Original Article

Mismatch Negativity (MMN) in children with Specific Language Impairment (SLI)

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ABSTRACT

Introduction: Mismatch Negativity (MMN) is an endogenous potential, which reflects the processing of difference occurring in the acoustic stimulus.

Objective: This work was designed to study the relationship between auditory processing and language deficits in children with specific language impairment (SLI) and compare their results with those of normal language development.

Patients and Methods: This study comprised 40 cases with SLI and 40 controls with normal hearing and language development in the age range 4-7 years. MMN was determined by subtracting the waves obtained by the stimuli 1KHz (frequent) and 2KHz (rare).

Results: There is no statistically significant difference between both groups regarding sex, chronological age, and IQ score. However, language age was statistically significant higher in the healthy controls than studied group ($p < 0.001$). All children in both groups had normal hearing. Phonological syntactic subtype of SLI was the most prevalent type in the study group. There was statistically significant difference in MMN latency and amplitude in SLI group when compared to normal control group ($p < 0.001$). Latency of MMN was more prolonged in SLI group than control group with lower amplitude in SLI group. Abnormal MMN test either abnormal latency or abnormal amplitude or both, was reported in 77.5% of SLI cases. Also, MMN was absent in 5 cases (12.5%) of SLI cases.

Conclusion: This data demonstrates that the language impairment in SLI children reflects underlying auditory processing deficits.

Key Words: Auditory processing, endogenous potential, language impairment, mismatch negativity.

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INTRODUCTION

(SLI) is defined by the National Institute of Deafness and Other Communication Disorders (2019) as a language disorder that affects the development of language skills in children with normal hearing and intelligence[1]. SLI exists despite normal speech motor skills, and no physical disability syndrome, or other medical causes known to cause language impairment in children[2].

It is difficult to determine the prevalence of SLI due to variability in the definition of SLI, the most trustworthy statistics, the prevalence rate of SLI is 7.4%, so SLI is one of the most childhood disorders[3].

The underlying mechanisms that cause SLI are incompletely understood, one major theory supposed that language deficits are secondary to auditory processing disorders affecting nonlinguistic and linguistic stimuli. Another hypothesis is that these children have impairment in processing brief or rapid input auditory or sensory stimuli[4].

Impairments in the auditory discrimination processes in children that is associated with deficits in timing, magnitude and topography of the neural activity, affect higher level processing of sound which is crucial for language development[5]. Mismatch negativity (MMN) is a signal produced by repeated auditory stimulation with an auditory stimulus(deviant) that differs in some way from frequent stimuli (the standard stimuli)[6].

MMN is an electrophysiological test that assesses the brain's ability to discriminate sounds independent of attentional or behavioral capacity. As a result, these auditory potentials hold promise for research into the neurophysiological basis of auditory processing[7].

The purpose of this study was to assess the discrimination of acoustic signals in children with (SLI) using MMN.

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PATIENTS AND METHODS:

Ethical approval for the current study was taken from the ethical committee in Menoufia University (number: 28419ENT 25, date: 28th April 2019).

Subjects:

This study was conducted between May 2019 to October 2020. The study group (SLI group) included 40 children in the age range of 4-7 years recruited from the Phoniatric unit, University Hospitals and were diagnosed as SLI according to the traditional exclusionary criteria for SLI[8&9].

The control group included 40 healthy children, with normal language development and in the age range of 4-7 years.

Methods:

All the children were submitted to:

A- Intelligence quotient (I.Q.) assessment: using Stand ford Binet intelligence scale[10].

B- Modified PLS (Preschool language Scale) Arabic edition[11].

C- Otological assessment

D- Audiological assessment:

• Play audiometry (children in the age rang 4-5years) or conventional pure tone audiometry (children >5years), including air conduction testing for the frequency range (250 - 8000)Hz and bone conduction for the frequency range (500 – 4000)Hz . Using r37a clinical audiometer and sound treated room model amplisilence S.P.A-10070.

