



# **Central Auditory Processing Functions in Learning Disabled Children: Electrophysiological and Behavioral Study**

Thesis

Submitted for the fulfillment of MD Degree in audiology

By

**Hebatallah Sherif Abd El Hady**

Masters of Audiology

Under the supervision of:

**Prof. Dr. Mohamed Tarek Ghannoum**

Professor of Audiology

Kasr Al-Ainy Faculty of Medicine

Cairo University

**Prof. Dr. Amani Ahmed Shalaby**

Professor of Audiology

Ein-Shams Faculty of Medicine

Ein-Shams University

**Prof. Dr. Abeir Osman Dabbous**

Professor of Audiology

Kasr Al-Ainy Faculty of medicine

Cairo University

**Prof. Dr. Ehab Ragaa Abd El Raouf**

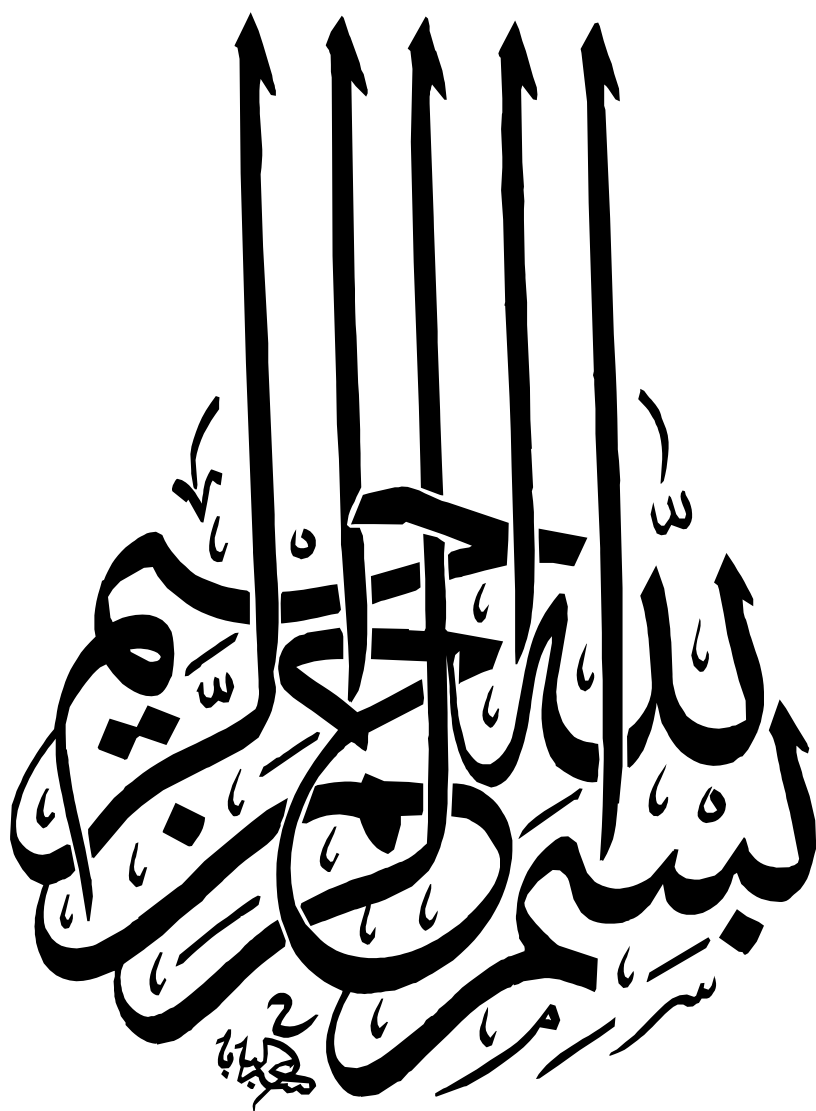
Professor of Genetics

National Research Center

Cairo, Egypt

Cairo University

2014



## **Acknowledgement**

At the beginning and endlessly my everlasting thanks is to **GOD**.

