# EVALUATION OF HEARING AID BENEFIT USING MMN

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A Master's Dissertation Submitted in Part Fulfillment of
The Degree of **M.Sc. (Audiology)**
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ALL INDIA INSTITUTE OF SPEECH AND HEARING,
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MAY - 2005

DEDICATED TO ........

**THE LORD ALMIGHTY,**

**My dear parents**
**[My first teachers],**

**&**

*My teachers [My second parents]*

# CERTIFICATE

This is to certify that this dissertation entitled **Evaluation of hearing aid benefit using** MMN" is a bonafide work in part of fulfillment for the degree of **Master of Science (Audiology)** of the student **(Register No. A0390006).** This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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Mysore
May, 2005

# CERTIFICATE

This is to certify that this dissertation entitled **"Evaluation of hearing aid benefit using MMN"** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier in any other university for the award of any diploma or degree.

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# DECLARATION

This is to certify that this dissertation entitled **"Evaluation hearing aid benefit using MMN"** is the result of my own study under the guidance of Dr.C.S.Vanaja, Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in any other university for the award of any diploma or degree.

Mysore,
May, 2005

Register No. A0390006

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*(James 1: 17)*

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**TABLE OF CONTENTS**

## LISTS OF TABLES

# INTRODUCTION

A variety of procedures are used for evaluation of amplification benefit. These procedures are either subjective or objective. Most routinely used evaluation procedures are subjective procedures, which includes comparison of aided and unaided thresholds as well as aided and unaided speech identification scores. A number of speech perception tests are available for evaluation of amplification benefit. These tests vary in terms of speech perception they tap, ranging from tests of supra segmentals to tests for sentence and discourse perception (Tyler 1995). However these tests require voluntary response from the subject and it may not be possible to elicit voluntary responses in some of the difficult-to-test population. For such population there is a need for the objective methods, for evaluation and verification of speech perception measures.

Recording of AEPs (Auditory Evoked potentials) is one of the objective method that can be used for evaluation of speech perception. Auditory Brainstem Responses (ABR), Auditory Middle Latency Responses (AMLR) and Auditory Steady State Response (ASSR) are found to be poorly correlating with the subjective speech perception abilities. Other cortical potentials such as N1P2 complex, P300 and Miss Match Negativity (MMN) have been found to be useful in evaluating speech perception (Kraus and McGee, 1994; Naatanen, 1995).

MMN is elicited by discriminable changes of repetitive sounds and can be elicited by stimulus difference that approximates the behavioral discriminable changes (Naatanen 1995). Since central auditory representations are involved in generation of MMN, it provides a unique window to view the neurophysiological process underlying hearing mechanism. (Ritter, Deacon, Gomes, Javitt and Vaughan 1995). MMN can provide an objective measure of individual discrimination abilities for different sound features (Picton.1995). Using MMN, auditory function can be studied even in individuals who are unable or not willing to co-operate.

Investigators have reported that MMN is not affected by pure tone thresholds when degree of hearing loss is less than 60dB HL (Sivaprasad 2000, Schroger et.al. 1994). Therefore, it can be used to check the speech discrimination in individuals with sensorineural hearing loss. Further studies have been carried to check if it can be used to evaluate the amplification benefit in individuals with sensorineural hearing loss. Kraus and McGee (1994) have demonstrated that MMN can be used to evaluate the hearing aid benefit. Gronen, Snik and Borek (1996), recorded good MMN similar to the normal group in cochlear implant children who had good speech perception abilities and poor MMN were recorded in another group who did not perform well in behavioral speech perception measures. Similar results were reported by Kraus (1993). However other investigators have reported contraversial results. Korczak, Kurtzberg and Stapells (2005), reported that discrimination through MMN and behavioral perception in hearing aid users did not correlate, and similar results were observed by Wable, Abbeele, Gallego, and Franchet (2000), for cochlear implant users.

