Original Article

Investigating the role of executive functioning in obsessive-compulsive disorder

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ABSTRACT

Introduction: New studies have identified the main aspects of Executive Functions (EF) as the working memory, inhibition, and cognitive flexibility and according to the Miyake model, these three criteria have a relationship with obsessive-compulsive disorder (OCD). The current research was conducted to investigate the role of EF in OCD. **Methodology:** Using a convenient sampling method, 17 individuals were selected to be in the experimental group and 19 individuals were selected to be in the control group of this study. The screening was done using a clinical interview based on DSM-5 and Yale-Brown Belief questionnaire to determine the insight level. Then, using an event-related potential device, patients` brain waves were recorded while presenting inhibition measurement tasks (Go/No-Go); having interpreted the waves, obtained data were analyzed using independent t-test statistics and SPSS, version 24, software. **Findings:** Patients having an OCD of high insight had better performance in total compared to those having moderate insight. Furthermore, having investigated brain waves, in the Go/No-Go task, the latency of the N2 wave in the control group was significantly more compared to the experimental group. Moreover, in P300 (P3) wave, in Go effort, the experimental group had a higher scope than the control group. **Conclusion:** In this research, the topography of investigated waves of each task had concordance with the topography of neurocognitive dysfunction in OCD and the obtained results supported the hypothesis of EF in OCD. Moreover, the **better performance of** individuals having OCD with high insight showed the role of insight in this disorder.

Keywords: Obsessive-compulsive, Executive functioning, Inhibition.

Introduction

Epidemiology studies have shown that obsessive-compulsive disorder (OCD) is the fourth common disorder in the world having a lifetime prevalence of 2 to 3 percent. The 12 months prevalence rate of this relatively common and often disabling disorder is almost 1.2 percent of the United States population and it is 1.8 on a global level. According to the last reported statistics of national mental health survey during 2010 and 2011, in Iran, 5.1% of the population aging 15 to 64 years, had this disorder. This disorder is identified through repetitive and disturbing thoughts or images that are created unintentionally (obsessive disorder) or repetitive behaviors and normalized formalities that one feels he is obliged to do them (compulsive disorder) or both of these disorders; in most of the cases, compulsive disorder (behavior) happens to reduce the anxiety resulting from obsessive thoughts. The high prevalence of this disorder, the possibility of beginning the symptoms in lower ages, long-term duration of its effects, and severe reduction of the efficiency in individuals having this kind of disorder shows the importance of conducting new studies and research having scientific novel approaches of specifically neurological etiology kind.

In the recent few decades, pathophysiology etiology of the obsessive-compulsive disorder have focused on the brain circuits involving in this disorder [1]. The results obtained from neurological pathophysiology imaging of this disorder have shown the corticostriatal-thalamocortical deficit [2]. Moreover,

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there is a hypothesis that more activities of frontal-striatal circuits are involved in the pathophysiology of obsessive-compulsive disorder [3].

A study and two meta-analyses have confirmed almost constant patterns of increasing the volume of grey matter in basal ganglia and anterior prefrontal cortex. Furthermore, the meta-analysis identified the structural differences between patients having the disorder and healthy ones, the reduction of grey matter in parieto-frontal cortical including supramarginal gyrus, dorsolateral prefrontal cortex and orbital frontal cortex [4]. In addition to this investigation, the results of imaging in other studies have frequently shown the abnormal activity and increase of metabolism in the key regions of the orbital frontal cortex.

Based on a hyperactivity model in OCD, neurological inefficiency in this disorder includes the constant effort of controlling actions related to thought overflow, inattention, negligence, and weakness in programming duties; these activities have high conformity with EF criteria`s efficiency [5, 6]. In sum, studies showed that EF deficits and attention have a significant relationship with obsessive-compulsive disorder [7, 8]. Executive functioning includes that kind of cognitive process that provides the ground for purposeful behavior that is constant with the activities of the frontal cortex [9, 10]. New studies know the basic aspects of EF as the working memory, inhibition, and cognitive flexibility/ task switching, and based on Miyake pattern, these three criteria have a relationship with OCD [11-13].