I would like to express my sincere gratitude, deepest appreciation to **Prof. Dr. Mohamed Tarek Ghannoum**, Professor of Audiology, Kasr Al-Aini Faculty of Medicine, Cairo University, for his valuable advice, meticulous supervision and guidance throughout this work.

I would like to offer my thanks to **Prof. Dr. Amani Ahmed Shalaby**, Professor of Audiology, Ein-Shams Faculty of Medicine, Ein-Shams University, for her valuable help, support and kind supervision.

I am very grateful to **Prof. Dr. Abeir Osman Dabbus**, Professor of Audiology, Kasr Al-Aini Faculty of Medicine, Cairo University, for her honest help, sincere support and scientific recommendations.

I would like to express my deepest gratitude to **Prof. Dr. Ehab Ragaa Abd El Raouf**, Professor of Genetics, National Research center, for his kind guidance, continuous encouragement and constructive supervision.

I would like to thank all the staff members and my colleagues at the Audiology unit, Cairo University and the National Research Center for their continuous support and help.

Lastly many thanks to my family specially my husband for their support and encouragement all over the work.

## **Abstract**

**BACKGROUND:** There is a high prevalence of auditory processing disorders in children diagnosed with learning disability; the deficits identified determine the appropriate management. So it is important to identify any auditory processing disorders in this population for optimum interventions so as not to compromise their learning process.

**OBJECTIVE:** To assess central auditory processing functions in children with learning disability through electrophysiological and behavioral testing, and to correlate between electrophysiological and behavioral test battery in learning disabled children.

**SUBJECTS AND METHODS:** The present study comprised 60 normal hearing children of both genders. Cases included 30 learning disabled children and the controls included 30 healthy children. Each group was further subdivided into three subgroups according to the age: Subgroup a: age ranging from 6-8 years, Subgroup b: age ranging > 8-10 years, Subgroup c: age ranging >10-12 years. All subjects were submitted to full history taking, otologic examination, basic audiological evaluation, central auditory processing testing and speech-ABR testing.

**RESULTS:** This study showed that the prevalence of CAPD in children with LD was 80 %. There were a statistically significant difference between the cases and controls regarding all the central tests except the LPFT and the youngest subgroup regarding the SPIN test. All LD children showed statistically significant delayed latencies of waves V, A and F in both ears in all tested subgroups, compared to their controls. Concerning the amplitude of the waves, there was statistically significant diminished amplitude of wave F in all tested subgroups in both ears when compared to their controls. In addition to a statistically significant decreased amplitudes of waves D and E in 6-8 years subgroup and waves C and D in 8-10 years subgroup. Wave F was the most common wave to correlate with the behavioral central tests especially SPIN, DDT and PPS tests, followed by wave E.

**CONCLUSION:** The high prevalence of auditory processing disorders in children diagnosed with learning disability suggests that central auditory processing disorder can be an underlying etiology for learning disability. Speech evoked response parameters were highly correlated with most of psychophysical tests in LD children, so it is a valuable tool in testing young children who are too young to perform the psychophysical test battery.

**KEYWORDS:** Learning disability, central auditory processing disorders, Speech evoked auditory brain stem response.

# Contents

	page
Acknowledgement .....	ii
List of Tables .....	iii
List of Figures .....	viii
Abbreviations.....	x
Introduction and Aim of the work.....	1
Review of literature.....	6
I) Learning Disability.....	6
Definitions.....	6
Incidence.....	7
Types.....	9
Etiology and Risk factors .....	14
Impact on affected individuals.....	14
Diagnosis.....	15
Assessment.....	17
Treatment and Intervention.....	18
Social Correlates.....	21
Contrast with other conditions.....	21
II) Central Auditory Processing.....	23
Central Auditory Abilities.....	24
Central Auditory Processing Disorders.....	30
Central Auditory Processing Disorders in children with LD.....	31
III) Speech Evoked ABR.....	33
Speech ABR.....	33
Factors affecting Speech ABR response.....	38
Speech ABR and Learning disability .....	45
Subjects and Methods.....	50
Results.....	62
Discussion.....	117
Conclusions.....	125
Recommendations.....	126
Summary.....	127
References.....	129
Appendices.....	148
Arabic summary	

