Long Latency Responses in Children with Learning Disorder

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Abstract: The purpose of the study was to investigate long latency response from the children with LD and compare the findings with controlled subjects (i.e. age-gender matched). LLR responses were recorded from 30 subjects with LD (experimental group) and 30 control groups, age range from 10 -14 year with means age of 11.2 years. The LLR responses were recorded by using the click stimulus. P1, N1, P2, N2 latency and amplitude were used for analysis. Result of the study indicates that both the group had statistically significant difference in latency. P1 and N1 amplitude were found to be significantly different between the two test groups. The present study findings suggest that click evoked auditory late latency response is easily traceable in all children with LD and typically developing children. However, prolonged latency responses in the present study suggest that the auditory stimulus processing at auditory cortex level is different in LD children compared to typical children. This functioning difference in the auditory cortical area results in altered auditory cortical recording. The present study has discussed how LLR test can be effective test tool to use clinically that differentiates between individuals with and without LD.

Keywords: Evoked potential, LLR, Normal Hearing, Learning disorder.

INTRODUCTION

Learning disorders mainly are of four types, characterized by difficulty of Reading, difficulty in Mathematics, difficulty in written expression and learning difficulty not otherwise specified (NOS) [1]. Many reviews of study has pointed out Learning Disability (LD) characterized by impairment in a particular or several areas of brain functioning. The clinical sign of children with Learning Disability (CWLD) is distinct gap between a person's level of expected achievement and their performance usually attributed to their laziness or inattentiveness. Earlier it was thought that only in English speaking children have difficulties in learning. In India, due to lower incidence report, this could be due to relative lack of concern, awareness and sensitivity about LD in educators. By considering Indian population, most of the classroom are over-crowded [2]. Epidemiology and Biostatistics, National Institute of Mental Health and Neuro-sciences, Bangalore, reported prevalence rate [3] of LD in 4-16 year old children in urban middle class, slum and rural area was 12%. The prevalence of LD in Mumbai city reported by the L.T.M.G. Hospital, Sion [4], reveals that the total number of 2,225 children visiting the hospital for certification of any kind of disability, out of which 640 was diagnosed as having Learning Disability. At the Lokamanya Tilak M.G. Hospital, Sion, Mumbai, the procedure for assessment of Learning Disability involves Neurological assessment, Vision and Hearing tests. As hearing is very important aspect in early age for learning, even mild HL can affect auditory processing stimulus. In India, necessary routinely used audiological test in CWLD are limited to pure tone audiometry and impedance audiometry only. In recent years, technological advancement and averaging technique has made auditory evoked potential reliably recorded from different site such as brain stem, auditory cortex etc. ABR is widely used in audiology and neurotology as an objective tool for assessing hearing sensitivity and auditory nerve function [5-8]. The late evoked potentials are complex signals of the neural processing of the acoustic signal in the auditory cortex, typically elicited in response to clicks and speech [5-7, 9]. Late latency auditory evoked waveforms are the cortical responses that occur within 50–300 ms after the acoustic stimulation to the ears. The peak potentials in the wave forms are denoted as P1, N_1, P_2, N_2 and P_3, N3 [5-9]. These peaks represents different site of generations in the auditory cortex mainly from structures of the thalamocortical and cortico-cortical auditory pathways, primary auditory cortex and associated cortical areas [10-14]. Peaks also reflect the neural activity even of the dendrites involved in the skills of attention, discrimination, memory, integration and decision making. The morphological change in the waveform indicates that response is being presented in the auditory cortex [10-15]. There are various researches which has indicated that it is possible to capture the LLAEP reliably, even in young children [13, 18]. Auditory cortical potential provide unique dynamic spatiotemporal window into brain processes underlying auditory processing and perception [19, 20]. P1 N1 P2 has been investigated for analyzing various groups of neurological dysfunction

