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THE REDUCTION OF AN AUDITORY CENTRAL PROCESSING DISORDER IN CHILDREN WITH DYSLEXIA USING THE BUFFALO MODEL

Waleed Fathi Abdulkarim

Faclty of Arts and Science, Northern Border University, Saudi Arabia.

Email: Mrwaleed.Abdulkaim @ gmail.com

ABSTRACT

Background: The central auditory processing disorder has a relationship with the incidence of dyslexia. Therefore, according to Buffalo's model, designing a number of training sessions in decoding, Tolerance-fading memory, auditory integration, auditory organization, may help in decreasing this disorder. Aims: This research seeks to prepare a training program to decrease the central auditory processing disorder, as well as to explore its effectiveness in decreasing the central auditory processing disorder. Methods: 32 childrens were identified as the final sample from 40 childrens in many schools in Rafha Province with an average age of 6.6 using the standard and validated scales. The quasi-experimental method revealed that after applying 32 sessions. Setting: A primary school in Rafha, Saudi Arabia. Results: There were statistically significant differences between the pre- and post-tests in favor of the post-test, as well as the continuity of the efficiency of the program after the follow-up term. Conclusion: The Buffalo's model is helpful in decreasing the central auditory processing disorder.

Keywords: *Buffalo, Dyslexia, Central auditory processing disorder, Rafha.*

INTRODUCTION

Central auditory processing implies the quality and effectiveness of the acousticinformation used by the central nervous system and the coordinationbetween the ears and the brain. Children with the central auditory processing disorder have difficulty in receivingand translating the signals into sounds, acknowledging the small distinctions between the phrases when the sounds are noisy enough to be heard (Heine and O'Halloran, 2015), knowing and understanding the sources of sounds, distinguishing between the sounds when race sounds have a background, after the fast speech, and/or when determining the sound source. These problems indicate the occurrence of an APD (auditory processing disorder) or a central auditory processing disorder (CAPD). In processing disorder, learning is hard mostly in reading and spelling (Moncrieff, 2017).
Due to the existence of a hearing sense with these childrens when they hear a tune or sound in ordinary instances, as well as the absence of unanimous definition or determination by scientists and professionals of immediate causes and clinical alternatives, core auditory processing is hard to diagnose and treat (Atcherson*et al.* 2013).
The lack of early identification of the central processing disorder will result in language delays and reduce the child's ability to speak (Bellis *et al*., 2012). This is clear from the performance

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of reading, math, and composition tests, where performance is much lower than expected for age and school (Sulaiman and Bamiou, 2010).

De Wit et al. (2016) analyzed 48 prior studies and referring to six databases, gathered the most significant characteristics of those with auditory processing disorder. These features include issues related to audio and visual performance, recognition, language, reading, physiological processes, and neurotic visualization because, despite the existence of the necessary degree of hearing sense, they cannot differentiate between the sounds of words.

There is a relationship between central auditory processing disorder and dyslexia, as it is the cause of learning difficulties within 3 out of 4 childrens suffering from central auditory processing disorder (Apola-Piorkowska, 2011). In particular, dyslexia is characterized by the inability to distinguish between the different sounds of spoken words, for example, they cannot recognize the word ' dog ' through its individual sounds or the harmony of those sounds (Raid 2016; British dyslexia, 2017).

Buffalo's model considervoice encoding as a basic component sincethe phoneme processing is carried out in the auditory cortex of the brain, a basic element in language and speech activity (Katz, 2016).

Buffalo's model consists of auditory progress, assembly, and differentiation in the context of noise, each of them covered a specific aspect of an auditory processing deficiency.

Therefore, the child's necessary ability to react includes decoding, Tolerance-fading memory, auditory integration, and auditory organization (Jutras *et al.* 2007; Katz, 2016).

Objective and purpose of the study

The objective of the study is to answer the following questions:

- Are there statistically significant differences between the average scores on the auditory processing questionnaire between the experimental and control groups in the post-test?
- Are there statistically significant differences between the average scores on the auditory processing questionnaire of the experimental group in the pre and post-test?
- Are there statistically significant differences average scores on the auditory processing questionnaire of the control group in the pre and post-test two months after the post-test?
- Are there statistically significant differences between average scores on the auditory processing questionnaire of the experimental group in the post-test and the follow-up tests?

