

# Statistical Performance Analysis of Blue Hearing System User Under Speech Therapy Sessions

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**Abstract:-** Blue Hearing System is the combination of cochlear implant followed by speech therapy sessions for deaf and mute fellow. In the present work, we have measured the performance of patient during speech therapy sessions. The overall performance has been computed in terms of the average of the performances of the patient in terms of Sound Detection Sensitivity(SDS), Sound Pattern Detection Sensitivity(SPDS), Sound Source Discrimination Sensitivity(SSDS), Speaker Identification Sensitivity(SIS) and Object Identification Sensitivity(OIS). Then the various performance measuring parameters have been analyzed statistically, which conclude that the regular speech therapy sessions improve the performance of Blue Hearing System user significantly.

**Keywords:-** Blue Hearing System, Speech Therapy, Statistical Performance Analysis, Performance Measuring Components.

## I. INTRODUCTION

The growing baby starts producing some noisy sounds approximately after one year or more. When gradually it grows, it starts to pay attention towards the sounds produced by nearby people and tries to copy the same sounds. Hence the process of speech development gets started. Speech development is the consequence of hearing, Speech can only be developed if the child has hearing sense already.

### A. Pre-Lingual and Post- Lingual Deafness:

Deafness in patients is of two kinds mainly, one is prelingual, which occurs by birth and in this kind of deafness the patient has no idea about sound or speech perception and other one is post lingual deafness in which the patient has sound sense fully or partially in past but due to some accidental cause hearing lose takes place in him or her. Hence there is a major difference between these two types of deafnesses. In case of prelingual deafness the patient has no idea of sound and listening. Hence we can say that the prelingual deafness is more challengeable in comparison to the post lingual deafness.

### B. Blue Hearing System as a Boon:

Blue Hearing System (BHS) plays very important role for the patients having prelingual deafness as it provides the efficient method to develop speech in the patient who does not possesses the sound perception at all [1]. BHS is a system having cochlear implantation followed by speech therapy sessions. With the help of Blue Hearing System the sound acquisition process and as a consequence the spoken language

both start to develop after proper speech therapy sessions in the patients. Blue hearing system is very useful for prelingual deafness as it helps to develop the sense of language in a child. It is equally well to overcome postlingual deafness to retrieve the hearing sense back and to increase the vocabulary of the implantee.

After cochlear implant surgery the next step to be taken is mapping process, which involves the proper optimization of voltage and frequency parameters. This process checks the responses of the patient for corresponding changes in the electrode voltage levels Some patients may respond good at lower voltage level for one electrode while others may respond good at higher voltage level hence this is a highly customized process which sets the voltage levels for all the electrodes in the cochlear implant device [2][3].

### C. How Hearing Occurs:

Hearing is very important perception which is developed earliest in a child. Hearing occurs when the external sound enters inside the ear to make eardrum to vibrate. Finally these vibrations are passed to brain to make a sense of sound perception[4]. Listening and speaking are the complementary mechanisms and both are very important for verbal communication.

### D. Processing of Speech in Blue Hearing System:

In some important applications as speech or speaker identification, some effective feature extraction techniques are needed, which contain speech or specific attributes of the speaker. The removal of silence or background impairments from the original input results in the reduction of required bandwidth [5][6].

The process of speaker identification involves the various speech processing techniques [7]. Speaker may be recognized uniquely by speech produced because the pronunciation of the words, interval between words, frequency and amplitude produced, vary from speaker to speaker [8][9]. The identification of exact speaker is the demand of today's erawhile resolving many critical issues. Though there may be slight similarity between two speakers, it is always possible to make a distinction between them. The reason behind this is that there are number of parameters to manipulate the speech.

The speech processing is very important part of BHS which is used to refine the speech content present in the sound signals and to produce the decrypted version of the electrically simulated signals. These signals are transmitted in

the form of radio frequency signals to the receiving stimulator, which converts these signals to electrical stimulation patterns. After implantation the listening and speech development both are the results of speech processing. First the speech is acquired from outside world with the help of sound receiver then after processing, it is used to stimulate the electrodes inserted through surgical operation around the cochlea of the patient. Finally these stimulated electrodes cause to evoke the brain of the patient towards these signals and the patient starts listening and repeating the words, after proper supervision this process causes the speech development in the patient.

