similar enough that they were appropriate for a spectrographic analysis. Because of this extremely limited N and the small percentage of the original sample it represents, the results of this probe should be taken cautiously and used only as an indication that further study in this area is perhaps warranted. A second limitation to the probe resulted from the small number of vowels available in the five samples for analysis: /e/, /o/, and /au/. The samples did indicate, however, that formant frequency appears to be a distinctive factor in making sex identification judgments. The five spectrograms analyzed represented three pairing combinations in the paired comparison task as well as five subjects in the single subject task. In the former, the subjects who were consistently misidentified tended to have formant frequencies for f_1 , f_2 , and f_3 more characteristic of the opposite sex, e.g., a male consistently misidentified as a female demonstrated formant frequencies higher than the female with whom he was paired regardless of his fundamental. In the single subject task, the same trend was observed. Subjects identified as the opposite sex tended to have formant frequencies for the first three formants more characteristic of that sex. These results offer further evidence of a factor which may influence a listener's identification of speaker sex.

SUMMARY

The present study offers normative data concerning the fundamental frequency characteristics of the pre-adolescent child, and generally suggests that as age increases, fundamental frequency decreases for both males and females. For particularly young children, males tend to have higher fundamental frequencies than females although this difference disappears as a function of age in the older child. An analysis of listener identification of speaker sex indicated that listeners are generally able to accurately identify the sex of a speaker, although the speaker's fundamental does not appear to be the primary feature which allows for such distinctions. A limited probe into this area revealed that perhaps formant frequency characteristics play a more important role, although the results must be taken cautiously because of the small sample available for study. Indeed, the only conclusive result that should be drawn from this last analysis would be a suggestion that additional study is indicated.

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