LITERATURE REVIEW

Auditory processing disorder

Auditory processing disorder is described by BSA, 2018 as “the poor perception of speech and non-speech sounds. It has its origins in impaired neural function, which may include both the afferent and efferent pathways of the central auditory nervous system (CANS), as well as other neural processing systems that provide ‘top-down’ modulation of the CANS. These other systems include, but are not limited to vision and the cognitive functions of language, speech, attention, executive function, fluid reasoning, memory, and emotion. APD is often found alongside and may contribute to primary disorders of those systems. Thus, APD may include both auditory and cognitive elements”.

In a study (Sulaiman and Bamiou, 2010), the auditory processing disorder was tested on a sample of people who referred to auditory testing hospitals, although they had an ordinary hearing feeling. The findings showed that in samples aged between 18 and 60 years, the proportion reached up to 20%. Auditory processing disorder was regarded to be one of the most complicated issues. This implies trouble in organizing and representing sounds, particularly when speaking (Mehta and Arizona, 2017).

A number of indicators show that this disorder is associated with blows to the child's head or chronicle inflammations in the ear. There are also many other possibilities. So, each individual child's case should be diagnosed separately (Loo *et al*., 2013). Children should be examined by an otolaryngologist and a language and discussion expert, as well as having the required tests to verify whether the symptoms persisted until the era of seven or eight years old, in relation to their association with the core auditory processing disorder (Miranda *et al.* 2017). They suffer from issues such as auditory background, auditory memory, auditory distinction, auditory attention, and auditory consistency.

This appears when listening tasks are at the greatest stage, such as extracting responses from discussions, understanding puzzles, or understanding verbal mathematical issues. These concentrations involve a high level of auditory processing and language skills (Sahli, 2009; DeBonis, 2015; De Wit *et al.* 2016)

In addition, it is discovered that a deficiency in separate auditory processing could provide an autonomous basis for the rise in language problems among children (Halliday *et al*., 2017) on a sample aged between 8 to16 years.

It can be categorized as a developmental auditory processing disorder with normal hearing, acquired after pregnancy or any medical or environmental event, and secondary auditory disorder as a result of the breakdown of hearing sensation (Mehta & Arizona, 2017).

Auditory processing disorder in Dyslexic children

Dyslexia is the most significant disability experienced by children with auditory processing disorder (Reid, 2016) because they are more susceptible to reading problems, where the where the sounds in spoken language are unclear, which makes it hard for them to create an accurate representation of those sounds in their mind in order to translate them to a written text (Sharma *et al*., 2009) also, in spoken expressions, because the ability to ' decode ' is one of the most significant reading abilities (Westwood, 2013).

Lallier *et al.* studied 17 dyslexic childrens and 17 qualified readers for simultaneous auditory processing assignments and it was shown that simultaneous auditory processing can be impaired in dyslexic children (Lallier, *et al*., 2013).

Dyslexia relates to the Greek term, meaning the trouble of words. It has a distribution of about 2.8% of the population (Marzooq, 2014). It is neither an illness with medication nor due to low IQ, but it creates an unexpected gap between learning aptitude and the real level of accomplishment. It is not regarded to be a behavioral, psychological or social issue and is not linked to motivation (Tahir, 2016).

Dyslexia is not necessarily followed by eye problems, but it appears due to changes in the brain structure and functions because the individual exhibits all the neural connections to the brain centers responsible for vision, language, and memory, but at the same time he/she faces issues with the tasks of reading (Sartawi, 2001).

Dyslexia is classified in to acquired and developmental; acquired dyslexia occurs in adolescents who have prior learning to read, but the developmental dyslexia is a difficulty in learning skills for no known purpose (Reid, 2016).

The forms of dyslexia involve the spoken language, reading, and written language (Westwood, 2013; Reid, 2016; Miranda *et al.*, 2017).

Ferguson *et al.* (2011) made a comparison between the features of the children with language difficulties and those with the central auditory processing disorder using the parents' reports about communication, listening, and observing the behavior of the children with language weaknesses, in addition to the auditory processing disorder. They used IQ, memory, language, phonetics, literacy, and speech tests. The study found the absence of statistically significant differences between the performance of the students with language difficulties and those with the auditory processing disorder, where the performance of both groups was generally less than that of the normal group.

Abdul-Hadi, (2017) found statistically significant differences between the normal people and those with dyslexia in the speed of information processing, the performance of some executive, and social capacity.

Al-Semmadi *et al.* (2016) showed the existence of statistically significant differences between the experimental and control groups on the total auditory awareness scale, as well as all dimensions for the group that was exposed to the training program. There were also statistically significant differences in the school achievement (reading) between the individuals of the experimental and control groups and for the experimental one, it was attributed to the effect of the training program.