**Need For The Study:**

There is a need for objective evaluation of hearing aid benefit in difficult-to-test population, especially in prelingually hearing impaired children. With advancement in technology it is possible to identify the hearing impairment early in the infancy. This alerts the audiologist to have reliable tools/techniques to provide appropriate rehabilitative measures to the hearing impaired infants/children. The audiologist should be able to evaluate infants/children with different hearing aids and asses the benefit they can get with the hearing aid, as those can not benefit with the hearing aid are referred for cochlear implant. The objective tests that are currently available for hearing aid evaluation are ABR and ASSR, but both have their own limitations. Also both of these tests are helpful in assessing thresholds, but do not reflect speech perception abilities. MMN has been found to be useful as a measure of objective assessment of speech discrimination. Investigations have also indicated that MMN can be recorded in subjects with cochlear pathology. However there is a dearth of literature on usefulness of MMN in evaluating hearing aid benefit. Some investigators have evaluated MMN in hearing aid users (Kraus & McGee 1994), but have not correlated with results of behavioral measures. Hence there is a need to check if MMN can correlate with behavioral measure.

**Aim:**

The aim of the present study was to evaluate the usefulness of MMN as a measure of amplification benefit evaluation in hearing aids users. This was carried out by investigating the relationship of MMN with behavioral speech identification measure, which used the same phonemes as that used for recording MMN.

# REVIEW OF LITERATURES

Attempts to use the objective procedure for hearing aid benefit dates back to 1975. Initially acoustic reflex threshold was used for the purpose of objective evaluation of amplification benefit. This procedure had various limitations and hence was not accepted as a tool for evaluating hearing aid benefit in clinical population. In 1980s ABR gained popularity as a clinical tool for assessment and the investigators started evaluating the usefulness of the ABR for objective evaluation of aided and unaided thresholds. Investigators attempted to use ASSR to fit hearing aid in late 1990's. However these tests do not asses the speech perception. Since there is a need for the objective evaluation of speech perception benefit through hearing aid, attempts are being made to use MMN for evaluating hearing aid benefit. This chapters briefly describes these various objective procedures used for assessment of amplification benefit

**Acoustic reflex thresold**

Tonisson (1975) reported that Acoustic Reflex Threshold (ART) can be used for hearing aid gain prescription as an alternative method to real ear measurements. Twenty normal hearing subjects (14 Males and 6 females), in the age range of 18 to 38 years served as subjects. Intra-aural acoustic reflexes were measured in right ear using a loud speaker, at six 1/3-octave bands (0.5, 1.0, 1.6, 2.0, 3.15, and 4.0 kHz). The difference in aided and unaided ARTs were considered as gain and these gains at different frequencies were compared with the gain prescribed using a 2cc coupler. Results indicated that a lot of individual variability and also variabilities across frequencies. On an average, average gain prescribed using ART was lesser than the gain measured in a 2cc coupler. This study has serious limitations as only normal hearing subjects were used as subjects and it is well known that the results obtained from the normal hearing subjects cannot be generalized to subjects with sensorineural hearing loss. Stelmachowicz and Gorga (1984), described ART as an alternative method for determining functional gain of hearing aids. Five normal hearing and five subjects with mild to moderate hearing loss participated in the study. Initially, sound field behavioral unaided and aided thresholds were found out using warble tones. Subsequently the sound field acoustic reflex thresholds were estimated using test frequencies 500, 1000, 1500, 2000, 3000 and 4000 Hz. Results indicated that for normal hearing subjects, the behavioral measures always under estimate the gain by 20-30 dB. For hearing impaired subjects, the functional gain predicted by behavioral measures and ARTs were in close agreement. They concluded that for individuals with frequency region of normal hearing, the acoustic reflex method might provide a good measure of real ear gain. However, very few hearing impaired individuals with normal hearing regions, require hearing aids. Also this study compared only the threshold measurements.