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E-ISSN: 2311-1917/15

such as language disorders, central auditory processing disorders and auditory neuropathy [20-27]. Previous researcher has reported children with LD are related to low level auditory perceptual dysfunction that affects the ability to learn to use phonics skills adequately [28]. Similar results reported by Reed *et al*. [29] (1989), perceptual deficit in CWLD, which interferes with the processing of phonological information. Jorm [30] (1983) concluded in CWLD the pattern identification and discrimination differences in the experiment group and control and significant relationship was found between reading level and speech discrimination. Marc *et al*. (2000) [31] research finding that children with LD and Language impairment group showed clear speech perception deficits, suggesting that such deficits affect only a subset of LD. Review suggest that CWLD having deficit in central auditory processing, therefore to get a clearer picture of the higher auditory functioning was assessed in present study. As LLR test appears to provide most suitable information of thelemo-cortical area of central auditory system i.e. auditory cortex functioning. This research will help us to increase our understanding of Neuro-auditory functioning in CWLDs.

Aim and Objectives

To compare the higher auditory cortex functioning in CWLD to that of a control group.

METHOD

Subjects

30 subjects enrolled in study who were had LD certification from LD certification board Maharashtra. 30 age- gender match subject were taken part as control group. Both the groups were audiologically normal children in age range of 10 to 14 years with mean age of 11.8 years. All subject (i.e. control group & experimental group) had normal hearing sensitivity of < 25dBHL on pure tone audiometry across audiometric octave band frequencies. All subjects had 'A' type tympanogarm with presence of reflexes at normal sensation levels. All were screened with TEOAE and ABR for any underlying auditory synchrony/ neuropathy.

Instrumentation

The AC 40 dual channel clinical audiometer (Version 2) was used for pure tone testing and speech audiometry. The GSI Tympstar middle ear analyzer was used for tympanometry and acoustic reflex measurement and recording. GSI Audio Screener was used to screen with TEOAE and ABR. The study was conducted on IHS Smart EP version 3.56. It was ensured that all the equipments were in calibrated condition. (ANSI X 3.6- 1978) [32].

Materials

Standard click provided by the manufacturer were used to record the AEPs.

Test Procedure

On the day of tests, each subject was evaluated using the tools noted above, and otoscopy was performed on all subjects to ensure that no visible external or middle ear abnormalities were present on the day of the test. Pure tone thresholds were acquired from 250 to 8000 Hz *via* air conduction, and when clinically appropriate, bone conduction thresholds were also acquired from 250 to 4000 Hz, using modified Hughson and Westlake procedure. As indicated above, tympanometry and acoustic reflexes were recorded to rule out middle ear pathology. Tympanometry test was carried out using 226 Hz probe tone at 85 dBSPL, and acoustic reflex test done at tone of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz ipsilaterally and contralaterally. TEOAE was also conducted to rule out for any underlying auditory synchrony/ neuropathy. Transient evoked otoacoustic emissions (TEOAE) were measured using click stimuli at 85 dBSPL in both ears. All the testing was performed in recommended test environment and with standardized test protocol. Subjects were seated in a reclining chair in an electrically shielded and acoustically treated room. Silver chloride electrodes (AgCl) were placed at the recording sites, after cleaning those sites with an abrasive gel. Electroencephalography (EEG) paste and surgical adhesive tape was used to hold the electrodes firmly in place. In essence, standard and well accepted ABR protocols were used throughout all ABR acquisitions.

For the LLR measurements, the electrodes were inserted for recording of auditory evoked potentials occurring on channel A and the recording of eye movements and blinking on the channel B. On channel A, the active electrode was placed at Cz connected to the input (+) of the pre-amplifier, and the reference electrode placed on the mastoid of the stimulated ear and connected to the input (-). The ground electrode was placed on Fpz connected to the ground position. [Kraus *et al*. (1993); Sharma *et al.* (2009)]. On channel

B, the active electrode was placed on the supraorbital position contralateral to the ear stimulated connected to the input (+) of the pre-amplifier and the reference electrode on the infraorbital position on the same side connected to the (-) input. With this arrangement of electrodes, we sought to establish the amplitude of the eye movement and blink and potentials in order to delimit the level of rejection that was used in each test. With this procedure, the interference of the eye movement artifacts was minimized. Since this rejection limit was adopted for channel A so that, consequently, eye movements were not captured by it, thus not interfering in the LLAEP recordings [11-15, 33].