**List of Tables**

<b>Table number</b>	<b>Title</b>	<b>Page Number</b>
Table (1)	Age distribution of the control and the study groups.	62
Table (2)	gender distribution of the control and the study groups.	63
Table (3)	IQ distribution of the control and the study groups.	63
Table (4)	Pure tone audiometric threshold (PTA) in dBHL at different frequencies for Rt and Lt ears in the control group.	64
Table (5)	Pure tone audiometric threshold (PTA) in dBHL in different frequencies for Rt and Lt ears in study group.	65
Table (6a)	Mean, Standard Deviation and 95% confidence interval of different central tests in subgroups Ia, Ib and Ic (of the control group).	66
Table (6b)	Prevalence of CAPD in study group.	67
Table (6c)	Prevalence of children with normal and abnormal central auditory tests.	67
Table (6d)	Comparison of the abnormal results among the 3 subgroups.	68
Table (7)	Comparison between subgroup Ia and subgroup IIa with regard to the different central auditory test scores.	69
Table (8)	Comparison between subgroup Ib and subgroup IIb in the different central auditory test scores.	71
Table (9)	Comparison between subgroup Ic and subgroup IIc in the different central auditory test scores.	73

Table (10)	Comparison between males and females to study the effect of gender on CAP test scores in children with LD.	75
Table (11)	Mean, standard deviation (SD) and t- test for comparison between Right and Left ear scores in CAP test of children with LD.	76
Table (12a)	Comparison among different age groups to study the effect of age in years on CAP test scores in children with LD.	77
Table (12b)	Comparison among different age groups using Post Hoc Test:	78
Table (13)	Mean, Standard Deviation and 95% confidence interval of the latencies (in msec) of Speech ABR waves in subgroup Ia, Ib and Ic of the control group.	79
Table (14)	Mean, Standard Deviation and 95% confidence interval of the amplitudes (in uV) of Speech ABR waves in subgroup Ia, Ib and Ic.	80
Table (15)	Mean, Standard Deviation and 95% confidence interval of the VA slope of Speech ABR waves in subgroups Ia, Ib and Ic of the control groups.	81
Table (16)	Comparison between subgroups a (6-8y) of the cases and controls with regard to the latencies (in msec) of Speech ABR waves.	83
Table (17)	Comparison between subgroups a (6-8y) of the cases and controls with regard to the amplitudes (in uV) of Speech ABR waves.	84
Table (18)	Comparison between subgroups a of the cases and controls (6-8y) with regard to the VA slope of Speech ABR waves.	85
Table (19)	Comparison between subgroups b of the cases and controls (8-10y) with regard to the latencies (in msec) of Speech ABR waves.	87
Table (20)	Comparison between subgroups b of the cases and controls (8-10y) with regard to the amplitudes (in uV) of Speech ABR waves.	88

Table (21)	Comparison between subgroups b of the cases and controls (8-10y) with regard to the VA slope of Speech ABR waves.	89
Table (22)	Comparison between subgroup c of the cases and controls (10-12y) with regard to the latencies (in msec) of Speech ABR waves.	91
Table (23)	Comparison between subgroup c in the cases and controls (10-12y) with regard to the amplitudes (in msec) of Speech ABR waves.	92
Table (24)	Comparison between subgroup c of the cases and controls (10-12y) with regard to the VA slope of Speech ABR waves.	93
Table (25)	Comparison between males and females to study the effect of gender on latencies of Speech ABR waves in children with LD.	95
Table (26)	Comparison between males and females to study the effect of gender on amplitude (in uV) of Speech ABR waves in children with LD.	96
Table (27)	Comparison between males and females to study the effect of gender on VA slope of Speech ABR waves in children with LD.	97
Table (28)	Comparison among the different age groups to study the effect of age in years on latencies (in msec) of Speech ABR waves in children with LD.	98
Table (29)	Comparison among the different age groups to study the effect of age (in years) on amplitudes (in uV) of Speech ABR waves in children with LD.	99
Table (30)	Comparison among the different age groups to study the effect of age (in years) on latencies (in msec) of Speech ABR waves in children with LD.	100