An attempt was made by Rappaport and Tait (1976) compared the hearing aid gain prescibed by ART method with speech identification scores. They obtained aided speech identification scores for 18 subjects, with sensorineural hearing loss. Monosyllabic word identification lists with a competing message of connected discourse at a signal-to-noise ratio of+10 dB were used as test stimuli. Measurements were made at four hearing aid gain settings for each subject. One of the gain settings was determined by acoustic reflex threshold for filtered noise in the ear contralateral to the aided ear. Two other settings were at +/- 10 dB relative to the acoustic reflex threshold gain settings. Fourth setting way determined with a traditional functional gain approach. Results indicated that the mean speech identification scores were similar to the gain prescribed using all procedure. Kiessling (1980) used input-output function of the hearing aid for gain prescription. The assumption was that, the pathological input-output function should be approximated to normal range by a suitable hearing aid. This was successfully used in 40 non-cooperative subjects. The pathological input-output functions were approximated to normal input-output characteristics with suitable hearing aids at all frequencies (0.5,1, 2 and 4 kHz). The major draw back of this is that, the prescribed gain settings were not validated through other procedures.

The advantage of using acoustic reflex as an objective test is that it requires no voluntary response and there is no demand on concentration or judgments by patients. However a major requirement is that the subjects should not have any middle ear pathology as even a slight conductive pathology may affect acoustic reflexes. (Klockhoff, 1961). Also clinical experience shows that acoustic reflexes are not elicited in all subjects with cochlear pathology.

**Auditory Brainstem Respons**

Some investigators have proposed the use of ABR in hearing aid selection. Cox and Metz (1980), reported that the wave V latency could be used to choose between various frequency responses of hearing aid with 75% to 100% accuracy as compared to traditional method of speech intelligibility. They also reported that shortest wave V latency was associated with best speech intelligibility scores. Kilency, (1982), measured wave V latency shift in 15 cochlear hearing loss subjects and reported that this can be used for the hearing aid prescription. Kiessling (1982) described a different method for hearing aid prescription through auditory brain stem responses. Twenty nine subjects in the age range of 10-19 years participated in the study. Amplitude projection technique which employed normal and pathological intensity-amplitude functions was used. Appropriate hearing aid was selected by approximating the normal intensity- amplitude function. However this method was based on assumption that ABR amplitude is directly related to the loudness of the signal. Davidson, Wall and Goodman, (1990), tested this assumption using ten normal hearing and three hearing impaired listeners. The results indicated that ABR amplitude measure obtained in a single trial did not correlate well with the loudness, but ABR amplitudes averaged over 9 trials do correlate well with the loudness. In the second phase of the study, a comparison was made between hearing aids chosen by ABR amplitude projection procedure and conventional methods. The results indicated that amplitude projection procedure prescribed appropriate gain and compression characteristics for two of three hearing impaired subjects.

Hecox, (1983) also reported that latency-intensity function of ABR can be used for hearing aid fitting latency-intensity function of ABR can be used for hearing aid fitting, using a large population of adults (18-56 years) and infants. He demonstrated that appropriate hearing aid could be judged by "normalization" of slope of latency-intensity function and shift in absolute latency of wave V. Gorga, Worthington, Reiland, Beauchaine and Goldgar (1985), compared puretone audiogram and latency, threshold of ABR in 194 subjects with sensorineural hearing loss of cochlear origin. They found that for click evoked ABR, the slope of wave V, latency- intensity function appeared to be related to configuration of hearing loss rather than loudness. McPherson and Clark (1983), used aided click evoked ABR to predict threshold of Most Comfortable Loudness level (MCL), and Un Comfortable Level (UCL). But as reported earlier the relation between ABR and wave V and loudness remains unclear. Beauchaine, Gorga, Reiland, and Larson, (1986), studied click evoked ABR in hearing aid selection process using fowl normal hearing and 4 hearing impaired subjects. They were tested with hearing aid set and three different frequency response settings. Results suggested that click evoked ABR does not distinguish between different amounts of low-frequency gain, although reasonable estimate of high frequency gain appears to be possible. This is because of the fact that click evoked ABR originates from higher frequency (basal) region of cochlea. But the inherent limitation in using ABR for hearing aid selection is the presence of electromagnetic interferences that may last up to 20ms, after the stimulus onset when tone tips were presented (Kileny 1982). This contaminates the ABR waveforms and results in disruption of frequency specific estimates.