• Tympanometry and acoustic reflexes (by GSI 38-Auto TYMP).

• MMN using Inter acoustic Eclipse 25: The auditory stimuli were presented in oddball paradigm. MMN was obtained by presenting acoustic stimuli1000 Hz tone (standard) and a2000Hz (deviant). Duration of each tone was (10 ms rise & fall time 30 ms plateau). Stimuli were presented at 70 dB SPL at a rate of 0.7 stimuli per second. Analysis time was (90 ms) pre stimuli and (630 ms) post stimuli. 1-30 Hz filter. The deviant tone occurred with a probability of 15 %. Children were kept awake by watching cartoon movies, they were told to ignore the auditory input and to focus their attention on the movie.

MMN was recorded by subtracting waveform obtained to stimuli presented as standards from those obtained to deviants. MMN was analyzed as regard its latency in msec and amplitude in µV.

Statistical Analysis:

Data were analyzed using SPSS, version 23.0, Armnok, NY: IBM Corp.

Qualitative data were expressed in: Number (N), percentage (%), while quantitative data were expressed as mean ($\overline{x}$), standard deviation (SD) Student's t-test and Mann Whitney's test were used for comparison of quantitative variables between two groups. Chi-square test (χ^2) was used to study association between qualitative variables. Pearson correlation was used to show correlation between two continuous normally distributed. $P > 0.05$ was considered significant.

RESULTS:

A) Demographic data, I.Q. assessment and language evaluation are demonstrated in (Table 1).

There was no statistically significant difference between the control and study groups regarding sex, chronological age, and IQ score. However, language age was statistically higher in healthy controls than SLI children.

B) Audiological evaluation:

All children in both groups had normal peripheral hearing.

C) MMN:

The latency and amplitude of MMN for the studied groups are demonstrated in (Table 2). MMN response was absent in 12.5% of SLI group. Abnormalities in SLI children were demonstrated in (Table 3). There was statistically significant difference between MMN latency, amplitude of both groups. SLI cases showed prolonged latency and lower amplitude than healthy controls.

There was statistically significant correlation between language age and MMN latency and amplitude. On the other hand, there was no statistically significant correlation between MMN latency and amplitude and chronological age (Table 4).

Table 1 : Comparison between studied groups regarding demographic data.?

Parameters	Controls no= 40		SLI cases no= 40		Test of sig.	*P value*
	n	%	N	%		
Sex:						
Male	19	47.5%	23	57.5%	X^2= 0.802	*0.370*
Female	21	52.5%	17	42.5%		
Chronological age (months):						
Mean ± SD	64.0 ±12.0		65.0 ±11.0			
Median	63.0		64.0		t= 0.104	*0.917*
Range	48.0 – 84.0		(48.0 – 84.0)			
Language age (months):						
Mean ± SD	64.0 ±12.0		42.0 ±11.0			
Median	63.0		41.0		t= -8.62	*<0.001*
Range	48.0 – 84.0		(24.0 – 72.0)			
IQ:						
Mean ± SD	91.5 ±1.9		91.2 ± 1.9			
Median	90.0		90.0		t= -0.691	*0.492*
Range	90.0 – 95.0		(86.0 – 95.0)			

No; number, SD; standard deviation, %; percentage, X^2= Chi-squared test, t; student t test, *p value*; probability value.

Table 2: MMN latency and amplitude of the study group (SLI) and control group.

Parameters	Controls no= 40	SLI Cases no= 35	Test of sig.	*P value*
MMN latency(ms)				
Mean ± SD	212 ± 28	330 ± 53	t=12.14	*<0.001*
MMN amplitude(uv)				
Mean ± SD	-2.53 ± 0.75	-1.20 ± 0.39	t=9.29	*<0.001*

t:student t test, *p value* :probability value.

Table 3: Abnormalities of MMN test in SLI cases.

