

Original Article

A study on cognitive-executive functions of frontal-parietal lobes in students with specific learning disorders and normal students

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Abstract

Based on DSM-5, specific learning disorder is a kind of neurodevelopmental disorder that begins by school age. It can potentially lead to persistent problems throughout person's life, including emotional, social and academic problems. Hence the aim of this research is to study cognitive-executive functions of frontal-parietal lobes among students with specific learning disorders and normal students. This study is a descriptive and causal-comparative research. The population under study included all male 5th-graders with specific learning disorders in Ardabil city (2018-2019). The sample included 80 students (40 normal students and 40 students with specific learning disorders) selected through multistage cluster sampling. The data collection was performed through Wechsler's subtests of similarities, mazes, and visual puzzles and Bender-Gestalt Test as well as the Tower of London Test and a diagnostic interview based on DSM-5. With regard to cognitive-perceptive functions of frontal-parietal lobes, the results of Multivariate Analysis of Variance (MANOVA) indicated that there was a significant difference between students with specific learning disorders and normal students. On the other hand, cognitive-perceptive functions of frontal-parietal lobes in students with specific learning disorders ($p < 0.001$) were significantly weaker than those of normal students. The results showed that malfunctioning mental mechanism related to cognitive-executive functions can cause such a disability; hence, it is necessary for curriculum developers and psychologists to give due attention to this issue and develop new methods of training to increase such functions as organizing, planning, logical reasoning and spatial understanding etc.

Keywords

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Introduction

Learning disorder is an issue that has attracted researchers' attention for a long time. This term was

suggested for the first time by Samuel Kirk to describe a group of children who showed disability in developing language, speech, reading and communication skills (Gorman, 2001). One of the main characteristics of specific learning disability is the persistent disorder in

learning key academic skills which starts from school age. Key academic skills include listening comprehension, fluency and accuracy in reading, written expression and spelling, mathematical calculations and reasoning (math problem solving). The second important characteristic of the students suffering from such a disability is that their academic performances are significantly lower than the average performance of their normal peers. The third characteristic of learning disability in many cases is the existence of such disorders from early school age, but it cannot be sometimes recognized until older ages when their lessons and syllabi become hard enough. The other important factor in recognizing specific learning disability is that the term does not apply to learning problems which are primarily the result of intellectual disabilities: visual, hearing, or motor impairments, neurotic or emotional disturbances (Association, 2013).

It seems that due to brain dysfunction, especially in frontoparietal region, students with specific learning disabilities have trouble in associating written letters with their sounds. Some theories of development emphasized the role of right hemisphere in causing such a disorder (Weintraub & Mesulam, 1983). Other theories emphasized the role of brain's white matter under the gray matter (cerebral cortex) (Liddell & Rasmussen, 2005); these two viewpoints go well together and act as complimentary in correct prediction of this syndrome in different situations. Functions of left and right parietal lobes are somehow different. In addition to sensing major sensory inputs (touch, temperature and pain) through the posterior slice of central sulcus, the left parietal lobe creates the spatial awareness of an individual. Damage to right parietal lobe can result in spatial navigation and neglecting left part of one's body in daily life; for example, one may forget to shave left part of his beard; in this case he has lost his ability to navigate spatially. Sometimes such a disorder is so intense that the one suffering from it forgets left part of his body and thinks it is for another person. In addition to sensing major sensory input and spatial navigation of the right parietal lobe, the left one also functions in processing language. Damage to the left parietal lobe can result in difficulty with mathematics and calculation, left-right confusion, difficulty with reading, writing and language (Ganji, 2013). Frontal lobes give us the ability to compare our behavior with that of others and to judge their reactions to get feedback for changing our behavior and attaining our valuable goals. Executive functions are also related to frontal lobes. Moreover, functions such as codifying, planning, doing meaningful activities and finally regulating and controlling emotions which are related to frontal lobe (Teeter & Smith, 1989). Vivisection of the people's brain suffering from dyslexia and dysgraphia shows some abnormalities in their frontoparietal regions. Moreover, there are abnormalities in the number and arrays of neurons in the posterior region of language.

