

# A Comparative of Perceptual and Objective measures of Speech Intelligibility in children with Hearing Impairment

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**Abstract:** The present study is to investigate the speech intelligibility in the hearing impaired population. It aims to measure speech intelligibility using rating scales and write down procedure. In order to get 60 speech samples varying in intelligibility, hearing impaired children and adolescents within the age group of 10-16 years with a Mean age of 13.51 years (S.D.=2.15) with different degrees of hearing loss were selected. Three groups of 20 subjects each were included, moderately severe hearing loss, severe hearing loss & profound hearing loss. The six point NTID and seven point AYJNIHH rating scales along with Hindi passage of 102 words were used. On the 6 point rating scale Pearson's 'r' correlation is indicative of very high positive correlation i.e 0.75. This is statistically significant ( $p < 0.01$ ) for moderately severe group. The positive correlation i.e 0.67 for the 7 point rating scale and word identification task for moderately severe group. A highly significant difference was found between word identification score and the various degrees of hearing loss ( $F(2,57)=357.55; P < 0.001$ ). Thus it emphasizes the point that both the perceptual and objective measures strongly suggests that the ratings and write down procedure provides a viable and significantly more accurate alternative for speech intelligibility assessment. The 6 point NTID scale however, appears slightly more sensitive than the 7<sup>th</sup> AYJNIHH scale.

**Index Terms:** Speech Intelligibility, NTID, AYJNIHH.

## I. INTRODUCTION

“The Speech intelligibility is in the ear of the listener as well as in the mouth of the speaker” (Trybus 1978, p.69).

Communication is one of the most complex of all human endeavors. Young children with communicative disorders are ignored or overlooked by people. Oral communication is an important aspect of communication, for oral communication to be successful speech intelligibility of the speaker to hearer is one of the most fundamental factors. The concept of speech intelligibility came into picture in 1920's from the telephony literature. The literature focused on the quality of voice transmission systems, and means by which the quality can be assessed. In 1949, Wood emphasized on the speaker side of this model when the speech intelligibility of children with articulation disorders was assessed. His main aim was to use the percentage intelligibility score as a metric of severity of an articulation disorder. Intelligibility is a part of more general concern and communicative competence can be studied with various methods. It has been a topic of great interest and concern for professionals. So far intelligibility has been investigated with a variety of techniques and on different levels. Therefore, when two persons may share some common idea of what basically speech intelligibility is, they may use very different methods to measure it and understand its correlates in the act of speaking (Weismer and Martin, 1989).

In general, it has found that as the hearing level increases the speech intelligibility decreases and vice versa. The speech intelligibility of children with moderate to severe hearing losses has been found to be better than that of children with profound losses. The systematic relationship between degree of hearing impairment and speech intelligibility breaks down, once the hearing level reaches 85 dBHL (Markides, 1970; Monsen, 1978). Hence some hearing impaired children develop intelligible speech whereas others do not. The differences in speech intelligibility of children with hearing impairment may also reflect factors such as early identification and intervention, consistent use of hearing aid and speech therapy.

Samar and Metz (1988) examined the interrater and intrarater reliability for the 5 point NTID scale. They found test retest correlations for spontaneous speech ratings of +0.96 and for oral reading 0.94 and intrarater coefficients of 0.98 and 0.97 for the same two tasks.

Reliability and validity of 7 point AYJNIHH intelligibility rating scaling was assessed in a study by Thomas (2000). Three groups of ten listeners each, rated the 35 speech samples on the 7 point AYJNIHH scale. A very high correlation was obtained between the ratings of the 3 groups. It was concluded that the 7 point rating scale of AYJNIHH (1984) has a good interrater and intrarater reliability.

## Need for the study

Two methods are used for assessing speech intelligibility in hearing impaired speakers namely,

- 1) Word Item Identification
- 2) Scaling

Literature shows more work done in word identification task i.e in closed set item identification as compared to open set item identification. Most studies have been done using the method of closed set item identification and scaling individually as well as in combination. Few studies have been done using open set item identification individually. However, there is paucity of research with

regard to the combined method of open set response format and scaling. No such study has been carried out in Hindi language in the Indian context.

