

Analysis and Synthesis of Speech of Hearing-Impaired

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"Deafness is a fearsome problem largely because of the barrier to communication which it creates. The obvious effect of this barrier is to prevent the deaf from understanding what others say, but it may also impede them from speaking intelligibly. The magnitude of their problem is illustrated by recent studies suggesting that of prelingually deaf children, hearing losses of 90 dB or more, about 75% have speech classified as "barely intelligible" or worse" (Conrad, 1979).

"Speech training must be efficient in order to get intelligible speech. An efficient speech training program requires that there are methods to assess the child's speech errors as well as methods to estimate the impact of these errors on the intelligibility" (Oster, 1985). The low speech achievement of the hearing-impaired has led to several investigators in the past to correlate speech intelligibility with several receptive and productive variables of speech.

Some attempts have been made to study the direct effect of segmental error corrections of speech of the hearing-impaired using modern computer processing techniques (Lang, 1975; Osberger and Levitt, 1979; Maassen and Povel, 1984 a, b, 1985; Oster, 1985). The advantage of such technique is that it is possible to determine the causal relationship between the error type and intelligibility without the presence of any other confounding variable. Also results of such studies will help in determining, the error type and kinds of errors that should be considered first while planning a training program for the improvement of speech of the hearing-impaired child.

No such studies have been reported in Malayalam speaking hearing-impaired children. The present investigation was undertaken in order to study the effect of some suprasegmental error corrections on the intelligibility of speech of the hearing-impaired.

Five congenitally hearing-impaired children in the age group of 5-9 years were selected from the therapy clinic of All India Institute of Speech and Hearing for the study. All these children had severe to profound sensori-neural hearing loss. They had no additional handicap other than that directly related to the hearing-impairment. All read simple bisyllabic words in Malayalam.

Ten simple bisyllabic meaningful Malayalam words were selected. The speech samples of all the four children were recorded as they read the words. Recordings were also obtained of a matched group (for age and sex) of five normal hearing children reading the same set of words.

Experiment - 1 : The samples were then analysed using computer programmes of VSS, Bangalore. The following parameters were obtained.

1. Vowel duration
2. Duration of pauses
3. Total duration of words
4. Average F_0
5. Formant frequencies (F_1 and F_2)
6. Bandwidth (BW_1 AND BW_2)

The obtained data was subjected to statistical analysis to determine the mean, SD and significance of differences between the two groups.

Experiment - II: Some aspects of the suprasegmental errors in the digitized data of hearing-impaired children's speech were modified in this stage. Two measures were considered. They are :

1. Correction of pauses, if any
2. Correction of vowel durations and
3. Combination of these two i.e. correction of both vowel duration and pauses.

All the measures were corrected towards the mean values of normal hearing group.

Thus, these two measures were corrected in isolation and in combination. All together three types of corrections were performed.

Experiment - III : The unaltered utterances and the corrected (total 152 utterances) were recorded randomly. This recording was presented to three judges for word identification task and intelligibility rating.

The number of words identified correctly were converted into percent scores using the formula.

$$\frac{\text{No. of words identified correctly}}{\text{Total number of words present}} \times 100$$

Total number of words present

The judges had to rate the intelligibility on a five point interval scale, ranging from '0' (intelligible) to '4' (highly intelligible).

The judges showed that the correction of vowel duration had a significant effect on intelligibility, while all the other types of corrections had determinantal effect on intelligibility.

The correction of vowel duration showed 23.4% of improvement when compared with the unaltered utterances.

The results were also analysed to find out which of the ten words has been identified correctly most of the time. The word /amma/ topped the list in both the conditions followed by /a:ma/, /i:cha/, /uppu/, /o:to/, /ila/, /eli/, /e:ni/, /u:nu/.

Analysis of the intelligibility ratings revealed that the words (21.7%) were rated as unintelligible, words with (43.42%) as poorly intelligible, (23.02%) as fairly intelligible (9.21%), as quite intelligible (2.6%), as highly intelligible.

Thus, it was seen that the correction of some of the suprasegmental characteristics of speech of the hearing-impaired caused a decrease in the speech intelligibility whereas the correction of vowel duration alone has a beneficial effect on the speech intelligibility. This result is in agreement with the results of previous studies quoted in the literature (Lang, 1975; Osberger and Levitt, 1979; Maasen and Povel, 1984; Oster, 1985).

It is suggested that the segmental correction may be started first in the training program so as to get a more intelligible speech. Once this is achieved, we can go for

correcting the suprasegmental aspects to have positive effects both on intelligibility and naturalness.

"How to achieve this results, that is, how and to what extend these suggestions can be applied in practical speech training especially in view of the high correlation between segmental and suprasegmental aspects in speech production is a question that can only be solved in practice (Maasens and Povel, 1985).

Results of the present study shows:

1. The hearing-impaired group had significantly longer vowel durations than that of normal hearing group.
2. Normal hearing children did not show any intersyllabic pauses (intra word) whereas 4 out of 5 children in the hearing-impaired group inserted intersyllabic pauses at least once in each word.
3. The total durations of the words uttered by the hearing-impaired children were significantly longer than that of the normal hearing group.
4. Higher average F_0 than that of the normal hearing group was exhibited by the hearing-impaired children.
5. The hearing-impaired children had higher first formant (F_1) and second formant frequency (F_2) smaller than the normal hearing group.

The synthesis of speech of the hearing-impaired children showed that the intelligibility -

a. Improved:-

1. When the vowel durations were corrected.

b. Deteriorated :-

1. When the intersyllabic pauses were corrected.
2. When the vowel duration and pauses were corrected.

Thus, the study established that there is significant difference in terms of vowel duration, pauses, formant frequencies F_1 , F_2 and bandwidth BW_1 , BW_2 between the normal and hearing-impaired speech and the intelligibility improves by correction of vowel duration alone and combination of the two i.e. Correction of pause and vowel duration had negative effect on intelligibility.

Recommendations:

1. Similar studies can be carried out with sentences as speech material.
2. Similar study may be carried out for segmental errors.
3. A study to find out the effect of correction of both the segmental and suprasegmental aspects of speech may be undertaken.
4. A study to establish relative impact on intelligibility of different types of speech errors and to develop an individual program for speech improvement can be carried out.
5. Study of larger population with suggested modification will be useful.