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The Effectiveness of Attention Facilitator-Inhibitor Rehabilitation on Executive Functions and Visual Perception of Children with Learning Disorder on the Basis of Integrated SNP/CHC Model

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Abstract

Executive functions and visual perception are variables that play important roles in learning and educational improvement. Therefore, the aim of this study was to investigate the effectiveness of attention rehabilitation on executive functions and visual perception of students with learning disorder and the study was of quasi - experimental type with pre-test, post-test and control group. The statistical population included all elementary school students in Rafsanjan in the second semester of 2018. The sampling method was multi-stage cluster method and the statistical sample of research involved 20 students with specific learning disorders, selected and replaced by a simple random method in two groups of experiment and control groups (2 groups of ten). The research tools were the visual perception test of Frostig and the Wisconsin cards. After performing pre-test on both control and experimental groups, the experimental group was trained using Captain Log software for 12 session, and at the end, the post-test was performed on both groups. The data were analyzed using SPSS v.24 software and statistical analysis of covariance (MANCOVA). The results of statistical analysis showed that attention facilitator rehabilitation is effective in improving students' ability in visual perception test. Also, the results revealed that rehabilitation of attention can significantly improve the performance of children with learning disorder in the executive functions.

Keywords: Cognitive rehabilitation, executive functions, learning disorders, visual perception

Introduction[#]

Learning is a fundamental process based on which the pre-disabled existence, with time and interaction and physical development, achieves a high level of cognitive and thought abilities. High diversity of learned material and the range of learning time develops differences among people in learning. But despite these differences, some people are experiencing difficulties in the normal process of learning and have a learning disability (Bagheri, Mohammadifar, & Mahdinezhad Gorji, 2015). Learning disorders are one of the greatest problems in the educational system, family and generally society. That is because the disadvantages of these disturbances are not only summed up in a particular educational field and the damage is far more widespread. Previous studies indicate that learning disorder in one or more specific fields, in addition to disrupting the academic achievement, is related to issues such as early dropout, and failure in career and hence economic dependence on others, and creating emotional and behavioral problems, low self-confidence and low self-esteem of the child (Estaki, Koochak Entezar & Zadkhoot, 2016).

Common approaches to define, diagnose and treat learning disorders can be identified mainly in three directions: 1) Definition and diagnosis based on the mismatch between intelligence and educational

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performance. 2) Definition and diagnosis based on the "Response to Intervention" method. And 3) Definition and diagnosis based on school neuropsychological models (Miller, 2013). Traditional definition of learning disorders, also called "difference approach", considers these disorders a state in which the child has natural intelligence, but the level of academic achievement is not consistent with the level of intelligence and is lower than expected level (Alipour & Amini, 2017; Hasani Rad, Arjomandniya & Bagheri, 2016; Oraki & Heydari, 2014). It is true that paying attention to the intelligence agent for detecting specific learning disorders is always necessary, but reliance on intelligence factor, and the difference between achievement level in school and intelligence level has been criticized e.g. there is no theoretical agreement between the various dimensions of academic and intellectual performance**.** Also, the fact that this approach assumes intelligence as an integrated construct, which can be measured by considering the individual's achievements, is criticized (Toffalini, Giofrè, & Cornoldi, 2017). The 'response to intervention' is the second approach that has been developed since 2006 in the assessment and treatment of learning disorders. According to this approach, people who do not show proper functioning in academic fields in contact with the normal level of education specifically receive more but common training in smaller groups, and are detected as children with learning disorders if they do not recover. Despite the support provided for it, the response to intervention model has a weak point: and it is that this model regards external factors, including classroom environment and type and degree of training, and it did not care about the underlying cognitive factors of learning disorders (Miller, 2010). One of the most recent models in the assessment and treatment of learning disorders is the school neuropsychology model (SNP) that was developed by miller in 2007. And in 2013, in conjunction with some theoretical categories of the Cattel- Horn- Carroll or "CHC" approach, this model was presented as the SNP / CHC model (Miller & Maricle, 2015; Miller, 2013; Philips, Longoria, & Downing, 2015). In supporting this model it can said, that the most comprehensive views of intelligence, in addition to looking at intelligence as a general factor, also believe in a number of dedicated factors as subsets of this general intelligence (Shahabi, 2016). Studies involving children with specific learning disorders have also shown, despite that these children are in general intelligence at the normal level, they suffer from problems in a number of specific factors and sub–categories. These problems include defect in attention , working memory and processing speed (Amani, Fadayi, Tavakoli, Shiri, & Shiri, 2017; Cornoldi, Giofre, Orsini, & Pezzuti, 2014; Eqlidi, Koobasi, Nejati & Tabatabai, 2013; Moshiriyan Frahi, Zarif Golbar Yazdi & Amin Yazdi, 2016; Peng & Fuchs, 2016; Zolfaghari, 2014). Based on this approach, recent models used to diagnose and treat learning disorders have come up with new theoretical foundations that consider different aspects of intelligence as the underlying factors that cause different types of learning disorders (Poushneh, Shafie far & Tavakoli Toroqi, 2012). CHC is a theory that focuses on different aspects of cognitive and educational capabilities, and has gained the greatest empirical support in describing cognitive structures (Mohammadi, Delavar, Farokhi, Minaie & Alizadeh, 2017). And a number of new theories in the diagnosis and treatment of learning disorders are derived from this theory (Poushneh et al, 2012). On the other hand, as stated, the school neuropsychology model was first introduced by Miller in 2007, and was presented in 2013 in conjunction with some of the theoretical categories of Cattel - Horn - Carroll's approach as the SNP / CHC model (Miller & Maricle, 2012, Miller, 2013). This model has attracted attention because of the special attention given to the cognitive underlying factors of learning disorders in the diagnosis and treatment process of these disorders (Miller, 2010; Miller, 2013; Philips et al, 2015). The SNP / CHC model that is a modern model of brain functions, show that neuropsychological function can be investigated by assessing four broad areas of cognitive functions: such as cognitive facilitating/inhibitors, sensory motor functions, cognitive processes, and knowledge obtained (Fournier, 2014; Hendricks, 2014).