Perceptual measures are done in Mumbai using AYJNIHH scale (1984) for assessing speech intelligibility. For the western population the NTID scale is used. Not much research has been done to evaluate if AYJNIHH scale is applicable on hearing impaired population. If it is found to be applicable individually or in combination (AYJNIHH and NTID), then it can be used to determine the severity of disability of hearing impaired speakers in clinical set ups and hearing impaired schools.

### Objectives of the study

- 1) To compare speech intelligibility measures of groups with various degrees of hearing loss (moderately severe, severe and profound).
- 2) To find out correlation between word identification task and rating task using 6 point NTID scale for moderately severe, severely and profoundly hearing impaired groups.
- 3) To find out correlation between word identification task and rating task using 7 point AYJNIHH scale for moderately severe, severely and profoundly hearing impaired groups.
- 4) To find out word identification score for each moderately severe, severely and profoundly hearing impaired groups.
- 5) To find out intelligibility rating of 6 point AYJNIHH scale for moderately severe, severely and profoundly hearing impaired groups.
- 6) To find out intelligibility rating of 7 point AYJNIHH scale for moderately severe, severely and profoundly hearing impaired groups.

### Hypothesis

- 1) There is a significant difference between the performances of groups with various degree of hearing loss on speech intelligibility measures.
- 2) There is no significant relationship between word identification task and rating task using 6 point NTID scale for moderately severe, severely and profoundly hearing impaired groups.
- 3) There is no significant relationship between word identification task and rating task using 7 point NTID scale for moderately severe, severely and profoundly hearing impaired groups.

## II. METHODOLOGY

The present study is an attempt to investigate the speech intelligibility in the hearing impaired population. It aims to measure speech intelligibility using rating scales and write down procedure.

### Subjects:

In order to get speech samples varying in intelligibility 60 hearing impaired children and adolescents with a Mean age of 13.51 years (S.D.=2.15) with different degrees of hearing loss were selected.

The following criteria were employed in the selection of the subjects.

Age range: Hearing impaired individuals in the age range of 10-16 years were selected.

Degree of hearing loss: Three groups of 20 subjects each were included, viz

Group I- Moderately severe hearing loss i.e PTA less than or equal to 70 dBHL in the better ear.

Group II- Severe hearing loss i.e PTA less than or equal to 90 dBHL in the better ear.

Group III- Profound hearing loss i.e PTA above 90 dBHL in the better ear.

Language: Only those subjects whose mother tongue was Hindi and who could read Hindi were included in the study.

School: All were attending Hindi medium special school for the Hearing impaired.

Onset of Hearing loss: The onset of hearing loss for each subject was at birth or before acquisition of language (prelingual hearing loss).

Intelligence: Only those subjects who were assessed as having average intelligence based on the previous test reports were included.

Other Impairments: Subjects had no other sensory or physical impairment.

### Material used:

Two scales were employed for rating speech intelligibility.

#### NTID Rating Scale:

The National Technical Institute for the Deaf (NTID) 6 point rating scale was developed by Schiavetti, Metz and Sitler (1981). This scale is an equal appearing interval scaling technique in which the speech intelligibility is rated on a 6 point scale. The scale provides descriptors for each of 6 numbers to partition intelligibility

#### AYJNIHH Rating Scale:

A 7 point rating scale was developed by Department of Speech Language Pathology of Ali Yavar Jung National Institute for the Hearing Handicapped (AYJNIHH) in 1984. The scale is a modification of the one developed by Subtely (1977). It is an equal appearing interval scaling technique in which speech intelligibility is rated on a 7 point scale. The scale provides descriptors for each of the 7 numbers used to partition intelligibility.

#### Hindi Passage:

The speech material that was used for generating the recorded speech samples was a passage in Hindi consisting of 102 words developed by Department of Speech Language Pathology, AYJNIHH in 1988.

**Procedure:**

The six point and seven point rating scales along with Hindi passage were used by the researcher to assess speech intelligibility. Initially subjects were engaged in an informal conversation which was carried out in order to get a rough idea about subject's intelligibility. The subjects were then asked to read the Hindi passage and simultaneously recording of speech were made on a T-series HF 60 tape using Sony compact cassettes recorder model No. TCM 333. The microphone was placed at a distance of 6 inches away from subject's mouth. Recording time was constant for all the subjects' i.e 3 minutes. Each sample was separated by a period of 10 seconds. Recording was done in a quiet room.

