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Speech evoked auditory brainstem responses in children with learning disability

Sachin¹, Sanjay Munjal², Adarsh Kohli³, Naresh Panda², Shantanu Arya²*

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*Correspondence: Dr. Shantanu Arya,

E-mail: shanu.arya143@gmail.com

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ABSTRACT

Background: Learning disabilities are characterized by significant impairments in acquisition of reading, spelling or arithmetic skills. A growing number of studies have used speech sounds to assess auditory processing to linguistic elements in children with learning disability. The present study seeks to report whether speech evoked Auditory Brainstem Responses can be used as a biological marker of deficient sound encoding in children with learning disability. The study aims to establish relationship between click evoked auditory brainstem responses (ABR) and speech evoked ABR in children with learning disability; to report whether speech evoked auditory brainstem responses can be used as a biological marker of deficient sound encoding in children with learning disability.

Methods: Pure tone audiometry, immitance audiometery, click and speech evoked brainstem responses were obtained in 25 children diagnosed with learning disability and the data was compared with the responses in the control group. Results: Statistical differences were seen in speech recognition threshold, speech discrimination scores, latencies and amplitude of speech evoked auditory brainstem responses between control and study group. This poor representation of significant components of speech sounds in children with learning disability could be due to synaptic efficacy distortion and poor synaptic transmission. Other reasons may be activation of fewer auditory nerve fibres in the auditory brainstem in response to speech stimulus.

Conclusions: The speech evoked auditory brainstem responses can serve as an efficient tool in identifying underlying auditory processing difficulties in children with learning disability and can help in early intervention.

Keywords: Learning disability, Speech evoked ABR, Electrophysiology

INTRODUCTION

Learning Disabilities (LD) or specific developmental disorders of scholastic skills are characterized by significant impairments in acquisition of reading, spelling or arithmetic skills. LD refers to a variety of disorders that affect the acquisition, retention, understanding, organization and use of verbal and/or non-verbal information. The DSM-IV reports prevalence estimates of 2% to 10% for LDs, depending on the nature of ascertainment and the definitions applied.¹

The children with learning disability despite having normal intelligence quotient have language based learning problems. A child with language based learning disorder presents problems with verbal language skills, such as the ability to retell a story and the fluency of speech, as well as the ability to understand the meaning of words, parts of speech, directions etc. Generalizing across studies is complicated by the heterogeneity of the LD population and the many methods used to evoke and collect the physiological responses, but taken together the evidence suggests that processing of sound differ between normal language and some LD children.²

¹Post Graduate in Speech and Hearing, PGIMER, Chandigarh, Punjab, India

²Department of ENT, ³Department of Psychiatry, PGIMER Chandigarh, Punjab, India

A growing number of studies have used speech sounds to assess auditory processing to linguistic elements.³ Similar to the click evoked ABR, the onset response of the speech evoked ABR is transient with wave duration lasting tenths of milliseconds and can be analyzed conventionally in terms of the latency of its major components which might be linked to abnormal perception of linguistic abilities.²

Despite decades of intensive research, the biological underpinnings of language based learning disabilities, affecting almost 10% of school aged children are not well understood.⁴

Various researchers have tried to establish association between speech sound perception and underlying neurological processes in normal and clinical population and suggested that speech evoked ABR provide an approach for establishing relationship between perceptual abilities and underlying central physiological processes.⁵

While substantial data have been obtained revealing how brainstem neurons encode simple acoustic signals like clicks and tones, little research has been done to assess the accuracy of brainstem representation of timing events for more complex signals such as speech and their efficacy in subjects with learning disability.

Song et al in 2008 tried to prove that brainstem timing deficits in children with learning disability may result from corticofugal origins. He described the early brainstem responses to speech in typically developing 8-12 year old children and children with LD. Moreover, the researcher found that children with LD showed abnormal components of the rostral speech-evoked ABR. The data was consistent with the view that the auditory deficits in the majority of the LD children with abnormal speech evoked ABR, originate from the corticofugal modulation of the subcortical acitivity.²

The present study had the following aims and objectives:

- 1) To establish relationship between click evoked auditory brainstem responses (ABR) and speech evoked ABR in children with LD.
- 2) To report whether speech evoked auditory brainstem responses can be used as a biological marker of deficient sound encoding in children with LD.

METHODS

Study design: Correlational study

Study place: The study was conducted at the Speech and Hearing Unit, Department of Otolaryngology, Head and Neck Surgery, Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh

Period: January 2017 to September 2017

Selection criteria

A total of 25 subjects in the age range of 5-12 years, diagnosed in the spectrum of learning disability (according to the International Classification of Diseases, 10th Revision: ICD-10) were referred from the out patient department of Psychiatry, Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh and were further evaluated based on the following inclusion and exclusion criteria.