Analysis of Evoked Potentials

Having identified the auditory evoked potential, amplitude was established as the difference between the 0.0 uV point and the maximum positive value. In this case the P1 and P2 components, and the negative value, specifically for N1 component was measured in uV. P1 N1 P2 accounts the maximum amplitude points. Testing was done in an acoustically and electrically treated room; subjects were seated comfortably in a reclining seat. P1 was marked as the relative positivity occurring within the range of approximately 50 to 100 msec. N1 was marked at the earlier negativity between 110 to 160 msec seen in all the subjects. Further waveform printouts were given to two examiners to mark potentials. Both the examiners had clinical experience of more than 5 years in the field of evoked potential measurement.

Following protocol were used for LLR [5, 6]

Table 1: Showing Test Protocol for LLR

Stimulus	LLR
Rate	1.1
Polarity	Alternate
Transducer	Insert earphone
Intensity	70dB nHL
Filters	1-30Hz
Stimulus	Click 100micro second
Amplification	100K
Runs	2
Analysis window	Overall 500ms
Sweeps	250

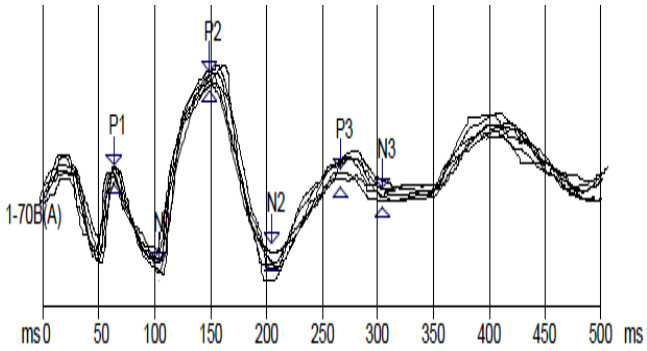


Figure 1: LLR wave form of control subject.

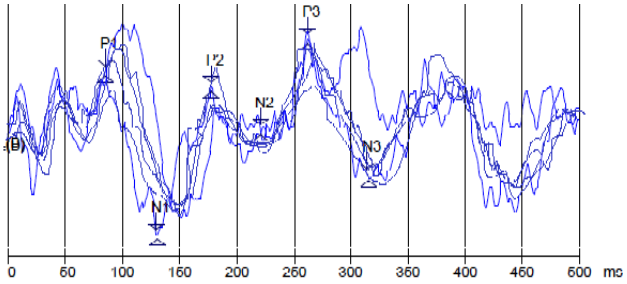


Figure 2: LLR wave form of LD subject.

RESULT AND DISCUSSION

Statistical Analysis

Descriptive statistical analysis of the scores in terms of mean, standard deviation, and parametric tests using independent 't' **tail** test was performed using Statistical package Social Science (SPSS 16.0) software for different parameters of evoked LLR. The results obtained are presented and discussed in the subsequent section.

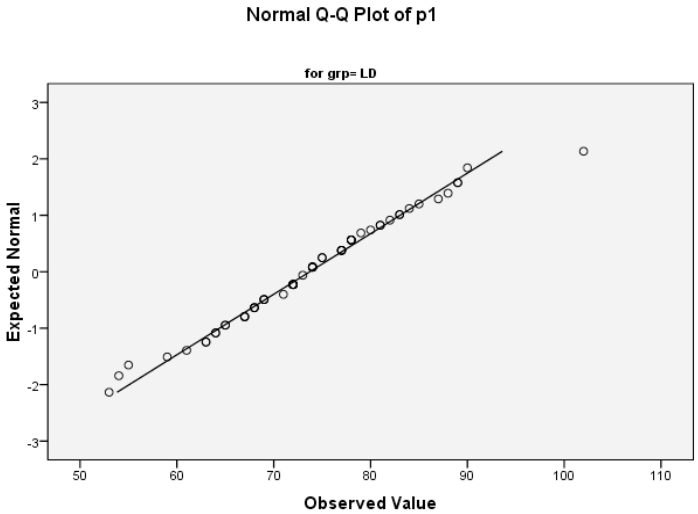
Descriptive statistics presented data in Table, Q plots, Box Plots Indicate that mean for LD group evoked potential and control group evoked potential are within normal distribution. The difference of means between the two groups is quite big in the context of their standard deviation. Positive skewness was observed in the distribution for both groups. The Kolmogorov – Smirnov Z value are not statically significant ($p>0.05$). Thus the small skewness in the two distributions is not major concern and the two distributions met the assumption of normality, therefore, further analysis was done by using parametric test.