**Analysis:**

Three judges (Speech Language Pathologist holding MASLP degrees with minimum one year experience), who were exposed to the speech of hearing impaired, were chosen for judging the speech intelligibility of children with hearing impairment. Initially the judges were given a brief idea about the study. Two judges were selected for the perceptual task (rating scale) and one judge for objective task (write down procedure). The recorded samples were presented randomly to the judges. The judges were not acquainted with the subjects of the present study and were not familiarized with the passage. For perceptual analysis the judges were provided with rating scales and response sheet on which they had to mark the rating for each subject. For the write down procedure the other judge was instructed to listen to the recording and write down each word said by the speaker from the passage. These raw scores were later converted into percentage scores.

Thus the speech intelligibility for objective measures was expressed as a percentage of words correctly identified by the judge. On the other hand, for the perceptual task, average ratings given by judges were employed.

The obtained ratings and percentage of correctly identified words were analysed using Statistical Package of Social Sciences (SPSS) to obtain Means and Standard Deviations. Pearson's correlation and one way ANOVA was applied and significance of the relationship between the variables was tested. The results of the analysis are presented.

**III. RESULTS AND DISCUSSION**

The present study was conducted to study speech intelligibility of sixty hearing impaired speakers. Both perceptual and objective measures were employed for this purpose. The data was subjected to statistical analysis in order to obtain means and standard deviations for perceptual and objective task. Speech intelligibility ratings were obtained by averaging the ratings, which were given by two experienced judges. Pearson's correlation was applied to establish if there exists a relationship between degree of hearing loss and speech intelligibility (ratings and word identification scores). One way ANOVA was applied to find out whether there was a significant difference between the performances of the three groups with hearing impairment on speech intelligibility measures. Speech intelligibility of the subjects was rated on the 6 point NTID and 7 point AYJNHH perceptual rating scales. On the 7 point scale, ratings towards the higher end of the continuum indicate poorer speech intelligibility i.e 0 indicates normal intelligibility and 7 indicates poor speech intelligibility. Whereas on the 6 point scale, ratings towards the higher end of the continuum indicate good speech intelligibility i.e 1 indicates poor speech intelligibility and 6 indicates normal intelligibility. Hence for analysis the 7 point scale was inverted in such a manner that 0 indicates poor speech intelligibility and 7 indicates normal intelligibility.

The details of the results are described below

**Speech intelligibility measures**

Means and Standard Deviations obtained for the various measures are reported below.

**a) Word Identification Score**

As observed from the Figure 1 there appears to be a difference in the means of the three groups for word identification score. The mean of the group 1 (moderately severe) is 96.91 which is higher than those of the other two. The mean of the group 2 (severe) is 45.29 while that of group 3 (profound) is 3.92. The standard deviation value for group 2 (severe) is 18.43 which is higher than those of groups 1 and 3 (3.46 and 3.57 respectively). The difference between them is remarkably high.

HL Group	Mean	Standard Deviation
Moderately severe	96.9075	3.4621
Severe	45.2895	18.4252
Profound	3.9200	3.5690

**Figure 1:** Showing Means and Standard Deviation for word identification score for the three groups of subjects.

**b) Ratings on the 6 point scale**

From Figure 2 it can be seen that there is a difference in the means of the three groups for perceptual assessment using the 6 point scale. The mean of group 1 (moderately severe) for the perceptual task is 9.20 (S.D= 2.19) which is higher than those of the other two. The mean of group 2 (severe) is 4.9 (S.D = 1.92) while that of the group 3 is 2.709 (S.D= 1.08). The standard deviation value for the 3 groups therefore does not vary widely.

HL Group	Mean	Standard Deviation
Moderately severe	9.20	2.19
Severe	4.90	1.92
Profound	2.70	1.08

**Figure 2:** Showing Means and Standard Deviation when 6 point scale was used for the three groups of subjects.

## c) Ratings on the 7 point scale

Figure 3 displays the means of the three groups for perceptual assessment using the 7 point scale. The mean of group 1 (moderately severe) for perceptual task using 7 point scale is 8.45 (S.D=2.37) which is the highest amongst the groups. The mean of group 2 (severe) stands at 3.30 (S.D =2.36) while that of group 3 (profound) is 0.80 (S.D=1.11). The standard deviation value of group 3 is lower than those of group 1 and 2.

