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Study of Audible Frequency Levels in Mapping Phase of Blue Hearing System using MATLAB GUI

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Abstract- The present study provides the study of audible frequency levels for blue hearing system for any patient during mapping session. Blue Hearing System[1] is an alternative system to provide the listening sense for deaf and mute patients. Here the neural response telemetry data has been compared with the comfort level data for the user for all the electrodes present in the inner instrument of BHS. The study significantly concludes that inner most and outer most electrodes have less difference between threshold and comfort level in comparison to middle electrodes of the spiral in the instrument. The analytical part and the graphical user interface has been designed and implemented using MATLAB.

Keywords: Blue Hearing System (BHS), Neural Response Telemetry(NRT), Mapping

I. INTRODUCTION

Hearing is very important sense of perception for human. Loss of hearing sense is very unfortunate for a human it may be due to accidental cause or by birth due to some complications in mother's medical history at the time of patient's birth. Blue Hearing System is the substitute system for the deaf and mute people to provide hearing sense and to develop speech in consequence by adopting a proper speech therapy treatment. This system uses the electromagnetic device cochlear implant (CI) including the learning phase. This often provides recipients with the ability to understand speech solely by listening through the implant. The implant is surgically placed under the skin behind the ear.The basic parts of the BHS include: External Parts, which contains a microphone, a speech processor and a transmitter, Internal Parts, which contains a receiver and stimulator and an array of up to 22 electrodes wound through the cochlea to send the impulses to the nerves and then directly to the brain through the auditory nerve system and at last but most important part is the learning phase, which includes the post implantation therapy.In all real life problems principally in medical cases, the accuracy of results is very important. The mechanism should be capable enough to provide the best solution to the patients.

This paper is divided into five sections: Section I contains introduction of Audible Frequency Levels in Mapping Phase of Blue Hearing System and MATLAB Graphical User Interface, Section II contains related work of Blue Hearing System and mapping of Cochlear Implant, Section III explains the mapping mechanism, Section IV describes results and discussion of Neural Response Telemetry and Comfort Level Frequency for 22 electrodes, and Section V concludes the present work with future directions.

II. RELATED WORK

P. Saxena (2010)[1] developed the model-Blue Hearing System (BHS), which uses the cochlear implantation followed by learning process of the Implantee. Elizabeth Rosenzweig (2011)[2] posted an article regarding mapping of a cochlear implant. Pradeep VR (2017)[3]compared the Neural Response Telemetry with behavioral mapping for cochlear implant. Greenwood et al, (1990)[4] told about Greenwood function to calculate channel frequency bands for cochlea.Hussnain Ali etal.(2015)[5] studied image guided customization of frequency place mapping in cochlear implant. R.Mittal,(2014)[6]studied the mapping of pediatricsImplantee.O. Stakhovskaya et al.,(2007)[7]studied the implications of cochlear implant in terms of the frequency map for spiral ganglion of human. It also sometimes depends on human ear anatomy also, because if cochlea is not developed in the human then implantation is not possible in the deaf and mute patient. In the present study the Neural Response telemetry has been compared with comfort level of the user and has been analyzed in a different way to produce a meaningful conclusion, also a graphical user has been designed and implemented to analyze these frequency levels in a single interface.

III. MAPPING MECHANISM

Basically in the inner part of CI there are number of electrodes in the shape of a spiral, which are fitted around the cochlea during the implant. These electrodes are stimulated by electric current to evoke auditory nerve system. The amount of the electric current necessary to trigger an auditory sensation is different for each individual and for each stimulation channel [1,2].The frequent MAP updation in the mapping parameters is required because as soon as the time passes after the implantation of the patient the reprogramming of the instrument becomes necessary.

The mapping process involves the resetting of electrical stimulation limits of the electrodes in the inner instrument.to grasp different sounds in a proper way. The BHS is having limited electrical range and all the real world sounds of different frequencies and amplitudes are to be mapped in this range. The standard stimulation levels are Threshold and Comfort. During the process of mapping these levels .are attuned for each electrode in the instrument. Threshold levels provide the access to soft speech and environment sound .to the user while Comfort levels refers to the amount of electrical current that the user requires to perceive the sound comfortably. The optimum values for the current session are stored in the speech processor[1,2].During the mapping process the Cochlear implant processor is connected to the computer of the audiologist, then T- Levels and C-Levels are set. T-Levels or Thresholds are the softest sounds that the CI user can detect. C-Levels (also sometimes called M-Levels), are Comfortable loudness levels that are tolerable for the CI user.

