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Executive Function and Clinical Parameters of Obsessive-Compulsive Disorder (OCD) in Indian Patients

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Abstract

This study attempts to examine variations in Working Memory, Cognitive Flexibility, and Response Inhibition in individuals with OCD with respect to the healthy control group. The study was conducted through multiple healthcare centers in Jaipur district of Rajasthan, recruiting 150 participants from both clinical and community settings. The clinical measures covered the Beck Anxiety Inventory, the Beck-II Depression Inventory, the Yale-Brown Obsessive Compulsive Scale, and the Obsessive Beliefs Spanish Inventory-Revised. The neuropsychological measures covered the Stroop Color–Word test, the Go-No-Go test, the Wisconsin Card Sorting test, the Digit Span test, and the Corsi Block Wechsler III Memory test. The performance of the control group was found significantly better than the OCD group on tasks involving CF, RI, and visuospatial WM. Deficiencies in these correlates of EF may be end-phenotypes of OCD. Performance was found to be affected by the severity of OCD symptoms, patterns of comorbidities, and levels of anxiety, depression, and obsessive beliefs.

Keywords: Working Memory, Response Inhibition, Cognitive Flexibility, Executive Function, Obsessive-Compulsive Disorder, Behavioral Disorder.

Introduction

Obsessive-Compulsive Disorder (OCD) is the most common, long-lasting, and demanding mental condition or disorder in which a person is unable to shake off unstoppable and recurring compulsive thoughts and/or behaviors, despite being powerless against these obsessive thoughts/ behaviors. Obsessive thoughts or recurring mental behaviors are a primary source of anxiety, obsessive beliefs, and amplified comorbidities . The most common symptoms are compulsive behaviors related to aggression, anxiety, fear of contamination, and intrusive thoughts about sex, religion, or destruction. However, many adults with OCD realize that their compulsions are illogical and still continue to engage in them.

Executive functions (EFs) and the relation among its various psychological and cognitive correlates, such as cognitive flexibility (CF), response inhibition (RI), and working memory (WM) have been the central issue of several studies on OCD (Dajani & Uddin, 2015; Robinson et al., 2014). When a person needs to focus, executive function is required, which comprises a set of top-down brain processes. EF refers to “the skills required for maintaining physical and mental health, academic and life achievement, and cognitive, social, and mental development” (Miyake & Friedman, 2012: p.8). Cognitive flexibility has been conceptualized as “an emergent property of efficient executive

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functioning and depends at least on component systems that support response inhibition and working memory" (Dajani & Uddin, 2015: p.571). Response Inhibition refers to "the mental processes responsible for voluntary and involuntary control, or the ability to prevent the interference of irrelevant information and to suppress previously relevant information that is useless when confronted with an ongoing response or response pattern" (Carlson & Wang, 2007: p.490). Working memory is the "maintenance or manipulation of information during a short delay when that information is not available in the environment and involves the short-term storage of information and the simultaneous manipulation of mental material" (Harvey et al., 2004: p.567).

Currently, there is no known explanation for OCD. There are some genetic factors at play, and matched twins are significantly more influenced in contrast to fraternal twins. Stress-inducing and abusive events may be a risk factor for OCD. In addition, the streptococcal infection has been associated with some reported cases. Disorders such as major depressive disorder, generalized anxiety disorder, obsessive-compulsive personality disorder, eating disorders, and neuropsychiatric symptoms are some of the conditions that share similar symptoms. More importantly, this condition is associated with an overall increase in suicidal attempts (Aardema & O'Connor, 2007).

Previous studies (e.g., Snyder et al., 2015; Shin et al., 2014) considered neuropsychological deficits as a key feature of individuals with OCD. These neuropsychological deficits are of clinical importance in order to understand the prevalence of OCD symptoms and reduce their severity (Saremi et al., 2017). Furthermore, previous studies in WM and RI (e.g. Abramovich et al., 2012; Ahmari et al., 2014; Heinzel et al., 2018; Kurt et al., 2017) reported conflicting observations. To fill the above research gap, this study sought to examine variations in WM, CF, and RI in individuals with OCD with respect to the healthy control group.

