MMN FOR DURATION DEVIANCE: A STUDY ON NORMAL CHILDREN, ADULTS AND CHILDREN WITH LEARNING DISORDER

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May - 2002

CERTIFICATE

This is to certify that this Dissertation entitled **"MMN for duration deviance: A study on normal children, adults and children with Learning Disorder"** is the bonafide work done in part fulfillment for the Final Year Master of Science (Speech and Hearing) of the student wilh Register No. M2K23.

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CERTIFICATE

This is to certify that this Dissertation entitled **"MMN for duration deviance: A study on normal children, adults and children with Learning Disorder"** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

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DECLARATION

This Dissertation entitled **"MMN for duration deviance:A study on normal children, adults and children with Learning Disorder"** is the result of my own study under the guidance of Dr. C.S.Vanaja, Lecturer, 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, 2002 Register No. M2K23

Dedicated to

My Parents

&

Brother

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CHAPTER I

INTRODUCTION

Mismatch negativity (MMN) is an auditory evoked potential that is generated by brain's automatic response to change in auditory stimulation (Naataen and Escera, 2000). MMN can be elicited by any discriminable change of a repetitive sound differing in terms of either frequency, intensity, duration or even complex phonemic changes. Currently MMN is being used as a powerful tool to evaluate automatic processing of such features in the central nervous system. As MMN is elicited without attention, it is free from attentional variations that contaminate behavioral measures and attention-dependent physiological measures of auditory function. Hence, auditory function can be studied even in individuals who are unable or unwilling to co-operate for behavioral testing. MMN provides an unique objective measure to view the central auditory processes underlying auditory perception in both normal and disordered population.

In literature, there are many studies demonstrating that children with learning disorder (LD) may have auditory and/or visual processing problems (Larsen, Rogers and Sowell, 1976; Kraus and McGee, 1994). Poor auditory discrimination has been described as one of the deficits present in central auditory processing disorders (ASHA Task Force, 1996, cited in Jerger, 1998). As research has indicated that MMN is an objective correlate of auditory discrimination (Kraus, Mc Gee, Carrel and Sharma, 1995), MMN can be used to assess this ability in children with central auditory processing disorders.

Research on MMN has indicated reduced amplitude (Korpihahti and Lang, 1994; Leppanen and Lyytinen, 1997; Radhika, 1998), reduction of the area of MMN (Kraus et al, 1996) and reduced duration (Kraus et al, 1996; Radhika, 1997) in children with learning disorder. All these studies have been carried out using frequency deviance, intensity deviance or using speech stimuli. There is a dearth for studies investigating MMN using durational deviance in both normal and disordered population.

Studying MMN for duration deviance, Korpihahti and Lang (1994) reported reduction in the amplitude when the deviance was 450 msec (50 msec and 500 msec) but not with 60 msec deviance (50 msec and 110 msec). Further they also reported that the latency for duration MMN was dependent on characteristics of the stimuli Latency of MMN was normal when stimuli of 50 msec and 500 msec duration was used where as shorter latency was observed for the stimuli of 50 msec and 110 msec duration. Further research in this area would probably probe into the neurological process underlying automatic duration processing.

Hence the aims of the following study were:

1. To investigate the minimum duration deviance needed to elicit MMN in normal hearing adults.

2. To compare the latency, amplitude and duration of MMN for 10, 5 and 3 msec duration deviance in normal hearing adults and children.

3. To compare the latency, amplitude and duration of MMN for 10, 5 and 3 msec duration deviance in normal hearing children and in children with learning disorder.

Need for the study

Adequate processing of temporal information such as duration has been found to play an important role in auditory perception. Processing of duration would also include the ability to adequately discriminate duration aspects of an auditory stimuli. Duration MMN can be used to objectively study an individual's ability to discriminate very brief changes in duration. The minimum deviance, which would elicit MMN is the electrophysiological threshold for discrimination. It has also been reported in literature that this electrophysiological threshold for intensity and frequency discrimination is equivalent to behavioral discrimination or less than the behavioral threshold (Sams, Paavilainen, Alho, Naatanen, 1985; Iyengar, 2000). However information regarding discrimination of duration is not available. Research regarding minimum duration deviance needed to elicit MMN will through light on physiology of duration processing. Hence, in this study an attempt has been made to investigate the duration discrimination threshold using MMN in normal hearing adult subjects.

In children with central auditory processing disorder, deficits in duration processing are largely reported using behavioral measures (ASHA Task Force, 1996, Cited in Jerger, 1998). But there is a need for studies that address the question of nature of duration processing in central auditory processing disordered population. Hence if information regarding MMN for duration deviance is made available in both normal and disordered population, it would enable us to objectively evaluate if the child with learning disorder has a deficit in duration processing of auditory signals. Joutsiniemi, Uvonen, Sinkkonen, Huotilainen and Naatanen (1998) have suggested that an abnormal MMN for duration decrement can be associated with deficits in automatic change detection mechanism and/or short term memory. Due to time constraints, it will be difficult to trace the electrophysiological threshold for duration discrimination in children. Hence information is collected in the present study regarding characteristics of MMN for duration deviance of 10, 5 and 3 msec in normal children and those with LD.

CHAPTER 2

REVIEW OF LITERA TURE

Audiologists have been using auditory evoked potentials as an objective test of hearing for over 30 years. These measures are essential in testing patients who cannot respond behaviorally. Many different auditory evoked potentials have been recorded for the purpose of auditory assessment. Even though the major aim of the auditory assessment is to track the auditory thresholds, they are also being used to assess how well the person is processing auditory informatioa Adequate processing requires the discrimination of fine acoustic differences in speech sounds (Kraus et al, 1995). The task of discrimination involves comparing one stimuli to another stimuli and judging whether they are same or different. Hence assessing the discrimination ability objectively gives valuable information regarding the auditory processing ability of the individual. Mismatch negativity (MMN) is an event related potential that can be used for this purpose.

MMN is an electrical brain response, a negative component of the event-related potential, elicited by any discriminable change (deviant) in some repetitive aspect of auditory stimulation (standard), usually peaking at 100-200 msec from change onset (Naatanen and Escera, 2000). It can be elicited by any discriminable change of a repetitive sound differing in terms of either frequency, intensity, duration or even complex phonemic changes. It is a potential evoked in a passive condition, by a deviant stimuli presented within a series of standard stimuli. It hence reflects a process specific to stimulus change. As MMN reflects auditory processing of very fine stimulus differences, it may provide a useful means for assessing neurophysiologic mechanisms involved in the perception of subtle speech contrasts (Kraus, Mc Gee, Carrel and Sharma, 1995).

MMN is a prerequisite for discrimination not requiring the subject to pay attention to the stimuli (Groenen, Snik and Broek, 1996). As the MMN may provide a diagnostic measure not confounded by attention and cognitive factor, it provides a supplement to P300 measurement. The P300 requires an overt response and is highly dependent on subject attention. Hence MMN can provide useful information concerning sound discrimination ability even in difficult to test population like children. Apart form this MMN also provides information regarding the underlying neurophysiologic processes. Results of studies that aimed at localizing MMN generators on the basis of scalp distribution, magnetoencephalographic (MEG), intracranial and brain-lesion data point to a major origin on the superior surface of the temporal lobe in the auditory cortex (Alho, 1995;Csepe, 1995).

Eventhough the classic paradigm for recording MMN involve presenting a regular train of auditory 'standard' stimuli in which occasional 'deviant' stimuli differ from the others in terms of some physical attribute, there are a host of other factors that have been reported to affect MMN. Some of these factors are discussed here.

(1) Age: According to Lang et al (1995) MMN can be without exception elicited in infants, children and adults. The peak latency of MMN has been found to shorten with increasing age, however a complicated interaction seems to exist between age, amplitude and stimulation parameters. Studies have been carried out to investigate the age related changes in MMN for school-age children. Kurtzberg, Vaughan, Kreuzer and Fliegler (1995) recorded MMN is four to ten years old children for stimuli presented with a 750 msec inter stimulus interval. The standard stimulus was l000Hz and the deviant was 1200Hz. They reported that approximately 2/3rd of the subjects showed a clear MMN in the grand mean responses. In the 1/3rd of the children, a clear MMN was not present, despite a robust obligatory response to both the standard and deviant stimuli. Kraus et al (1993) compared the MMN recorded using stimuli which were just-perceptibly different variants of the phoneme /da/ in school aged children and adults. They reported that both the adults and children show a robust MMN despite the

developmental difference in the preceding Pl-Nl waves. Results indicated that children showed a larger MMN, with the difference being apparent in a significantly large peak to offset amplitude and a larger overall area compared to adults. Similar findings have also been reported by (Csepe 1995).