Dawes and Bishop (2010) compared children with APD diagnosis (N=25) to dyslexic children (N=19) in a set of standardized auditory processing, language, literacy, and non-verbal intelligence quotient measures, as well as parental communication and listening skills. Similarly, there were high levels of attention, reading, and language problems in both groups.

Buffalo Model

The Buffalo Central Auditing Model is the most basic category of speech decoding. The auditory cortex processing phonemes are essential for the brain's speech-language activities (Katz, 2016). The Buffalo model tries to answer the question, ' How can people process what they hear efficiently? or how to harmonize the brain with the ear. It relates to elements other than the fundamental functions of the central nervous system because any behavioral selection of speech or therapy requireslanguage and cognitive background understanding (Jutras *et al.*, 2007).

The Buffalo model investigates the auditory central processing in the following areas*:*

- Assessment of the hearing function by evaluating the efficiency of the right and left ears independently and then checking when they are working together. Thus, the performance in these two test types can be compared to see if there is a large distinction (the SSW test).
- Assessment of the child's capacity to differentiate between the speech sounds, the degree to effectively recall them, and then to recognize how these sounds are placed together in words. In 1-1.5 seconds, the phonemes (sound topics) are displayed and the person is requested to tell the created phrase (e.g.: father: dad). (Phonemic test of synthesis)
- Analysis of the child's ability to understand what he/she hears in a noisy background with the same ear, where the adapted duties in the noise are applied on each ear, and then, the

response to the same duty is recognized at a quiet background for the same ear (The speech-in-noise test) (Zalewski, *et al.*, 2010; Katz, 2016).

The Buffalo model suggests that the four following sub-items are the skills required for the correct response to each of the previous three sub-areas of each child:

- Decoding: This implies the capacity to comprehend speech accuracy and is linked to the brain's auditory cortex at the rear of the upper temporal lobe responsible for sound distinctions, phonemic memory, and auditory synthesis.
- Tolerance-Fading Memory: The word ' tolerance ' relates to the capacity of the child to comprehend speech in a loud context, and the term ' fading ' relates to the weakness of short-term auditory memory and the working memory. This is in the front of the brain.
- Auditory integration: This is linked to a cell corpus callosum in the brain that clearly shows a lower output of the left portion, which is clearly discovered among those with problems in reading and/or dictation (dyslexia).
- Auditory organization: It is associated with listening sequences, front times, and wall times in the same frontal areas, where the child seems to be willing to follow the correct direction. (Paul, 2008; Katz, 2016; 2017).

Jutras *et al.* (2007) conducted a retrospective study examining 178 documents of (C)APD children, of whom 48 have been kept for examination. They found that in the Buffalo Model categories, more than 80% of children could be classed; more than 90% were not classified as Bellis/Ferre model. The reason for this discrepancy is the fact that the Buffalo model's classification is based on a single key auditory test while the Bellis/Ferre Model classification utilizes a combination of the auditory test result.

METHODOLOGY

Participants

The study's final sample comprises of 32 childrens from 40. The experimental and control group included n=17 and n=15, respectively. Table 1 summarizes the equivalence in age, IQ, dyslexia, and auditory processing disorder. It indicates the equivalence of the children of the experimental groups in age, IQ, a score above the 15th percentile score on the dyslexia rating scale, and buffalo questionnaire of the central auditory disorder. The above Table demonstrates that the calculated Z-score reached 1.4, 0.4, 1.01, and 0.36, for age, IQ, dyslexia, and auditory processing disorder respectively, which are considered to be lesser scores than the marginal value 1.96. This indicates the lack of any statistically significant differences between the average ranked degrees, between the experimental and the control groups, prior to implementing the program.

Instruments

Raven’s IQ Test: This is one of the progressive matrices prepared by the psychologist John Raven in (1938). It is considered as a test of non-verbal intelligence, which is unaffected by any culture and depends on group application, but it also can be applied individually. It consists of three sections: A, AB, and B, each of which includes 12 items. It was prepared in order to provide the formula of the details of mental processes for the children aged five years and a half to eleven. Each item of the matrix consists of a basic shape with a part that has been

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cut it off, with six parts below, of which the subject has to choose the one that completes the shape.

Table1. Equivalence of the study samples.

