IJBS
10.30491/IJBS.2022.310690.1675
International Journal of Behavioral Sciences
Original Paper

Comparing the Effectiveness of Teaching Mirror Neuron Strategies and Brain Executive Function on the Function of the Frontal Lobe of Boys with Conduct Disorder

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Submitted: 25 April 2022
Accepted: 9 June 2022

Int J Behav Sci. 2022; 16(2): 155-161

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Abstract

Introduction: The purpose of this study was to compare the training strategies of executive functions of the brain and mirror neurons on the function of the frontal lobe in boys with behavioral disorders.
Method: In this research, a quasi-experimental method of repeated measurement (pre-test, post-test and follow-up) was used with a control group. The statistical population included 9-12-year-old students with behavioral disorders in Tehran. The sample size included 45 boys with behavioral disorders which were selected from the male students of the 7th district of education in Tehran and were divided into two experimental groups and one control group. The tools used in this study included the Stroop test, the Children's Morbid Symptoms Questionnaire (Parent Form, 1991), and the Behavior Disorder Diagnosis Questionnaire. The data was analyzed using repeated measure analysis of variance with SPSS 22 software.
Results: The intervention of educational strategies of executive functions had a positive and significant effect on the performance of the frontal lobe and its components, including cognitive flexibility and pre-test inhibitory response components in the post-test and follow-up phases, but it did not affect the selective attention component. Also, teaching mirror neuron strategies had a positive and significant effect on the function of the frontal lobe and its components.
Conclusion: The interventions of both strategies have been effective in improving frontal function, but mirror neuron strategies have had a more effective role on the frontal function and its components.

Keywords: Executive Functions, Mirror Neurons, Forehead, Behavior Disorder

Introduction

Conduct disorder is a common and very vulnerable mental disorder that usually occurs during childhood or adolescence and is characterized by severe antisocial and aggressive behaviors. It is often associated with attention deficit hyperactivity disorder and leads to antisocial personality disorder in adulthood. It actually affects 3% of school-aged children and is twice as common in men as in women. The etiology of conduct disorder is very complicated due to the participation of genetic and environmental risk factors and various forms of interaction between genes and the environment and their correlation. In addition, behavioral disorder with neurocognitive disorder and problems in limbic areas, such as amygdala, insula, and frontal cortex and functional abnormalities, exist in the overlapping brain circuits responsible for processing and regulating emotions, decision-making based on reinforcement and emotional and social disorders. This in fact reveals a complex picture of conduct disorder [1]. In some of these studies, children and adolescents with conduct disorder perform worse than their peers in cognitive tests related to the frontal lobe, but

perform similarly to their peers in cognitive tests unrelated to the frontal lobe. Some studies have shown that there is a relationship between the inefficiency of the activities of the frontal lobe and common aggression in these children [2], which consists of three motor parts, premotor and prefrontal cortex. The motor cortex is responsible for making movements. The premotor cortex selects movements and the prefrontal cortex controls cognitive processes so that the right movements are selected at the right time and place. This choice can be controlled by internalized information or external cues, or in response to one's own behavior or information. Damage to this area of the brain impairs a person's ability to perform a variety of movements, movement sequence, spontaneity, learning and memory, social and interpersonal behaviors, obeying the law, and even speaking [3, 4]. Based on this, conduct disorder is the result of weak executive functions of the brain i.e. inhibition of response or working memory [5, 6]. The executive functions of the brain as a theoretical construct helps to explain psychopathology with many disorders by establishing a connection between brain structures, especially the prefrontal cortex, along with psychological functions such as problem solving, abstract thinking and changing strategies [7, 8].