Table (31)	Comparison among different age groups using Post Hoc Test.	101
Table (32)	Mean, standard deviation (SD) and t- test for comparison between Right and Left ear parameters in Speech ABR test results of children with LD.	102
Table (33)	Correlation between subjective (CAP)and objective tests (latencies Speech ABR) in the RT ears of the control group.	103
Table (34)	Correlation between subjective (CAP) and objective tests (amplitudes of speech ABR) in the RT ears of the control groups.	104
Table (35)	Correlation between subjective (CAP) and objective tests (VA slope of speech ABR) in the RT ears of the control group.	105
Table (36)	Correlation between subjective (CAP) and objective tests (latencies of speech ABR) in the RT ears of the cases.	106
Table (37)	Correlation between subjective (CAP) and objective tests (amplitudes of speech ABR) in the RT ears of the cases.	107
Table (38)	Correlation between subjective (CAP) and objective tests (VA slope of speech ABR) in the RT ears of the cases.	108
Table (39)	Correlation between subjective (CAP) and objective tests (latencies of speech ABR) in the LT ears of the controls.	109

Table (40)	Correlation between subjective (CAP) and objective tests (amplitudes of speech ABR) in the LT ears of the controls.	111
Table (41)	Correlation between subjective (CAP) and objective tests (latencies of speech ABR) in the LT ears of the controls.	112
Table (42)	Correlation between subjective (CAP) and objective tests (latencies of speech ABR) in the LT ears of the cases.	113
Table (43)	Correlation between subjective (CAP) and objective tests (amplitudes of speech ABR) in the LT ears of the cases.	115
Table (44)	Correlation between subjective (CAP) and objective tests (VA slope of speech ABR) in the LT ears of the cases.	116

**List of Figures**

<b>Figure number</b>	<b>Title</b>	<b>Page number</b>
Figure (1)	Subcortical encoding of the syllable /da/.	38
Figure (2)	mean scores of central auditory tests in subgroup Ia and subgroup IIa of controls and cases respectively.	70
Figure (3)	mean scores of central auditory test in subgroup Ib and subgroup IIb of controls and cases respectively.	72
Figure (4)	mean scores of central auditory test in subgroup Ic and subgroup IIc of controls and cases respectively.	74
Figure (5)	Speech ABR waves in a normal child.	82
Figure (6)	Speech ABR waves in a learning disabled child (showing delayed waves).	82
Figure (7)	Comparison between subgroup Ia and subgroup IIa with regard to the latencies (in msec) of speech ABR waves.	85
Figure (8)	Comparison between subgroup Ia and subgroup IIa with regard to amplitudes (in uV) of speech ABR waves.	86
Figure (9)	Comparison between subgroup Ia and subgroup IIa with regard to the VA slope of speech ABR.	86
Figure (10)	Comparison between subgroup Ib and subgroup IIb with regard to the latencies in (msec) of speech ABR waves.	89
Figure (11)	Comparison between subgroup Ib and subgroup IIb with regard to the amplitudes (in uV) of speech ABR waves.	90
Figure (12)	Comparison between subgroup Ib and subgroup IIb with regard to the VA slope of speech ABR.	90