FMRI studies on young children suffering from dyslexia and dysgraphia indicate that during reading their left hemispheres (in many parts) are less active than those of their normal peers. Studies on the damages to cerebral frontoparietal lobes indicate that this region plays an eminent role in analyzing written words and paraphrasing symbols to sounds related to language structure (Ceci, 2013; Teeter & Smith, 1989). Studies on brain imaging indicate that by using other regions of brain, people with dyslexia and dyscalculia try to compensate lack of activity in their frontoparietal lobes; they use these regions to recognize the words and turn them into their respective sounds. Moreover, FMRI studies show abnormalities in left parietal-temporal lobe and low prefrontal lobe and in parietal sulcus of the people with specific learning disability (Cavazos-Gonzales, Alvarado, & Burns, 1997; Ganji, 2013). Some researches indicated the outbreak of learning disorder and the low performance of cognitive-executive processing among the people suffering from learning disabilities. Moreover, emotional and academic consequences of such a disorder are emphasized (Cappa, Giulivi, Schilirò, Bastiani, & Muzio, 2015). Another piece of research studied cognitive structures of students with and without specific learning disabilities. The results indicated that cognitive structures of students with specific learning disabilities are of weaker performance than those of normal students. Moreover, general intelligence factor (g) was different between the two groups (Giofrè & Cornoldi, 2015). According to the findings, some genetic or developmental defects result in abnormalities in some parts of brain which are responsible for processing numbers and mathematical calculations.

Based on the obtained documents and the role of brain mechanisms in defining academic achievements, it is necessary to pay due attention to learning disorders and functions of brain related to such disorders; hence, through the present study we tried to answer to the following research question: whether frontoparietal functions of students with specific learning disabilities and normal students are different or not?

Method

Participants

This is a descriptive and causal-comparative research. The population under study included all male 5th-graders with specific learning disability in Ardabil city (2018-2019). After getting the required permission from Ardabil Education Office and with observing all ethical issues and explaining research goals to the subjects, we conducted the research: first through multi-step cluster sampling we randomly selected 360 students from 8 male primary schools, and then from each selected school 3 classes were selected randomly. By explaining symptoms of specific learning disability to the teachers, we identified and selected those who showed symptoms of such disability.

Then for exact identification of students with specific learning disability, we used diagnostic interviews with regard to DSM-5 criteria and tests of reading and writing disabilities, Key Math diagnostic test and Raven IQ Test (to identify intellectual disability). Finally, 44 subjects were identified with specific learning disabilities and 40 of them were selected randomly as research sample. Then 40 normal peers were selected based on similar age, education, and economic condition. The minimum number of sample in each subgroup must be 15 subjects in causal-comparative researches, but for increasing external validity we selected 80 subjects (40 subjects for each group). Moreover, inclusion criteria included being male, not suffering from intellectual disability or other diseases and exclusion criterion was the participants' unwillingness to cooperate.

Instrument

For data collection following tools were used

Structured clinical interview for DSM-5

In this research for identifying symptoms of attention deficit/hyperactivity disorder we used structured clinical interview on the basis of symptoms described for such a disability in DSM-5 (Association, 2013).

Picture arrangement subtest

This test includes ten cards with printed pictures on them. In each test some cards with scrambled order are given to the participants who are asked to put them in order and make the story meaningful. The numbers on the back of the cards show left to right order of presenting them to the participants. The printed letters on the back of the cards is the numbering key. The time of answering to each item is given. The test would be stopped after 4 successive incorrect answers. Maximum score in this test is 20 (Wechsler, 1945).

Similarities subtests

This test requires the ability of verbal conceptualization and abstract reasoning and includes 14 items (questions). Participants are asked to state the similarities between the two presented items. The test would be stopped after 4 successive incorrect answers. With regard to the presented descriptions each item will be scored 2 or 0 (Wechsler, 1945).