ABR is a good measure for threshold estimation, comparison of aided and unaided ABR gives information about the detection of the signals. Studies have shown a poor or absent correlation between ABR and behavioral speech perception (Brown et al 1995; Firszt, Chamber and Kirceus 2002). As reported by Jacobson, Seitz, Mencher, and Parrot (1981) ABR has some limitations in using it as an aided measure for assessing amplification benefit as electrical energy that radiates from both transducer and hearing aids can contaminate the recording and there are no standards for the electromagnetic leakage from the hearing aids. Also since stimulus used in ABR is shorter than the attack time of hearing aid, the compression characteristics cannot be studied using ABR.

**Auditory steady state response**

Picton et al. (1998) reported that ASSR can be recorded in hearing aid users and hence ASSR can be used for hearing aid evaluation. They also reported that aided thresholds for auditory steady state responses were approximately 13 to 17dB, higher than behavioral thresholds. Vanaja and Manjula (2004) compared the functional gain obtained through ASSR and with the behavioral functional gain. There was a positive correlation between these two different measures, suggesting that ASSR could be used for selecting hearing aid. Gorga, Neely, Hoover, Dieking, Beauchaine and Manning, (2004), reported that ASSR was contaminated with artifacts above 100 dBHL. Hence one should be cautious while evaluating at high intensities and while testing subjects with high gain hearing aid.

**Middle latency response**

There are only very few studies which indicate that MLR reflects speech perception. Firszt, Chamber and Kircues (2002) studied 11 subjects, who were adult implantees of clarion cochlear implant. AMLR was compared with words and sentence recognition tests which evaluated subject's speech perception in quiet and in noise. Results revealed that normalized amplitude and lower thresholds of MLR were associated with good speech perception. Gronen, Snik and Broek (1997) also reported a similar study in which they recorded EMLR for 12 post lingually deaf and 4 congenitally deaf cochlear implant users. Comparison of EMLR with behavioral measures of speech perception indicated that poor performers had more diversity in amplitude of EMLR component peaks and more diffuse MLR peak latency organization across the electrode than better performer. Makhdoum, Groenen, Snik, and Borek (1998) investigated the correlations between amplitude and latencies of evoked potential peaks EABR, EMLR, EALR and/or correlations with long-term speech perception measures obtained from 15 postlingually deaf subjects implanted with nucleus multichannel device. Spondee identification was used, which consisted of 40 items and administered in 4 interval forced choice method. No significant correlation was found between any of the EABR or EMLR peak amplitudes and speech perception test results. There are no studies, which compares the AMLR usefulness in hearing aid users.

**Late latency response and Miss match negativity**

Auditory Late Latency Responses (ALLR) and speech perception are found to be highly associated. Trembley, Kraus, McGee, Ponton and Otis (2001) studied Nl and P2 in 10 normal hearing young adults in response to two synthetic speech variants of |ba| in terms of VOT. The subjects were presented with behavioral and electrophysiological measure for -20 and -10 msec of |ba|, and were trained further for the same. Before training the subjects perceived both VOTs as |ba|. The results of post training suggests that there was an increase in the behavioral discrimination of variations in |ba|, there was an increase in N1-P2 peak-to-peak amplitude; hence they suggested that LLR can reflect the behavioral speech perception abilities. Kraus and McGee (1994) reported that MMN could be used as an objective measure for measuring the discrimination that can be applied for assessment of central auditory processing.

The MMN is a cortical potential that occurs when there is a change in repetitive sequence of auditory stimuli, hence it is a response of discriminability. Studies have reported that the amplitude of MMN increases as the discriminability of standard and deviant stimuli increases (Aaltonen, Tumainen, Laine, & Niemi 1993; Lang, Nyrke, Ek, Raimo, & Nataanen.1990; Tiitinen, May, Reinikainen, & Nataanen 1994). Hence MMN can be used for evaluation of improvement in audibility and discriminability of auditory stimuli provided by hearing aids for difficult to test population with hearing loss. But little is known about the use of MMN in assessment of performance using hearing aids.