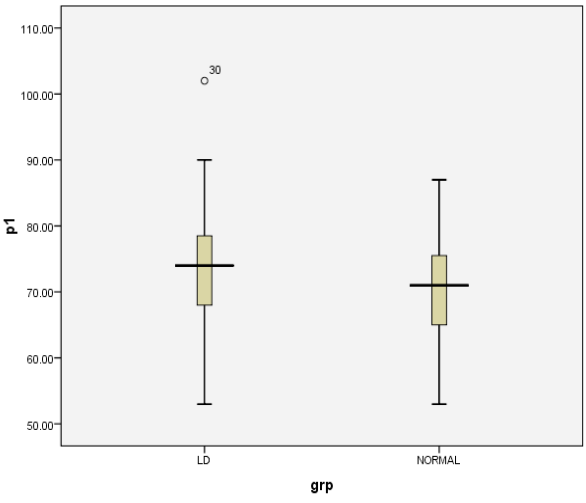
Latencies

Mean score and standard deviation were calculated for both the groups. Independent 't' tail test was used to

Table 2: Showing Test of Normality Finding of LD and Control Subjects

Tests of Normality							
peaks	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
p1	LD	.067	30	.200*	.985	30	.658
	NORMAL	.062	30	.200*	.982	30	.496
n1	LD	.071	30	.064	.932	30	.202
	NORMAL	.123	30	.025	.958	30	.339
p2	LD	.100	30	.200*	.973	30	.207
	NORMAL	.202	30	.24	.917	30	.201
n2	LD	.198	30	.100	.903	30	.200
	NORMAL	.107	30	.083	.972	30	.176
ap1	LD	.117	30	.140	.965	30	.080
	NORMAL	.119	30	.133	.962	30	.057
an1	LD	.113	30	.155	.975	30	.246
	NORMAL	.123	30	.125	.945	30	.009
ap2	LD	.112	30	.058	.916	30	.501
	NORMAL	.112	30	.159	.933	30	.013
an2	LD	.102	30	.187	.977	30	.312
	NORMAL	.164	30	.0510	.958	30	.039





(Figure 3). Continued.