The common denominator of all "executive functions" is the inhibition of behaviors, thoughts and feelings that are purposeful and require effort and the use of mental capabilities. Executive functions are generally defined as neural processes that guide problem-solving skills as well as independent and goal-directed behaviors and are the basis of many cognitive, emotional, and social skills. The use of neuropsychology, especially interventions in the field of training and helping children and adolescents with behavioral disorders, is aimed at increasing the function of the frontal lobe of the brain, which is done using the phenomenon of mirror neurons in the brain [9-11]. Mirror neurons are a group of sensory-motor cortical neurons in the brain that create involuntary visual-motor and auditory coordination between the observer brain and the operator of a physical activity. Their relationship with motor nerves forms an observational-motor network [12]. The most basic feature of mirror neurons is adaptation. These neurons enable the observer to understand the adaption of his motor behavior to the observed person's behavior [13]. Various theories support the idea that people can perceive movements made by others by activating their own motor system. These theories suggest that when a person observes an action, he performs a movement similar to the observed movement. In this diagnosis, mirror neurons are activated both during the person's own performance and when observing the sensory-motor functions in the person and act exactly like a mirror. That is why they are called mirror neurons. The function of mirror neurons in the processing of received information is carried out in three ways: auditory, visual and motor [14, 15]. Mirror neurons, when damaged in the brain, can help reorganize that damage and function because of their plasticity. Observing and imitating the actions of others leads to organizational changes in the mirror neuron system of the brain [16, 17].

Considering the growth and expansion of knowledge and technological development of human sciences, as well as interdisciplinary discussions, especially neuropsychology, it is appropriate to change our perspective on the issues of psychology and examine them more accurately and practically. By emphasizing counseling, educational and neuropsychological interventions, we compared the effectiveness of these interventions on the function of the frontal lobe of the brain and examined its effect on the social and behavioral functions of adolescents with conduct disorder. The hypothesis presented in this research was whether there is a significant difference between the effectiveness of the educational strategies of the executive functions of the brain and mirror neurons on the function of the frontal lobe of 9-12-year-old boys with conduct disorder in Tehran.

Method

The statistical population of the present study included 9-12-year-old students with behavioral disorders in Tehran. In this research, a semi-experimental research design with repeated measurements (pre-test, post-test and follow-up) has been used. Criteria for entering the research included obtaining an average or higher score in the conduct disorder scale questionnaire. Also, a psychological interview was conducted between 9-12-year-old male students. Those without physical and movement disorders were included in this study.

The exclusion criteria of the present study included the existence of disorders with conduct disorder, history of epilepsy, use of psychiatric drugs (Ritalin and methylphenidate), and not attending more than two sessions.

The number of 45 students with behavioral disorder who were selected by simple random sampling were randomly divided into two experimental groups and a control group of 15 students. It was assumed that the subjects had the ability to pass elementary school under normal conditions, so their intelligence was normal. The selection of the subjects was done based on the diagnostic interview of the therapist with the subjects based on the diagnostic criteria of conduct disorder in DSM-5 along with the interview with the parents based on the children's behavior assessment questionnaire.

The tools used in this study were as follows:

Clinical Interview for Disorders (CV-5-SCID): This tool is a semi-structured clinical interview used to diagnose disorders according to DSM-5. The DSM-5 (2013), the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders, published by the American Psychiatric Association (APA), is the Diagnostic and Statistical Manual of Mental Disorders. The English version of the SCID-5-CV reported a diagnostic agreement of greater than 0.06, overall agreement for current diagnoses of 0.52, and total lifetime diagnosis of 0.55.

Behavior Disorder Diagnosis Questionnaire (Shahrivari 2010): This questionnaire has 35 questions prepared by Shahriuri et al. (2010) and measures the components of aggression, irresponsibility, deception,

vandalism and weak interpersonal relationships. Cronbach's alpha coefficient is 0.97. The construct validity of the correlation test with the children's symptoms questionnaire was 0.87 and its reliability was 0.97 using the Cronbach's alpha method [18]. The Cronbach's alpha of this research was 0.85.

Stroop Test (Stroop 1935): This test is one of the most widely used tests for selective attention and response inhibition, which was invented by Stroop in 1935 and is a laboratory model that is used as a primary test of frontal brain function. The indicators measured in this test include accuracy (number of correct answers) and speed (average reaction time). The reliability of the test based on Othello's research method and retest for all three attempts was equal to 0.01, 0.83 and 0.90, respectively. Using the retest method, the reliability of all three tests was reported as 0.6, 0.83 and 0.97, respectively. In this study, a software test was performed. Stimulus response time scores were used to assess cognitive flexibility, interference to assess response inhibition, and interference time to assess selective attention. Retest reliability for all three attempts was 0.08 and 0.90, respectively. The test-retest reliability of all three attempts of this test was reported as 0.83,93 and 0.97, respectively [19].