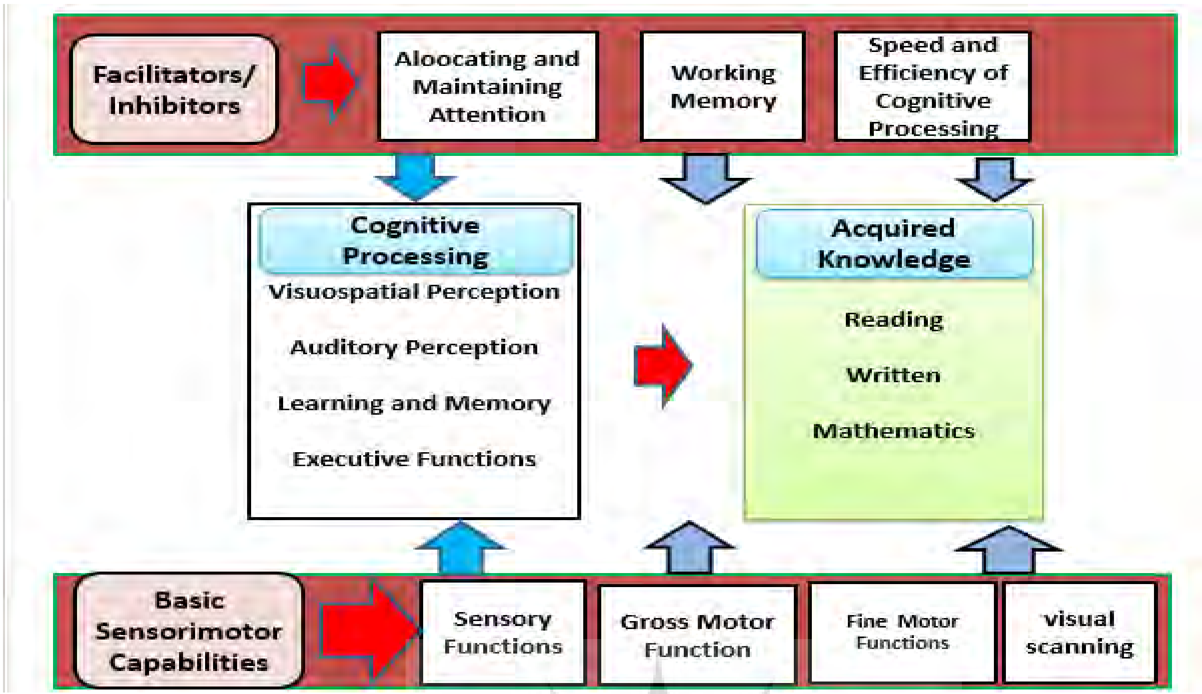

Figure 1.
Integrated SNP/CHC Model

In this model, attention processes, working memory and processing speed are identified as facilitators-inhibitors of all basic cognitive processes such as visual perception, visual reasoning, auditory perception, auditory reasoning, executive functions, temporal memory and long-term memory. Also, attention processes, working memory and processing speed as facilitators are considered to be effective in improving acquired knowledge such as reading, writing, and math (Miller, 2013). As mentioned, visual perception is known as one of the basic cognitive processes in this model that are influenced by facilitators-inhibitors (Benners, 2017; Miller, 2013; Rouse, 2014). Vision is one of the sensations that play a significant role in the student's learning process. Visual perception involves a process in which the information received from the visual senses is analyzed. Visual perception causes a person to have a right perception of shape, size, color, and spatial relationship (Garmabi, Adib Sereshki, Taheri, Movaleli, & Seyyednouri, 2016). Weakness in the visual perception is effective in the emergence of learning disorders in students (Vatan Doost, Abedi, Yar Mohammadiyan, & Rezapour, 2013). In a study called as "comparing the visual-movement perception of normal students and children with a learning disorder in the Gestalt test", the results showed that there is a significant difference in visual perception among children with learning disorder and normal children (Nazari, Siyahi, & Afrooz, 2013). Also, Hasani Rad et al. (2016) in their study entitled "Comparing the visual perception skills and the selective attention of elementary school students with and without learning disorders" came to the conclusion that students with a reading disorder demonstrate a lower performance in all five sub–tests of Frastig test. According to the SNP/CHC model, the other underlying cognitive process that can affect learning disorders is executive functions (Miller, 2013). The executive functions generally consist of cognitive processes based on target behavior, and are associated with activity within the frontal cortex (Best & Miller, 2010). These functions involve complex planning of behavior and problem solving, and they are involved in many of the individual's daily activities (Khalfi, 2015), and they manage the cognitive processes that students use in the classroom environment to perform tasks and homework activities. In fact, these functions are known as a collection of cognitive capacities that act in a coordinated manner to guide students' actions in an organized, strategic and purposeful process (Rosen, Boyle, Cariss, & Forchelli, 2014). According to the past researches, the executive functions of children who have learning disorders are weak (Aminayi & Mousavi Nasab, 2014; Narimani & Soleymani, 2013).