A study conducted by Iyengar (1999) using intensity deviants indicated a clear developmental trend in MMN latency i.e., latency decreased with increase in age. The latency was maximum for the youngest age group i.e., seven to eight year old children and minimum for adults group. Duration of MMN was also found to decrease with age. Even with amplitude it was seen that seven to eight years old children had highest amplitude, where as adult group had the least amplitude. Thus, it can be concluded from these studies that there is a developmental trend and maturation of MMN, eventhough it is to be present at a very early age.

(2) Gender: There have not been many reports on the differences between MMN in males and females. However in a study by Aaltonsen, Erola, Lang, Vusiparkka and Toomainen (1994), it was observed that gender influenced the latency of MMN. A significantly longer latency of MMN was reported in females than in males to complex stimuli.

(3) Type of stimulus deviance: For eliciting MMN, different investigators have made use of different stimuli depending on the need of their study. They include both simple stimuli i.e., the puretones and complex stimuli (speech). The initial studies of MMN were carried out using pure tones, but later studies have used more of speech stimuli because of the hypothesis putforth that if MMN reflects the processing of fine differences in simple stimuli, it could also be elicited by just perceptibly different acoustic contrasts that are important for speech perception (Kraus et al 1993). As the task difficulty may vary depending on the type of deviance, the latency, amplitude and/or magnitude of MMN obtained for different stimuli will not be the same

(4) Magnitude of deviance: Naatanen (1995) has reported that when the physical difference between the standard and the deviant stimuli is small, it is easier for the subject to ignore the test stimuli. But with small difference, MMN amplitude less and latency is long. With increase in the magnitude of deviance, the amplitude increases and latency decreases (Sams, Paavilainen, Alho and Naatanen, 1985; Jose, 1999). However, when the deviance exceeds a certain critical limit i.e., for a highly deviant, obtrusive stimulus, there is passive switch of attention. Lang et al (1995), reported that the safe upper limits for the deviance of duration, intensity and complex stimuli is not known. But for a puretone of 1 kHz as standard, deviance of about 50-100 Hz or more is usually obtrusive.

(5) Rate of stimulus presentation: In 1987 Naatanen et al (cited in Lang et al, 1995) have reported that if simple stimuli are used, MMN amplitude increases when the inter stimulus interval is shortened, provided that the intervals between the deviants are of same duration. A possible explanation of this phenomenon is that when the repetition rate of the standard stimuli increases, the memory trace evoked by it becomes more intense. This in turn strengthens the MMN response generated by the comparison process (Naatanen, 1995). Accordingly, in addition to the selective increase of the MMN, a higher stimulation frequency shortens the recording session, thus contributing to an improved recording quality. Lang et al (1995) recommended, an inter stimulus interval of about 300 msec for MMN applications when using simple or vowel stimuli.

MMN for duration deviance

A review of literature indicates that a majority of the studies using MMN have been carried out using frequency, intensity deviance or speech stimuli. Very few studies have investigated MMN for duration deviance. Joutsiniemi et al (1998) studied amplitude and latency of duration MMN in 40 healthy subjects in the range of nine to eighty four years. Four thousand stimuli were presented at

80 dBSPL binaurally through headphones. The standard stimuli were 75 msec, 700 Hz sinusoidal tones with an inter stimulus interval of 300 msec. Two types of deviant stimuli were presented in the same block randomly (50 msec and 25 msec, 700 Hz pips) both with 6% probability. About 150 to 230 responses were averaged for each deviant stimulus. Analysis period of 350 msec included the 50 msec bases line. The MMN responses were visually detected in the latency range of 100 msec to 250 msec. The results indicated that 25 mesc deviant tone evoked a clear response in thirty nine subjects, while 50 msec deviant tone evoked an observable MMN in only thirty two subjects. Also the MMN peak amplitude for the 25 msec deviants was significantly larger than for the 50 msec deviants. There was no significant difference in the peak latency. With increasing age, the amplitude of MMN for 25 msec deviant tone was found to diminish. Replicability of MMN was also reported to be good for 25 msec deviance.

Korpilahti and Lang (1994) investigated duration MMN in 12 normal children (7-13 years). Standard tone was 50 msec stimuli of 1000 Hz and deviants were of 110 msec or 500 msec tones of 1000 Hz. Each tone had a rise and fall time of 5 msec and were presented at 70 dBSPL with 350 msec ISI. It was observed that the peak amplitude of the duration MMN increased as the physical difference between the standard and the deviant stimuli expanded (50/110 msec versus 50/500 msec). Also they found a significant negative correlation between the MMN peak latency and age.

These studies have used a large deviance to elicit MMN and the results indicate that the larger the deviance, better the MMN. However MMN can also bo elicited by finer differences in standard and deviant stimuli. Also MMN represents the physiological processes that occurs during auditory discrimination near or at behavioral discrimination threshold. Research on MMN for intensity or frequency deviance have shown the presence of MMN when the deviance is close to psychoacoustic difference or even less than difference limen (Sams, Paavilainen, Alho and Naatanen, 1985; Iyengar, 2000).

duration of tones (AT) depended on the overall length of the tones (T). AT was found to be about 0.5 msec for tones of 0.5 msec (T) duration. For tones with a T of 500 msec AT was about 50 msec, where as in the region of interest in speech perception, that is with T of 10 to 100 msec, AT was about 2 to 5 msec.

Irwin and Purdy (1982) investigated the minimum detectable duration of a brief burst of noise using 2AFC (Alternate Forced Choice) method. The subject had to detect either a brief increment or a brief decrement in the noise. They found that the average minimum detectable duration of a burst with a 10 dB SNR was 1.2 msec. Fitzgibbons and Gordon-Slant (1998) investigated temporal order discrimination using an adaptive three interval cued two-alternative forced choice procedure. Testing was conducted in 65 trial blocks with initial tone durations of 250 msec and an initial step size for duration changes of 15 msec. This was reduced to 2 msec after three reversals in the direction of duration changes. A threshold estimate was calculated by averaging duration values of the reversal points of the final ten reversals associated with the small step-size changes in tracking procedure. Results indicated that in young normal hearing adults the mean duration discrimination was about 7.2 msec with several individuals who had discrimination thresholds as small as 2-3 msec.

Clinical applications of MMN:

MMN is an automatic cortical evoked potential that signifies the brains detection of acoustic change, it provides an objective tool for evaluating central auditory perceptual mechanisms involved in speech perception. Discrimination of small acoustic differences is an important aspect of normal speech perception (Karus et al, 1995). There are several features of MMN, which makes it a specially suitable tool for auditory research and clinical practice. Naatanen (1995) summarizes the linical applications of the MMN as follows.

- The MMN is elicited by any discriminable change of a repetitive sound and can be elicited by stimulus differences that approximate the behavioral discrimination threshold. Therefore it provides an objective measure of an individuals discrimination ability for different simple and complex (such as phonemic) sound features.

- As it can be elicited without attention, the MMN is free from attentional variations that contaminate behavioral measures and attention dependent physiological measures of auditory function. In addition, auditory function can be studied even in individuals who are unable or unwilling to cooperate.

- MMN provides a unique window to view the neurophysiological processes underlying normal hearing.

- 'MMN also provides a means for studying auditory short-term memory, which is of crucial importance for correct speech processing and understanding. Consequently, MMN opens a view to the temporal dimension of auditory function which in contrast to vision, is to a great extent, sequential in nature.'

Studies done in the past on clinical population using MMN, have reported a deviance in children with LD. A few studies have reported reduced amplitude (Korpilahti and Lang, 1994; Leppanen and Lyytinen, 1997; Radhika, 1998), reduction in the area of MMN (Kraus et al, 1996) and reduced duration (Kraus et al, 1996; Radhika, 1998). A majority of the studies in this direction have been carried out using either frequency deviance or speech stimuli.

Studies using duration deviances are relatively few. Korpilahti and Lang (1994) reported reduction in the amplitude of MMN using duration deviance of 450 msec (50 msec and 500 msec) but not with 60 msec deviance (50 msec and 110 msec). Further they also reported that latency for duration MMN was

Kraus et al (1993) have reported that MMN can be obtained to speech stimuli that are just perceptibily different. They collected MMN from ten children (7-11 years) and eleven adults for speech stimuli that were variants of the voiced stop consonant /da/. Acoustically, the two stimuli differ in the onset frequency of the second and third formant transitions. The results indicated that a significant MMN was elicited in both children and adults to the stimuli that were just perceptibly different. The peak latency and duration of MMN were similar in adults and children. However measures of MMN magnitude (peak to peak amplitude and area) were significantly larger in children than in adults. Sams, Paavilainen, Alho and Naatanen (1985) studied MMN for frequency deviance in six subjects. Stimulus blocks consisted of standard stimuli of 1000 Hz, 80% of the time and deviant stimuli of 1002, 1004, 1008, 1016 or 1032 Hz, 20% of the time. In each block one deviant type was used. A constant inter stimulus interval of 1 sec was used and the order of stimuli was randomized. Even though MMN was elicited by deviants equivalent to behavioral threshold, a significant MMN was found to be elicited by stimuli that were slightly above the threshold of behavioral discrimination for that frequency. A large MMN was elicited with a peak latency of approximately 170 msec, by those deviants exceeding the discrimination threshold (1016 Hz and 1032 Hz) and the deviants at threshold (1008 Hz) tended to elicit a small MMN. Similarly, Iyengar (2000) investigated MMN for intensity deviance. Results of the study demonstrated a high positive correlation between psycho physical difference limen for intensity (DLI) and physiological DLI. The mean values for psychophysical DLI's were greater that the physiological DLI. That is, physiological discrimination threshold was smaller than psychophysical discrimination.