The simulation rate and programming strategy may also be adjusted. Neural Response Telemetry (NRT) measures the nerves responses to the beeps stimulating the CI from the Computer. NRT is not solely responsible for perfect mapping. Behavioral Observation Audiometry, Visual Reinforcement Audiometry, Conditioned Play Audiometry or Conventional Audiometry (which depends on the patient's age and development levels) are also very important to measure the patient's response in perfect manner[3].The range of mapping parameters varies from patient to patient as it also depends on the dimensions of implantation.

IV. RESULTS AND DISCUSSION

Table 1:Neural Response Telemetry and Comfort Level Frequency

Electrode No.	Lower Cutoff Frequency in Hz.	Higher Cutoff Frequency in Hz.	Bandwidth in Hz	Centre Frequency using NRT in Hz.	Patient comfort Frequency Level in Hz	Difference
1	188	313	125	250	583	333
2	313	438	125	375	668	293
3	438	563	125	500	812	312
4	563	688	125	625	938	313
5	688	813	125	750	1160	410
6	813	938	125	675	1327	652
7	938	1063	125	1000	1531	531
8	1063	1188	125	1125	1888	594
9	1188	1313	125	1250	2267	1017
10	1313	1563	250	1438	2594	1156
11	1563	1813	250	1688	2955	1267
12	1813	2063	250	1938	3423	1485
13	2063	1313	250	2188	3729	1541
14	1313	2688	375	2500	4058	1558
15	268	3063	375	2875	4410	1535
16	3063	3563	500	3313	4787	1474
17	3563	4063	500	3813	5192	1379
18	4063	4688	625	4375	5627	1252
19	4688	5313	625	5000	6093	1093
20	5313	6063	750	5688	6592	904
21	6063	6938	875	6500	7128	628
22	6938	7938	1000	7438	7703	265

Table1 represents the data collected for all the 22 electrodes, the values of lower and higher cutoff frequency can be obtained easily by neural response telemetry for a particular patient using Greenwood function for channel frequency bands for cochlea[4]. This is the default frequency allocation for the analysis of bands in Advance Combination

Encoder(ACE)[5,6] table. The lower cutoff frequency set, higher cutoff frequency set, center frequency set and bandwidths are calculated easily for each electrode, then the comfort level frequencies are estimated after applying proper mapping mechanism. Then the differences are calculated between the Threshold and comfort level frequencies[7].