Even though the first non-invasive tool for investigating EF was using an electroencephalogram (EEG), the advantages of using event-related potential (ERP) has identified it as a key instrument in neurological studies and the investigation of this variable [14]. It could be stated that psychological research in the evaluation of EF has been bloomed since ERP was created from about two previous decades. The advantages of using ERP are to the extent that it is usable despite having new brain imaging techniques; the exactness that an ERP has in recording electrophysiological activities has made it an important reason for using it [15].

New neurological studies have solidarity in the EF deficits of patients having obsessive-compulsive disorder regarding the confirmation of commonly involved brain circuits [16-19]; however, due to the existence of different theories in determining key criteria of EF and its effect on the intensity of obsessive-compulsive disorder`s symptoms, the age range of studied groups are different and various oppositions are seen in the studies. In this research, it has been sought to use healthy individuals and obsessive-compulsive disorder group to study the inhibition EF of patients having this disorder using ERP.

Methodology

The statistical population included all individuals referring to the outpatient psychological clinic of Emam Hossein hospital having the age range of 18 to 60 years, who were diagnosed having an obsessive-compulsive disorder and the statistical population of normal individuals included those having no experiences of psychological disease diagnosis. Using convenient sampling, 23 subjects were placed in the group of individuals having obsessive-compulsive disorder diagnosis and 26 subjects were placed in the normal group; finally, 17 individuals were placed in the experimental group and 19 individuals were placed in the normal group.

The inclusion criteria for the group of individuals having obsessive-compulsive disorder were: 1. The patient should have had obsessive-compulsive disorder, which was diagnosed using the Yale-Brown obsessive-compulsive intensity scale (Y-BOCS) after doing primary evaluation based on the clinical interview of DSM-5 as done by the psychologist. 2. Educational level: middle school education and higher. 3. Nonexistence of clinical and neurological diseases which was diagnosed in the clinical interview by the psychologist. The exclusion criteria of the individual from those having obsessive-compulsive disorder: patients` having other mental disorders as well as clinical and neurological diseases while conducting the study. The inclusion criteria of individuals to the normal group: nonexistence of any kind of psychological disease experience (such as mental subnormality), clinical and neurological diseases. The exclusion criteria of the individuals from the normal group: having mental disorders, clinical and neurological diseases while conducting the research.

Yale-Brown Obsessive-Compulsive intensity Scale (Y-BOCS): Y-BOCS is a clinical measurement scale that has been provided to determine the intensity of disorders and obligations, regardless of paying attention to the number and content of current disorders and obligation by Goodman et al., (1989) [20]. The reliability and validity of the scale in Iran shows that the signs` checklist and Yale-Brown intensity scale, both, have high internal consistency, split-half validity, and re-test validity. Internal consistency of two parts including Signs` Checklist (SC) and Intensity Scale (SS) was respectively, 0.97 and 0.95 and the split-half validity for SC and SS were respectively, 0.93 and 0.89, and re-test validity was obtained as 0.99. There was a positive and significant correlation between SCL-90 scores and the total sign checklist as well as between SCID-I scores and the total scores of intensity ($P<0.001$) [21].

Event-Related Potential (ERP): It was first in 1935 that Davis et al., started the first studies using ERP device [22] and Walter et al., almost 30 years later, reported its cognitive criteria [23]. The advantages of using ERP has identified it as a key instrument in neurological studies [14]. ERP measures the brain's electrical response to visual, hearing, and touching-physical events almost 150 to 500 milliseconds after presenting the stimuli. At first, after presenting the stimuli, a negative wave is observed (N150), then a second negative wave is appeared (N200) and a positive evacuation is then observed (P300). Finally, a second positive climax appeared. (N150) and (N200) are the components that depend on the diagnosis and positioning

of the sign, while P300 is related to the evaluation of the first sign in the forehead [24].