Methodology

The study was conducted through multiple healthcare centers in Jaipur district of Rajasthan. The study sample constituted 150 individuals aged between 18 and 50 years (mean = 34.6, standard deviation = 8.3), recruited from both clinical and community settings. 75 individuals were diagnosed with OCD symptoms and 75 individuals constituted a healthy control group. The control group was based on equality in age, gender, educational qualifications, and marital status. The main obsessions were aggression (30.7%), superstition (27.3%), pollution (19.4%), somatic (11.2%), symmetry (7.1%), and sexual (4.3%). The main compulsions were checking (61.8%), cleaning/laundry (17.3%), ordering/organizing (10.2%), repetition (6.9%), and others (3.8%). The average duration of OCD among participants was 9.8 years. There were 37 patients diagnosed with OCD with comorbidities. The average dose of antidepressants and antipsychotics administered to participating patients was fluvoxamine, 200 mg/day; sertraline - 100 mg/day; fluoxetine - 40.5 mg/day; citalopram - 20 mg/day; and haloperidol - 1 mg/day. The demographic characteristics are summarized in Table 1 below:

Table 1 – Demographic Characteristics of Participants

Demographic Characteristics		**OCD Patients (n=75)**	**Control Group (n=75)**	**F/χ^2**
Age	Mean ± SD	33.3 ± 7.93	35.9 ± 8.71	Not significant
Gender	Male	36	35	Not significant

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	Female	39	40	
Educational Qualification	Secondary & Below	8	5	Not significant
	Higher Secondary	12	10	
	Graduation	14	15	
	Post-graduation	17	15	
	Professional	24	30	
Marital Status	Single	21	20	Not significant
	Married	46	50	
	Divorced	8	5	
Nature of Medication	Antidepressant	37	--	
	Antipsychotic	2	--	
	None	34	75	
	Both	2	--	
Beck Anxiety Inventory (BAI)	Mean ± SD	19.3 ± 9.87	8.7 ± 6.77	F (1, 150) = 5.711 p < .001
Beck-II Depression Inventory (BDI)	Mean ± SD	20.2 ± 10.38	8.1 ± 5.16	F (1, 150) = 6.027 p < .001
Obsessive Beliefs Spanish Inventory-Revised (OBSI-R)	Mean ± SD	207.1 ± 38.6	137.3 ± 35.84	F (1, 150) = 5.073 p < .001

Source: SPSS output

The clinical measures covered the Beck Anxiety Inventory (BAI), the Beck-II Depression Inventory (BDI), the Yale-Brown Obsessive Compulsive Scale (Y-BOCS), and the Obsessive Beliefs Spanish Inventory-Revised (OBSI-R). The Y-BOCS assesses the severity of OCD symptoms and had a total of 10 items with Cronbach alpha coefficient = 0.864. The BDI was used to assess the severity of depression and had a total of 21 items with Cronbach alpha coefficient = 0.883. The BAI was used to assess the severity of anxiety and had a total of 21 items with Cronbach alpha coefficient = 0.871. The OBSI-R was used to assess the psychometric properties and had a total of 50 items measured on a 5-point Likert scale (from 1 to 5 rated as strongly disagreed to strongly agreed) with Cronbach alpha coefficient = 0.895.

The neuropsychological measures covered the Stroop Color–Word (SCW) Test and the Go-No-Go (GNG) Test to assess response inhibition, the Wisconsin Card Sorting (WCS) Test to assess cognitive flexibility, and the Digit Span (DS) Test, and the Corsi Block Wechsler III Memory (CBWM) Test to assess the working memory. The reliability of these tests in this study were found adequate, with coefficients all higher than 0.7.

Initially, chi-square (χ^2) and one-way analysis of variance (ANOVA) techniques examined group variations in demographic and clinical parameters. Subsequently, multivariate analysis (MANOVA) assessed variations between CF, RI, and WM. If significant variations between groups of variables were considered to have an impact on their performance, an analysis of covariance (ANCOVA) was performed. Kruskal–Wallis H-test was performed for each group, considering gender, comorbidities,

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OCD subtype, and substance use. Pearson correlation analyzed the association between study variables. Cohen's d score estimated the effect size of the difference between groups. For the purpose of this study, a d score between the range 0.20-0.50 was considered low, a d score between the range 0.50-0.80 was considered moderate, and a d score higher than 0.80 was considered high. All participants were included and data were statistically analyzed using SPSS for windows version 23.0.

Results

Group Equivalence

As evident from the results depicted in Table 1, no significant variations were observed among the groups with respect to age, gender, educational qualification, and marital status. Hence, the equivalence between the groups is clear. The scores of BAI and BDI for OCD participants represented moderate severity. The mean score of OBSI-R was observed at 207.1 among OCD participants.

