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The Relationship between Poor Executive Functioning and Social Functioning and the Efficacy of Brain Training on Social Functioning

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ABSTRACT

Background: Brain processes are controlled and directed by some brain functions called Executive Functioning. Poor EF affects amelioration of brain functions and related behaviors in social and academic life. In the present research, we investigated the relationship between EF and social functions and tested the brain training effect on EF and social functioning improvement.

Methods: The present study aims to investigate the correlation between poor EF and social self-efficacy and social adjustment and examine the efficacy of cognitive EF training on selected components of social functioning. Through available sampling, 369 healthy high school students aged 16-18 participated in the experiment who were randomly assigned into experimental and control groups; the experimental group consisted of 183 persons (105 girls and 78 boys) and the control group consisted of 186 persons (117 girls and 69 boys). Main EF processes (working memory, shifting, inhibition and problem solving) and social functions (social adjustment and social self-efficacy) were assessed and their correlations were measured. In a randomized controlled trial with pretest, post-test and follow-up assessment, the effects of cognitive brain training was studied on self-efficacy and social adjustment performance of the experimental group. The intervention tool was Practical Cognitive Strategy Training (PCST) which used cognitive awareness, cognitive strategy training and cognitive training to accomplish both goals of EF training in twelve ninety-minute sessions, once a week.

Results: Result showed significant moderate correlation between social and executive functions ($p \leq .001$). After twelve weeks of brain training practice, participants showed a significant difference in social adjustment and self-efficacy compared with the control group. The pre-, post- and follow-up tests were time-consuming and might have affected the results.

Conclusion: Social functions correlate with EF performance and cognitive brain training can improve social adjustment and self-efficacy.

Introduction

Executive functions comprise of metacognitive and motivational/emotional sub-types [1] the first of which concerns cold cognitive functions such as perception, reasoning, critical thinking, planning, decision making, attention, self-monitoring, self-management, cognitive flexibility and inhibition, while the latter deals with what is known as hot cognition and primarily incorporates emotions and feelings. Three basic executive functions

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(working memory, cognitive flexibility, and inhibitory control) are found to be responsible for socially, emotionally and biologically adaptive and flexible behavior [2] and determine the life success. Poor executive functioning causes some recognized deficiencies in biological, psychological, social and educational normal life activities which in turn directly and indirectly lead to poor working memory (lack of ability to hold and process data properly), poor inhibitory control (inability to prohibit predominant response to the present stimuli), or poor cognitive flexibility (insufficient capability to shift attention to the urgent stimulus). Rumination -a prevalent phenomenon in depressive disorders, alcohol binge drinking, and quality of life correlate with poor EF. Individuals with poor EF have higher anxious arousal, higher rates of eating disorders, inaccurate judgment, and insufficiency in reading and mathematics.

Social functioning refers to the way a person performs in one's social environment and how one deals with interpersonal and social duties and is manifested in social adjustment and social self-efficacy. Social adjustment has been defined as the capability for adaptation to the social environment and environmental change [3], for which stress, psychological adjustment, belonging, depression, anxiety and differentiation of self are common precursors. Self-efficacy, on the other hand, is defined as the person's belief about one's own ability to succeed or produce the desired outcome in a given situation [4] which is determined by EF capacity.

Cognitive training provides a set of exercises for improving cognitive processes that gradually become more difficult by adding complexity, decreasing reaction time, or both. It is used to improve cognitive functioning in variety of psychological impairments and cognitive functions [5]. The aim of the present study was to assess how poor EF affects declined social functioning. This research is in line with the research which used creativity training to enhance creative self-efficacy in which EF training was performed for creativity improvement to enhance some social functions [6]. Some scholars used neuro-EF training to augment social functions. We could not find any studies to directly address the relationship between EF and social functions. We found some studies that addressed some aspects of EF and specific social functions in psychological conditions but no studies to focus on healthy individuals or compare EF and social functioning success. Although many studies support the idea that EF performance and cognitive flexibility affect social adjustment [6], we found no specialized non-digital paper and pencil EF training to address social functioning. This kind of EF training can be performed in schools with limited equipment in any circumstances. Social self-efficacy and social adjustment are the major concerns of any learning and social institution that plans for wellbeing and success.