		N	Mean	Standard Deviation	Mean rank	Sum of ranks	U Value	Z Value	Sig
Age	Experimental	17	8.8	1.1	17.7	266.00	79.00	1.4	No
	Control	15	8.2	.96	13.27	199.00			
IQ	Experimental	17	96.4	2.6	16.10	241.50	103.5	0.4	No
	Control	15	96.0	2.4	14.90	233.50			
Dyslexia	Experimental	17	71.2	3.7	13.90	208.50	88.5	1.01	No
	Control	15	72.9	3.8	17.10	256.50			
Auditory processing disorder	Experimental	17	120.2	4.5	15.1	250.50	90.6	0.365	No
	Control	15	115.4	4.6	19.1	290.50			

Colors were used as a background for the puzzles in order to make the test more interesting and exciting for the children's attention. The problem of part A depends on the ability of the subject to complete the progressive shapes and towards the end of the group, the progressive shape changes to have two dimensions at the same time. The subject's success in part AB depends on his/her ability to recognize the separate shapes in a whole one, based on space relation.

In part B, the solution of the problems depends on understanding the rule that controls the variables in the logically or spatially connected shapes, which require the individual's ability to abstract thinking. The late problems in parts B are just as difficult as that of the normal progressive matrices test. It is also considered as a test of high integrity and constancy.

Dyslexia Rating Scale (Al- Zayyat, 2007):

It consists of the formulation of a list of 20 draft items or phrases diagnosing Dyscalculia. The simple instructions are put in place, where teachers would respond to each draft item. Then, the responses are given weightings on a 4-point Likert scale, as follows: Always (4), Sometimes (3), Rarely (2), Never (1), where 20 and 80 represent the minimum and maximum degree, respectively to be scored by a student on the whole scale.

Validity is determined by calculating the correlation between the degree of every single item and the dimension to which it belongs. All correlation coefficient values were proved positive and indicative ranging from 0.76 to 0.18. In addition, the correlation coefficient values of the total score for each items ranged between 0.615 and 0.87. All these values are significant at 0.01. This makes us believe in the validity of the final scale. The reliability equation is calculated through alpha, resulting in the stability of 0.79, along with calculating the Guttman indivisible split-half technique. All items of the scale were proved to range from 0.701 to 0.880, which are all indicative values at 0.01. This confirms the stability of the final list.

Buffalo questionnaire of the central auditory disorder:

This scale consists of 48 phrases that precisely describe the behaviors indicating the existence of the central auditory processing disorder, as 144 is the highest degree to be obtained by the child. This degree indicates the existence of the disorder; whereas 48 is the lowest, that indicates the absence of the disorder in the child.

After carefully translating the questionnaire, the researcher consulted with 10 experts in psychological health and disorders to make sure that it was appropriate for the Arab World. He also sent out copies of the questionnaire to seven teachers to evaluate the understanding of the used terminology. The referees, as well as the teachers, accepted all the items of the scale.

The constancy was measured by repeating the application on 30 childrens, indicating an acceptable amount of integrity and constancy. The researcher also considered structural integrity by using lateral comparison at 27% as the lowest degree to be obtained by the child. It was also found that the relationship is functional at 0.01.

Description of the current program:

The following is a description of the procedures and steps followed by the researcher to achieve the main objective of the research.

- After obtaining the principal's consent, the agreement was reached on all the program information, the number of meetings, and the related tasks required of the school administrative boards. Then there was a room with several resources. Special approvals were acquired from the learners' parents throughout the session.
- Content: The researcher followed the aims and recommendations for those with learning difficulties, through the Ministry of Education, Kingdom of Saudi Arabia and dealing with their age. Then, he started to develop a group of auditory central processing activities. Table 2 shows the distribution of the teaching plan for the program.

Table 2. Distribution of the teaching plan for the program.

Skills	No. of Sessions
Decoding Activities	8
Tolerance-fading memory Activities	8
Auditory integration Activities	8
Auditory organization Activities	8
Total	32

Program Strategies Applied

- Warm-up: Where the objective is described in the teaching method and where the lesson is related to previous experiences.
- Modeling: The instructor provides a model of mental processes that create auditory problems and provides many new and varied solutions.
- Reinforcement: Teacher participation with the student: This step is taken when the teacher feels that the technique of modeling and observation is difficult.
- Homework: Each student does the exercises he did but at home for another auditing problem.

- Assessment: When the teacher asks a question about the student's performance and the strengths and weaknesses to be determined.

