OXFORD
UNIVERSITY PRESS

Archives of Clinical Neuropsychology 26 (2011) 364–376

Archives of CLINICAL NEUROPSYCHOLOGY

Neuropsychological Impairments and Their Association with Obsessive-Compulsive Symptom Severity in Obsessive-Compulsive Disorder

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Accepted 18 March 2011

Abstract

Neurobiological research in obsessive-compulsive disorder (OCD) consistently demonstrates an association between abnormal brain activity and symptom severity. Conversely, research addressing the corresponding neuropsychological impairments in OCD and their association with symptom severity has produced inconsistent results. This study reexamines neuropsychological performance and its association with symptom severity in 30 participants with OCD while controlling for confounding variables. We used a computerized neuropsychological battery that was expected to provide more objective and accurate information and minimize examinee–examiner interactions, which may affect performance by reducing anxiety. The OCD group revealed dysfunctions on all neuropsychological domains compared with controls. OCD severity correlated significantly with the composite performance, executive functions, and verbal domain indexes. These results did not change after controlling for depression severity. We suggest that controlling for potential confounding variables and using a computerized battery may have contributed to the association found between obsessive symptoms and neuropsychological impairments. Theoretical implications are discussed.

Keywords: Obsessive-compulsive disorder; Executive functions; Depression; Assessment; Attention; Anxiety

Introduction

Obsessive-compulsive disorder (OCD) is a highly debilitating condition and one of the most common psychiatric disorders, with lifetime prevalence of 2%–3% (Crino, Slade, & Andrews, 2005). Research into the etiology of OCD is consistent in implicating a major role for heredity (Nicolini, Arnold, Nestadt, Lanzagorta, & Kennedy, 2009), but the relationship between the genotype and its symptomatic expression in OCD is complex. This relationship has been addressed in recent years in research on endophenotypes in neuropsychiatric disorders in general and specifically in OCD (Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005; Menzies et al., 2007; Rao, Reddy, Kumar, Kandavel, & Chandrashekar, 2008). Endophenotypes are "hidden" features that mediate genotypes and phenotypic expression. For example, it has been suggested that abnormal frontostriatal brain activity and response inhibition deficits are endophenotypical markers of OCD (Chamberlain et al., 2005; Menzies et al., 2008).

A large body of research has demonstrated neurobiological abnormalities associated with OCD both at rest and during symptom provocation. Numerous neuroimaging studies found functional brain abnormalities in OCD, primarily hyperactivation along the frontostriatal network (Harrison et al., 2009; Maltby, Tolin, Worhunsky, O'Keefe, & Kiehl, 2005) and specifically the orbitofrontal cortex (OFC), the basal ganglia, and the anterior cingulate cortex (ACC; Baxter, 1992; Harrison et al.,

doi:10.1093/arclin/acr022 Advance Access publication on 14 April 2011

2009; Lacerda, Dalgalarrondo, Caetano, Camargo, et al., 2003; Saxena & Rauch, 2000; Whiteside, Port, & Abramowitz, 2004). We should note that whereas these findings are very robust, some studies found certain regions of interest to be hypoactive in OCD, mainly during the performance of specific tasks, such as reversal learning (Remijnse et al., 2006) and implicit sequence-learning (Rauch et al., 1997).

However, findings regarding the pathophysiology of OCD are considered to be among the most robust in the psychiatric literature (Chamberlain et al., 2005). In contrast, whereas significant neuropsychological deficits have been implicated in OCD, these findings are considered inconsistent (Kuelz, Hohagen, & Voderholzer, 2004).