Table 2 – Results of Multivariate Analysis

Dimensions		Group	Mean ± SD	F-score	p-value	Cohen's d
WCS Test	Categories	OCD (n=75) CG (n=75)	4.98 ± 1.36 5.90 ± 1.21	13.11	<.001	0.715
	Persistent responses	OCD (n=75) CG (n=75)	38.84 ± 11.07 49.76 ± 7.41	22.47	<.001	-1.162
	Overall errors	OCD (n=75) CG (n=75)	37.91 ± 8.84 50.43 ± 4.87	41.06	<.001	-1.754
	Persistent errors	OCD (n=75) CG (n=75)	37.78 ± 10.33 48.61 ± 6.12	25.43	<.001	-1.276
	Non-persistent errors	OCD (n=75) CG (n=75)	38.94 ± 6.7 49.67 ± 4.28	43.82	<.001	-1.909
CBWM Test	Forward score	OCD (n=75) CG (n=75)	11.08 ± 2.27 11.19 ± 2.44	0.08	.778	-0.047
	Backward score	OCD (n=75) CG (n=75)	8.81 ± 2.87 9.56 ± 2.64	1.53	.218	-0.272
	SPAN forward	OCD (n=75) CG (n=75)	10.96 ± 2.74 10.47 ± 2.71	0.55	.459	0.18
	SPAN backward	OCD (n=75) CG (n=75)	8.81 ± 3.33 9.54 ± 2.82	5.04	.026	-0.237

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	Overall score	OCD (n=75) CG (n=75)	16.29 ± 3.17 18.15 ± 3.61	1.93	.167	-0.548
DS Test	SPAN forward	OCD (n=75) CG (n=75)	6.26 ± 1.19 6.17 ± 1.28	0.28	.597	0.073
	SPAN backward	OCD (n=75) CG (n=75)	4.83 ± 1.16 5.03 ± 1.54	0.47	.494	-0.147
	SPAN increasing	OCD (n=75) CG (n=75)	5.93 ± 1.29 5.63 ± 1.45	0.17	.681	0.219
	Scalar score	OCD (n=75) CG (n=75)	9.82 ± 3.11 10.14 ± 3.28	0.22	.640	-0.1
SCW Test	Stoop distraction	OCD (n=75) CG (n=75)	49.62 ± 7.52 54.02 ± 7.38	5.93	.016	-0.591
GNG Test	Omission errors	OCD (n=75) CG (n=75)	1.36 ± 2.21 0.54 ± 1.38	5.38	.022	0.445
	Commission errors	OCD (n=75) CG (n=75)	2.36 ± 1.95 1.87 ± 1.27	4.23	.041	0.298

Source: SPSS output

Comparative Analysis of OCD and Control Group in WM, IC, and CF

The multivariate analysis of all variables was based on the Wilks Lambda scale. The test results, as summarized in Table 2, showed significant multivariable group effects in the WCS test, CB test, SCW test, and GNG test. Significant variations in univariate analysis results could be explained as signs of neuropsychological functioning in the OCD group, particularly in the WCS test, categories ($p < .001$), persistent responses ($p < .001$), overall errors ($p < .001$), persistent errors ($p < .001$) and non-persistent errors ($p < .001$); Corsi SPAN backward ($p = .026$); and distraction ($p = .016$) in the SCW test; omission ($p = .022$) and commission ($p = .041$) in the GNG test, where the control group achieved the best scores. The effect sizes for the measures assessed using the SCW test were found to be moderate. The magnitude of the WSC test variable was observed to be high and the backward Corsi SPAN was found to be moderately low.

CF, RI, and WM Variations for Level of Anxiety, Depression, and OBSI-R

Subsequent to observing statistically significant variations for anxiety, depression, and OBSI-R variables between groups, ANCOVA was performed. The level of depression had no impact on the results. Further, Corsi backward SPAN failed to show a significant variation while controlling for anxiety and OBSI-R ($p = .243$). Statistically significant variations remained in the following measures, particularly in the WCS test: Stroop distraction ($p = .024$), categories ($p = .013$), persistent

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responses ($p = .001$), overall errors ($p < .001$), persistent errors ($p < .001$) and non-persistent errors ($p < .001$), the control group achieved the best score.

Comparative results based on gender, comorbidities, substance use, and OCD subtype

No gender variation was observed in executive functions ($p > .05$). For comorbidities, commission error ($p = .026$), Stroop distraction ($p = .029$), Forward Corsi ($p = .021$), Backward Corsi ($p = .004$), Overall Corsi ($p = .029$), digit SPAN forward ($p = .035$), and digit scalar score ($p = .014$) were found to have significant variation. Corsi SPAN backward was slightly significant ($p = .052$). Participants without comorbidities showed greater performance. Drug type affected Corsi backward scores ($p < .001$). Patients taking antipsychotic drugs scored the worst.

For the OCD type, statistically significant variations were not found in any of the variables analyzed ($p > .05$). However, OCD types showed significant variations in the GNG test ($p = .036$), with repeaters performing worse on omission errors. In the Corsi SPAN forward, there was a slightly significant variation, with repeat patients receiving better scores ($p = .054$).