Statistical tool: ANOVA

Inclusion criteria

Inclusion criteria were age range 5-12 years; diagnosed as learning disabled and having normal hearing sensitivity.

Exclusion criteria

Exclusion criteria were no history of middle ear infection, family deafness, ototoxic drug usage; IQ not less than 70.

Instruments

- National Institute of Mental Health and Neurosciences Index of Specific Learning Disabilities (Kapur et al 2002) originally developed by A. John (unpublished observation)
- Malin's intelligence scale for Indian children
- Pure tone audiometer was used to assess the behavioral thresholds, speech reception thresholds and speech discrimination scores of all the subjects.
- Immitance Audiometer was used to assess the middle ear function and to measure acoustic stapedial reflex of the subjects
- Click and speech evoked brainstem responses were measured with a computer based auditory brainstem response measuring system. The software used was the Smart Evoked System Version 2.1x of the Intelligent hearing system.

Both click and speech evoked ABRs were measured in individual ears at 90 dB nHL. Peaks I, III, V were identified for click stimuli whereas peaks V, A, B, C, D and E were identified for speech stimuli.

The following criterion was used for ABR abnormalities.

- 1) Wave I-III interpeak latency delay >2.4 msec
- 2) Wave III-V IPL Delay >2.2 msec
- 3) Wave I-V IPL Delay >4.4 msec

RESULTS

In the present study, speech evoked brainstem responses were measured in 25 children with learning disability.

Table 1: Speech recognition threshold and speech discrimination scores.

Group	Speech recognition threshold (right ear) in decibels	Speech recognition threshold (left ear) in decibels	Speech discrimination scores (right ear) in percentage	Speech discrimination scores (left ear) in percentage
Control	13.12	13.98	96.13	96.15
Study	14.21	14.12	95.88	96.01

Table 2: Latencies of waves in response to click stimuli of 90 decibels.

Waves	Latency in control group (Rt ear)	Latency in study group (Rt ear)	Latency in control group (Lt ear)	Latency in study group (Lt ear)
V	5.6	5.7	5.6	5.66
III	3.7	3.8	3.7	3.7
I	1.5	1.59	1.5	1.58

Table 3: Amplitudes of waves to 90 dB click stimulus in control and study group.

Waves	Amplitude in control group (Rt ear)	Amplitude in study group (Rt ear)	Amplitude in control group (Lt ear)	Amplitude in Study Group (Lt ear)
I	0.46	0.47	0.44	0.44
III	0.41	0.43	0.37	0.36
V	0.79	0.8	0.77	0.82

Table 4: Latencies of speech evoked brainstem responses.

Waves	Latency in control group (Rt ear)	Latency in study group (Rt ear)	Latency in control group (Lt ear)	Latency in study group (Lt ear)
V	7.21	7.44	7.17	7.43
A	8.38	8.5	8.34	8.51
В	19.39	19.6	19.47	19.62
C	28.28	28.35	28.29	28.34
D	37.57	37.61	37.6	37.7
E	46.77	46.94	46.76	46.94

Table 5: Amplitudes of waves to 90 dB speech stimulus in control and study group.

Waves	Amplitude in control group (Rt ear)	Amplitude in study group (Rt ear)	Amplitude in control group (Lt ear)	Amplitude in study group (Lt ear)
V	0.42	0.32	0.4	0.29
A	0.1	0.1	0.11	0.09
В	0.35	0.22	0.38	0.22
C	0.49	0.3	0.57	0.4
D	0.51	0.38	0.48	0.3
E	0.45	0.3	0.48	0.32

Air and bone conduction thresholds revealed no significant differences between the control group and the test group (p=0.7300) (p=0.7938).

Thus, there were significant statistical differences in the speech recognition thresholds (p<0.0001) and speech discrimination scores (p=0.0266) between the control group and the study group.

The interpeak latencies of waves I-III, III-V, and I-V were also calculated.

To conclude, there was significant prolongation of wave V latency in the right ears of the LD group. Moreover, a considerable prolongation of the wave III latency in the right ear of the LD group was also observed. However, no alterations were observed in the latency of wave I in both the groups. No interpeak latency differences in any of the ear of both the groups was observed.

There was also no statistical difference in the amplitudes of the waves in both the ears of control and study group. It is evident from the above table that there was statistically significant difference in the latencies of Waves V, B and E between the two groups.

To sum up, there was statistical significant reduction in the amplitudes of Waves V, B of right ear, C of left ear, D and E, of Speech ABR in children with learning disability.