After selecting the subjects, the experimental groups received relevant interventions in 16 45-min group sessions three times a week. This is while the control group did not receive any intervention. In the group of executive functions, after training and narrating the relevant story, the discussed solutions were presented by the subjects through questions and answers and in the form of brainstorming, and the results were told to their friends in the form of a story in their daily assignments in the next meeting. In the mirror neuron group, along with the training, the desired story was told in the sessions. The subjects expressed their opinion. The groups participated in the post-test. The subjects were re-evaluated after three months.

A research treatment program was prepared by the researcher under the supervision of a neuropsychologist based on the adaptation of "Integrated protocols for the transdiagnostic treatment of emotional disorders in children and adolescents" (16 and 20) with slight changes and based on the opinions of experts and the approval of five psychologists and consultants and was used.

Table 1. Interventions

Meeting	Purpose	Content	Behavior change	Task
1, 2	Recognize self-esteem	Learning to make a friendly relationship, talking about communication problems, preventing physical aggression, strengthening self-esteem, problem solving skills training, the first stage of the Stacking Cups game	Tendency to change behavior, reduce aggression	Practicing strategies at home and at school
3, 4	Recognize emotions and behaviors	Recognizing the physical symptoms of anger, discussing the purpose of expressing of emotions, introducing emotional parts, changing negative self-concept, controlling anger, the second stage of the Stacking Cups game , practicing stages 1 and 2	Reflect on the reaction of performance and movement inhibition in the presence of others	Discovering new solutions in situations
5, 6	Emotion-focused behaviors	Introducing the concepts of contrasting behavior and testing emotion-focused behaviors, preventing physical aggression, boosting self-esteem, problem solving skills training and group practice, stages game, Training Step 3,	Paying attention to situations and emotions, practicing attention and concentration	Identify situations where emotions occur and record them
7, 8	Awareness of body senses	Investigating the relationship between bodily emotions and negative emotions, identifying body emotions, learning to tolerate unpleasant emotions, preventing physical aggression, practicing the game steps 1,2,3 and speed training in stages.	Paying attention to bodily emotions in unfavorable emotional situations, preliminary visual-motor sequence	Registration of negative emotions and ways to deal with unpleasant emotions
9, 10	Thinking Flexibility	Developing the ability to think flexibly in emotional situations, introducing cognitive distortions, communicating thoughts through problem-solving skills, negative self-concept change, recognizing the physical symptoms of anger, learning step 4 of the game.	Recognizing cognitive distortions and reducing emotional behaviors, visual-motor recognition and differentiation.	Investigating distortions-based on behaviors and their notes
11, 12	Awareness of emotional experiences	Introducing and practicing awareness of the moment, unjudging, Prevent the physical occurrence of aggression, Problem solving skills training. Group practice 4 consecutive stages of the Stacking Cups game by observing the rules of group play and the right of priority.	Implementing awareness skills in the face of emotional drivers, sequencing in tasks and movement inhibition	Practicing coping strategies with emotional drivers
13, 14	Facing situational emotions	Reviewing previous skills, discussing the logic of dealing with situational emotions, performing a group show, teaching anger management techniques, running the Stacking Cups game with recording each stage separately.	Emotional inhibition when face of negative emotions, practicing accuracy and then motor reaction speed.	Determining how to deal with environmental emotions (home and school)
15, 16	Maintain training and strengthen self-concept	Reviewing skills and progress towards goals, designing problem-solving skills and training programs, performing a group show, holding a group competition of the Stacking Cups.	Paying attention to position and decision making	Practicing behaviors and executing the written program

Results

The subjects were 9-12-year-old students of the 4th or 6th grade of the 7th education district in Tehran. Their parents' educational level were between bachelor and diploma with moderate economic status, most of which had a sibling.