According to what was said earlier, in the SNP/CHC model, the range of cognitive facilitating/inhibitors are considered to be made from attention, processing speed and working memory, that operate in coordination to enable or limit basic cognitive processes in creating knowledge such as visual perception and executive functions (Fournier, 2014). One of the facilitators/inhibitors is the attention variable that works as a base for all higher order processes (such as visual perception, language skills, memory, and learning). Therefore, considering the importance of basic cognitive abilities such as visual perception and executive function in children's educational ability, and the results of previous researches that show, improving these basic processes can be effective on improving the children's learning problems, finding a way to promote these abilities seems necessary. This study sought to answer the question of whether rehabilitation of attention, which is identified as a facilitator of cognitive processes, can influence the improvement of visual perception and executive functions.

Method

The research method was of quasi-experimental kind with pretest-posttest and control group.

Participants

The statistical society of this study consisted of all 7-9 years old students with a variety of learning disorders that were studying in elementary schools in Rafsanjan in the second half of 2018. Among these students, 20 students were selected with a multi-stage cluster sampling method and were assigned to two groups of 10 students as Intervention and control group. Group matching was done based on age, gender and physical and mental health. It should be noted that the condition of entrance to the study was consisted of natural intelligence quotient, gender, age of 7 to 9 years and parents' conscious consent about the presence of children in the study. The condition of departure from the study was the absence of more than two sessions of the training sessions. Among the ethical conditions that was respected in the study, it can be referred to the confidentiality of information and freedom in entering into the study.

Instruments

1. Wisconsin Card Sorting Test (WCST): In the software version of the Wisconsin cards, 64 cards are presented to the individual. On each card, there are 1 to 4 shapes of stars, circles, triangles, and plusesthat are displayed with one of the colors of red, green, yellow or blue. There are four main cards on top of the screen, a red triangle, two green stars, three yellow pluses and four blue circles, respectively. The Individual should place each of the cards based on one of the rules (color, shape, number of cards) below the original card, and based on the feedback that the software provides, determines that this choice is correct or incorrect. After discovering any rule, the individual must give 10 correct answers in order to change the rule. The experimenter would have to give the necessary explanation to the individual before testing, and not give a guidance during the conduct of the examination (Khodadadi, Shahgholiyan, & Amani, 2014). The Cronbach's alpha coefficient reported by the developers of the software version of the test has been reported 0/73 for the finished floors, and 0/74 for the stay error (Shahgholiyan, Azad Falah, Ashtiyani, & Khodadadi, 2011)