Methods

Participants

The present study consists of two parts; the first part is a correlative study that correlates participants' executive and social functions and the second part is a quasi-experimental study that uses experimental and control groups with pre-, post, and follow-up assessment. The participants consisted of 369 healthy individuals aged 16-18 years old (M=16.75, SD= ±0.82) who were randomly assigned to experimental and control groups using block randomization according to age (for the second study). The experimental group consisted of 183 persons (105 girls and 78 boys) and the control group consisted of 186 persons (117 girls and 69 boys) who studied in Qom high schools. All of them participated in both studies. For the first study, they participated in the full assessment battery. For the second study, the participants were randomly assigned to an experimental group (n=183) and a control group (n=186). Both groups underwent the pre-, post- and follow-up assessment (the full assessment battery) but only the experiment group received the intervention (PCST). The follow-up assessment was conducted one month after the completion of intervention. The inclusion criteria was being a student in a high school and the exclusion criteria was any psychological and physical condition that hindered the process of training or test taking, or a diagnosed psychological condition which was assessed by participant's background. We ran a single blinded study. They did not know whether they are the control or the experimental group because they were in different schools and were not aware of the other group. The experimental group thought that the intervention was a pre-course until the end of the experiment and the control group was treated as a waiting list group who would receive the treatment shortly.

Assessment Battery

The test battery consisted of three parts: a self-report questionnaire (first name & family name, grade, gender, name of school, age, health issues). Six other tests were also used as the following:

N-back test was used to assess working memory and its reliability and validity has been approved [7]. In this test, a series of trials were presented to the participants for 3000 ms while s/he had to remember a certain pervious stimulus. Time interval for two successive stimuli was 4000 ms. each correct answer received one point while the wrong answer receives to point.

Trial Making Test was used for cognitive flexibility where validity and reliability were confirmed [8]. Participants linked the circles containing letters and numbers together in a correct order without lifting the pen for 300 s. Completion time was recorded as a measure of cognitive flexibility.

Stroop test for inhibitory control was validated and approved for reliability [9]. In this test, participants chose the color of the typed color names while ignoring the color of the typed word. Each correct answer received one point while wrong answers received zero.

Hanoi tower was used for problem solving and its validity and reliability were confirmed [10]. There were four disks that had to be moved from a column to another using a third column. They were allowed to move one

disk per movement and no large disk was allowed to be put above a smaller disk. Number of movements was recorded as the problem solving index.

Self-Efficacy Questionnaire for Children (SEQ-C) was employed for assessing self-efficacy [11] and was approved for validity and reliability. There were 21 questions assessing social, educational and emotional self-efficacy. Bell Adjustment Inventory (BAI) was also employed for assessing social adjustment [12] validated and approved for reliability; it had 32 questions that report health, social, emotional and educational adjustment. For the last two tests, one can self-assess him/herself by choosing points 1-3 for each question.

Data Analysis

The data was analyzed using SPSS 23; we calculated correlation coefficient with $p \leq .05$ as the level of significance for the first study and repeated measure ANOVA for the second one with $p \leq .001$ as the level of significance.

Ethical Considerations

All participants were informed about the process and aim of the study and were assured of their anonymity and freedom to leave the study in all research procedure. They were presented with a written informed consent and were asked to sign. We did the research only on secondary school students and focused on social functioning, using certain assessment tools. This study was not funded and all procedures followed were in accordance with the ethical standards of the clinical studies. Informed consent was obtained from all individual participants included in the study. All study procedures received Science Department ethics committee approval in October, 26, 2016 through a letter numbered SBU.ICBS.95.1009.

EF Training Intervention using PCST: A summary of the intervention is presented below by session.

1. Introduction to the Course and Executive Functioning
2. Working Memory (WM) and WM Span Enhancement Techniques
3. Categorization and Chunking Techniques: Teaching and Practice
4. Multi-sensory Enhancement Techniques: Teaching and Practice
5. Visual Working Memory Enhancement Techniques: Teaching and Practice
6. Mental imaging Techniques: Teaching and Practice
7. Memory and Mnemonics Techniques: Teaching and Practice
8. Active Learning Techniques: Teaching and Practice
9. Cognitive Flexibility and Inhibition Techniques: Teaching and Practice
10. Mental Shifting and Inhibition Techniques: Teaching and Practice
11. Planning and Problem Solving Techniques: Teaching and Practice
12. Recapitulation

The intervention package for the second study was designed for twelve 90-minute sessions held once a week. The package called Practical Cognitive Strategy Training employed real-life practices and cognitive task analysis. The Practical Cognitive Strategy Training package (PCST) [in Persian called (*R*ahborod-haye *Sh*enakhti-ye *D*anesh-amoozan) *Roshd*] was used as a brain-training package to enhance social functions.