It can be inferred from these results that MMN can be elicited for duration deviance close to differential limen for duration. Psychophysically, the ability of human listeners to discriminate between tones of different durations has been studied. Abel, 1972 (cited in Ainsworth, 1976) found that the difference in dependent on the characteristics of stimuli. Latency of MMN was normal when stimuli of 50 msec and 500 msec duration was used where as shorter latency was observed for stimuli of 50 msec and 110 msec duration. When data was compared with control subjects, they found that duration of MMN showed significant difference between the two groups, only for stimuli with highly contrasting values i.e., 50 msec versus 500 msec.

There is a lack of studies using smaller deviances in duration for eliciting MMN in both normal and clinical population. Also there is not much data available regarding the minimum deviance in duration that can elicit MMN. Hence the study is planned in this direction.

CHAPTER 3

METHOD

I. Subjects.

The study consisted of three groups of subjects.

Group A: Sixteen subjects (8 males and 8 females) in the age range of 18-22 years were selected for the study. All subjects had normal hearing sensitivity with no history of any otological or audiological problems.

Group B: Sixteen subjects (8 males and 8 females) in the age range of 8-12 years with good academic achievement, normal hearing and no history of otological or audiological problems. All the children also had normal scores on Early Reading Skills.

Group C: Six subjects in the age range in the age range of 8-12 years diagnosed as having learning disorder using Early Reading Skills - Informal Reading Diagnosis (Rae and Potter, 1973) were taken. Norms developed by Loomba (1995) for Indian population were used. The children had normal peripheral hearing and average intelligence. None of the children were exposed to any formal remedial therapy.

//. Instrumentation.

The following instruments were used in the study.

1. A calibrated audiometer.
2. A calibrated immittance meter.
3. Biologic Navigator evoked potential system with EP 317 software (Bio-Logic Inc) to generate stimuli and record MMN.

lll. *Test procedure.*

- Ø ***Hearing screening:*** All the subjects were screened to ensure that they normal hearing with thresholds equal to or less than 15 dBHL at octave frequencies from 250 Hz to 8 kHz. This was followed by immittance screening to rule out any middle ear pathology.

- Ø ***MMN recording:*** Subjects were seated comfortably in an armed chair and were instructed not to pay any attention to the stimuli. Five silver chloride electrodes were placed on the following five sites.

Fpz: Common.

Pz and Cz : Non-inverting.

M_1 and M_2 : Inverting.

The electrode sites were cleaned by rubbing the surface with cotton dipped in rectified spirit and using skin preparing paste. Appropriate amount of gel was used to stick the electrodes in their respective positions. They were secured in their place by a piece of plaster. It was ensured that the impedance at all electrode sites was < 5kOhm and inter electrode impedance was < 2kOhm. Earphones were then placed without dislodging the electrodes. Earphones diaphragm was placed directly over the ear canal so that accurate stimulus intensity levels were delivered to the ears.

The parameters used for recording were as follows:

Stimulus parameters

Type	Tone bursts
Polarity	Alternating
Frequency	1000 Hz
Intensity	60 dBnHL

Rate	3.1/sec
Number	500
Duration	
Standard stimuli	50 msec
Rise/Fall	10 msec
Plateau	30 msec
Deviant stimuli	(1) 60 msec, 55 msec, 53 msec for groups A, B & C (2) For group A deviance was also varied to arrive at the minimum deviance which elicited MMN
Probability of deviant stimuli	20 %

Acquisition parameters

Analysis time	500 msec
Gain	50,000
Filter setting	0.1-30 Hz

Electrode Montage

Channel 1	$Cz\text{-}M_1\&M_2$
Channel 2	$Pz\text{-}M_1\&M_2$
Ground	Fpz

Ø ***Analysis of MMN***

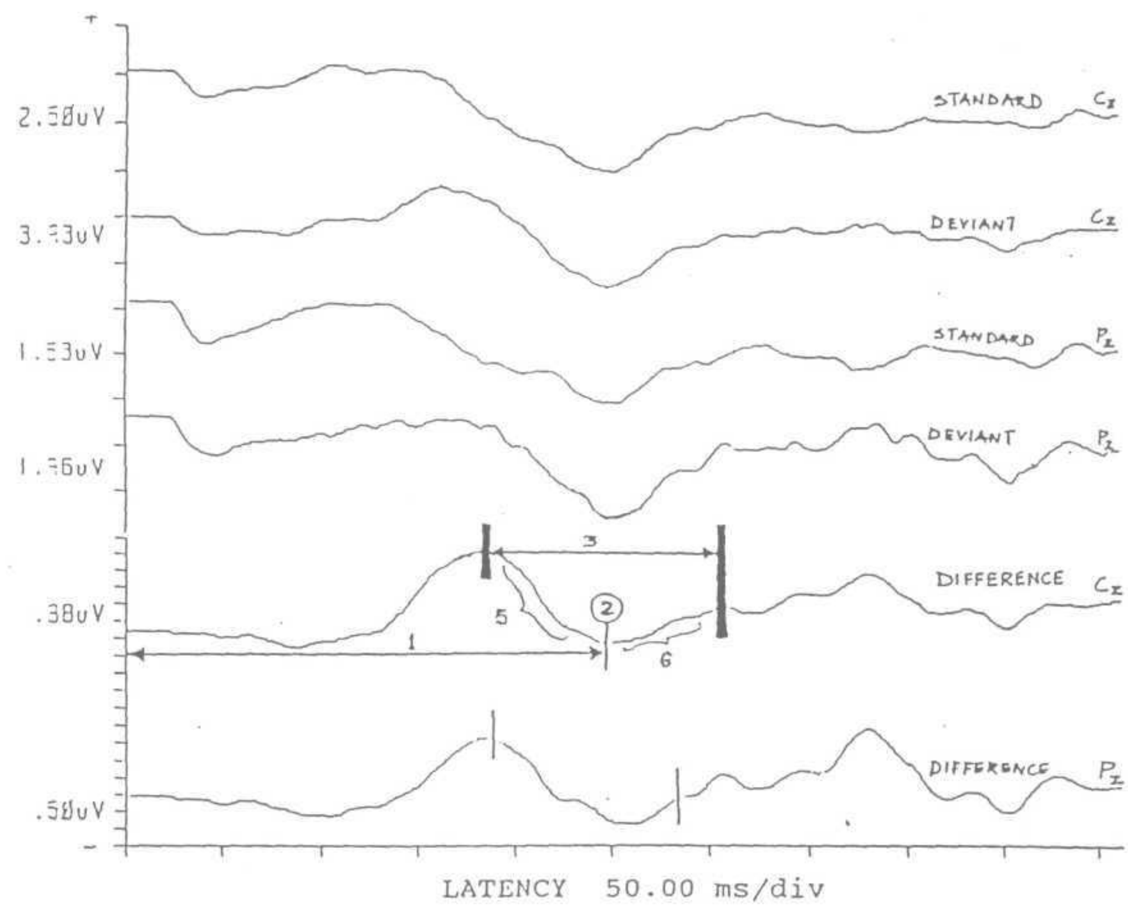
The MMN response was obtained by subtracting the response for the frequent stimulus from the response for the infrequent stimulus, at both Cz and Pz sites. For the identification of the MMN true response through visual detection the following criteria were used:

- Ø MMN is the first negative trough in the subtracted waveform with absolute amplitude less than — 0.3 μV in the latency range of N_1P_2 or P_2N_2 complex of LLR.
- Ø LLR should be present in the unsubtracted frequent and/or infrequent waveform.
- Ø The negative trough should be followed by a positive peak (Absolute amplitude more than + 0.3 μ,V).

MMN response obtained was analyzed for the following parameters:

- Ø Peak latency: The time taken for the peak to occur after the stimulus presentation. (1 in Figure 1)
- Ø Onset latency: Latency measured from the onset of negativity to the maximum negativity. (5 in Figure 1)
- Ø Offset latency: Latency measured from maximum negativity to the offset of negativity. (6 in Figure 1)
- Ø Peak amplitude: The maximum absolute amplitude of the peak of MMN with respect to the zero voltage line. (2 in Figure 1)
- Ø Onset amplitude: Amplitude measured from the onset of negativity to the maximum negativity. (5 in Figure 1)
- Ø Offset amplitude: Amplitude measured from maximum negativity to the offset of negativity. (6 in Figure 1)
- Ø Duration: The time lapse between the onset of the negativity till its offset in the following positive peak.(3 in Figure 1)

Figure 1 : Representative MMN waveforms.