Kraus and McGee (1994) reported two case studies whose MMN was abnormal suggesting auditory processing problem. One of the subject had a mild low frequency hearing loss. ABR was consistent with hearing loss and MLR was normal. Aided MMN elicited for |da|-|ga|, pair was normal, whereas the variations within |da| were not discriminate revealing cognitive -integrative difficulties. Another child with moderately severe SNHL was evaluated, aided sound field thresholds were 25 dBHL., whereas aided auditory late latency potentials and MMN was absent for |da|-|ga| pairs. Since there is lack of behavioral speech discrimination measures, the result of these studies should be interpreted with caution.

In a study by Groenen, Snik and Broek. (1996), two experiments were conducted on cochlear implant users. In one of the experiment they compared the subject's speech perception performance with MMN. For speech perception evaluation, Antwerp-Nijmegen test, which includes monosyllable identification, spondee identification, long vowel recognition test, and a short vowel recognition test were used. Based on performance on speech perception test, subjects were grouped in to two groups, good performers and moderate performers. MMN on the other hand was elicited using |ba|-|da| contrast. The results indicated that MMN elicited from good performers were similar to normals, whereas moderate performers did not have a good MMN. Similar results were reported by Kraus et.al. (1993) who elicited MMN in eight successful cochlear implant users by synthesized speech stimulus pair |da|-|ga|. It was observed that responses were remarkably similar to the MMN measured in normal hearing individuals to the same stimuli. In contrast there are a few studies, which says that there is no correlation between MMN and speech perception for example. Wable, Abbeele, Gallego, Frachet (2000), also investigated the relation between speech perception and MMN in six subjects with cochlear implant. Four speech identification tests were used to found that there is no correlation between MMN and speech performance.

On the other hand Korczak, Kurtzberg and Stapells (2005), recorded MMN and P300 for |ba| and |da| pair in 14 adults with SNHL with and without their personal hearing aids and from 20 normal hearing subjects. The hearing loss in the hearing impaired groups ranged from moderate to profound hearing loss. MMN was recorded at two levels, 65dBHL and 80dBHL. Behavioral discrimination was also obtained and d' was calculated. Results revealed that P300 amplitude was highly correlated with behavioral d' than MMN and Nl amplitude, which a poor correlation.

These studies which used MMN for assessing the amplification benefit, have used speech identification measure for comparison. The correlation between these two may also depend on the factors like, status of the subject, working condition of hearing aids and speech stimuli materials. And also in MMN we use specific contrasts, whereas in standard speech identification measure include identification all phonemes in the language. These factors may lead to variability in the correlation values obtained. Hence, the present study is designed to study the relationship between speech identification task and MMN when same phonemes are used for both the task.

# Method

A total of 42 subjects were participated in this study. These subjects were divided into four groups. Number of subjects and subject selection criteria for all the groups were shown in the Table 1

Table. 1

*Subject selection criteria*

| | | | |
|---|---|---|---|
| Group I<br>Normal adults | Group II<br>Hearing impaired adults | Group III<br>Normal children | Group IV<br>Hearing impaired children |
| 18-60 years | 18-60 years | 5-15 years | 5-15 years |
| Hearing thresholds >15dBHL | Hearing thresholds >25 dBHL | Hearing thresholds >15dBHL | Hearing thresholds >25dBHL |
| No middle ear pathology | No middle ear pathology | No middle ear pathology | No middle ear pathology |
| No history of associated neurological disorder | No history of associated neurological disorder | No history of associated neurological disorder | No history of associated neurological disorder |
| Native Kannada speaker | Native kannada speaker | Native Kannada speaker | Native Kannada speaker |

Group I consisted of 10 normal adults (6 males and 4 females), group II consisted of 10 hearing impaired adults (6 males and 4 females), group III consisted of 10 normal children (4 males and 6 females), and group IV consisted of 12 hearing impaired children (4 males and 8 females). The mean age of group I, II, III and IV were 32.3 years, 40 years, 6.1 years and 10.3 years respectively. The mean hearing threshold of group I and III were within 15 dBHL and group II and IV were 53.1 and 93.1 respectively. The subjects participated in group ii and iv were included hearing aid users, who had sensorineural hearing loss and were prescribed the most suitable hearing aid by qualified audiologist.