The descriptive statistics of variables during three stages are shown in Table 1. In the pre-test stage, there was no significant difference between the experimental and control groups in the performance scores of the frontal lobe and its components. In the post-test and follow-up phase, there was a significant difference between the experimental and control group.

Based on the results of the Shapiro-Wilk test, the significance level in the function of the frontal lobe and its components is more than 0.05. The results of Levin's test showed a significance level greater than 0.05, so the null hypothesis is confirmed and the variance of the groups is equal. The values of skewness and kurtosis are in the range of 2 and -2, the data are also normal.

From the analysis of variance of repeated measurements, the results of Machelli's sphericity test showed a significance level of more than 0.05. In the Lambda Wilks test, the results of the comparison of the three stages indicate the adjustment of the effect of the pre-test on the stages of the research. However, there is a difference between the experimental groups in the post-test and follow-up phase ($p < 0.01$).

Furthermore, there is a significant difference between the results of the inter-group effects, between the experimental and control groups (variable scores are different in one of the three stages of the experimental and control groups) ($p < 0.01$). Also, the effect of the experimental group and the control is significant ($p>0.01$). Table 2 shows a significant difference in the group of executive functions and mirror neurons between pre-test and post-test, which indicates the positive effect of educational strategies of executive functions and mirror neurons on the performance of the subjects' frontal lobe. Also, there is a significant difference between pre-test and follow-up that is maintained over time. Therefore, the research hypothesis is confirmed ($P<0.01$).

In Table 3, the existence of a significant difference in the scores of the executive functions group and mirror neurons compared to the control group, in the post-test and follow-up phase ($p<0.01$), shows the confirmation of the research hypothesis. In both experimental groups, but in a discriminating comparison, the absence of a significant P difference between the post-test and follow-up phases is the reason for not confirming the research hypothesis. In the result of the Green-House test, there is a significant difference in the effect of the test for repeated variance analysis of the frontal function components in the group ($p<0.01$). In regards to the results between the groups, the interaction between the experimental and control groups was significant, and there was a significant difference in the scores of one of the components in the three stages in the experimental and control groups ($p<0.01$).

Table 2. Performance of the Forehead Function and its Components in Three Stages

Variable	Group	Pre-test		Post-test		Follow-up	
		Average	SD	Average	SD	Average	SD
Forehead function	Executive functions	234.73	59.07	152.72	74.79	127.73	33.02
	Mirror neurons	226.93	70.51	109.46	40.9	98.06	44.54
	Control	228.08	52.7	222.20	62.67	218.72	43.8
Cognitive flexibility	Executive functions	88.73	25.23	50.06	24.81	45.20	16.60
	Mirror neurons	87.73	41.5	45.66	21.65	47.80	19.80
	Control	86.66	25.11	83.67	42/21	81.85	16.50
Inhibition response	Executive functions	70.80	18.68	41.60	36.89	22.73	11/9
	Mirror neurons	69.93	27.66	31.60	22.30	18.86	19.10
	Control	66.26	17.16	67.46	35.5	64.53	26.91
Selective attention	Executive functions	75.20	39.9	61.06	34.2	59.8	27.2
	Mirror neurons	71.26	26.1	32.20	13.1	31.40	23.8
	Control	76.13	32.98	73.33	19.2	71.93	19.01

Table 3. Postural Test, Scores of Pre-test Stages, Post-test and Follow-up of Forehead Function

Group	Stage	MD	SD	P
Executive functions of the brain	Pre-test - post-test	82.33	17.9	**0.001
	Pre-test - follow-up	142.24	14.6	**0.001
	Post-test - follow-up	58.48	15.9	**0.003
Mirror neurons	Pre-test - post-test	140.56	15.1	**0.001
	Pre-test - follow-up	151.33	23.3	**0.001
	Post-test - follow-up	11.34	14.6	0.460
Control	Pre-test - post-test	10.5	14.2	0.495
	Pre-test - follow-up	24.71	16.9	0.172
	Post-test - follow-up	14.4	18.1	0. 441