DISCUSSION

The purpose of the present study was to report whether speech evoked Auditory Brainstem Responses can be used a biological marker of deficient sound encoding in children with learning disability. Auditory Brainstem responses for simple stimuli like clicks do not truly reflect how the speech is being encoded at the brainstem level and central level. Speech stimuli processing involves cortical analysis of the physical features of the speech signal. In this study, the relationship between brainstem encoding of click and speech signals in normal learning children and in those with language-based learning problems has been explored. This procedure may help in increasing the likelihood of early identification of language based learning problems and further consequent early intervention. The speech reception thresholds had significant elevation in the children with LD as compared to the normal subjects (p<0.0001). Furthermore, the speech discrimination scores of the study group were significantly poorer than that of the normal children (p<0.05). This finding is consistent with the study of Tallal and Piercy 1974 in which it was suggested that abnormal neural encoding of auditory information (verbal or nonverbal) appears to play a major role in the disruption of normal language skills. The results of these subjects were compared to the responses for normal children (referred here as control group)already established by Munish et al in 2008.8

In the control group, 50% of the children were in the age range of 5-9 years and 50% were in the age range of 9-12 years. In the study group, 9 subjects were in the age range of 5-9 years and 16 subjects were in the age range of 9-12 years

There was no observable difference in the tympanogram and stapedial reflex finding between the two groups. On the contrary, Thomas et al confirmed 32% of his subjects of LD group to be having abnormal contralateral and ipsilateral acoustic reflex thresholds.¹⁰

Click evoked ABR waveform analysis at 90 dB nHL revealed wave I, III and V to be presently consistently in all the subjects of both the groups. There was significant prolongation of Wave V Latency in the right ears of study group to 90 dB nHL click stimulation (p<0.05). A considerable prolongation of the Wave III latency in the right ear of the study group was also observed (p<0.05). Additionally, no alterations were observed in the latency of wave I in both the groups. There was no significant

difference in the interpeak latencies and amplitudes of waves in both the groups. These findings are in agreement with those of Kauni, who demonstrated that the latencies and interpeak latencies of the various peaks, to a click stimuli were not delayed in children with learning problems.¹¹

Furthermore, out of all the waves in response to Speech evoked ABR, only wave V originating from the rostral part of the brainstem was delayed in both the ears of children with LD. However, no statistically significant delay was found in the latency of the next wave "A" in children with learning problems. (p=0.21; p=0.13). However, Song et al in 2008 showed that early brainstem responses in children with LD (V and A) were delayed. They hypothesized that the auditory deficits in the majority of the LD children with abnormal speechevoked ABR originate from corticofugal modulation of the subcortical activity.²

Additionally, out of the next 4 waves, only B wave and E wave were consistently delayed in all the children having learning based problems as compared to the normal subjects. Hence, it can be inferred that there was a significant delay in the latencies of most of the components of speech ABR in children with LD. Moreover, it is to note that the presence of latency shifts demonstrates temporal processing abnormalities across multiple levels of the auditory system. On examining the amplitudes of the waves in response to the speech stimulus, a statistically significant reduction in the amplitude was observed for the waves V. D and E. However, there was also statistically significant decrease in the amplitudes of A, B and C waves but only in the right ears of the subjects diagnosed with learning disability. These data may indicate a specific relationship between temporal acuity in the auditory brainstem and cerebral asymmetry for speech sounds associated with auditory processing and learning ability. This may further correspond to the representation of the speech in the left hemisphere and may help us in unfolding the mechanisms responsible for language deficits. Our mentioned conclusions are in agreement with those of Wible et al who in 2004 demonstrated that speech auditory brainstem response (ABR) had a significantly shallower slope in LP children, suggesting longer duration and/or smaller amplitude.12

This poor representation of significant components of speech sounds could be due to synaptic efficacy distortion and poor synaptic transmission. Other reasons may be activation of fewer auditory nerve fibers or fewer neurons in the auditory brainstem in response to speech stimulus. Hence, error in encoding of speech at brainstem level as depicted by the current findings could be the possible reason for the language based problems of children of the study group. Also, these deficits may be attributed to poor neural recovery time in the children with learning based problems.

It can also be stated that if a neural system is more sensitive to the effects of desynchronization, this susceptibility will become more apparent in response to the speech stimulus.

Implications of the present study is that speech ABRs can help in early identification of children with learning problems and can serve to help organize the highly heterogeneous population of children with Learning Disability into more homogenous subgroups, at least with respect to the physiological correlates.

CONCLUSION

The speech evoked auditory brainstem responses can serve as an efficient tool in identifying underlying auditory processing difficulties in children with learning disability and can help in early intervention. Thus speech evoked auditory brainstem responses may help to determine when to refer a child to training and reduce the frustration of parents and educators from the uncertainty of outcomes.

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Ethical approval: The study was approved by the

Institutional Ethics Committee

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