After implantation and first mapping the speech therapy process is started. Speech therapy is the most important part of Blue Hearing System. Basically this part is concerned with the patients with prelingual deafness. In this therapy session the patient is asked to create appropriate response towards various sounds and speakers. These responses measure the improvement in the listening of the implantee. Simultaneously the implantee is encouraged to produce various sounds as the outcome of listened sounds for speech development. Hence as soon as the patient starts to perceive sound it starts to speak. The speech therapy sessions are conducted in a proper mode. What to teach, how to teach, when to teach and where to teach, these all things are decided by the therapist in a very supervised manner.

## II. SOUND DETECTION AND LANGUAGE DEVELOPMENT

### A. Sound Detection Process (SDP):

This process is very much similar as the process when a child feels first the sound perception because after surgery and first mapping the patient first time produce response for the sound produced.

### B. Sound Pattern Recognition Process (SPRP):

In this step the patient is asked to produce different response towards soft and loud sounds, that is the patient is expected to have a sense that the detected sound is soft or loud.

### C. Sound Discrimination Process (SDP):

In this step the patient is expected to produce the different responses towards the sounds from different speakers of different domains. The speakers may be from different categories as male female, child adult, animal bird etc. category.

### D. Sound Identification Process (SIP):

This step takes place after few weeks of speech therapy sessions as at this stage the patient starts to identify the meaning of sound and he/she becomes able to correlate the sound with objects also.

### E. Comprehension:

In this step the patient start logical thinking and starts to follow small instructions. The time taken by the patient to follow the instruction may vary from patient to patient. Here we have proposed following terms and formulae to measure

the language skills developed in the implantee to detect and discriminate various sounds.

## III. PERFORMANCE MEASURING COMPONENTS

Here we have proposed some important parameters to judge the performance of BHS user under various speech therapy sessions.

- *Sound Detection Sensitivity (SDS):*

$$SDS = \frac{\text{Number of Times when sound was detected by the patient}}{\text{Total Number of Times when sound was produced}}$$

- *Sound Pattern Detection Sensitivity (SPDS):*

$$SPDS = \frac{\text{Number of Times when sound Pattern was recognized by the patient}}{\text{Total Number of Times when different sound patterns were produced}}$$

- *Sound Source Discrimination Sensitivity (SSDS):*

$$SSDS = \frac{\text{Number of Times when sound Source was recognized by the patient correct}}{\text{Total Number of Times when sound was produced by different sources}}$$

- *Speaker Identification Sensitivity (SIS):*

$$SIS = \frac{\text{Number of Times when speaker were recognized by the patient}}{\text{Total Number of Times when the sound was produced by different speakers}}$$

- *Object Identification Sensitivity (OIS):*

$$OIS = \frac{\text{Number of Times when the correct object was identified by the patient}}{\text{Total Number of objects asked to identify to the patterns were produced}}$$

- *Overall Performance(OP):*

The overall performance (OP) may be measured as follows

$$OP = \frac{SDS + SPDS + SSDS + SIS + OIS}{5}$$

The value of all these performance measures always varies between 0 and 1, and the performance of any patient may be measured efficiently.