Neuropsychology of OCD

The developing consensus regarding the frontostriatal functional abnormalities as endophenotypic markers of OCD has boosted the interest in the neuropsychology of the disorder. Generally, research findings indicate neuropsychological deficits in OCD (Aycicegi, Dinn, Harris, & Erkmen, 2003; Chamberlain et al., 2005; Kuelz et al., 2004; Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003; Penades, Catalan, Andres, Salamero, & Gasto, 2005). Compared with normal participants, individuals with OCD display deficits in executive functions and perform poorly on response inhibition (Bannon, Gonsalvez, Croft, & Boyce, 2002; Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006; Penades et al., 2007), planning (van den Heuvel et al., 2005), and set shifting tasks (Aycicegi et al., 2003; Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003). Memory was also found to be impaired in individuals with OCD, particularly non-verbal memory (Muller & Roberts, 2005; Segalas et al., 2008) but also verbal memory (Savage et al., 2000; Segalas et al., 2008). In an attempt to account for memory impairments in OCD, several studies indicate that memory impairments in OCD are mediated by deficient encoding strategies that result in a reduction in the amount of encoded information and consequently diminished performance on recall tasks (Greisberg & McKay, 2003; Penades et al., 2005; Savage et al., 1999, 2000). Finally, research suggests deficits in attention, predominantly slower information processing, and psychomotor slowness (Burdick, Robinson, Malhotra, & Szeszko, 2008; Chamberlain et al., 2005; Harris & Dinn, 2003; Purcell, Maruff, Kyrios, & Pantelis, 1998).

In contrast to the findings reviewed above, a number of studies did not find cognitive performance deficits in OCD. Some studies did not find performance deficits in neuropsychological tests of executive functions, including response inhibition (Bohne, Savage, Deckersbach, Keuthen, & Wilhelm, 2008; Harris & Dinn, 2003), planning (Purcell et al., 1998), set shifting (Abbruzzese, Ferri, & Scarone, 1995; Henry, 2006), and fluency (Aycicegi et al., 2003). Similarly, other studies did not find cognitive deficits in verbal and nonverbal memory (Moritz, Kloss, von Eckstaedt, & Jelinek, 2009; Moritz, Ruhe, Jelinek, & Naber, 2009) and attention (de Geus, Denys, Sitskoorn, & Westenberg, 2007; Simpson et al., 2005).

A number of alternative explanations have been suggested for the inconsistency reviewed above. Basso, Bornstein, Carona, and Morton (2001) argued that comorbid depression, rather than OCD, accounts for the executive dysfunction in OCD (Basso et al., 2001). Others suggested that OCD is characterized by problems with confidence in memory rather than real memory deficits (Dar, Rish, Hermesh, Fux, & Taub, 2000; Tolin et al., 2001). Finally, it has recently been postulated that, neuropsychologically, OCD is characterized primarily by psychomotor slowing and deficit in information processing speed, which may influence performance on neuropsychological tests in a way that might be erroneously interpreted as deficits in other domains (Bedard, Joyal, Godbout, & Chantal, 2009; Burdick et al., 2008).

Other explanations presuppose that OCD is associated with genuine neuropsychological deficits, which were missed by some studies due to methodological and/or statistical problems. Kuelz and colleagues (2004) cite a number of studies that overlooked the potential confounding effects of demographic variables (e.g., sex, age, and years of education), but later studies that did control for demographic variables have continued to produce inconsistent results (Bedard et al., 2009). An additional problem is that neuropsychological research involves an examination of a number of domains (attention, memory, executive functions, language, psychomotor functions, visual-spatial functions, etc.) that are commonly further divided into subdomains. As a result, neuropsychological research may be susceptible to inflation of Type I errors, particularly in cases of relatively large number of dependent variables and relatively few participants. This issue was brought forth specifically in neuropsychological studies in OCD (Bedard et al., 2009; Kuelz et al., 2004; Purcell et al., 1998). The two most commonly suggested solutions for this problem (apart from substantially increasing the number of participants) are to perform statistical correction for multiple univariate analyses and to combine subdomains into larger domains in order to decrease the number of dependent variables. Recently, a study that amalgamated tests, which represent subdomains into larger domains, found minor differences between OCD and control participants (Burdick et al., 2008). It is important to note that it has been suggested recently that there is no scientific grounds for alpha correction due to a large number of tests (O'Keefe, 2003). However, a number of studies that did control for confounding variables and/or implemented statistical corrections continued to report conflicting neuropsychological findings (Bedard et al., 2009).