Association between executive functions, Y-BOCS scores, and OCD duration

OCD patients depicted a significant relationship between Y-BOCS and Corsi SPAN scores in the opposite direction ($r = -0.371$, $p = .05$), with lower score being associated with higher overall Y-BOCS scores. The findings indicated an insignificant association between executive function and OCD duration.

Discussion

The foremost purpose of the study was to analyze the association between executive functions and core elements of executive functions (such as cognitive flexibility, response inhibition, and working memory) and to analyze differences in these core elements in individuals with OCD with respect to a healthy control group.

The results of the WCS and DS tests presented lower scores in CF for the OCD patients, which match the findings of previous studies (Dittrich & Johansen, 2013; Lei et al., 2020). In the current study, OCD participants achieved lower performance in terms of persistent errors and categories, which are considered core symptoms of frontal dysfunction (Rhodes et al., 2017).

Higher distraction was observed in the SCW and GNG tests, suggesting lower cognitive and motor performance in response inhibition, which is consistent with previous findings (e.g., Ravandi et al., 2018; Saremi et al., 2017). Error processing and failure to enforce response inhibition may underlie deficits in unwanted compulsive behaviors in inhibitory disorders.

In line with other studies (e.g., Heinzel et al., 2018; Martoni et al., 2015; Perna et al., 2018), patients with OCD performed worse on tasks assessing visuospatial WM, as shown by Corsi SPAN backward. Perna et al. (2018) observed that patients with OCD have lower spatial storage capacity, which may lead to distrust of memory and greater reliance on external validation. Martoni et al. (2015) observed similarly that visuospatial WM deficits appeared to be more severe in OCD patients with increased workload and that they could be modulated by task strategies (executive dysfunction). The achieved effect sizes were high for cognitive flexibility, low to moderate for visuospatial WM, and low for response inhibition (Ravandi et al., 2018; Shin et al., 2014; Snyder et al., 2015).

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Furthermore, when looking at variations in WM due to anxiety, depression, and obsessive beliefs, the results for cognitive flexibility and response inhibition remained unchanged, but there was no variation in visuospatial WM between the two groups. Thus, these results suggest that anxiety and obsessive beliefs may affect response inhibition and WM tasks (Sahin et al., 2018). In contrast, depression did not play a moderating role, which is consistent with the study by Abramovitch & Cooperman (2015).

Additionally, when examining variations in executive function with respect to gender, comorbidities, and OCD subtype, no significant variations were observed between OCD patients. This observation is in line with the study of Krishna et al. (2011). Comorbidities affected response inhibition, with significant variations in commission errors, Stroop distraction, and higher scores in the control group. Comorbidities were also associated with variations in WM, with participants without comorbidities achieving higher performance. These findings are consistent with the study of Vandborg et al. (2014).

However, drug use affects visuospatial WM, with non-drug users performing better. This outcome indicates that some psychotropic drugs might have cognitive side effects. Nevertheless, drug intake did not affect cognitive flexibility and response inhibition in the current study, which contradicts some previous findings (Kalanthroff et al., 2016; Snyder et al., 2015) but is in line with other findings (Cols et al., 2002). There may be several reasons for this, for instance, OCD patients who are not on medication may not have previously been on medication, which may have permanently affected their executive function in some way; the difference between drug-based and non-drug treatment does not take into account the type of drug nor the fact that OCD samples are heterogeneous across OCD subtypes (Stein et al., 2008).

As for the main symptoms of OCD patients, there was no significant variation in executive function between different OCD types. However, when looking at OCD subtypes in OCD individuals, variations in omission errors were found, with repeats performing worse. Furthermore, slightly significant variations were seen in visuospatial WM of repeat patients. Those with other OCDs performed better on these tasks. This result is in line with the study by Berlin & Lee (2018), which observed a relationship between response inhibition and compulsion, supporting the idea that compulsion may be a behavioral manifestation of a potential deficit in response inhibition (Verbruggen & Logan, 2009).

In addition, a significant relationship was observed between OCD duration and visuospatial WM, with lower EF performance being associated with higher Y-BOCS scores. This result is in line with the observations of Abramovich et al. (2019), which highlighted a negligible negative correlation between the severity of OCD symptoms and visuospatial WM.

Conclusion

To sum up, EFs are the key to many of the skills that most say are critical to success in the twenty-first century, such as creativity, resilience, self-control, and discipline. EF allows us to mentally play with ideas, adapt quickly and flexibly to changing circumstances, take the time to think about what to do next, resist temptation, stay focused, and respond to new ideas, allowing us to tackle unexpected challenges. The performance of the control group was found significantly better than the OCD group on tasks involving CF, RI, and visuospatial WM. Deficiencies in these correlates of EF may be end-

phenotypes of OCD. Performance was found to be affected by the severity of OCD symptoms, patterns of comorbidities, and levels of anxiety, depression, and obsessive beliefs.

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