Go/No-Go task has been observed in the research literature of neuropsychology as a measurement tool for evaluating cognitive control especially inhibition since the past [25, 26]. To evaluate the inhibition skill from responding to the task Go/No-Go was utilized. Since subjects had been evaluated by the selective attention of the Posner test, to better compare and keep the basic task and add inhibition to the basic task, the modified task of Go/No-Go having Posner features was used. In this task, 120 cues were observed, whose half was in the Go form and the rest half were in the No-Go form. Figure 1 shows the design of this task.

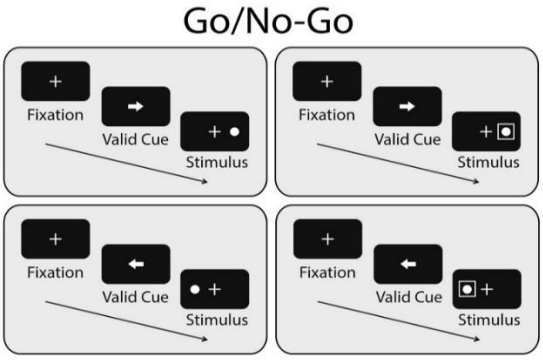

Figure 1. The schematic view of the Go/No-Go task

Results

In this research, regarding the behavioral dimension of the mentioned three tasks. Overall, there were no significant differences between two groups of individuals having obsessive-compulsive disorder and control group; however, patients having an obsessive-compulsive disorder and high insight showed better performance compared to those having moderate insight. Moreover, in brain waves' investigations, in the Go/No-Go task, the latency on the N2 wave was significantly more in the control group than the experimental group. Furthermore, in P300 (P3) wave, in Go cue, there was a more scope observed in the experimental group than the control group; however, there were no significant differences observed in the latency of this wave in both groups. While in the P3 wave of No-Go cue, there were no differences between both groups, the control group showed more significant latency compared to the experimental group.

Table 1. The results of two-sample independent t-test of the peak scope in the considered brain points in Go situation (Go-Peak)

Variable	Levin test		T value	Significance level	Mean difference	95% confidence scope for the mean difference		Mean	
	F	Significance level				Low limit	High limit	Control group	Experimental group
F3_N2	1.24	0.27	-0.02	0.98	-0.03	-2.60	2.53	1.91	1.95
Fz_N2	0.84	0.36	0.44	0.66	0.64	-2.34	3.63	1.98	1.34
F4_N2	0.41	0.52	0.19	0.85	0.26	-2.45	2.96	1.49	1.23
Cz_N2	8.65	0.006	-0.38	0.70	-0.60	-3.80	2.60	1.73	2.33
P3_P300	3.84	0.059	-1.88	0.07	-2.28	-4.76	0.20	9.39	11.67
Pz_P300	0.25	0.61	-1.71	0.10	-2.32	-1.29	1.20	12.71	15.03
P4_P300	1.85	0.18	-2.98	0.01	-4.03	-0.21	3.06	10.37	14.39

Table 1 shows that the significance level for P4_P300 was less than the obtained error level of 0.05, which means that the existence of difference in this variable was confirmed in both control and experimental groups. Considering the mean of this variable between both considered groups, it could be stated that P4_P300 of the control group was less than the experimental group.

Table 2. The results of two-sample independent t-test of Peak latency in the considered brain points in Go situation (Go-Latency)

Variable	Levin test		T value	Significance level	Mean difference	95% confidence scope for the mean difference		Mean	
	F	Significance level				Low limit	High limit	Control group	Experimental group

F3_N2	4.78	0.036	-0.51	0.616	-2.76	-14.03	8.50	250.05	252.8
Fz_N2	7.66	0.009	-2.31	0.030	-9.94	-18.81	-1.07	249.35	259.2
F4_N2	0.80	0.37	-0.65	0.523	-3.12	-12.96	6.72	252.17	255.29
Cz_N2	11.7	0.002	0.87	0.393	7.00	-9.59	23.59	263.8	256.8
P3_P300	0.12	0.72	-0.54	0.594	-5.94	-28.39	16.51	368.4	374.3
Pz_P300	3.26	0.08	0.35	0.727	5.59	-26.75	37.93	378.5	372.9
P4_P300	9.17	0.005	1.93	0.065	29.24	-2.02	60.50	401.1	371.8

It could be concluded from Table 2 that: the significance level for Fz-N2was less than the obtained error level of 0.05, which means that the existence of difference in this variable was confirmed in both control and experimental groups. Considering the mean of this variable between both considered groups, it could be stated that Fz_N2 of the control group was more than the experimental group.