Another reason for the inconsistencies in neuropsychological research in OCD may be associated with the basic flaws of classic pencil and paper neuropsychological tests used in almost all neuropsychological studies on OCD. One of the major shortcomings of traditional neuropsychological testing is their inability to measure response time and response time latencies accurately and to assess the time versus accuracy tradeoff (Kertzman et al., 2006; Wilken et al., 2003). Consequently, time-limited tests that assess complex executive functions may mistakenly interpret underlying psychomotor, attentional, or processing slowing as executive function deficits.

Another important issue that has not received attention in the OCD literature is the impact of the interaction between examinee and examiner in neuropsychological assessment settings. Traditional pencil and paper neuropsychological batteries in research setting are constructed from a number of different tests and may take several hours (Gur et al., 2001). This time frame and the number of shifts between one test to another involve numerous verbal and non-verbal informal interactions between examiner and examinee. These "informal breaks" not only provide the examinee short periods of "recovery time," but may serve as means of reducing anxiety. In fact, explicit instruction on how to calm examinees and on the need to provide reassurance in order to reduce anxiety is included in major neuropsychological assessment textbooks (Strauss, Sherman, & Spreen, 2006; Vanderploeg, 2000). Reassurance seeking is considered a common form of control strategy in OCD that is often considered a type of compulsion, in the sense that it provides short-term relief from anxiety (Clark, 2004). Therefore, the impact of reassurance on behavioral, emotional, and cognitive performance in OCD may be significantly larger than in other clinical populations and may contribute to the inconsistent findings in this field.

Neuropsychological Test Performance and OC Symptom Severity

As reviewed above, there is a significant gap between the robustness of the findings regarding neurobiological abnormalities in OCD and the inconsistent findings regarding the corresponding neuropsychological deficits in this population. The same problem arises with regard to the association between the two endophenotypes and symptom severity. Functional imaging research consistently reveals a significant positive association between symptom severity and brain activity in OCD (Harrison et al., 2009; Lacerda, Dalgalarrondo, Caetano, Camargo, et al., 2003; Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003). More specifically, symptom severity in OCD was found to be positively correlated with brain activity in the bilateral, medial, and anterior OFC, the right thalamus, the inferior frontal cortex, the right basal ganglia, and on the neuronal network connecting the anterior OFC and the ventral striatum (Chamberlain et al., 2008; Harrison et al., 2009; Lacerda, Dalgalarrondo, Caetano, Camargo, et al., 2003; Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003). A similar association between brain activity and symptom severity was found in studies utilizing symptom provocation methodologies (Cottraux et al., 1996; Rauch et al., 1994). Finally, some studies reported specific brain activity profiles that were associated with specific types of symptoms such as hoarding, washing, checking, and so on (Mataix-Cols et al., 2004; Saxena et al., 2004). Nevertheless, findings regarding the association between OC symptom severity and neuropsychological test performance are limited and inconsistent. Several studies found significant association between OC symptoms and neuropsychological performance on memory tasks (Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003; Segalas et al., 2008). One study found that only severity of obsessions and not compulsions was significantly associated with some memory tests (Penades et al., 2005). Kuelz and colleagues (2006) found improvement in neuropsychological performance in non-medicated OCD individuals after behavioral therapy, suggesting an association between symptom severity and cognitive functions.

Finally, some studies reported no association between OC symptom severity and neuropsychological test performance (Bedard et al., 2009; Bucci et al., 2007).