Maze subtests

Some activities such as planning, conceptual organization, visual-motional consistency, rapidity and verbal reasoning can be done through this test. Coefficient of validity in this test is reported between 0.82 and 0.88. Shahim has reported its coefficient between 0.60 and 0.84 among Iranian children (Shahim, 1998).

Tower of London Test

It is developed by Shallice (Shallice, 1982) with the aim of evaluating planning ability of patients with frontal lobe damage. Subjects are asked to replace a set of colorful nuts in the three vertical rods to match them with a specific goal. In each test upper arrangement never changes, which shows target arrangement and lower row includes segments that must be rearranged to be matched with upper arrangement. Target position for segments is variable, but the starting point will be fixed. The problem would be solved with 2, 3, 4 and 5 movements, which are in fact the minimum number of movements (R. Morris, Rushe, Woodruffe, & Murray, 1995). The used indicators include a) total administering time, b) total copying time, and c) total acquired score by the subject (R. G. Morris, Ahmed, Syed, & Toone, 1993). Shallice reported that those with left frontal lobe damage (especially during work space, and before start) spend more time for matching model than control group (normal people).

Bender-Gestalt Test

Bender Gestalt test consists of nine geometric figures, each on its own card. This test is used to evaluate visual-motor maturity and to screen children for brain damage and neurological deficits. Figures are presented to the subjects, one at a time and they are asked to copy it onto a single piece of 11 × 8.5 blank paper. After testing is complete, the results are scored based on accuracy and organization. The test has really proven effective in recognizing people with brain damage. Test-retest reliability reported by Koppitz based on age and time interval of the two tests ranged from 0.53 to 0.90 (with the mean of 0.77). The reported validity based on visual-motor integration developmental test is 0.65 (Groth-Marnat, 2009). This test is utilized to assess brain damage, reading and learning disabilities, intellectual disabilities, emotional disorders and academic achievements. Based on Koppitz's grading, Bender-Gestalt test has reported with acceptable reliability by several researches in Iran. A piece of such researches conducted on a sample of 1008 subjects in primary schools of Tabriz city, Iran. The reported validity through several criteria showed high value correlations from 0.60 to 0.90. Moreover, for assessing test reliability, retest conducted randomly on 100 subjects with 4-6 weeks interval, which showed reliability coefficient of 0.89 (Poursharifi, Sobhgharamaleki, Alizadeh, & Rakhshan, 1996).

Procedure

After getting the required permission from Ardabil Education Office and informing and satisfying subjects with observing all ethical issues (such as assuring privacy of information and giving freedom of choice to participate in the research), students with LD were identified. After explaining research goals to the subjects, the testes were administered and they were asked to complete each test carefully. The required information was collected

individually from the related high schools. Finally collected data were analyzed through multivariate analysis of variance (MANOVA).

Results

Table 1. Mean and standard deviation of Wechsler, Bender-Gestalt and London Tower tests among the two groups

Major test	Subtests	Students with LD		Normal Students	
		M	SD	M	SD
Wechsler	Picture regulation	5.08	1.62	7.65	2.40
	Similarities	3.90	1	5.50	1.08
	Maze	4.95	3.52	5.27	1.17
London Tower	Copying time	153	3.56	121.54	4.86
	Administration time	161	4.30	132.13	5.76
	Total score	17.64	2.04	25.48	3.11
Bender-Gestalt		3.50	1.10	0.2	0.4

Table 2. The results of multivariate variance analysis based on mean scores of Wechsler, Bender-Gestalt and London Tower tests among the two groups

Dependent variable	Subtests	SS	DF	MS	F	P
Wechsler	Picture regulation	355.43	1	355.43	32.11	0.001
	Similarities	214.67	1	214.67	24.66	0.001
	Maze	270.27	1	270.27	28.36	0.001
London Tower	Copying time	5923.82	1	5923.82	20.60	0.001
	Administration time	6943.87	1	6943.87	17.21	0.001
	Total score	349.93	1	349.93	29.68	0.001
Bender-Gestalt		534.33	1	534.33	39.20	0.001

As it is seen from Table 2, there is a significant difference between the two groups in the subtests of picture regulation ($F=32.11$), similarities ($F=24.66$), maze ($F=28.36$), London Tower ($F=20.60$), Bender-Gestalt ($F=39.20$). On the other hand, the results indicate that the function of frontal lobe in ADHD students is weaker than normal students.