Instruments: The following instruments were used for the study,

> A calibrated diagnostic audiometer MA53 with sound feild facility was used for pure tone and speech audiometry. A calibrated middle ear analyzer GSI 33 version-2 was used for assessing the middle ear function

> MMN was recorded using IHS (Intelligent Hearing System) SmartEP version 2.39

> Subjects' own hearing aid was used at prescribed settings for all the aided measurements.

**Materials**

Speech identification task: Ten picturised words in Kannada starting with the phoneme |ka| and |ga| were used for speech perception task.

Stimuli for MMN: for MMN stimuli, phonemes |ka| and |ga| were spoken by an adult male and was recorded using Praat software version 7.03. The recorded phonemes were then converted into .stm format using "stimulus converter" software in **IHS**

**Test environment:** All measurements were done in acoustically treated double room situation. The ambient noise level was within the permissible limits according to ANSI (1991, cited in Wilber 1994)

**Procedure:** Pure tone thresholds were obtained at octave intervals between 250 Hz and 8000 Hz for air conduction and between 250 Hz and 4000 Hz for bone conduction stimuli PTA was calculated using 500 Hz, 1000 Hz and 2000 Hz. Immittance evaluation was carried out to rule out the middle ear pathology. The following tests were conducted for subjects who met the criteria.

**Speech identification task**

Aided speech identification were obtained by presenting speech material through loud speaker kept at a distance of 1 meter away from the hearing aid at 0° azimuth. The testing was carried out in two intensities 45 dBHL and 65 dBHL. The subjects own hearing aid was used at prescribed settings. It was ensured that the hearing aid was in good working condition at the time of testing. The subject's task was to point to the appropriate picture. The responses were scored in a two point scale with 0 for incorrect response and 1 for correct response. The total numbers of correct responses were then calculated.

MMN;

MMN was recorded from Cz with nasion as ground and nose tip as reference. The subjects were seated comfortably to avoid muscular artifacts and were asked to watch a silent movie, in order to make sure of the passive listening condition. The skin surface of above mentioned sites were cleaned and disc electrodes were placed. After obtaining permissible impedance the data was acquired using the protocol shown in the Table 2. The stimuli were presented through loud speaker kept at a distance of 1 meter away from the hearing aid of the subject and at 0° azimuth. The stimuli were presented two intensities 45 dBHL and 65 dBHL. The subjects were wearing their own hearing aids at prescribed settings.

The difference waveform was obtained by subtracting the frequent from infrequent waveform. In the difference waveform the MMN was identified using the following criteria.

A negative peak of more than -0.3μv in the region of $N_1P_2$ or $N_2P_2$ region

The MMN was identified by the investigator and two other audiologists who had experience in identification of MMN and they were not aware of the subject's speech identification scores.

Table 2

*Protocol used for MMN recording.*

| | |
|---|---|
| Type of stimulus | Frequent \|ga\|<br>Infrequent \|ka\| |
| Intensity | 45 dBHL and 65 dBHL |
| Duration | 250 msec |
| No. of averages for in frequent stimuli | 100 |
| Repetition rate | 1.1/sec |
| No. of channels | 1 |
| Gain | 50,000 |
| Filter settings | 0.1 Hz to 30 Hz |
| Recording window | 0 to 400 msec |
| Transducer | Loudspeaker |

# RESULTS AND DISCUSSION

The aim of the present study was to evaluate if the MMN can be used to asses hearing aid benefit. The hearing impaired subjects, both adult and children were divided in to two groups as good and poor performers based on the speech identification scores. The subjects with speech identification score of 7 and above were considered as good performers, and subjects with speech identification score of 6 and below were considered as poor performers. In children the number of poor performers were 9 subjects and good performers were 3 in number in both the intensities. In adults the number of good and poor performers were 5 and 4 respectively at 65dBHL and 4 and 6 subjects respectively at 45dBHL.