In sum, while neuroimaging research strongly implicates abnormal brain activity in OCD, findings pertaining to neuropsychological deficits in OCD are contradictory. Similarly, while research strongly supports a significant association between abnormal brain activity and symptom severity in OCD, the association between OC symptom severity and neuropsychological functioning has not been established conclusively. In fact, in a critical review, Kuelz and colleagues (2004) reported that out of 22 studies examining this association almost half found no correlation between OC symptom severity and neuropsychological functioning in individuals with OCD.

In light of the foregoing review, our aim in the present study was to compare the neuropsychological functioning of individuals with OCD and normal controls and to assess the association between OC symptoms and neuropsychological profile. We assumed that by controlling for confounding variables suggested in OCD literature and by administering a computerized neuropsychological battery, we would be able to obtain more reliable results. In concordance with the majority of research on neuropsychology of OCD, we predicted that individuals with OCD would show impaired performance on most neuropsychological tasks, especially in tasks of executive functioning. In addition, in light of previous findings and the strong association between symptom severity and abnormal brain activity in OCD, we hypothesized that OC symptom severity will be associated with neuropsychological deficits that correspond to the current models of frontostriatal abnormalities in OCD.

Method

Participants

The initial sample consisted of 37 individuals diagnosed with OCD, who were recruited from an outpatient unit in a large mental health center in Israel. Inclusion criteria were male gender (this study was part of a larger project to which only male participants are recruited), age range 18–60 and primary diagnosis of OCD. Participants with a history of any neurological or psychotic disorder, post-traumatic stress disorder, bipolar depression, Tourette's syndrome, Attention Deficit/Hyperactivity Disorder, tic disorder, substance abuse disorder, or DSM-IV axis II disorder were excluded from this study. Diagnoses were re-assessed for the present study using the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1997; Sheehan et al., 1998). Seven OCD participants were excluded from the study based on these criteria (two were in remission and did not meet formal criteria for diagnosis of OCD, four had psychotic disorders, and one had substance abuse disorder and bipolar depression) resulting in 30 participants in the OCD group. Thirteen of these were unmedicated, 13 were taking selective serotonin reuptake inhibitors (SSRIs), and 4 were taking a combination of SSRIs and a low dose of antipsychotic medication. Twenty-four of the OCD participants had additional DSM-IV axis I disorders (Dysthymia, Social Phobia, Panic Disorder with Agoraphobia, Generalized Anxiety Disorder and Depression), whereas 6 were diagnosed only with OCD. As presented in Table 1, the Yale-Brown Obsessive Compulsive Scale (Y-BOCS) mean score represents severe degree of illness, stratified as follows: 10 participants fell into the "moderate" range of severity, 15 participants fell into the "severe" range of severity, and 5 participants fell into the "extreme" degree of severity. Nearly, all OCD subtypes (with the exception of hoarders) were represented in our sample. Using convenience sampling, the control group comprised 30 males matched for age and education. In order to employ strict procedure of matching the clinical and control groups, participants in the control group were recruited from the community by the research assistants primarily through friends and family members of their peers. All participants in the control group were free from the past or the present learning disability and any neurological, developmental, or psychiatric condition, as verified with the MINI. This study was approved by the mental health center and the university IRBs. All participants signed an informed consent in accordance with the Declaration of Helsinki.

Measures

The Hebrew version of the "MINI" version 5.0.0 (Sheehan et al., 1997, 1998) was used for the diagnosis of OCD and for the screening of comorbidities in both groups. The MINI is a well-validated brief structured psychiatric diagnostic instrument that was found to have 96% accuracy in identifying OCD (Sheehan et al., 1997).

The "Y-BOCS" (Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989), a widely used semi-structured clinician administered interview, was used to measure the severity of obsessions and compulsions. The Y-BOCS comprises 10 items rated on a 4-point scale. Five items are summed to derive the obsessions score and five to derive the compulsions score. In addition, a total score is computed.

"Beck Depression Inventory II" (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a gold-standard self-report measure for severity of depressive symptoms. The BDI-II comprises 21 groups of statements, and participants are asked to choose the statement that best describes the way they have felt in the past 2 weeks.