Study Application Procedures

Following these steps, the scientists completed preparing the iPad products and preparing the research instruments in their final forms:

- The appointment of the sample primary schools.
- Raven's IQ test, dyslexia-rating scale, the Buffalo central-auditory disorder questionnaire were conducted after their teacher nominees had been appointed at the four elementary schools of the Province of Raphael.
- Divided by random means study and control into two groups (see Table 3).
- The experimental and control samples were pre-tested with a central auditory disorder Buffalo questionnaire as the main tool for the studies before the implementation of the program.
- Implementation of the program. The time allotted was 28 and 45 minutes for each session. Four sessions were held a week.
- The experimental and control post-test was carried out on the topics of the samples of the two groups immediately after the program was finalized by re-applying the Buffalo questionnaire of the central auditory disorder.
- Carrying out suitable statistical procedures to investigate the study questions.

The study design

This research had two variables, a semi-experimental: an independent variable and a dependent one. Pre/post/follow-up tests were followed by a layout of the control and experimental groups (Table 3).

Table 3. The study design.

The groups	Pre-test	procedure	Post-test	Follow up test
Experimental	Buffalo questionnaire of the central auditory	Teaching by Auditory activities	Buffalo questionnaire of the central auditory	Buffalo questionnaire of the central auditory
Control	Buffalo questionnaire of the central auditory	Teaching by using the traditional method	Buffalo questionnaire of the central auditory	

Study variables: the current study consisted of the following variables:

- Independent variable: the program.
- Dependent variable: Reducing auditory processing disorder.
- Results were analyzed using an equivalent group method to determine the effect of the

independent variable on the dependent variable. The study used a group of statistical methods to analyze the results:

- Correlation, medians, means, and standard deviation
- T-test to find out the significant differences between the means

RESULTS:

-The differences in the post-test.

To test this hypothesis, the two groups were compared using the T-test for the comparison of the experimental and control groups as shown in Table 5.

Table 4. Differences between the experimental and control groups in the post-test.

Tools	Groups	No.	Means	Standard Deviation	Degree of Freedom	T Value	Significance Level
Auditory Rating Scale	Pre	17	63.41	4.38	30	27.3	0.00
	Post	15	105.66	4.33			

Table 4 shows the existence of statistically significant differences at (0.1) between the experimental and control groups on the questionnaire of the central auditory processing in the post-test.

-Differences of the experimental group in pre- and post-test.

To test this hypothesis, the two groups were compared using the T-test to evaluate differences between pre- and post-tests in the experimental group as shown in Table 5.

Table 5. Differences between pre- and post-testsin the experimental group.

Tools	Groups	No.	Means	Standard Deviation	Degree of Freedom	T Value	Significance Level
Auditory Rating Scale	Pre	17	107.23	5.15	16	85.78	0.00
	Post	17	64.35	4.47			

Table 5 shows the existence of statistically significant differences at (0.1) between the averages of pre- and post-tests for the experimental group, which indicates the rejection of the zero hypothesis and the acceptance of the alternative one, which is the existence of a statistical significance between the pre- and post-tests.

-The differences between pre- and post-tests in the control group two months after the post-test.

T-test was used to compare the pre and posttests.

Table 6. Difference between the pre- and post-tests for the control group.

Tools	Groups	No.	Means	Standard Deviation	Degree of Freedom	T Value	Significance Level
Auditory Rating Scale	Pre	15	104.33	3.73	28	.759	0.43
	Post	15	105.46	4.08			

Table (6) shows the absence of statistically significant differences between the pre- and post-tests for the control group, which indicates the acceptance of the zero hypothesis.

-The differences for the experimental group in the post and the follow-up tests.

Table 7. Differences between the post and follow-up tests for the experimental group.

Tools	Groups	No.	Means	Standard Deviation	Degree of Freedom	T Value	Significance Level
Auditory Rating Scale	Post	17	64.35	4.47	32	1.70	0.25
	Follow	17	62.64	3.99			

Table 7 shows the absence of statistically significant differences between the post and follow-up tests for the experimental group, which indicates the acceptance of the zero hypothesis.
Figure1 shows the performance improvement in the experimental group after the training program sessions by comparing the averages of pre, post, and follow-up tests, indicating the effectiveness of the proposed program in reducing the central auditory processing disorder.