Figure (13)	Comparison between subgroup Ic and subgroup IIc with regard to the latencies (in msec) of speech ABR waves.	93
Figure (14)	Comparison between subgroup Ic and subgroup IIc with regard to the amplitudes (in uV) of speech ABR waves.	94
Figure (15)	Comparison between subgroup Ic and subgroup IIc with regard to the VA slope of speech ABR.	94

**List of Abbreviations**

<b>ABR</b>	Auditory brainstem response
<b>ADHD</b>	Attention-deficit hyperactivity disorder
<b>AFT-R</b>	Auditory fusion test–Revised
<b>CANS</b>	Central auditory nervous system
<b>CAP</b>	Central auditory processing
<b>CAPD</b>	Central auditory processing disorders
<b>CAS</b>	Central auditory system
<b>CD</b>	Compact discs
<b>CLD</b>	Cultural learning disability
<b>CTOPP</b>	Comprehensive test of phonological processing
<b>CV</b>	Consonant vowel
<b>DDT</b>	Dichotic digit test
<b>DSM IV</b>	Diagnostic and statistical manual of mental disorder 4 <sup>th</sup> edition.
<b>FFR</b>	Frequency-following response
<b>GDRT II</b>	Gray's diagnostic reading tests–2nd edition
<b>GORT IV</b>	Gray oral reading test IV – Fourth edition
<b>ICD 10</b>	International classification of disease (version 2010).
<b>IEP</b>	Individual education plan
<b>IPI</b>	Inter pulse interval
<b>IQ</b>	Intelligence quotient
<b>LD</b>	learning disability
<b>LP</b>	learning problems
<b>LPFT</b>	Low pass filtered speech test

<b>NJCLD</b>	National joint committee on learning disabilities
<b>NL</b>	Normal-learning
<b>PIQ</b>	Performance IQ
<b>PPS</b>	Pitch pattern sequence test
<b>PPD</b>	Pitch pattern discrimination
<b>PTA</b>	Pure tone audiometry
<b>RTI</b>	Response to intervention
<b>SES</b>	Socioeconomic status
<b>SLD</b>	Specific learning disabilities
<b>SPIN</b>	Speech intelligibility in noise test
<b>SRT</b>	Speech reception threshold
<b>TORCS</b>	Tests of oral reading and comprehension skills
<b>TORCS-3</b>	Test of reading comprehension 3
<b>TOWRE</b>	Test of word reading efficiency
<b>TIQ</b>	Total IQ
<b>VIQ</b>	Verbal IQ
<b>WIAT II</b>	Wechsler individual achievement test II
<b>WRAT III</b>	Wide range achievement test III
<b>WJ III</b>	Woodcock-Johnson III

## **Introduction**

Learning Disabilities (LD) are chronic difficulties in learning to read, write, spell, or calculate, which are believed to have a neurological origin. Though their causes and nature are still not fully understood, it is widely agreed that the presence of a learning disability does not indicate subnormal intelligence. Rather it is thought that the learning-disabled have a neurologically based difficulty in processing language or figures, which must be compensated for with special learning strategies or with extra effort and tutoring. Examples of learning disabilities include difficulty in reading (dyslexia), writing (dysgraphia), and mathematics (dyscalculia) (**Wright and Digby, 1996; Pandit, 2006**).

LD is associated with a variety of behavioral signs including oral language, reading, and writing deficits. These three domains require a common facility with speech sounds, whether realized as auditory processing, phonological decoding, or sound symbol translation. Therefore, the auditory processing capabilities of individuals with LD deserve scrutiny (**Norrix et al., 2006**).

Prevalence of auditory processing disorder in children diagnosed with LD is estimated to be as high as 30–50% (**King et al., 2002; Ramus, 2003**). Learning Disabilities are diagnosed when a subject's achievement on individually administered standardized tests in reading, mathematics or written expression is substantially below (defined as a discrepancy of more than 2 standard deviations from the mean) that expected for age, schooling and level of intelligence (**Iliadou et al., 2009**).