CHAPTER IV

RESUL TS AND DISCUSSION

The aims of the present study were:

1) To investigate the minimum duration deviance needed to elicit MMN in normal hearing adults.

2) To compare the latency, amplitude and duration of MMN for 10,5 and 3 msec duration deviance in normal hearing adults and children.

3) To compare the latency, amplitude nnd duration of MMN for 10,5 and 3 msec duration deviance in normal hearing children and in children with learning disorder.

The MMN response was obtained by subtracting the response for the frequent stimulus from the response for the infrequent stimulus at both Cz and Pz sites. For the identification of the MMN true response through visual detection, the criteria mentioned in the method were used. The lowest duration deviance at which MMN could be identified in adults was taken as the physiological threshold for duration discrimination. The MMN response obtained was analyzed for the following parameters:

a) Latency (Peak, Onset, Offset) (PL, ONL, OFL)

b) Amplitude (Peak, Onset, Offset) (PA, ONA, OFA)

c) Duration (DUR)

I. MINIMUM DURA TION DEVIANCE TO ELICIT MMN IN ADULTS

For tracking the minimum duration deviance needed to elicit MMN, the initial deviance was kept 5 msec, then depending on the presence or absence of MMN, deviance was varied in steps of 1 msec to estimate the threshold of deviance, to elicit MMN. The mean duration deviance, needed to elicit MMN. was found to be 2 msec with a standard deviation of 0.51. The minimum duration varied from 1 msec to 3 msec across subjects. Thus in the present study 2 msec was the physiological difference limen for duration in normal hearing adults. This result is found to correlate with psychophysical data for duration discrimination reported in literature. Abel, 1972 (cited in Ainsworth, 1976) reported that for tones of duration (T) 10 to 100 msec the difference in duration (AT) that can be identified was found to be about 2 to 5 msec. It can be noted here that in this study the duration of tone was 50msec (with onset and offset duration of 10 msec and plateau of 30msec). Irwin and Purdy (1982) found that the average minimum detectable duration of a burst with l0dB SNR was 1.2 msec.

These results indicate that the minimum change in duration, that is detectable using both psychophysical and physiological methods are comparable. The results of this study are similar to those studies using frequency and intensity deviance, which have also found a correlation between psychophysical and physiological difference limen. (Sams, Paavilainen, Alho and Naatanen, 1985; Iyengar, 2000). This reinforces the concept that MMN is a physiologic correlate of discrimination of various acoustic parameters (Kraus, Mc Gee, Carrel and Sharma, 1995). In other words, MMN represents the underlying neurophysiological processes, which are a prerequisite for behavioral discrimination.

Table 1: Mean and standard deviation of MMN parameters at threshold of deviance.

Site		PL (msec)	PA	ONL (msec)	ONA	OFL (msec)	OFA	DUR (msec)
Cz	Mean	155.94	-0.97	21.68	-1.13	24.79	-1.18	46.47
	S.D	37.47	0.46	6.94	0.84	10.77	0.6	13.17
Pz	Mean	155.94	-0.96	21.68	-1.07	24.79	-1.19	48.47
	S.D	37.47	0.44	6.94	0.73	10.77	0.48	13.17

The peak latency, amplitude and duration of MMN at threshold of duration deviance is as shown in Table 1. The peak latency, amplitude and duration at threshold of discrimination using intensity deviance, was reported to be 162.38 (38.79), -2.43 (1.29) and 64.09 (20.79) at 40 dB SL by Iyengar (2000). A comparison of these results reveal that MMN for duration deviance has shorter peak latency and lesser peak amplitude with short duration compared to that for intensity deviance. This could probably be due to either or both of the following two reasons.

1. In the present study MMN was recorded at 60 dBnHL, however Iyengar (2000) used an intensity of 40 dBSL. The relatively lower intensity at which MMN was recorded compared to this study could have resulted in longer latencies.

2. The physiologic mechanism underlying generation and processing of the intensity and duration MMN may be different, resulting in the differences of various parameters of MMN recorded. Alho (1995), reported that even though the major source of MMN is situated in the auditory cortex, the exact location of the generator appears to depend on which feature of a sound is

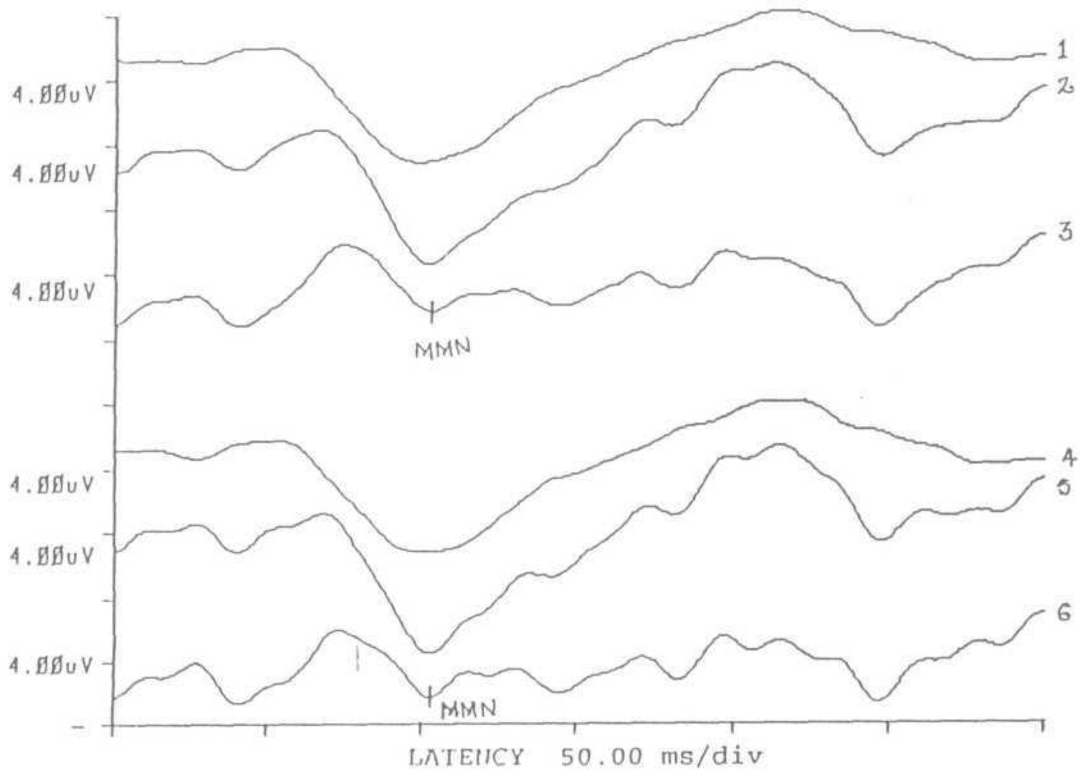
changed (i.e., frequency, intensity or duration) as well as on the complexity of the sound (i.e., simple tone Vs complex sound).

//. MMN IN ADULTS

An attempt was made to study the effect of 10 msec, 5 msec, 3 msec duration deviance on the various MMN parameters. Statistical analysis were performed using two way ANOVA in order to find the effect between / within groups for different duration deviance (stimulus condition) and electrode placement. Duncans Multiple Range Post hoc test was used to identify the locus of significant difference between the means. All statistical comparisons were performed using SPSS for windows (version 10.0) [SPSS Inc. Chicago. II].

Figure 2 shows representative waveform of MMN for duration deviance in adults. In the present study MMN was present for all the subjects for 5 msec and 3 msec deviance. However, there were no MMN in 2 subjects, for a deviance of 10 msec According to Lang et al (1995), a highly deviant, obtrusive stimulus causes a passive switch of attention which may not be suitable for MMN generation. Hence it can speculated that for those two subjects in whom MMN was absent for 10 msec deviance, the deviance was probably large enough to cause a passive switch of attention. However, drawing decisive conclusions regarding this would be difficult without further investigation. MMN was present for 10 msec deviance with peak latency in the range of 91.42 to 183.42 msec. For 5 msec and 3 msec deviances peak latency was in the range of 93.17 to 184.59 msec and 99.03 to 227.37 msec respectively.

Figure 2 : Representative waveforms for 10 msec deviance in adults.