2. Test of visual perception: The test was developed by Frastig in 1963 as a tool that identifies the visual perception disabilities. The results of this test show that this test is suitable for measuring the visual perception of children aged 4 to 10 years old (Mousavi & Tabrizi, 2013). The test of visual perception of Frastig has five sub - tests:

A. Eye Motor Coordination: The test has 16 questions that include these three forms: 1) Drawing the straight line between two parallel lines without removing the pen, 2) Drawing the line between two curved and angled line, and 3) connecting two or three points from right to left without removing the pen. The maximum score that can be obtained in this subtest is 30 points.

B. Detecting the shape of the field: This test consists of eight questions that are presented in two parts A and B, and the child should be able to identify and highlight the various shapes in the fields that are presented. The questions of this test gradually become more complicated. The maximum score that can be obtained in this subtest is 20 points.

C. Shape stability: The test has two parts A and B. In this test, a set of geometric shapes are presented in different sizes and fields, and the child must find the desired shape on the screen and highlight the lines of it. The higher are the number of diagnosed shapes, the better is the child's score. The maximum score that can be obtained in this subtest is 17 points, that 9 of which belong to Form A and 8 to Form B.

D. The detection of status in space: There are eight questions that are presented in two sections. In the first section, a number of shapes are shown to the child, one of which is different from the others. In the second part, five shapes are presented in a row to the child, and the child is asked to identify the shape that is similar to the first. The total score that can be obtained for this subtest is 8 points. This means that the child gets 1 point with each correct answer.

E. Spatial relations: The test has five questions asking the child to link the points that are on the right side of the image, similar to the left side of the image. The maximum score in this subtest is 8 points. It means that depending on the accuracy of the drawn shape by the child, a score of 0 or 1 was awarded to the child for each question.

The obtained reliability coefficient of the test is 0/69 to 0/98 for the total score with the re-test method, and 0/29 to 0/80 for sub–tests. Also, according to the two halves test method, the reliability coefficient for this test is 0/78 to 0/89 for the total score, and 0/35 to 0/96 for the sub-tests. The results reported the internal consistency of 0/98 (Hasani Rad et. al, 2016).

Procedure

After referring to the education department of Rafsanjan and obtaining a list of girls' Elementary schools, three schools were randomly selected. After gaining permission from the provincial education department to enter the schools, the school's teachers introduced 37 students as children with learning disorder. After performing the test that the experimenter and the teachers had designed to identify the students with learning difficulties, 20 of them were selected in terms of grade. After administering the Wechsler test on all of them, and implementing the Key-Math test on children with math disorder and the Nema test on children with reading and writing disorder, they were randomly assigned to experimental and control groups. The unification of groups was done based on age, gender, and physical and mental health. In both experiments and control groups, the Wisconsin Cards Sorting Test and Frastig visual perception tests were implemented. After that, using the Captain Log software, the games related to the types of attention, including selective attention, focused attention, continuous attention, and … were performed on the test group. The number of training sessions included twelve sessions of forty-five minutes for each child individually. Then, using a post-test of both groups, the effectiveness of attention rehabilitation on visual perception and executive functions of children was assessed. Finally, the obtained data were analyzed using the version 24 of SPSS software, and by covariance analysis (MANCOVA).

Findings

In order to know the descriptive information of the research, the mean and standard deviation for each of the study variables were investigated. Table 1 summarizes the mean and standard deviations of the data in the visual perception variables and executive functions.

Table 1.

The Mean and Std Error of the Pre-test and the Post-test of Visual Perception and Executive Functions

Variables	Subtests	Groups	Mean and std error in pre-test	Mean and std error at post-test
Visual perception	General visual perception score	Intervention	55/10 ± 2/21	71/90 ± 0/87
		Control	56/80 ± 2/04	57/40 ± 2/12
Executive functions	Staying error	Intervention	9/40 ± 0/70	3/90 ± 0/58
		Control	8/50 ± 0/56	8/80 ± 0/53
	Correct responses	Intervention	30/80 ± 1/39	36/20 ± 1/14
		Control	30/30 ± 0/95	30/60 ± 1/43
	Number of completed floors	Intervention	2/90 ± 0/27	5/40 ± 0/22
		Control	2/70 ± 0/21	4 ± 0/47

According to the above table’s data, the mean of both the visual perception and executive functions in post-test of the intervention group differed from the pre-test. In the general visual perception, the mean was 55/10, which has increased in post-test to 71/90. In the executive functions, the staying error in post-test (3/90) shows the mean's reduction comparing to pre-test (9/40). Also, the mean of post-test in the correct responses (36/20), and number of completed floors (5/40) increases comparing the mean of these tests in pre-test. The results of Shapiro-Wilk Test for visual perception and executive functions are presented in table 2, in order to investigate the statistical variables homogeneity.