Table 3. The results of two-sample independent t-test of Peak latency in the considered brain points in No-Go situation (No-Go-Latency)

Variable	Levin test		T value	Significance level	Mean difference	95% confidence scope for the mean difference		Mean	
	F	Significance level				Low limit	High limit	Control group	Experimental group
F3_N2	2.63	0.11	1.49	0.147	10.41	-3.86	24.68	261.7	251.2
Fz_N2	20.76	0.00	2.32	0.029	16.29	1.79	30.80	274.4	258.1
F4_N2	6.87	0.013	4.30	0.000	24.65	12.80	36.49	279.4	254.8
Cz_N2	18.23	0.00	0.58	0.567	5.35	-13.86	24.57	258.6	253.2
P3_P300	18.46	0.00	0.80	0.435	11.00	-17.88	39.88	446.1	435.1
Pz_P300	21.92	0.00	1.53	0.145	26.53	-10.08	63.14	439.9	413.4
P4_P300	13.81	0.001	3.46	0.002	46.88	18.64	75.12	434.5	387.6

The results of Table 3 showed that:

1. The significance level for Fz-N2 was less than the obtained error level of 0.05, which means that the existence of difference in this variable was confirmed in both control and experimental groups. Considering the mean of this variable between both considered groups, it could be stated that Fz_N2 of the control group was more than the experimental group.
2. The significance level for F4-N2 was less than the obtained error level of 0.05, which means that the existence of difference in this variable was confirmed in both control and experimental groups. Considering the mean of this variable between both considered groups, it could be stated that F4_N2 of the control group was more than the experimental group.
3. The significance level for P4_P300 was less than the obtained error level of 0.05, which means that the existence of difference in this variable was confirmed in both control and experimental groups. Considering the mean of this variable between both considered groups, it could be stated that P4_P300 of the control group was more than the experimental group.

Discussion and Conclusion

According to the statistical results obtained from Go/No-Go task, from the behavioral aspect, the experimental group had a more reaction in terms of deletion error, commission error, and reaction time compared to the control group; this difference was not significant. Moreover, those having moderate insight had a more deletion error and reaction time compared to the control group; this difference was significant but, there were no significant differences between two groups in terms of commission error.

In investigating ERP data of the current study in Go cue and No-Go cue in the N2 wave, no significant differences were observed in the scope; however, in the latency of this wave in the control group was significantly more compared to the experimental group. This obtained result was in line with the study conducted using an event-related potential and Go/No-Go task on three groups having 20 individuals (the group having obsessive-compulsive disorder, the group having panic disorder and control group) using Go/No-Go task. In this study, the latency of the N2 wave in the control group was increased through increasing difficulty in inhibition. However, despite the result of the current study showing that both groups had a disorder in Go cue, there was lower reaction time [27]. But, the results of other studies in line with the current study, more reaction time in Go cue was reported for the group having obsessive-compulsive disorder [28]. A similar study showed the reduction of latency in the N2 wave in Go cue in patients having disorder compared to the control group [29]. However, in a study not in line with the current study, the increase of N2 wave scope in No-Go cue in the group having disorder was observed compared to the control group [30]. It is recognized that the results of the studies regarding the changes in the N2 wave in obsessive-compulsive disorder were different compared to the control group.