1. Frequent wave recorded from Cz
2. Infrequent wave recorded from Cz
3. Difference wave (Cz)
4. Frequent wave recorded from Pz
5. Infrequent wave recorded from Pz
6. Difference wave (Cz)

A. Latency of MMN

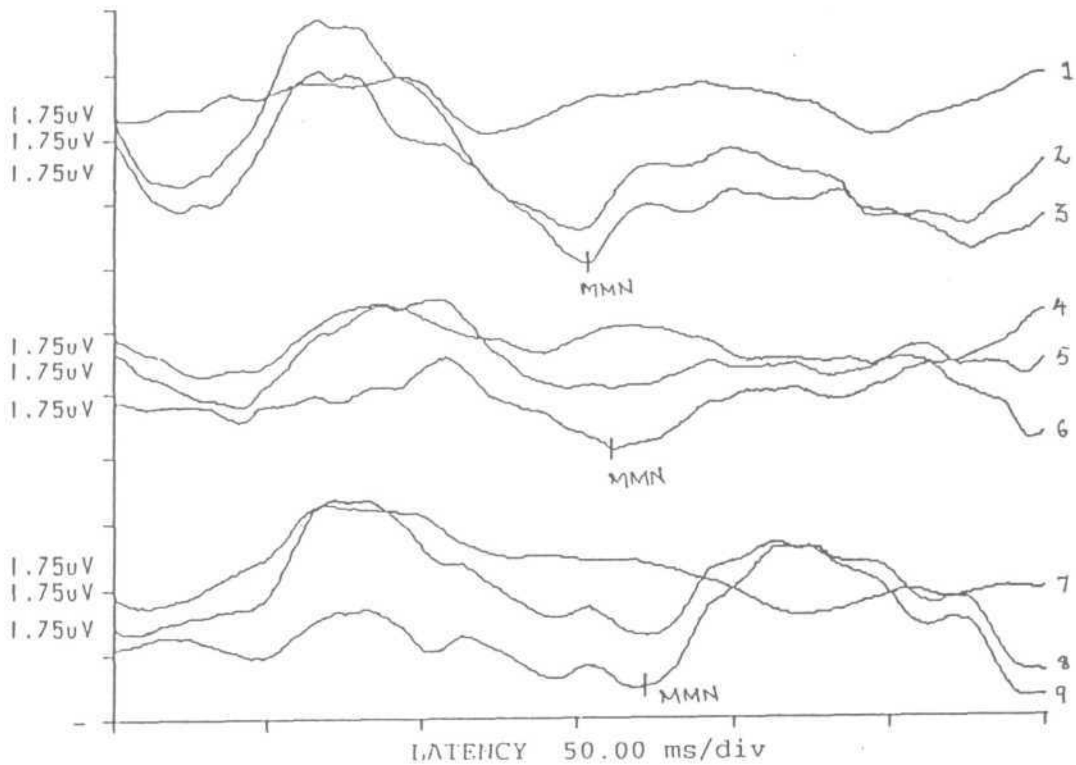
Table 2 summarizes the mean and standard deviance of various latency measures for three stimulus deviance and two electrode placements. Results indicated that there was no statistically significant effect of placement of electrodes (Cz or Pz). However the magnitude of stimulus deviance had a significant effect on peak latency (F: 10.178; P = 0.000) and offset latency (F: 3.657; P=0.031). There was no significant interaction between effect of magnitude deviance and placement of electrodes.

Table 2: MMN latency measures for three stimulus deviance and two electrode placements in adults.

Deviance		Peak Latency (msec)		Onset Latency (msec)		Offset Latency (msec)	
		Cz	Pz	Cz	Pz	Cz	Pz
10msec	Mean	122.34	122.34	27.91	27.91	29.42	29.42
	S.D	26.02	26.02	11.38	11.38	9.04	9.04
5msec	Mean	137.74	137.74	25.45	24.45	26.66	26.18
	S.D	26.99	26.06	7.39	7.39	7.08	7.71
3 msec	Mean	15.78	150.78	24.83	24.83	22.74	22.74
	S.D	30.93	30.93	9.79	9.79	8.22	8.22

Results of post hoc analysis indicated that peak latency significantly differed across all the stimulus deviances. There was a significant increase in the peak latency with decrease in the magnitude of stimulus deviance. This can be observed in figure 3. However the offset latency tended to decrease with decrease in the magnitude of deviance. But the significant difference was only between offset latency of 10 msec and 3 msec. There was no significant between offset latency for 3 and 5 msec or 5 and 10 msec deviance.

Figure 3 : Representative waveforms for duration deviance recorded from Cz for adults.



1. Frequent wave for 10 msec deviance
2. Infrequent wave for 10 msec deviance
3. Difference wave for 10 msec deviance
4. Frequent wave for 5 msec deviance
5. Infrequent wave for 5 msec deviance
6. Difference wave for 5 msec devianc
7. Frequent wave for 3 msec deviance
8. Infrequent wave for 3 msec deviance
9. Difference wave for 3 msec devianc

The observation that as the magnitude of deviance between the standard and the deviant stimuli decreased, there was a significant increase in the peak latency is similar to that reported in literature. It has been reported that the peak latency is inversely related to the degree of deviance when frequency (Sams. Paavilainen, Alho and Naatanen, 1985), intensity (Jose, 1999; Iyengar, 2000) or speech deviance (Kraus et al, 1993) were studied.

The offset latency was found to significantly decrease with decreasing deviance. Similar findings was also reported by Jose (1999) for intensity deviance. Even though onset latency was found to decrease with decreasing deviance in this study, it did not reach statistical significance. Lang et al (1995) reported that for MMN for frequency deviance, the onset latency seemed to vary less that peak latency. It was observed in the present study that onset latency decreased with decrease in magnitude of deviance. But this decrease was lesser than that observed for offset latency. As the variation was lesser probably the difference was not statistically significant.

B. Amplitude of MMN

Two way ANOVA conducted revealed a main effect of magnitude of deviance on all the three measures of amplitude, but not for electrode placement. There was no interaction between the effects of magnitude of deviance and electrode placement. The magnitude of deviance had a significant effect on peak amplitude (F: 6.800; P = 0.02), onset amplitude (F: 8.673; P = 0.000) and offset amplitude (F: 4.306; P = 0.017).

Table 3: MMN amplitude measures for three stimulus deviance and two electrode placements in adults.

Deviance		Peak amplitude (μV)		Onset amplitude (μV)		offset amplitude (μV)	
		Cz	Pz	Cz	Pz	Cz	Pz
10msec	Mean	-1.49	-1.39	-1.77	-1.62	-1.50	-1.54
	SD	0.58	0.67	0.92	1.01	0.75	0.75
5msec	Mean	-1.24	-1.15	-1.37	-1.40	-1.51	-1.50
	SD	0.59	0.54	0.95	0.76	0.82	0.87
3 msec	Mean	-1.02	-0.92	-1.17	-1.08	-1.14	-1.01
	SD	0.45	0.48	0.64	0.64	0.55	0.53

A look at table 3 reveals that with decrease in the magnitude of stimulus deviance, all the amplitude measures also showed a decreasing trend. From the post hoc test, it was found that peak amplitude and onset amplitude differed significantly only between 10 msec and 3 msec but offset latency was found to differ significantly between 3 and 10 msec conditions and also 3 and 5 msec.

The results of the amplitude measures of this study are in accordance in the literature, that amplitude of MMN decreases with decreasing deviance. For duration MMN, Joutsiniemi et al (1989) have reported significantly larger peak amplitude for larger duration deviance than for shorter deviance. Using speech stimuli Kraus et al (1993) also reported that MMN became larger as the acoustic difference between the stimuli increased Csepe (1995) reported that the MMN amplitude measures depend on the stimulation parameters and the degree of deviance. Similar findings have also been reported by Jose (1999) and Iyengar (2000) for intensity deviance. Sams. Paavilainen, Alho and Naatanen (1985) reported similar results for frequency deviance. Hence this trend which is common across studies using different types of deviant stimuli suggest that probably the decrease in amplitude with decrease in difficulty may have a common underlying neurophysiologic cause related to magnitude of deviance or task difficulty. Also Picton, Alain, Otten, Ritter and Achim (2000) have reported that the amplitude of the MMN in general increases with increasing differences between the standard and deviant stimuli. This relationship is generally monotonic but may show some ceiling effects as the difference becomes large.

C. Total duration of MMN.

Table 4: MMN total duration for three stimulus conditions and two electrode placements in adults.

Total Duration	10 msec deviance		5 msec deviance		3 msec deviance	
	Mean (msec)	SD	Mean (msec)	SD	Mean (msec)	SD
Cz	57.70	16.30	52.11	11.21	47.55	13.09
Pz	57.70	16.30	51.63	11.76	47.55	13.09

Table 4 reveals that with decrease in the magnitude of stimulus variance, there is a decrease in the total duration of MMN. Also two way ANOVA conducted indicated that there is no significant effect of either stimulus deviance or placement of electrodes.