Table 2.
Results of Shapiro Test in Visual Perception and Executive Functions

Variables	Subtests	Groups	Test	Value
Visual perception	General visual perception score	Intervention	Pre-test	0/36
			Post-test	0/38
		Control	Pre-test	0/14
			Post-test	0/84
Executive functions	Staying error	Intervention	Pre-test	0/25
			Post-test	0/06
		Control	Pre-test	0/63
			Post-test	0/51
	Correct responses	Intervention	Pre-test	0/054
			Post-test	0/65
		Control	Pre-test	0/70
			Post-test	0/46
	Number of completed floors	Intervention	Pre-test	0/08
			Post-test	0/09
		Control	Pre-test	0/06
			Post-test	0/34

Results of the Shapiro-Wilk Test show that the significance level obtained for the distribution of the visual perception variable is higher than 0.05. Also, the significance level achieved in all three phases of executive functions is higher than 0.05. As a result, we can say that the difference between the distribution of visual perception and executive functions in the pre-test and post-test of the Intervention and Control groups with normal distribution is not significant, and the result shows there is a variable homogeneity in the data.

Another assumption of the covariance analysis is that the variance inside each house from the data table should be the same. The Leven Test was used to study the variance homogeneity of the variables' variance. Table 3 shows the results of the Levin variance homogeneity test in the dependent variables of the study in the intervention and comparison groups**.**

Table 3.
Leven Test of Equality of Error Variances

Subtests	DF1	DF2	F	Significance level
General visual perception score	1	18	2/68	0/11
Staying error	1	18	0/73	0/40
Correct responses	1	18	0/55	0/46
Number of completed floors	1	18	0/63	0/43

As the data in Table 3 show, F values are higher than the significance level (0/05) in the visual perception variable, as well as in the sub-tests of the executive functions' variable. These values indicate the effect of the null hypothesis. Therefore, the homogeneity of variance of the intervention and comparison groups was considered in these variables.

Table 4.
M-Box Test Results

M- Box	F	DF_1	DF_2	P
20/05	1/75	10	1549/004	0/06

According to the results in Table 4, in the M-Box Test the null hypothesis is confirmed and the homogeneity of the covariates of the dependent variables is established in groups.

To investigate the effect of intervention, multivariate analysis of covariance was performed on the post-test scores of subscales of executive functions and the overall score of visual perception variable. Table 5 shows the results of the multivariate analysis of covariance on the post-test scores.

Table 5.
Results of the Multivariate Analysis of Covariance on the Post-test Scores

Effect	Test	Value	F	Hypotheses df	Error df	sig
Group	Pillais Trace	0/87	20/06	4	11	0/000
	Wilks Lambda	0/12	20/06	4	11	0/000
	Hotellings Trace	7/29	20/06	4	11	0/000
	Roys Largest Root	7/29	20/06	4	11	0/000

According to the results in Table 5, the Pillais Trace as the most conservative index of covariance analysis indicates that attention rehabilitation was significantly effective on the sub-tests of executive functions and visual perception variable. The results also show that there is a significant difference between the intervention and control groups in at least one of the dependent variables.

To investigate the more specific hypotheses, the difference of covariance analysis was performed on the dependent variables. Table 6 shows the results of the analysis of covariance in the MANCOVA context, which is used to compare post-tests in the dependent variables.