**MMN in good performers:**

The mean and standard deviation of MMN latency and amplitude of MMN for normal adults and children were calculated for both 45 and 65dBnHL. The results are tabulated in Table 3. For normal adults, the normal range for amplitude and latency are -6 to -2 µv and 229.0 to 249.0 msec at 65 dBnHL and -2.8 to -1.2 µv and 232 to 268.0msec at 45 dBnHL. For normal children, the normal range for amplitude and latency are -8.0 to -1 µvand 153.0 to 279.0msec at 65dBnHL and -1.4 to -5.0µ.v and 185.0 to 231.0msec at 45 dBnHL.

Table.3

*MMN latency and amplitude for adults and children at both the intensities.*

| Normal group | 65dBnHL | | 45dBnHL | |
|---|---|---|---|---|
| | Adults | Children | Adults | children |
| Amplitude of MMN in uv in adults | -4.5 | 2.0 | -2.5 | 0.8 |
| Amplitude of MMN in msec in adults | 239 | 10 | 250.0 | 18 |
| Amplitude of MMN in uv in children | -4.5 | 3.0 | -3.2 | 1.8 |
| Latency of MMN in msec in children | 216 | 63 | 208 | 23 |

Table.4

*Results of MMN in good performers*

| Results of MMN | 65dBnHL | | 45dBnHL | |
|---|---|---|---|---|
| | Adults | Children | Adults | children |
| Normal latency and normal amplitude | - | 2 | 2 | - |
| Normal latency and reduced amplitude | 1 | - | - | - |
| Increased latency and normal amplitude | 1 | 1 | 1 | 2 |
| Increased latency and reduced amplitude | 1 | - | - | 1 |
| Absent MMN | 1 | - | 1 | - |

Table 4 describes the results of MMN in good performers. As shown in the above table, among good performers only one subject had absent MMN at both the intensities. The reason for the absence of MMN in this good performer is not known. It is possible that this subject had a higher level processing problem, becuase of which MMN was absent. The subject probably performed well in the behavioral task, as there were contextual cues in the words. Also a closed set task was used making the task easier for the client. Similar results were reported earlier in the literature by Korczak, kurtzberg and stapells (2005) where d' prime sensitivity for speech stimuli was within normal limits where as the MMN was prolonged, they explained this type of results could be because of cortical processing problem, which may manifest only in difficult listening environment.

A majority of the subjects in this group had MMN at both the intensities, though the latency and amplitude were affected in a few of subjects. The normal latency in the hearing aid users indicates that the hearing aid compensates for the peripheral cochlear pathology and these subjects did not have any auditory processing deficit. The normal amplitude in a majority of the subjects suggests that the number of neurons firing is similar to normal hearing subjects when stimuli are presented at suprathreshold. Florentine, Read, Rabinowitz, Braida, Durlach, and Buus (1993) have also reported that there was no change in amplitude of MMN in subjects with cochlear hearing loss. Though they have observed an increase in latency, it was not statistically significant. Sivaprasad (2000) also studied MMN evoked by tone burst in sixteen cochlear hearing loss subjects and reported that MMN is not affected by pure tone thresholds till 60 dBHL. Similar results were reported by and McPherson (1996) in cochlear hearing loss subjects. Increased latency and reduced amplitude in some subjects also suggest a processing problem, which a closed set identification task in quiet will fail to detect. Further tests to evaluate processing disorders are warranted in these subjects.

**MMN in poor performers:**

As shown in the Table 5, MMN was absent in a majority of subjects at both the intensities in majority of the poor performers. This indicates that these subjects are not benefiting with their hearing aids. Since the subjects were tested only with their own hearing aid in this investigation, it cannot be concluded that they have processing deficit;

it is possible that these subjects could have performed better if a different hearing aid was recommended.