Various techniques that were used to enhance executive functions that mainly dealt with individuals' life style and contained some recommendations for the participants for improving a healthy life style in order to help boost their brain activation and enhancement. Participant were asked to provide their own suitable life style and check it with the checklists they provided for themselves. Their schedule and checklist received feedback each session. Cognitive strategies -techniques that help learners to overcome their cognitive shortcomings- were directly taught and practiced for each EF component as follow: 1) categorization [13] -participants learned and practiced categorization and were asked to categorize different aspects of their life such as their homework, room, reading materials, affects and so on; 2) memory strategies [14]- different memory strategies were taught and practiced to decrease the cognitive load in different situations; 3) chunking the large data into smaller and more manageable parts [15] to help participants to decrease their cognitive load and avoid procrastination and therefore avoid anxiety and worry; and 4) planning & problem solving [16] -to handle and monitor life issues; 5) mental Imagery practice [17] -to help modify negative thoughts and improve memory and cognitive skills; 6) mental calculations [18] -to helps brain boosting; 7) critical thinking - to increases flexibility of mind and guarantees better problem management; 8) delayed recall [19] – to aid memory and retrieval; and 9) role plays [20] -to provide a good ground for cognitive processes.

Results

First Study

We used SPSS 23 to assess one sample correlation between social adjustment and social self-efficacy with executive functioning measures. initially, we started with the descriptive data.

In Table 1, the descriptive statistics for the component of EF in the pre-test are presented as follows: working memory (M=56.9, StD=19.4), cognitive flexibility (M=62.0, StD=19.0), inhibitory control (M=50.1, StD=5.45), and problem solving (M=38.9, StD=18.3). Descriptive data for social functions are as follows: social self-efficacy (M=61.6, StD=15.4) and social adjustment (M=18.2, StD=18.8).

Analysis approved normal distributions in all components by measuring skewness and kurtosis. After tests of normality, we ran two-tailed one sample Pearson correlation analysis. The results are presented in Table 2 below ($P \leq 0.01$):

Before we explain Table 2, it should be noted that in the present research, lower scores for cognitive flexibility, inhibitory control and problem solving indicate better performance, while in other components higher

scores show better performance. Therefore, a positive correlation between social functions (social self-efficacy and social adjustment) and working memory, and a negative correlation between social functions (social self-efficacy and social adjustment) and cognitive flexibility, inhibitory control and problem solving indicate that improvements in EF components significantly correlate with the improvement in social functions, although a causal effect can be concluded.

Second Study

We used SPSS 23, Repeated Measure ANOVA, to assess the efficacy of intervention for the participants. Skewness and Kurtosis of data indicated the normality of data. Box's M also supports the normality of co-variances (sig≤0.01; Box's M=246.643). T-test showed no significant difference between components of control and experimental group in pre-test measures but there was a significant difference between the two groups in the post-test and follow-up tests (Table 3).

Table 4 presents the results of between-subject effects of intervention (PCST).

Discussion

The first study showed a significant correlation between social functions and working memory capacity which is in line with the previous studies that suggest poor working memory is associated with social impairment in behaviors such as peer rejection, physical aggression and impaired conflict resolution skills [21]. This may be due to low verbal working memory that limits the ability to express the conflict in words and prefer physical aggression instead. It also affects the amount of vocabulary a person can learn and hold in working memory and therefore may have lower capacity to resolve problems and self-talk to self-regulate [22]. Poor social adjustment and working memory decreases one's self-efficacy that is replicated in the present research. A significant correlation was observed between social functioning and cognitive flexibility which is in accordance with the literature which indicates that higher cognitive flexibility predicts

Table 1: The descriptive data of the participants

	Components	Mean	STD	min	max
Participants	Age	16.75	0.82	16	18
	Grade	-	-	10	12
EF Components	Working Memory	56.9	19.4	8	98
	Cognitive Flexibility	62.0	19.0	26	121
	Inhibitory Control	50.1	5.45	35	62
	Problem Solving	38.9	18.3	15	96
Social Functions	Social Self-Efficacy	61.6	15.4	24	96
	Social Adjustment	18.2	18.8	0	89