Table 6.
Results of the One-way Covariance Analysis in the MANCOVA Context

Variable	Sub-test	Test	Sum of squares	df	F	Sig	Partial Eta squared
visual perception	General visual perception score	pre-test	116/90	1			
		Intervention group	895/91	1	95/53	0/000	0/87
		Error	131/28	14			
Executive functions	Staying error	pre-test	4/85	1			
		Intervention group	102/35	1	35/04	0/000	0/71
		Error	40/88	14			
	Correct responses	pre-test	2/39	1			
		Intervention group	116/09	1	16/08	0/001	0/53
		Error	101/07	14			
	Number of completed floors	pre-test	11/93	1			
		Intervention group	3/57	1	4/61	0/05	0/24
		Error	10/83	14			

According to the results of the multivariate analysis of covariance shown in table 6, in the visual perception variable, the effect of the intervention (group) with a statistical value of F (1, 14) = 95/53 was significant. (P> 0.000). The effect of intervention was 0.87 with respect to Eta square. In the staying error there was a significant (P <0.000) F in the intervention (group) with a statistical value of F (1, 14) = 35/04. Also, the effect of intervention was 0.71 with respect to Eta square. In the correct response subscale, the effect of intervention (group) with a statistical value of F (1, 14) =16/08 was significant (P <0.05). The effect of the intervention was 0.53 with respect to the eta squared. Finally, in the number of classes subscale, the effect of intervention (group) was statistically significant (F (1.14) = 4/61, (P = 0.05)). The effect of the intervention was 0.24 with respect to the eta squared.

The results of covariance analysis showed that attention facilitator/inhibitor rehabilitation had a significant effect on increasing the ability of children with learning disorder in all executive function subscales as well as visual perception variable.

Discussion and Conclusion

Concerning the first hypothesis of the study, which examines the impact of attention-based cognitive rehabilitation on visual perception of students with learning disorders, the results show that attention-based cognitive rehabilitation improves students' visual perception. This result is in agreement with the results of Azizi, Mirdrikvand and Sepahvandi (2017). The results of the study are also in line with the results of a study on the effectiveness of cognitive rehabilitation on spelling errors in students with dyslexia performed by Nazari, Dadkhah, and Hashemi (2015). The results of this study show a significant improvement of visual errors due to the use of cognitive rehabilitation.

Concerning the second hypothesis of the research on the effect of attention facilitator rehabilitation on executive function, the results of the research data show that cognitive attention rehabilitation can significantly improve executive function in children with learning disorder. This result is in agreement with the research results of Narimani and Soleimani (2013), Najarzadegan, Njati, Amiri and Sharifiyan (2015), Qaedi, Khalili, Afshin Majd, Rahmati and Karimi (2017) and Eyvazi, Yazdanbakhsh and Moradi (2018). These studies have all reported a significant impact of cognitive rehabilitation on executive functioning improvement.

Attention acts as the facilitator/inhibitor of all cognitive activities of the individual. This variable plays its facilitation role by improving cognitive activities such as perceptions and executive functions. And in the area of inhibition, it also improves the individual’s control of executive functions such as inhibition. As stated, research has proven that factors such as visual perception and executive functions are fundamental and underlying factors in causing learning disorders. Therefore, relying on a model that can provide ways to improve these cognitive processes and provide a solid framework for evaluating, diagnosing, and treating learning disorders for professionals can be effective. Learning disorders do not only affect the child's educational status. Rather, the side effects of these disorders are far more damaging from the child's educational problems. The child gradually loses hope in his or her progress by comparing his or her weaknesses with that of other students, and loses confidence, self-esteem, and positive thinking in all aspects of his or her life. Therefore, diagnosis and treatment without an organization can have disastrous results. And that is why having a structured model for evaluation is so important. This structure and framework make it possible for educators to have targeted planning, even before the child enters school, in order to prevent learning disorders. And by reinforcing the underlying processes of disorders such as attention, in addition to success in facilitating the child's educational affairs, prepares him or her for success in all aspects of personal life.

The school neuropsychology approach, especially the SNP/CHC model, is a new one. And this approach examines the factors that cause learning disorders in a categorized and completely rooted way. It is suggested that this approach be further used in the diagnosis and treatment of learning disorders. On the other hand, categorized attention towards the underlying factors that are involved in a child's learning disorder, such as those considered in the SNP/CHC approach, can formulate structured and targeted assistance programs for primary school students with disabilities. And it can even be helpful in formulating preventive exercises and programs for pre-school children. Research on the impact of attention-enhancing on the improvement of visual perception, which is one of the important and effective cognitive abilities in children's learning problems, is very limited. Therefore, it is recommended to increase the amount of research in this area, with larger groups and with other methods of increasing attention. One of the limitations of this study is the lack of Persian researches in the school neuropsychology and SNP/CHC model field. Therefore, researchers who are working to identify the factors that cause learning disorders and their treatment are advised to pay more attention to this approach, which examines the essential factors affecting learning disorders.

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