Table.5

MMN in poor performers

| Results of MMN | 65dBnHL | | 45dBnHL | |
|---|---|---|---|---|
| | Adults | Children | Adults | children |
| Normal latency and normal amplitude | - | 5 | - | 1 |
| Normal latency and reduced amplitude | - | - | - | 1 |
| Increased latency and normal amplitude | 1 | - | 2 | 4 |
| Increased latency and reduced amplitude | - | - | - | 1 |
| Absent MMN | 3 | 4 | 3 | 4 |

It was observed that MMN could be recorded in some of the subjects in poor performers and some subjects even had normal latency and amplitude. All these subjects in whom MMN was present were children, this suggest that the hearing aid was providing the children with cues required for speech discrimination of |ka| and |ga| contrast. Training is required to improve the children's speech identification abilities. It is well established that MMN check pre attentive discrimination, the process required for the behavioral discrimination is more than that involved in MMN. Adults participated in this study were post lingual hearing impaired, they would have already developed these abilities, hence they need a compensation for their peripheral hearing loss. These results supports the earlier findings of Korczak, kurtzberg and stapells (2005), where they reported that it is possible for MMN to be present in the absence of behavioral identification, this specific pattern of findings provide evidence that the speech signal has been neurally coded at the level of cortex and the brain is able to discriminate the acoustic changes present in the signal. However, further auditory training is might be necessary for brain to consciously make the identification.

Thus the results of the present study suggest that MMN can be reliably recorded in hearing aid users including children. It also can be used to evaluate the hearing aid benefit. MMN also helps to predict the prognosis of clients through auditory training. This is especially important in prelingual children where a hearing aid evaluation will not be based on behavioral speech perception.

# SUMMARY AND CONCLUSION

A variety of subjective and objective procedures are used for evaluation of amplification benefit. One of the objective procedures that can be used for evaluation of amplification benefit is MMN. MMN is an electrophysiological response to stimulus change. Presence of MMN reflects the cortical neural coding of discrimination. MMN has been used in evaluation of cochlear implant benefit. But there is a dearth of studies investigating the useful ness of MMN in hearing aid users for amplification benefit evaluation. A few studies on hearing aid users have not revealed any conclusive results. Hence there is a need to establish MMN a measure of amplification benefit and also to find out the relation between MMN discrimination and behavioral identification.

This study consisted of four groups of subjects. Group I consisted of 10 normal adults, group II consisted of 10 hearing impaired adults, group III consisted of 10 normal hearing children and group IV consisted of 12 hearing impaired children. MMN was recorded for in sound field from Cz using |ka| and |ga| stimuli pair. Behavioral speech identification was carried out in sound field using 10 words which had phonemes used for recording of MMN, in initial position. Both the measures were carried out at two intensities 45 dBHL and 65 dBHL. During sound field measurements both the hearing impaired group used their personal hearing aids in prescribed settings.

MMN was analysed for peak latency and amplitude and speech identification performance was scored on a two point scale. Based on speech identification scores, hearing impaired subjects were grouped into good and poor performers. A speech identification score of 7 and above was considered as good performers and below 7 was considered as poor performers. The MMN latency and amplitude of both the good and poor performers were compared with that of normal subjects.

The results of the present study revealed a good correlation between MMN amplitude and speech identification performance. Also a majority of subjects in poor performer group had absent MMN, when MMN was present it was not different from the good performers. This again shows a good relationship between MMN and behavioral measure. Only one subject in the good performer group had absent MMN irrespective of good speech identification scores, this probably indicates a processing deficit at a higher level. Some of the subjects in the poor performer group also had good MMN, which indicates that discrimination is coded in cortical neurons at preattentive levels, but probably because of inadequate training and/or attentional process it is not reflected in the behavioral identification.

Hence from the above results it can be concluded that MMN can be recorded in hearing aid users including children. The presence and absence of MMN provide an index of cortical discrimination abilities. Hence aided MMN can be used to evaluate the hearing aid benefit as well as a measure of prognosis of auditory training program

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