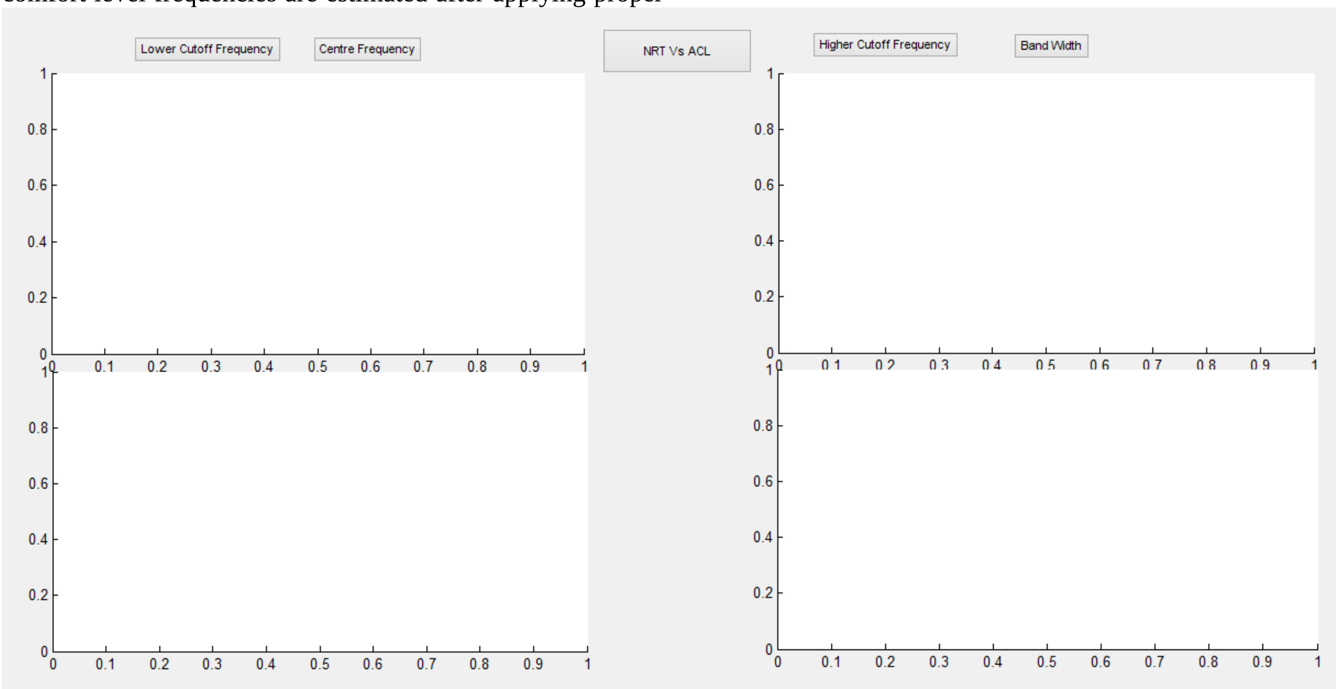

Figure1: Graphical User Interface for the study of Mapping Parameters

Figure 1 represents the Graphical User Interface to analyze the mapping process. Four different buttons lower cutoff frequency, center frequency, higher cutoff frequency and bandwidth produce the graphs represented in the Figure 2, Figure 3, Figure 4 and Figure 5 respectively when are triggered. The Button NRT and ACL produces the graphs represented in the Figure 6 and Figure 7 which represent the comfort level mapping parameters and the difference between center frequencies and comfort level frequencies. In Figure 2, the lower cutoff frequency for any electrode tells the least permissible frequency that can be passed through the filter system of the electrode. The frequencies less than this frequency cannot pass the filter combination of that electrode. In Figure 3, the center frequency for any electrode tells about the central tendency about the permissible frequency. In Figure 4, the higher cutoff frequency for any electrode tells the highest permissible frequency that can be passed through the filter system of the electrode. The frequencies higher than this frequency cannot pass the filter combination of that electrode. Figure 5 represents the bandwidth frequency for each electrode in the spiral, which defines the permissible range of frequencies that can be passed within this range. Figure 6 represents actual comfort frequency for each electrode, which is estimated after behavioral observation audiometry, visual reinforcement audiometry and conventional audiometry. The difference graph in Figure 7 shows that the difference increases gradually for the electrodes having lower center frequency and it decreases for the electrodes having higher center frequency. The difference is maximum for the central electrode having middle level frequencies and less for starting and ending electrodes. This significantly produces the result that for the starting and ending electrodes the threshold levels and comfort levels are closer rather than for the electrodes situated in the middle for which there is a big difference between threshold and comfort level.