HL Group	Mean	Standard Deviation
Moderately severe	8.45	2.37
Severe	3.30	2.36
Profound	0.80	1.11

**Figure 3:** Showing Means and Standard Deviation on the 7 point rating scale used for the three groups of subjects.

### Relationship of Perceptual and Objective measures

Correlation of word identification score and perceptual ratings on the 6 point and the 7 point scales for the three groups is described below.

## a) On the 6 point rating scale

Pearson's 'r' correlation as observed from Figure 4 is indicative of very high positive correlation i.e 0.75. This is statistically significant ( $p < 0.01$ ) for moderately severe group. The low positive correlation (0.27) was obtained for the severe group whereas the correlation for profound group was 0.39, both being statistically not significant.

HL Group	Correlations	Word Identification Score
Moderately severe	Pearson's Correlation Sig. (2-tailed) 6 point	0.753 0.000 $P < 0.01$
Severe	Pearson's Correlation Sig. (2-tailed) 6 point	0.274 0.243 $P < 0.01$
Profound	Pearson's Correlation Sig. (2-tailed) 6 point	0.388 0.091 $P < 0.01$

**Figure 4:** Correlations of word identification score and perceptual assessment using 6 point scale for Moderately severe, Severe and Profound loss groups.

## b) On the 7 point rating scale

Figure 5 displays the positive correlation i.e 0.67 for the 7 point rating scale and word identification task for Moderately severe group. For the Severe group a low positive correlation of 0.30 was obtained which was statistically not significant. Children with Profound hearing loss a positive correlation of 0.38 was obtained which was not statistically significant.

HL Group	Correlations	Word Identification Score
Moderately severe	Pearson's Correlation Sig. (2-tailed) 7 point	0.669 0.001 $P < 0.01$
Severe	Pearson's Correlation Sig. (2-tailed) 7 point	0.304 0.192 $P < 0.01$
Profound	Pearson's Correlation Sig. (2-tailed) 7 point	0.379 0.099 $P < 0.01$

**Figure 5:** Correlations of word identification score and perceptual assessment using 7 point scale for Moderately severe, Severe and Profound loss groups.

### Degree of Hearing impairment and speech intelligibility measures.

The data was subjected to statistical analysis using one way ANOVA. In order to establish if the differences between the groups for word identification scores was statistically significant one way ANOVA was applied. A highly significant difference was found between word identification score and the various degrees of hearing loss ( $F(2,57)=357.55; P < 0.001$ ).

Source of Variance	Sum of squares	df	Mean square	F	Sig.
Between Groups	86816.857	2	43408.429	357.552	0.000 P<0.001
Within Groups	6920.050	57	121.404		
Total	93736.907	59			

**Figure 6:** Mean sum squares, Degree of freedom, Mean square, F- ratio and Significance of F of word identification score for moderately severe, Severe and Profound hearing loss groups

#### IV. SUMMARY AND CONCLUSIONS

The present study was taken up with the purpose of investigating if there exists a significant relationship between perceptual and objective measures of speech intelligibility in children with various degrees of hearing impairment.

The performance on word identification and rating task (using 6 point NTID and 7 point AYJNIHH Scale) were obtained for 3 groups of subjects with varying degrees of hearing loss (Moderately severe, Severe, Profound). Each group had 20 subjects. The age range of the subjects was between 10 to 16 years (Mean 13.5). Three judges were chosen for assessing the speech intelligibility of the subjects in the study: two judges for the perceptual task and one judge for the objective task. Judges were speech language pathologists with MASLP degree and with minimum one year's work experience.

The data obtained was subjected to Pearson's 'r' correlation and one way ANOVA. The results of this study revealed that the degree of hearing loss has a significant impact on speech intelligibility measures. There is also a positive correlation between the word identification task and ratings using both the 6 point scales for the 3 groups with hearing impairment.

Thus it emphasizes the point that both the perceptual and objective measures strongly suggests that the ratings and write down procedure provides a viable and significantly more accurate alternative for speech intelligibility assessment. The 6 point NTID scale, however, appears slightly more sensitive than the 7<sup>th</sup> AYJNIHH scale.