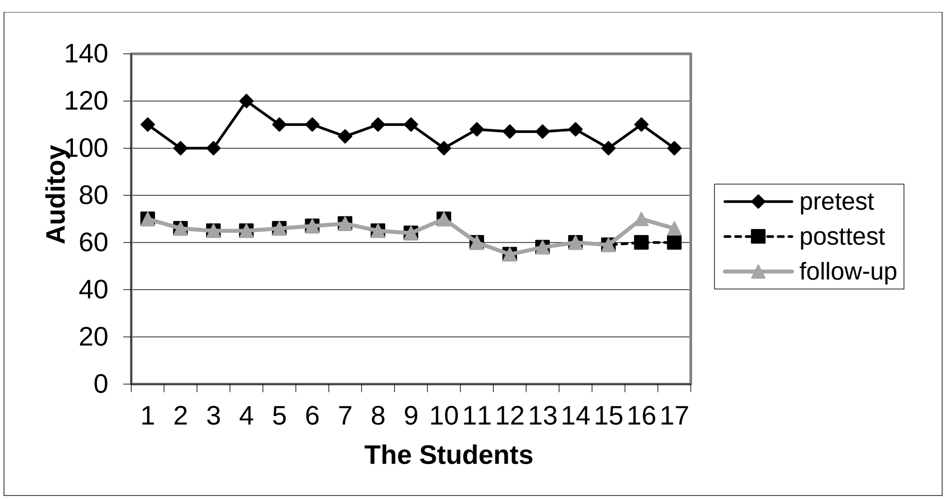

Figure 1. Differences between the pre, post, and follow-up tests for the experimental group.

DISCUSSION

The current research project aimed at testing the efficiency of the Buffalo program in reducing the central auditory processing disorder in children with dyslexia in Rafha Province, KSA. This was done through the comparison of the results of the experimental and control groups. The results in Tables 4, 5, 6 and 7 show the existence of statistically significant differences between the two groups after (32) sessions.

These results agree with what was presented by in literature review and the previous studies (Osman, 2009; Marzooq and Al-Qarioti, 2010; Al-Masri *et al.*, 2016; Al-Semmadi *et al.*, 2016). The researcher clearly observed the high marks of the experimental and control groups on the questionnaire of the central auditory processing disorder at the stage of pre- and post-tests.

This can be explained according to what the previous local and international studies stated the fact that people with dyslexia suffer from the central auditory processing disorder in comparison to their normal peers (Sulaiman and Bamiou, 2010; Ferguson *et al.*, 2011; Nagao *et al.*, 2016; Halliday *et al.*, 2017), which makes it necessary to deal with a great care with the central auditory processing disorder.

The researcher also thinks that there is a number of factors that led to achieving the goals of the program. Among these is the school environment that was carefully prepared for the sessions of the program, as well as the existence of various audio stimulants that promoted the child's right response.

Individual differences were been considered through the division of the program sessions into three graded levels according to their difficulty, in order to suit the child's abilities.

It was also found that the central auditory processing disorder affects the child up to the age of going to university, which reduces the chances of his/her success and motivation and therefore, his/her learning outcome (Wilson *et al.*, 2013; Marzooq, 2014)

The application of the program showed statistically significant differences between the experimental and control groups on all items of the questionnaire of the central auditory processing disorder, as the researcher observed an improvement in the performance of the experimental group, which could be attributed to the developmental interpretation of learning difficulties, taking into account the characteristic of human development. This is what the current program involved as it presented sessions, which included suitable activities for the abilities and interests of each child. It also applied the program sessions in a gradual and varied way in order to suit the child's aptitude. Therefore, the current program agrees with the developmental trend in the interpretation of learning difficulties and considers in its content (Tahir 2016; Al-Masri *et al.*, 2016; Al-Qubali, 2017).

Figure 1 demonstrates the continuity of the efficiency after eight weeks and emphasizes the efficiency of the program based on Buffalo Model in the amalgamation of the central auditory processing disorder. This was found from the absence of statistically significant differences between the post and the follow-up tests for the experimental group. In this study, the necessity of supporting and promoting the role of family in the reduction of central auditory processing disorder as well as early interference to discover children with the central auditory processing disorder was proved.

CONCLUSION:

The current program, based on the Buffalo Model, contributed to reducing auditory central processing in children with dyslexia. That was carried out by introducing a variety of tasks, contributed to facilitating the extraction of the form and meaning of words, as well as the facilitation of using structures of multiple shared meanings and relations, which helps produce a linguistic signal that shows a proper response in a situation.

Conflict of interest

The researcher has no conflict of interest.

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