MMN test	SLI cases N= 40	
	No.	(%)
Absent	5	(12.5%)
Latency		
Prolonged(≥268)	30	(75.0%)
Normal (156-268)	5	(12.5%)
Amplitude		
Low(≤ -1.03)	14	(35%)
Normal (-1.03 - -4.03)	21	(52.5%)
MMN test		
Abnormal	31	(77.5%)
Normal	4	(10%)
Absent	5	(12.5%)

This table shows the percentage of MMN abnormalities .Total abnormalities was 90 %, included absent and abnormal MMN.
NB: Any value beyond Mean ± 2SD from the control group was considered abnormal.
Abnormal MMN test either abnormal latency or abnormal amplitude or both.

Table 4: Correlation between chronological age, language age and MMN amplitude, and latency.

Parameters	MMN-Amplitude	MMN-latency
Chronological age	r= 0.1 *P value = 0.391*	r= -0.023 *P value =0.844*
Language age	r= 0.354 *P value = 0.037*	r= -0.582 *P value < 0.001*

r: Pearson correlation coefficient, *P value*: probability value

DISCUSSION

The discrimination of acoustic characters, such as frequency, is an important factor in language acquisition[12]. A lack of ability to discriminate phonemes is linked to difficulties learning new words, which is a common problem in SLI[13]. It has also been proposed that SLI results from deficits in auditory processing, but it is unclear whether this deficit affects temporal processing, frequency discrimination (FD), or both[14]. Gathercole[15] reported improper storage capacity for the verbal short term memory in SLI children. Few longitudinal studies are available in this area, so it is difficult to determine whether any deficit represents a developmental lag or more permanent impairment.

So the current study assessed MMN in children with SLI to assess their discrimination ability for difference in auditory stimuli. MMN also provides a measure for auditory echoic memory and the underlying neurochemical mechanisms[16]. The amplitude and latency of mismatch negativity (MMN) have been used to shed light on the nature of sensory memory. A clear MMN response indicates that a representation of the frequently occurring stimulus to which the deviant stimulus was exposed has been stored in sensory memory, also elicitation of MMN response indicates auditory processing at the level of auditory cortex[17].

The peak latency (measured in milliseconds) reflects neural conduction and processing time, whereas peak amplitudes (measured in microvolts) reflect the quantity of neural activation. Prolonged latencies and decreased amplitudes occur when the synchronous representations are compromised[18]. It is proposed that the MMN latencies provide information about the mental speed of auditory encoding. Because auditory information is time-related, mental speed is a crucial factor in language processing[19].

In the current study, MMN was clearly present in all children with normal language development. However, in the SLI group; abnormal MMN test; either abnormal latency, abnormal amplitude or both, was reported in 77.5% of SLI cases. Higher latency values and lower amplitudes were observed in the SLI group, compared to the normal group which reflects auditory processing impairment and neural impediment to discriminate difference in auditory stimuli. On correlation between MMN and language age: MMN latency levels were inversely proportional to the language age, but MMN amplitude levels was directly proportional to language age. So, the better the language age, the higher will be the amplitude and the shorter will be the latency of MMN.

These findings agreed with the findings of Rinker *et al*.[20], who discovered a frequency discrimination deficit in SLI children using two pure tones of different frequencies (700 Hz versus 750 Hz). Also, Rocha-Muniz *et al*.,[21] reported that the SLI group had prolonged latency values and lower amplitudes when compared to the normal control group on using speech stimuli with absent MMN in 16% of the SLI group.

According to our findings, language impairment in SLI children is induced by underlying auditory processing deficits. More research is needed to understand the processing mechanisms of SLI. MMN with different stimuli should be used in the study of children with SLI to investigate possible similarities and differences between these changes, as well as to investigate why only some of the children with auditory processing alterations develop language disorders.

CONCLUSION

Abnormal MMN parameters were elicited in children with SLI. Prolonged latency values and lower amplitudes were observed in the SLI group, compared to the normal group. So, the language impairment in SLI children reflects underlying auditory processing deficits.

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CONFLICT OF INTEREST

There are no conflicts of interest.

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