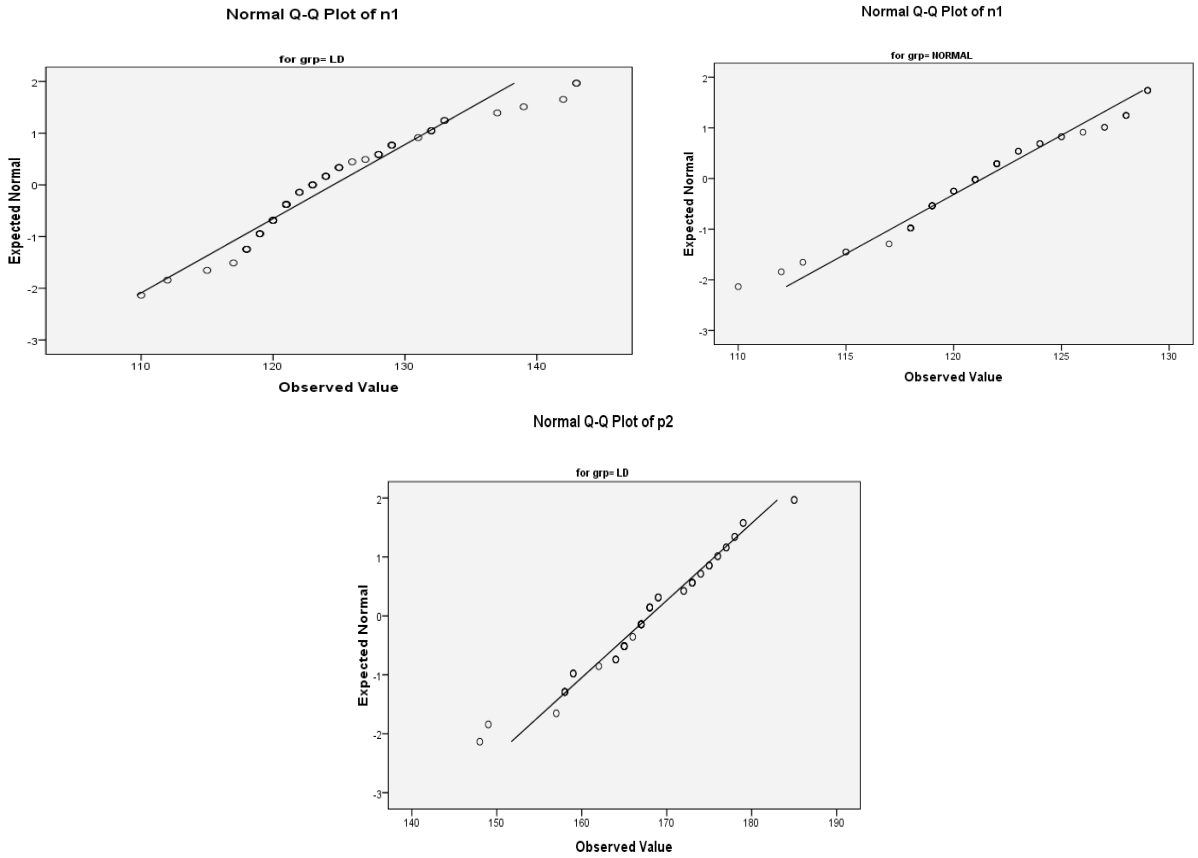


Figure 3:

Group Statistics

Table 3: Showing Descriptive Value of LLR Different Peaks Mean Latency and Amplitude

	Group	N	Mean	Std. Deviation	Std. Error Mean
p1	LD	30	72.8167	9.32118	1.20336
	NORMAL	30	63.2333	7.92415	1.02300
n1	LD	30	125.57	6.97542	.90052
	NORMAL	30	111.35	4.27379	.55174
p2	LD	30	167.00	7.63578	.98577
	NORMAL	30	157.73	5.85088	.75535
n2	LD	30	226.62	12.14055	1.56734
	NORMAL	30	218.50	4.90417	.63313
ap1	LD	30	3.938	.75564	.09755
	NORMAL	30	4.295	.78804	.10174
an1	LD	30	4.388	.99947	.12903
	NORMAL	30	5.365	1.14994	.14846
ap2	LD	30	3.147	.85969	.11099
	NORMAL	30	3.917	.79654	.10283
an2	LD	30	2.10	.58072	.07497
	NORMAL	30	2.68	.56963	.07354

Table 4: Showing Independent 't' Tail Test Result of LD and Control Subjects LLR Peaks Potential

Peaks	T	Df	Sig(2 tailed)	Std. Error. Difference	Level of significance at 0.05	
					Lower	Upper
p1	2.205	58	.001	1.57943	.35563	6.61104
p2	1.825	58	.001	1.24189	-.19262	4.72595
n2	4.210	58	.000	1.69038	3.76925	10.46409
ap1	3.294	58	.0002	.14095	.18522	.74345
an1	-.090	58	.001	.19669	-.40717	.37184
ap2	1.408	58	.162	.15130	-.08662	.51262
an2	.563	58	.574	.10502	-.14880	.26713

check for any statistically significant difference between the two groups. Results obtained indicated a prolonged P1 in CWLD as compared to normal hearing children. Prolonged latencies were observed in CWLD which had a statistically significant difference in comparison to the control group. Also, wave morphology was inconsistent and poor in CWLD. The present study findings reveal that CWLD have a significant difference in central auditory processing system when compared to the normal hearing children. This cortical abnormality indicates that children with LD have some difficulty in perception of auditory stimulus. Similar result findings reported by Pinkerton *et al.* (1981) [34]; Picton *et al.* (2001) [35] stated that, the late auditory evoked potentials in children with reading, writing and spelling difficulties and their research finding also reported a prolonged latency and reduced amplitudes of responses and inferred that the abnormalities in the auditory cortical area results in altered auditory cortical recording. Purdy *et al*. (2001) [36] also studied LLR in children with learning disabilities and reported that the only latency of P1 was earlier whereas P3 latency was prolonged compared to control group.