Table 4. Paired Comparison in Post-test and Follow-up Stages

Stage	Group I	Group J	MD	SD	P
Post-test	Executive functions	Control	-69.46	22.30	**0.003
	Mirror neurons	Control	-112.7	23.36	**0.0001
	Executive functions	Mirror neurons	26.43	22.01	0.059
Follow up	Executive functions	Control	-91.01	14.9	**0.0001
	Mirror neurons	Control	-120.66	14.8	**0.0001
	Executive functions	Mirror neurons	66.29	14.3	0.053

In Table 4, there is a significant difference in the components of cognitive flexibility and response inhibition between the three stages, in the group of executive function ($p<0.01$). However in the component of selective attention, there was a significant difference between the components of cognitive flexibility and response inhibition ($p<0.05$). In addition, in the group of mirror neurons, there was a significant difference between the pre-test and post-test stages of all three components of the frontal lobe which has been maintained over time. ($p<0.01$)

Table 5 shows a significant difference in the components of cognitive flexibility and response inhibition of both experimental groups compared to the control group in the post-test and follow-up stages ($p<0.01$). However, there was no difference in the selective attention component of the scores of the executive function group compared to the control group in the post-test and follow-up stages. This is while there was no significant difference between the mirror neuron group and the mirror neuron group. The control group did not show any significant difference in the post-test and follow-up phase ($p<0.05$). The results indicate that there is no significant difference between the two experimental groups in the components of cognitive flexibility and response inhibition in the post-test and follow-up stages, but in the component of selective attention, the mirror neurons group was more effective. There was also a significant difference between the groups in regards to the executive functions ($p<0.05$).

Table 5. Beferoni Post-test, Pre-test, Post-test and Follow-up Scores of Forehead Components

	Group	Stage	MD	SD	p
Cognitive flexibility component	Executive functions	Pre-test - post-test	34.66	8.79	0.001**
		Pre-test - follow-up	43.53	8.9	0.001**
		Post-test - follow-up	21.97	5.6	0.406
	Mirror neurons	Pre-test - post-test	41.4	9.5	0.001**
		Pre-test - follow-up	4.08	10.3	0.001**
		Post-test - follow-up	2.13-	5.7	0.702
Response inhibition component	Executive functions	Pre-test - post-test	29.20	7.67	0.002**
		Pre-test - follow-up	48.06	5.43	0.001**
		Post-test - follow-up	18.86	9.88	0.077
	Mirror neurons	Pre-test - post-test	37.6	5.9	0.001**
		Pre-test - follow-up	50.06	9.3	0.001**
		Post-test - follow-up	12.37	7.14	0.149
Selective attention component	Executive functions	Pre-test - post-test	14.13	9.6	0.165
		Pre-test - follow-up	15.4	9.5	0./127
		Post-test - follow-up	2.1	4.9	0.802
	Mirror neurons	Pre-test - post-test	43.3	6.7	0.001**
		Pre-test - follow-up	45.06	9.4	0.001**
		Post-test - follow-up	2.73	5.5	0.692

Table 6. Parallel Comparisons in Frontal Lobe Components

Variable	Stage	Group I	Group J	MD	SD	P
Cognitive flexibility component	Post-test	Executive functions	Control	-31.33	9.82	0.003**
		Mirror neurons	Control	-31.73	9.8	0.001**
		Executive functions	Mirror neurons	1.35	8.7	0.956
	Follow up	Executive functions	Control	-37.06	7.06	0.001**
		Mirror neurons	Control	-34.46	8.06	0.001**
		Executive functions	Mirror neurons	-3.43	39.3	0.587
Response inhibition component	Post-test	Executive functions	Control	-25.86	11.78	0.005**
		Mirror neurons	Control	-35.85	12.6	0.001**
		Executive functions	Mirror neurons	10.2	11.4	0.089
	Follow- up	Executive functions	Control	-41.80	7.39	0.001**
		Mirror neurons	Control	-45.66	7.39	0.001**
		Executive functions	Mirror neurons	-4.8	5.1	0.200
Selective attention component	Post-test	Executive functions	Control	-12.26	8.72	0.167
		Mirror neurons	Control	-41.13	8.7	0.001**
		Executive functions	Mirror neurons	28.78	9.7	0.001**
	Follow up	Executive functions	Control	-12.13	8.37	0.155
		Mirror neurons	Control	-40.53	8.35	0.001**
		Executive functions	Mirror neurons	-28.89	9.3	0.001**