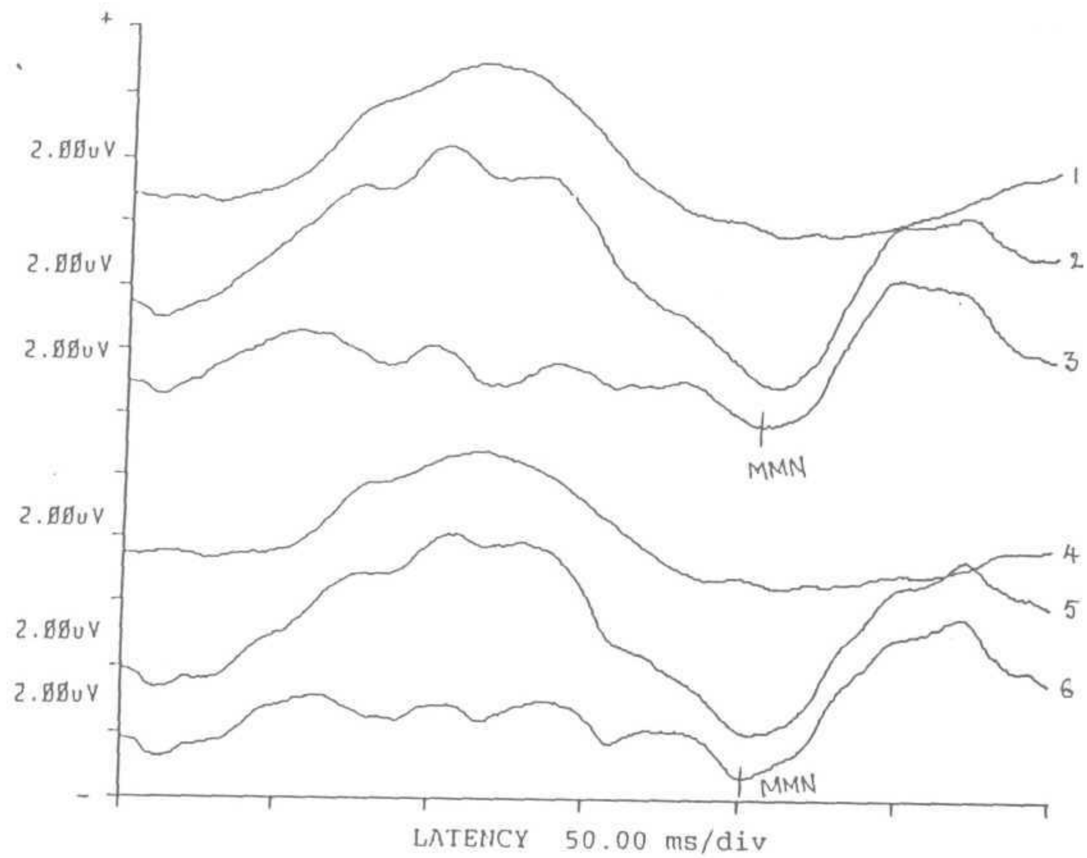
There are very few reports regarding the nature of change in total duration and magnitude of deviance. The results of the present study are similar to are those reported by Jose (1999) who also observed that the total duration increases with increase in stimulus deviation.

III. MMN IN CHILDREN

Figure 4 shows representative waveform of MMN for duration deviance in children. MMN could be identified for all the subjects for 10 msec and 5 msec deviance, however for 3 msec deviance, MMN could not be identified for four subjects. MMN was present for 10 msec deviance with peak latency in the range of 155.88 to 242.6 msec. And for 5 msec and 3 msec stimulus deviances in a range of 164.67 to 256.67 msec and 170.53 to 282.45 msec respectively.

The fact that for 3 msec deviance, four children did not have MMN, probably suggests that 3 msec deviance was below these subjects electrophysiological threshold for processing duration deviance (or just noticeable difference for duration). But as all the adult subjects had MMN for 3 msec deviance suggests that with age probably the minimum differences in duration (or just noticeable difference) that can be processed as different stimuli also increases. This observation supports the results of a study by Kraus et al (1993) using speech stimuli, which indicated a significant decrease of just noticeable difference with age. They studied children in the age range of six to fifteen years for /ba-wa/ stimuli which varied in terms of duration of the first and second formant transitions using behavioral discrimination task. And they reported that younger children have elevated just noticeable difference compared to those of older groups. They attributed this to maturation effects.

Figure 4 : Representative wave forms for 10 msec deviance in children



1. Frequent wave recorded from Cz
2. Infrequent wave recorded from Cz
3. Difference wave (Cz)
4. Frequent wave recorded from Pz
5. Infrequent wave recorded from Pz
6. Difference wave (Cz)

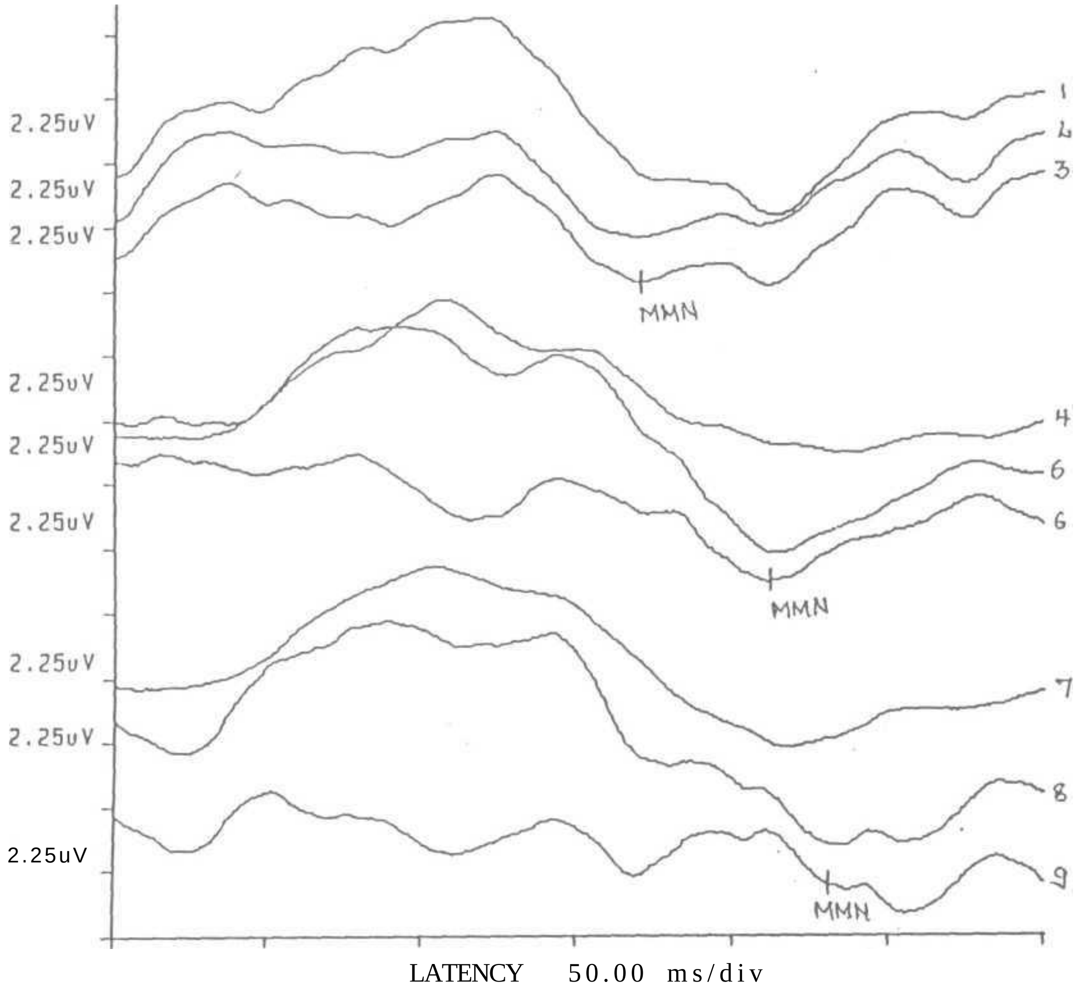
A. Latency of MMN.

Table 5: MMN latency measures for three stimulus deviance and two electrode placements in children.

Deviance		Peak latency (msec)		Onset latency (msec)		Offset latency (msec)	
		Cz	Pz	Cz	Pz	Cz	Pz
10msec	Mean	198.34	198.34	26.56	26.56	30.97	31.33
	SD	24.11	24.11	7.38	7.38	14.20	13.90
5msec	Mean	216.44	216.44	26.56	25.12	24.13	25.12
	SD	27.73	27.73	10.69	8.44	7.92	7.63
3 msec	Mean	240.40	239.08	29.59	28.28	23.97	25.29
	SD	33.29	32.77	8.74	9.01	12.11	12.82

Two way ANOVA conducted revealed that electrode placement and interaction (Table 5) did not have significant effects, but similar to adults stimulus deviance had statistically significant effect on peak latency (F: 15.581; P = 0.000) and offset latency (F: 3.284; P = 0.044). Results of post hoc analysis indicated that peak latency significantly dilfercd across all the stimulus deviances. A significant increase in peak latency with decrease in the magnitude of stimulus deviance was found. This can be observed in figure 5. For offset latency, a significant effect was found between 3 msec and 10 msec and 5 msec and 3 msec. A decrease in offset and onset latency with decrease in magnitude of stimulus deviance was found.