In the current study, P300 (P3) wave in Go cue had significantly more scope in the experimental group compared to the control group; however, no significant differences were observed in the

latency of this wave in both groups. While there were no differences in the scope of the two groups regarding the P3 wave of No-Go cue, the control group showed significantly more latency compared to the experimental group. In a research conducted in 2007 using event-related potential on 13 patients having obsessive-compulsive disorder with 13 individuals of the control group to measure inhibition using the Go/No-Go technique, both groups didn1t show differences in P3 wave in both Go and No-Go cues [30]. In research, the reduction of the P3 wave`s scope in No-Go cue in patients having the disorder had been reported [29]. In another study, a similar increase of the P3 wave`s scope was observed in Go and No-Go cues in the group having the disorder compared to the control group [31]. Overall, much of the studies have reported the increase of latency in N2-P3 waves of No-Go cue compared to Go cue, most of which know it as a result of involving high-level processes in the inhibition compared to the administration of predicted action [27]. In the Go/ No-Go task, when healthy people abstain from responding to the stimuli in No-Go cue, the N2 criterion usually increases, and the P3 criterion increases. Moreover, the latency of the P3 wave in No-Go cue was more than Go cue, showing higher-level demands of processes in No-Go cue [32, 33]. The analysis of ERP criteria in Go/No-Go task showed that P3 wave in Go cue started from bilateral parietal lobes and P3 wave in No-Go cue started from inferior anterior cingulate cortex and lateral orbitofrontal parts and N2 wave started from the middle orbital frontal cortex [34, 35]. Since stated regions are involved in the neurological etiology of obsessive-compulsive disorder, the Go/ No-Go task is overall, common in the studies of this disorder [27]. Studies and research on imaging, and topography of N200 wave (N2) and ERN wave is known to be related to the anterior cingulate cortex (ACC) [36]. There is a confirmed hypothesis that the N2 wave appeared while diagnosing the opposition and as a result shows the cognitive activities before doing actions. Various findings have shown that this wave is involved in controlling cognitive oppositions and starts from prefrontal dorsal parts and ACC [36, 37].

As it was mentioned before, in explaining the etiology of obsessive-compulsive disorder, various hypotheses exist. Having referred to the neurological orientations of the current studies, it could be stated that neurological theories in the etiology of this disorder have had more acceptance and focus in scientific meetings than before. One of the prominent research and therapeutic subjects regarding neurological aspects in the brain administrative actions that their aim of the current study was investigating its performance in patients having obsessive-compulsive disorder. The results of this study indicated that the positioning of the considered waves in Go/No-Go task was conformed with the positioning of neurological dysfunction in obsessive-compulsive disorder and the statistical results obtained from the significance of the differences observed in the experimental and control group supported the hypothesis of EF deficits especially inhibition in obsessive-compulsive disorder. These findings and its considerable conformity with the results of similar studies and previous research can have an effective role in explaining therapeutic purposes for the improvement of the signs of this disorder. Comprehending performance dysfunctions in patients having an obsessive-compulsive disorder and especially dividing these deficits can be a guide for designing therapeutic protocols with an emphasis on the improvement of the performance of the index and effective criteria of EF in this disorder.

According to the results of the current study as well as inline and opposing studies, there have been various views in interpreting and explaining the results. Moreover, we witness the opposite results in similar ERP studies especially in the tasks of the current study. A major part of these oppositions depends on the environmental disruptive while recording brain waves (such as light, noise and physical as well as mental conditions of the subjects) other than the dependency of these studies on the current technologies (improvement and development of the exactness of the ERP device) and sensitivity of this device and its sensitive standardized conditions. The other determining factor is the volume of the studied samples, which have been mentioned before. Most of these studies had been conducted on less than 30 individuals due to the time consumption and complexity of the results` interpretation. In the current study, in addition to the mentioned limitations of such kind of studies such as the low number of samples and difficulty in providing exact standard conditions of recording the waves, sampling method, which was selected as convenient and the amount of statistical population`s representativeness of the experimental group (patients having obsessive-compulsive disorder) were also among the important limitations. It is suggested that in future studies, the sample volume be increased and more exact sampling methods be used. Moreover, gender differentiation of the subjects be considered and other paradigms and tasks are used for measuring EF criteria and having more exact and generalizable data.

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