Discussion

The findings of the present study indicate the effectiveness of teaching executive function strategies and mirror neurons on improving the function of the frontal lobe and its components in subjects. The results are implicitly consistent with previous research [10, 11, 20]. Experimental evidence indicates that the clinical symptoms of conduct disorder are related to cognitive impairment [21]. Various neuropsychological studies have shown that patients with this disorder have statistically significant differences in executive functions compared to healthy individuals. The results of research on the cognitive dimensions of conduct disorder have shown the role of this disorder in the occurrence of defects in some cognitive functions such as attention, memory, executive functions, visual spatial skills and information processing speed [22]. Executive functions are the guiding potentials that are responsible for engaging a person in purposeful, organized, strategic and self-directed perceptions, feelings, thoughts and actions. The concept of executive functions as a theoretical structure has been able to create a strong link between brain structures, especially the frontal and prefrontal regions of the brain, and mental actions, thereby contributing to a better understanding of psychopathology. The damaged frontal cortex hypothesis has been widely used to explain and justify many mental disorders in children including autism, attention deficit/hyperactivity disorder, conduct disorder and other mental disorders [4]. The ability to successfully achieve goals in these functions includes learning, applying rules, abstract reasoning, problem solving, self-monitoring, maintaining attention, focusing, and inhibiting inappropriate responses, often with improved performance. Therefore, dysfunction of the frontal lobe leads to the inefficiency of cognitive processes, and the child faces difficulties in the process of solving problems. In studies that have examined the neuropsychological function of patients with conduct disorder, people with severe clinical symptoms of aggression have more difficulty in starting and completing tasks and not making decisions compared to other patients with conduct disorder. Also, these people show more learning disabilities than the control group [23]. The results obtained from the components of the frontal lobe based on the effect of executive function strategies and mirror neurons show the effect of interventions of mirror neuron strategies on the components. The frontal part is the function of mirror neurons in the processing of received information in three models: auditory, visual, and movement. Therefore, due to having these characteristics, mirror neurons have affected the frontal function with strategic interventions. This result is consistent with previous studies [8, 16, 17, 24].

Conclusion

In explaining the results obtained from the absence of a significant difference between the executive function group and the control group in the component of selective attention, it can be said that one of the reasons for the ineffectiveness of the method of teaching executive function strategies is the problem of these people in attention. The performed neuropsychological tests revealed that the subjects have problems in selective attention towards other children. It should be noted that in the research done so far on mirror neurons, the changes are measured by the relevant devices, but in this study, we have observed the changes resulting from neuropsychological tests through the training of neuropsychological strategies and have paid attention to them. Changes in the post-test and follow-up phases include changes in flexibility, sustained attention, response inhibition, and improved working memory, all of which are part of frontal lobe activity. Therefore, according to the obtained results, signs and evidence, the teaching of these strategies have created a spark of change in the subjects and lit a flame. These flames can light thousands of candles.

In regards to the limitations of this study, it can be stated that the studied subjects were only boys with conduct disorder symptoms, so its generalization in girls should be done with caution. Poor cooperation of parents and teachers in the screening stage and its prolongation could be mentioned. Controlling courses in academic levels was also another limitation. It is suggested to use both boys and girls in future research. Special attention should be paid to the family in teaching communication skills at the same time, especially in schools.

Conflict of Interest

The authors of this study declare that they have no conflicts of interest.

Ethical Approval

In order to observe the ethical principles of research and to respect the rights of the participants, the research aims and its process were explained to all the participants. The option of leaving the study at any point was also introduced. They were ensured that their information will always be confidential and the collected data will be published without revealing any personal information.

Also, the parents of the subjects gave a written consent in order to participate in the research with the ethical code of IR.IAU.B.REC.1398.022.

Acknowledgments

The authors would like to thank Professor Hassan Eshairi for his cooperation, constructive guidance and friendly behavior in the advancement of this research.

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