Figure 5 : Representative wave forms for duration deviance recorded from Cz for children



1. Frequent wave for 10 msec deviance
2. Infrequent wave for 10 msec deviance
3. Difference wave for 10 msec deviance
4. Frequent wave for 5 msec deviance
5. Infrequent wave for 5 msec deviance
6. Difference wave for 5 msec devianc
7. Frequent wave for 3 msec deviance
8. Infrequent wave for 3 msec deviance
9. Difference wave for 3 msec deviance

The findings of MMN latency measures for different deviance of duration in children are similar to those in adults. Hence, these findings also support the notion that even in children the latency is inversely related to the degree of deviance (Kurtzberg, Vaughan, Kreuzer and Fliegler, 1995; Kraus et aL, 1993. Similar to adults even here, peak latency and offset latency had a significant effect with respect to magnitude of deviance but not onset latency. This indicates that similar neurophysio logical processes that could be the cause for these changes in latency measures.

A. Amplitude of MMN.

Table 6: MMN amplitude measures for three stimulus deviance and two electrode placements in children.

Deviance		Peak amplitude (μV)		Onset amplitude (μV)		Offset amplitude (μV)	
		Cz	Pz	Cz	Pz	Cz	Pz
10msec	Mean	-1.82	-1.66	-2.07	-1.93	-2.12	-1.24
	SD	0.95	0.71	1.46	1.49	2.33	1.41
5 msec	Mean	-1.50	-1.41	-1.56	-0.91	-1.92	-0.96
	SD	0.89	0.80	1.58	0.99	1.18	1.17
3 msec	Mean	-1.67	-1.74	-1.73	-0.95	-1.30	-0.65
	SD	0.91	0.82	1.95	0.94	1.59	0.91

Two way ANOVA conducted to see the effect of magnitude of deviance and site of electrode placement for amplitude (Table 6) measures revealed statistically significant effect of stimulus deviance on offset amplitude (F:3.151, $P = 0.050$) only. No significant effect of electrode site or interaction was found. Post hoc analysis indicated a significant difference only between 10 msec and 3 msec deviance. Offset amplitude tended to decrease with decrease in the magnitude of deviance.

As opposed to adults where all the amplitude measures decreased with decreasing deviance, here only offset amplitude was found to significantly decrease with decreasing deviance.

B. Total duration of MMN.

Table 7 reveals that total duration of MMN in children does not show a specific trend with respect to magnitude of deviance. Here, it can be recalled that in adults there was a decrease in total duration with decrease in magnitude of deviance was found even though it did not reach statistical significance. However, in children no significant effect of either stimulus deviance or placement of electrodes was observed.

Table 7: MMN total duration for three stimulus conditions and two electrode placements in children.

Total duration	10 msec deviance		5 msec deviance		3 msec deviance	
	Mean (msec)	SD	Mean (msec)	SD	Mean (msec)	SD
Cz	57.53	16.54	48.82	12.03	53.56	16.80
Pz	57.90	16.17	50.12	12.61	53.57	16.80

To summarize, the trend in latency and amplitude measures of duration MMN with respect to magnitude of deviance was similar in both adults and children. It has been found that as the magnitude of deviance decreases, the latency of MMN increases and amplitude decreases. According to Schroger (1995) MMN is assumed to be a result of the operation of a mechanism that compares each current auditory input with a trace of recent auditory input stored in auditory sensory memory when a discrepancy is detected MMN is elicited. Therefore, as the deviance decreases discrepancy in memory traces also decreases which would result in increased task difficulty, probably reflecting as increase in latency and decreased amplitude at or near threshold of discrimination.

McGee, Kraus and Nicol (1997) have reported that MMN responses appears to reflect a neuronal process specific to the discrimination of a change in a pattern of auditory stimuli. Also Kraus et al (1995) have reported an increase in the number of neurons firing at or near the same time would result in an earlier and larger evoked responses. Thus, it can be inferred that a discrimination process which is easy with larger difference results in neurons reflecting a process of discrimination which is easy leading to an increase in number of neurons firing resulting in earlier latency and more amplitude of elicited MMN. Similar trends seen across age groups indicates that these physiologic processes which could be responsible for these results are same in different ages.

IV. COMPARISON OF MMN FOR DURATION IN ADULTS AND CHILDREN.

For each stimulus deviance considered in the study (10 msec, 5 msec, and 3 msec), various parameters of MMN were compared using one way ANOVA across adult and children data to see for any effect of age on each of the stimulus deviance.

(a) *MMN for 10 msec deviance.*

Table 8: Comparison of various parameters of MMN for 10 msec deviance between adults and children.

AGE		PL (msec)	PA (μV)	ONL (msec)	ONA (μV)	OFL msec)	OFA (μV)	DUR (msec)
Adult	Mean	122.34	-1.44	27.91	-1.71	29.42	-1.52	57.70
	SD	25.54	0.62	11.17	0.95	8.87	0.74	16.00
Children	Mean	198.34	-1.74	25.56	-2.00	31.15	-2.22	57.72
	SD	23.72	0.83	7.26	1.45	13.82	1.31	16.09

The results of ANOVA for 10 msec deviance (Table 8) revealed that peak latency (F:137.744, P = 0.000) offset amplitude (F:6.106, P = 0.017) differed significantly between adults and children. Peak latency was significantly prolonged and offset amplitude was larger in children.

(b) MMN for 5 msec deviance.

Table 9: Comparison of various parameters of MMN for 5 msec deviance between adults and children.

AGE		PL (msec)	PA (μV)	ONL (msec)	ONA (μV)	OFL (msec)	OFA (μV)	DUR (msec)
Adult	Mean	137.74	-1.20	25.45	-1.38	26.42	-1.50	51.87
	SD	26.55	0.56	7.27	0.84	7.29	0.83	11.31
Children	Mean	216.44	-1.46	25.84	-1.57	24.63	-1.86	49.51
	SD	27.28	0.83	9.50	0.94	7.67	1.05	12.14

For 5 msec deviance (Table 9) results of ANOVA showed that only peak latency (F: 132.333; P = 0.000) differed significantly between the adults and children group. As seen in the results for 10 msec, even here children had prolonged peak latency for MMN.

(c) *MMN for 3 msec deviance.*

For 3 msec stimulus deviance (Table 10) results of ANOVA indicated that there were four MMN parameters that differed significantly between adults and children. Consistent with results in the other two stimulus deviances even for 3 msec deviance, peak latency (F: 107.067; P = 0.000) of MMN was significantly prolonged in children. Peak amplitude (F: 16.352; P = 0.000), onset amplitude (F: 11.297; P = 0.001) and offset amplitude (F: 4.428; P = 0.040) were found to be significantly more in children.

Table 10: Comparison of various parameters of MMN for 3 msec deviance between adults and children.

AGE		PL (msec)	PA (μV)	DNL (msec)	ONA (μV)	OFL (msec)	OFA (μV)	DUR (msec)
Adult	Mean	150.78	-0.97	24.83	-1.12	22.74	-1.07	47.55
	SD	30.43	0.46	9.63	0.63	8.09	0.54	12.88
Children	Mean	239.74	-1.71	28.93	-1.84	24.63	-1.45	53.57
	SD	32.31	0.85	8.70	0.93	12.21	0.79	16.43

Even though there are reports that MMN matures early (Alho et al 1990; Kurtzberg, Vaughan, Kreuzer and Fliegler, 1995; Lang et al 1998), some age related developmental trends similar to those observed for other late potentials could be expected. Korpilahti and Lang (1994) have reported that in event related potentials wave forms of adults, the MMN components usually overlaps with N1. In children the MMN overlaps with N250. This could be the reason that in this study also MMN components in children have appeared much later than in adults. Further they have also reported that in normal children the peak latency of MMN correlated significantly with age. But in this study within group age comparison in children could not be done as each group had relatively very small number of subjects (n=4).

Iyengar (1999) using intensity deviance reported longer latency and greater amplitude in children compared to adults. Even in this study, also a similar trend of increased latency and greater amplitude was observed for children, which probably would decrease over age to reach adult like values owing to similarity in trend seen for other late potentials. For duration MMN, Joutsiniemi et al (1998) have reported that with increasing age, the MMN peak amplitudes decreased. The amplitude and age were found to be monotonically dependent. Significant decrease in latency measures with respect to age have also been reported in the literature. Korpilahti and Lang (1994) and Kurtzberg, Vaughan, Kreuzer and Fliegler (1995) have reported significant decreases in MMN peak latency during the school age years in response to pure tone contrasts differing in frequency and intensity.