Discussion

The aim of this research is to study cognitive-executive functions of frontopareital lobes among students with specific learning disability and normal students. The obtained results with regard to the functions of frontopareital lobes indicated that there was a significant difference between students with specific learning disability and normal students. On the other hand, cognitive-perceptive functions of frontopareital lobes in students with specific learning disability were significantly weaker than those of normal students. Findings of this research are in line with those of other

studies (Cappa et al., 2015; Cavazos-Gonzales et al., 1997; Ceci, 2013; Ganji, 2013; Giofrè & Cornoldi, 2015; Teeter & Smith, 1989) and indicate that students with learning disabilities suffer from under or malfunctioning of all structures and functions related to frontopareital lobes. These functions can include planning, organizing, logical reasoning, spatial understanding, and linguistic processing. With regard to the subjects' performances in Bender-Gestalt test, neurologic researchers believe that one of the major problems among children with learning disability is the disorder in executive functions of cognitive neurons related to psychological processes responsible for controlling awareness, thought and action (Huang, Bardos, & D'Amato, 2010). In order to support the research findings, we can say that students' involvement with their lessons and school subjects can improve their brain functions in different parts. Just like physical exercises, brain exercises and learning study skills can improve our brain functions. Since these students didn't learn study skills and other exercises that could help them to increase their performance, little by little their brain functions fell into decline (Armstrong, 2007). According to Posner (Posner, 1995) there is a frontal attention system in the frontal lobe and a parietal system in the parietal lobe. The frontal system is active during the assignments that one needs awareness and the parietal lobe controls and harmonizes eye movement; perhaps the region related to attention and awareness as well as cognitive processing is less active among people with learning disorder. Moreover, in line with Prentice, Gold, and Buchanan (2008), findings of this research indicated that low performance in Bender-Gestalt test was an indicator of impairment prefrontal-parietal lobe. The findings showed that people with such a disorder were meaningfully weaker than normal people in such performances related to test of similarities which is an abstract reasoning. The findings were also in line with the findings of Alipor, Baradaran, & Imanifar (2015). In their research they showed that students with learning disabilities obtained low scores in Wechsler's test than those of normal students. In support of these findings they argue that some researchers emphasized the importance of successive processing in recognizing learning disabilities and pointed that children with such a disorder obtain low scores than those of their normal peers in assessing subtests of special skills related to processing numbers (Taddei, Contena, Caria, Venturini, & Venditti, 2011). Other researchers discussed that this group of children due to their less curiosity, have an imperfect perception about the world around them; they are not flexible and have problem in reasoning, problem solving, perception of part and whole. As a result, due to having low processing speed and concentration, they spend more time on responding than their normal peers. These issues when combined with other cognitive disorders make it difficult to cope with the changes of life (Telzrow & Bonar, 2002).

Conclusion

We can conclude that cognitive-executive functions both in type and quality or being better or worse are related to different regions of the brain. Although it is not possible to study and assess cerebral capacity proportionate to each activity comprehensively, we can use different tests to assess the levels of cognitive-executive functions and this is in turn paved the way to discover some mechanisms related to actions and brain. These findings indicated that students with learning disability have some weaknesses in cognitive-executive functions related to frontoparietal lobes. Although these findings may open a new window on the way of using these tests and studying cerebral mechanism related to learning disabilities, it is noteworthy that the present research is limited to Ardabil city. Moreover, the subjects were male students with the age range of 10-11. So, it is really difficult to make a generalization out of the results. Hence, it is suggested the research be conducted on different age groups and gender in different regions of Iran.

Disclosure Statement

The authors declare that there were no conflict of interests regarding the publication of this article.

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