#### REFERENCES

- [1] W.G.Beck and C.Speaks. "Intelligibility of selected passages from the speech intelligibility rating test," Journal of Speech and Hearing Research, vol 36, pp.1075-1082,1993.
- [2] A.Boothroyd. "Auditory perception of speech contrasts by subjects with sensorineural hearing loss", In M. J et al Osberger. Speech intelligibility of children with cochlear implants. The Volta Review, vol 96(5), pp.170,1984.
- [3] S.N.Bowman and C.L. Parsons. "The effect of signing & non signing on intelligibility in a young hearing impaired speaker", Australian Journal of Human Communication Disorders, vol 15, pp.71-76,1987.
- [4] J.H Connolly. Intelligibility: A linguistic view," British Journal of Disorders of Communication, vol 21, pp.371-376, 1986.
- [5] J. Doyle. "Audiologist's predictions of speech intelligibility from pure tone audiograms", The Volta Review, vol 90, pp. 155-165, 1988.
- [6] P.Flipsen. "Speaker-Listener familiarity: Parents as judges of delayed speech intelligibility," Journal of Communication Disorders, vol 28, pp 3-19, 1995.
- [7] K. A Kangas and G.D Allen. "Intelligibility of synthetic speech for normal hearing & hearing impaired listeners," Journal of Speech and Hearing Disorders, vol 55, pp. 751-755, 1990.
- [8] C.Kelly, J.Dancer and R. Bradley. "Correlation of SPINE test scores to judges ratings of speech intelligibility in hearing impaired children," The Volta Review, vol 88, pp.145-150,1986.
- [9] B. Maassen. "Marking word boundaries to improve the intelligibility of the speech of the deaf," Journal of Speech and Hearing Research, vol 29, pp.227-230,1986.
- [10] A. Markides. "Speech Intelligibility: Auditory oral approach versus total communication," Journal of British Association of Teachers of the deaf, vol 6(12), pp.406-411,1988.
- [11] D.E. Metz, V.J. Samar, N.Schiavetti & R.W Sittler. Acoustic dimensions of hearing impaired speakers intelligibility: Segmental & suprasegmental characteristics," Journal of Speech and Hearing Research, vol 33, pp.476-487,1990.
- [12] D.E. Metz, N.Schiavetti & S.D. Knight. The use of artificial neural networks to estimate speech intelligibility from acoustic variables: A preliminary analysis. Journal of Communication Disorders, vol 25, pp.43-53,1992.
- [13] R. B. Monsen. "The oral speech intelligibility of hearing impaired talkers. Journal of Speech and Hearing Disorders," vol 48, pp.286-296, 1983.
- [14] M.T Osberger; A.M Robbins, S.L Todd & A.I Riley. Speech intelligibility of children with cochlear implants, The Volta Review, vol 96, pp.169-180, 1994.
- [15] C.R Smith. Residual hearing and speech production in deaf children. In R.Kent. Intelligibility in speech disorders, theory, measurement, and management. pp. 75. 1992.
- [16] E. J. "Thomas. "Reliability and validity of the intelligibility rating scale developed by AYJNIHH for assessing the speech of the hearing impaired," Unpublished Master's Dissertation, University of Mumbai.2000.
- [17] M.A.Svirsky; S.B.Chin; R.T. Miyamoto; R. B.Sloan & M.D. Catdwell. Speech intelligibility of profoundly deaf pediatric hearing aid users. The Volta Review, vol 102(4), Monograph, pp.175-198, 2002.
- [18] N.Tye Murray; J. Barkmeier & J.W. Folkins. Scaling and transcription measures of intelligibility for populations with disordered speech. Journal of Speech and Hearing Research, vol 34, pp.697-698,1989.
- [19] R.L.Whitehead; N. Schiavetti; D.J.Mackenzie & D.E. Metz. Intelligibility of speech produced during simultaneous communication. Journal of Communication Disorders, vol 37, pp. 241-253,2004.
- [20] D.C.Wold; C.R.Evans; J.C.Montaque & J.E. Dancer. A pilot study of SPINE test scores and measures of tongue deviancy in speakers with severe to profound hearing loss. American Annals of the Deaf, vol 139, pp.352-357,1994.