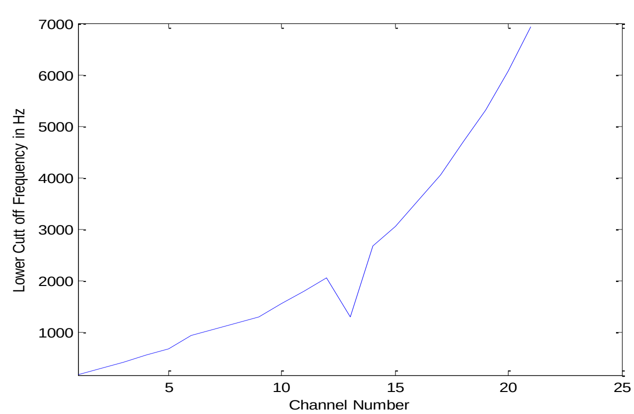

Figure 2: Lower Cutoff Frequency for all electrodes

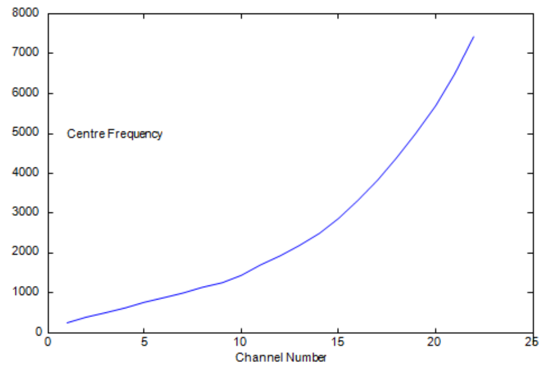

Figure 3: Centre Frequency for all Electrodes

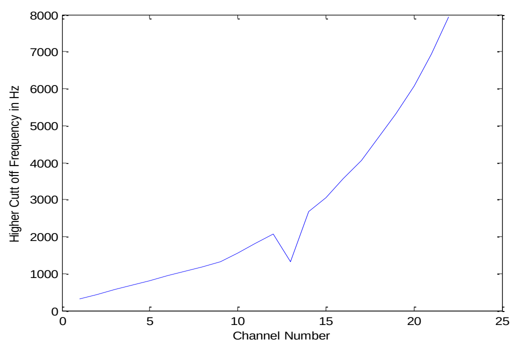

Figure 4: Higher Cutoff Frequency for all electrodes

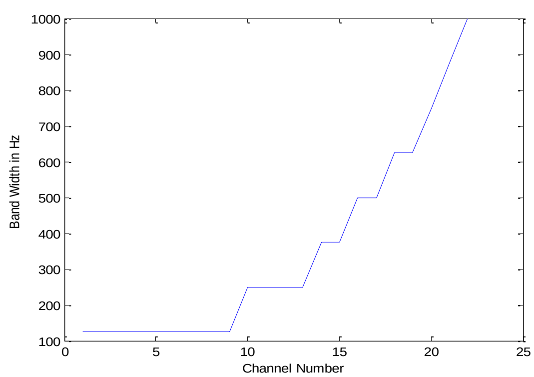

Figure 5: Bandwidth Frequency for all electrodes

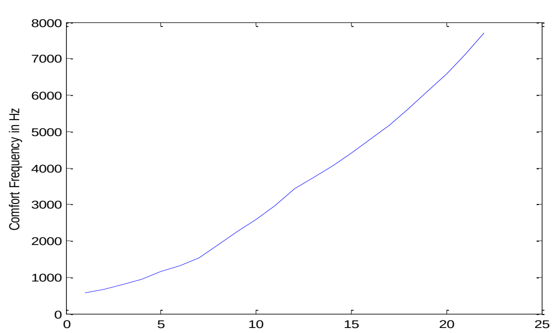

Figure6:Actual Comfort Level Frequency for the user for all electrodes

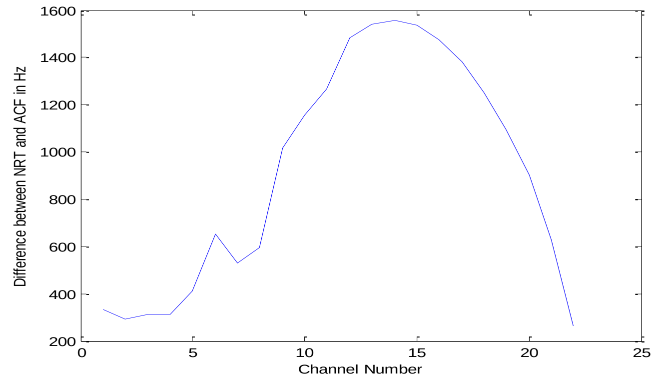

Figure7:Difference between NRT Frequency and ACL Frequency for all electrodes

V. CONCLUSION AND FUTURE SCOPE

The present study produces very significant results for Blue Hearing System and concludes that the middle electrodes are more sensitive in comparison to starting and ending electrodes in blue hearing system, hence more attention should be paid on the middle electrodes while mapping in comparison to starting and ending electrodes. In other words it can be concluded that very low or very high frequency electrodes in the inner part of the threshold level and comfort level vary slightly in comparison to middle electrodes. This is very valuable information for any mapping audiologist or mapping programmer. In future various optimization techniques may be applied to find out comfort level of frequency for each electrode.

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