Amplitude

In the current study only P1and N1 amplitude showed statically significant difference whereas other peaks i.e. P2, N2, P3, N3 did not shown any difference with control subject. CWLD group with P1, N1 had smaller amplitude compared to control group. In a study by Satterfield *et al*. (1987) [37], reported that click-evoked P1 amplitude, P2 amplitude, P1/N1 amplitude and P2/N2 amplitude in children with attention difficulties did not have significant difference. Similarly, Byring and Jaryilehto (1985) [38] studied the late latency auditory evoked potentials in individuals who exhibits high rate of spelling errors. They also reported a prolonged latency and reduced amplitude of late latency response.

DISCUSSION

Many school-age children have difficulty in demonstrating basic proficiency in academic areas and are eventually diagnosed with learning and/or attention problems. There is growing evidence to suggest that in some children the root cause of these learning problems may lie in auditory perceptual deficits specifically related to the processing of signals [39-41]. Present study finding indicated that the difference between normally developing children and CWLD using cortical evoked potentials that reflect different and more elementary levels of sensory encoding. P1/N1/P2/N2 response complex has been described for decades that characterized as a series of positive and negative waves of robust nature and easily identifiable in adults [42]. Normal hearing sensitivity along with present reflexes does not necessarily mean that they have a normal higher auditory processing. The LLR potential is the measurement choice for estimating auditory threshold for any patient who is co-operative or non co-operative [43,48]. LLR potential is also very useful in demonstrating higher – level cortical functioning to acoustic stimulus. Further the absence or abnormality of LLR responses in the presence of normal early evoked potential (i.e. ABR) may be used to suggest central auditory dysfunction [44-47]. LLR test has been investigated various groups such as patients with dysfunction, neurological cases, delayed language development and central auditory processing disorder [20, 48, 49]. Although in India LLR test currently being not diagnostic tool.

For individual patients with specific disorders, much has and will be learned from this response about normal and dysfunction auditory system. LLR test results with other behavioral measures from groups of clinical populations may help us understand the brain processes underlying the dysfunction of particular group. Such information may help us to new therapeutic intervention and also to better understand auditory cortex functioning. These LLR potential provides opportunity unique dynamic spatio-temporal window in to the auditory cortex processes underlying auditory processing and perception – LLR test is far more temporally precise than current functional MRI technique [19,20]. In considering Indian situation LLR test equally good test available that may be faster or less expensive than other imaging test.

CONCLUSION

The neurobiological bases and speech pathology is the manifestations of learning disorders. This study contributes to our knowledge of the particularities of electrophysiological measures like auditory cortex functioning, emphasizes that the latencies of waves P1, P2and N1 were prolonged in children with learning disorders. And also demonstrates the diversity of these measures, which could be explained by the heterogeneity of the functional processes of learning in human brain. It can be concluded from the present study that click evoked auditory late latency response is easily traceable in all children with LD and typically developing children. However, children with LD exhibited prolonged latency responses in the present study. Hence auditory evoked potential late latency response may be used as a tool to differentiate between individuals with and without LD. Therefore, this research study recommends that CWLD should be subjected to higher central auditory tests such as MLR, LLR, P300. These are non invasive and objective procedures with significant clinical efficacy that will be helpful in underpinning the physiological processes involved in higher auditory function in normal as well as clinical population. Further research is required in this area to use Long latency response as a tool to clinically differentiate between individuals with and without LD.

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Received on 23-03-2015 Accepted on 28-05-2015 Published on 17-09-2015

DOI: http://dx.doi.org/10.12970/2311-1917.2015.03.02.7