It was observed that for all the deviance, eventhough peak latency differed significantly between adults and children, for the shortest duration deviance (3 msec), four MMN components were found to be significantly differing between both the groups. Similar results have also been reported by Joutsiniemi et al (1998) using duration deviance of 25 msec and 50 msec. For the shortest deviance of 25 msec age was found to have significant effect on both amplitude and latency but with 50 msec deviance, no significant age dependence was seen. It can be speculated that a shorter deviance which taxes the system with greater task difficulty a significant age effect on many parameters of MMN is seen which may not be present for larger deviance.

V. MMN IN CHILDREN WITH LEARNING DISORDER

Six subjects in the age range of 8-12 years (Table 11) diagnosed as having learning disorder using Early Reading Skills - Informal Reading Diagnosis (Rae and Potter, 1973) were taken.

Table 11 : Number of subjects with learning disorder in each age group

Number of Subjects	Age	Sex
3	8 years	Male
2	10 years	Male
1	12 years	Male

MMN was recorded in all the subjects for stimuli presented through right ear for duration deviance of 10,5 and 3 msec. Among the six subjects, MMN was found to be present in only two subjects for 10 msec and 5 msec deviance whereas was absent in four subjects. These results indicate that children with LD show some difficulty in duration processing. Also it can be seen that in both the subjects, MMN was absent for 3 msec deviance. This probably indicates that they have difficulty in discriminating fine differences in stimuli.

In the literature there are a few studies that have tried to study MMN in children with LD using deviance such as frequency, intensity, speech. Radhika (1998) reported of absence of MMN in three out of twelve subjects studied using frequency deviance. For intensity deviance Guruprasad (2000) observed that MMN for intensity was absent in three out of seven subjects. Kraus and McGee (1994) have reported that certain patients with auditory processing deficits have difficulty perceiving small acoustic differences and that patients with learning problems require larger acoustic differences to discriminate speech sounds than normal children.

Comparison of the results on MMN for frequency and intensity deviances and the current study, shows that comparitively more number of subjects are showing an absence of MMN for duration. From this it can be speculated that a relatively larger percentage of children with LD have difficulty in processing duration. However studies need to be done to further probe into this aspect.

The latency and amplitude measures obtained for duration MMN in children with LD was compared with that for normal group. This indicated that among the two subjects, one had latency measures which were similar to that obtained by normal children for 10 and 5 msec deviance. There was no difference for latency measures collected at Cz and Pz sites. In the amplitude measures, it showed a decrease for 10 msec deviance at Cz site but was normal for Pz and for 5 msec deviance. In the second subject however, it was observed that the latency of MMN for 10msec deviance was delayed but not for 5 msec deviance. The amplitude measures were similar to that of the normal subjects. There was no difference in MMN measures for this subject between Cz and Pz recording sites.

Increase in latency for MMN in subjects with LD has also been reported for frequency MMN (Radhika, 1998), intensity MMN (Guruprasad, 2000) and duration MMN (Koriphanti and Lang, 1994). Similar reductions in amplitude has also been reported in the literature (Korpilianti and Lange (1994); Leppanen and Lyytinen (1997); Radhika, (1998); and Guruprasad, (2000).

Thus, the results reveal that there is a wide variety of abnormalities in children with LD for duation MMN. It includes absence of MMN, reduced amplitude and prolonged latency. As adequate processing of basic acoustic parameters (like frequency, intensity, duration etc) is essential for adequate processing of a complex stimuli of speech it can be expected that these children would also have problems in speech perception. This support the notion that there is a subset of children with LD who really have difficulty perceiving speech sounds at a basic acoustic elemental level. Hence probably identifying deficits in processing elemental acoustic features and training children with LD for that aspect would also eventually lead to an improvement in speech perception. There are reports which indicate a training related improvement in MMN using speech stimuli (Tremblay, Kraus and McGee, 1998; Kraus et al, 1995)

Kraus and colleagues (cited in kraus, Koch, McGee, Nicol and Cunningham, 1999) hypothesized that, for some children, the difficulty in perceiving fundamental acoustic parameters stems from abnormalities in the central sensory representation of speech stimuli that occurs after peripheral sensory encoding and before conscious perception.

Thus, the results of this study reinforces the notion, that children with auditory processing disorders encompass a heterogeneous population .

CHAPTER 5

SUMMARY AND CONCLUSIONS

MMN is a cortical potential that occurs when there is a change in a repetitive sequence of auditory stimuli (Kraus and McGee, 1994). MMN is a response to stimulus change which is present even at psychophysical discrimination threshold. Due to this MMN may provide an objective measure of discrimination that can be applied to the assessment of central auditory processing disorders. Diagnostic assessment of many hearing problems could be greatly aided by an electrophysiologic response that is sensitive to the discrimination of small changes in acoustic stimuli. A majority of the studies using MMN in the past have been carried out using either frequency, intensity or speech deviance. There is a dearth for studies investigating MMN using duration deviance in both normal and disordered population. And further research in this area would probably probe into the neurophysiological processes underlying automatic duration processing.

Hence the aims of the current study were:

1. To investigate the minimum duration deviance needed to elicit MMN in normal hearing adults.
2. To compare the latency, amplitude and duration of MMN for 10, 5 and 3 msec duration deviance in normal hearing adults and children.
3. To compare the latency, amplitude and duration of MMN for 10, 5, and 3 msec duration deviance in normal hearing children and six children with learning disorder.

Subjects for the study consisted of sixteen adults (18-22 years) sixteen children (8-12 years) and six children with earing disorder. Data was collected using Biologic Navigator evoked potential system with HP 317 so 11 ware (Bio-Logic Inc). Auditory "odd ball" paradigm was used to record MMN for duration for both the groups. Standard and target stimuli were 1000 Hz tones at 60 dBnHL. MMN was recorded for duration deviance of 10 msec, 5 msec and 3 msec in all the three groups, (normal adults, children and children with Learning disorder). For normal adults, the minimum duration deviance required to elicit MMN was also tracked. MMN response obtained was analysed for peak latency, peak amplitude, onset latency, onset amplitude, offset latency, offset amplitude and total duration.

The following conclusions seem warranted from the study :

A. MMN in adults :

(1) In normal hearing adults, the minimum duration deviance needed to elicit MMN is 2 msec.

(2) There is a significant increase in the peak latency of MMN with a decrease in the magnitude of deviance.

(3) Both onset and offset latencies decrease with a decrease in the magnitude of deviance. But the difference is significant only for offset latency.

(4) There is a significant decrease in all the amplitude measures (peak, onset, offset) with decrease in magnitude of deviance.

(5) There is a decrease in the total duration of MMN with decrease in the magnitude of deviance, but the difference is not statistically significant.

B. MMN in children :

(1) Even in children there is a significant increase in peak latency with decrease in magnitude of deviances.

(2) There is a decrease in onset and offset latencies will decrease in magnitude of deviance, but this difference is significant only for offset latency.

(3) Among amplitude measures only a significant decrease in the offset amplitude is seen with a decrease in magnitude of deviance.

(4) No specific trend is seen for total duration of MMN when the magnitude of deviance is changed.

C. Comparison of MMN for adults and children :

(1) For all the 3 deviances, peak latency of MMN is significantly greater in children when compared to that of adults.

(2) For 10 msec deviance the offset amplitude is significantly larger for children.

(3) For 3 msec deviance, a significantly larger peak, onset and offset amplitude are observed in children when compared to MMN in adults.

D. MMN in children with Learning disorder:

(1) Children with learning disorder have abnormal MMN for duration, indicating some difficulty in processing subtle changes in duration.

Implications of the study:

Adequate processing of temporal information such as duration has been found to play an important role in auditory perception. In children with central auditory processing disorder, deficits in duration processing have been largely reported using behavioral measures. Such deficits could be identified early and objectively using MMN for duration, therapy could be guided by such information. It has been reported that training - associated changes in neural activity can precede behavioral learning (Tremblay, Kraus and McGee, 1998). Further it is also suggested that speech sound learning occurs at a pre-attentive level, which can be measured neurophysiological even in the absence of a behavioral response. Hence MMN may also serve as an objective indicator of neurophysiologic changes in the central auditory system resulting from learning or auditory experience.

Suggestions for further research:

a) Needs to be carried out on a larger population for generalisation

b) With in children group, sub groups can be taken to study differences in MMN among children.

c) Needs to be done on a large group of pathological population

d) Psychophysical threshold for discrimination can be and compared with electrophysiological threshold for duration.

e) Effects of therapy could be studied for these measures of MMN

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