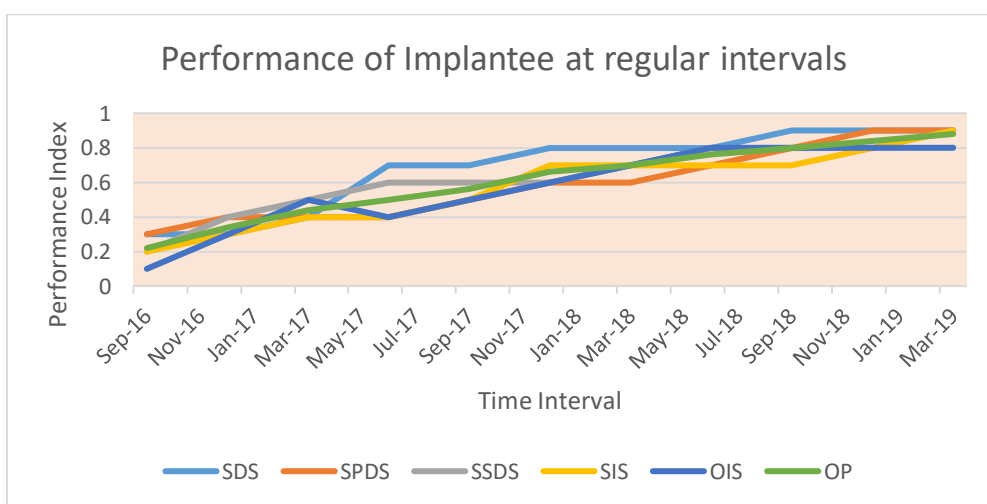
## IV. RESULT AND DISCUSSION

The data developed by the responses of the cochlear implantee at various time intervals has been shown in Table 1. The queries were made at eleven different intervals, out of these eleven intervals the responses against the queries have been observed and overall performance of the implantee have been measured as the mean of all the five parameters. The intervals vary in terms of frequency map and voltages map of the implantee in minute way. From the Figure 1, it is clear that the performance of the implantee is improving significantly at each time interval. This performance has been validated by

statistical measures as shown in Table 2. From Table 2 it can be concluded that the improvement in the performance of BHS user is very significant.

**Table 1: Response Observation Table**

Attributes	Sep-16	Dec-16	Mar-17	Jun-17	Sep-17	Dec-17	Mar-18	Jun-18	Sep-18	Dec-18	Mar-19
SDS	0.30	0.30	0.40	0.70	0.70	0.80	0.80	0.80	0.90	0.90	0.90
SPDS	0.30	0.40	0.40	0.40	0.50	0.60	0.60	0.70	0.80	0.90	0.90
SSDS	0.20	0.40	0.50	0.60	0.60	0.60	0.70	0.80	0.80	0.80	0.90
SIS	0.20	0.30	0.40	0.40	0.50	0.70	0.70	0.70	0.70	0.80	0.90
OIS	0.10	0.30	0.50	0.40	0.50	0.60	0.70	0.80	0.80	0.80	0.80
OP	0.22	0.34	0.44	0.50	0.56	0.66	0.70	0.76	0.80	0.84	0.88



**Figure1: Performance of the Implantee**

**Table 2: Statistical Descriptive for Various Parameters**

Parameters	SDS	SPDS	SSDS	SIS	OIS
Mean	0.6818	.5909	.6273	.5727.	.5727.
95% Conf Interval for Mean	.5234	.4485	.4893	.4222	.4222
95% Conf Interval for Mean	.8403	.7333	.7653	.7232	.7232
5% Trimmed Mean	.6909	.5899	.6359	.5753	.5753
Median	.8000	.6000	.6000	.7000	.7000
Variance	.056	.045	.042	.050	.050
Std. Deviatio	.2358	.2119	.2053	.2240	.2240
Minimum	.30	.30	.20	.20	.20
Maximum	.90	.90	.90	.90	.90
Range	.60	.60	.70	.70	.70
Interquartile Range	.50	.40	.30	.30	.30
Skewness	-.909	.299	-.786	-.301	-.301
Kurtosis	-.838	-1.301	.418	-1.121	-1.121

## V. CONCLUSIONS

With the help of the proposed performance measures SDS,SPDS,SSDS,SIS, and OIS, the Overall Performance (OP) can be determined very efficiently. The overall performance is the average of all observed measures SDS,SPDS,SSDS,SIS and OIS. There is a significant improvement in the performance of the implantee after every interval. It may be concluded that as soon as the therapy sessions increase the vocabulary of the implantee is also increased which causes the significant improvement in the overall performance of the implantee.

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