Table 2: The correlation data of the participants

	Components			
	Working Memory	Cognitive Flexibility	Inhibitory Control	Problem Solving
Social Self-Efficacy	+0.489	-0.381	-0.448	-0.501
Social Adjustment	+0.483	-0.336	-0.474	-0.468

Table 3: The descriptive data of the participants in pre-test, post-test and follow-up in control and experiment group

Variable	Test	Experimental Group		Control Group		F	Sig.
		M	SD	M	SD		
Working Memory	Pre-test	63.82	18.14	50.02	18.06	1.03	0.31
	Post-Test	71.21	19.33	52.20	20.00	1.49	0.03
	Follow-up	68.19	18.15	52.62	17.95	1.69	0.02
Inhibition	Pre-test	50.36	5.31	49.91	5.58	0.35	0.55
	Post-Test	55.77	4.19	51.26	5.31	22.16	0.00
	Follow-up	54.71	4.62	52.09	4.79	8.12	0.19
Cognitive Flexibility	Pre-test	62.24	19.11	61.86	18.91	0.05	0.94
	Post-Test	41.91	9.83	53.87	11.46	13.16	0.02
	Follow-up	38.82	8.20	45.80	10.51	5.32	0.07
Problem Solving	Pre-test	39.00	19.60	38.81	17.04	4.64	0.32
	Post-Test	23.55	9.28	34.23	13.64	35.44	0.00
	Follow-up	20.13	6.99	32.40	13.53	68.58	0.00
Self_Efficacy	Pre-test	63.82	18.14	50.02	18.06	1.03	0.31
	Post-Test	71.21	19.33	52.20	20.00	1.49	0.03
	Follow-up	68.19	18.15	52.62	17.95	1.69	0.02
Social Adjustment	Pre-test	50.36	5.31	49.91	5.58	0.35	0.55
	Post-Test	55.77	4.19	51.26	5.31	22.16	0.00
	Follow-up	54.71	4.62	52.09	4.79	8.12	0.19

Table 4: Comparison of the efficacy of the cognitive intervention in control and experimental groups after cognitive training by PCST

	Components	F	Sig.
EF Components	Working Memory	3548	0.00
	Cognitive Flexibility	6965	0.00
	Inhibitory Control	43149	0.00
	Problem Solving	3181	0.00
Social Functions	Social Self-Efficacy	27457	0.00
	Social Adjustment	95473	0.00

higher social skills and social support [23]. No surprise to become more agreeable and as a result receive more social support when one behaves more flexible and adjust better into the immediate society. It is also observed that low cognitive flexibility is associated with lower facial-affect recognition that can affect social functioning. Problematic cognitive flexibility corresponds with aggressive antisocial behavior that may explain why low cognitive flexibility attributes to low social function. The correlation between social functioning and inhibitory control was also significant which is in line with the prior literature which indicates that poor inhibitory control causes problems in personal and social life. Deficient inhibitory control causes sleep deficits and decreased ability for conflict resolution that are associated with depressive symptoms and eating disorders, all of which can hinder social adjustment and social self-efficacy. Inhibitory control moderates conscious and unconscious threat perception and lead to anxious behavior and as a result the response to the perceived threat can be affected and affect interpersonal relationships. Meaningful correlation was found between problem solving and social functions that is in line with literature [24]. Life is full of problems that must be resolved day by day and a good ability to resolve problems will create a better social environment.

EF training using PCST improved EF performance which can be explained by the correlation detected in the present research and is in accordance with the literature [6, 25, 26]. Cognitive training by PCST could enhance cognitive performance as already was found out in researches. Most of the researches focus on using video games for cognitive training [27], but our research showed that paper and pencil cognitive training can be beneficial as video games do. The most significant part of the research was the transferability of EF training to social functions which can be useful in psychological problems and conditions. Brain training can change the structure and the activity of the brain region the focus on, as indicated in brain imaging studies [27]. This explains why our research worked to ameliorate cognitive functions and social functions.

Conclusion

To summarize, brain training, as an essential and noteworthy instrument, can be considered to improve brain processes in healthy as well as cognitively-impaired individuals almost at any age [27]. It is logical to use different ways of brain training activities to improve social functioning of young adults and help them enrich their life experiences, while working on their cognition. Brain training does not contain the by-effects of drugs and it carries the benefits of drugs in moderate cognitive impairments.

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Conflict of interest: None declared.

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