Table 1. Demographic and clinical characteristics

	OCD ($N = 30$)		HC ($N = 30$)		$F(1, 58)$	Significance
	SD	Mean	*SD*	Mean		
Age	31.95	7.86	30.19	6.36	0.905	ns
Education	13.17	1.84	13.97	1.65	3.140	ns
Age of onset	18.96	6.80				
BDI-II	13.26	8.66				
Y-BOCS Total Score	27.40	6.98				
Y-BOCS Obsessions	13.87	3.81				
Y-BOCS Compulsions	12.60	4.11				

Notes: Age of onset = age of onset of symptoms matching DSM-IV criteria for OCD; Y-BOCS = Yale Brown Obsessive Compulsive Scale; HC = healthy controls; BDI-II = Beck Depression Inventory—revised; OCD = obsessive-compulsive disorder. Y-BOCS score represent "severe" degree of illness.

Neuropsychological testing was administered via the "Mindstreams computerized neuropsychological battery". A detailed description of the Mindstreams battery is reported elsewhere (Dwolatzky et al., 2003; Schweiger, Abramovitch, Doniger, & Simon, 2007). In brief, the Mindstreams is a relatively short (~45 min), comprehensive, and well-validated computerized neuropsychological battery that samples a wide range of cognitive domains, including verbal memory, non-verbal memory, executive function, visual-spatial orientation, information processing speed, and motor skills. The battery has strong reliability and construct validity in accurately identifying cognitive deficits in psychiatric (Paleacu et al., 2007; Ritsner, Blumenkrantz, Dubinsky, & Dwolatzky, 2006; Schweiger et al., 2007; Strous et al., 2007) and neurological disorders (Doniger et al., 2006; Dwolatzky et al., 2003; Hausdorff et al., 2006). In fact, more than one hundred reports using the battery in research have been published so far (Neurotrax Corporation, 2003). In this study, we used the Hebrew version of the Mindstreams battery that utilizes Hebrew normative data to produce scaled score. Over 40 reports using the Hebrew version in research have been published (Neurotrax Corporation, 2003).

The battery provides raw data and scaled scores (i.e., similar to Wechsler IQ scales, with $M = 100$ and $SD = 15$) that are produced by comparing each individual's performance to an age- and an education- matched control group. The Mindstreams normative database comprises over 1,500 normal individuals, stratified by education and age (age range 9–95). Where relevant, the battery also provides two types of performance indexes. Every test involving speed and accuracy provides an index score that combines the two ([accuracy/reaction time] × 100). Finally, the battery provides index scores for each cognitive construct (memory, attention, executive functions, psychomotor, visual-spatial, verbal functions, and a Composite Performance Index score), derived from the similar elements across different tests. The following nine Mindstreams tests were used in this study.

Expanded Go-NoGo test. In this timed Go-NoGo continuous performance test, participants are asked to respond as quickly as possible to a series of any colored stimuli (squares), except red.

Mindstreams' Stroop test. This computerized version of the well-known Stroop test (Stroop, 1935) comprises three phases. In the first phase, the participant is asked to choose the color of the letters of general words. In the second phase (the Choice Reaction Time phase), the participant is asked to select the color named by a word in white-color letter. In the third and final phase (the Stroop phase), the participant is presented with words that name colors but are colored with a different color (e.g., the word Red in blue font).

Staged information processing test. This test comprises three levels of information processing load in which single digits, two-digit arithmetic problems (e.g., $9 - 3$), or three-digit arithmetic problems (e.g., $7 - 2 + 1$) are presented. For each of the three levels, the stimuli are presented in three fixed rates which increase as the test progresses. Participants are asked to press as fast as possible the left mouse key if the result is equal or <4, or the right mouse key if the result is >4.

Finger tapping. This test examines hand–eye coordination and psychomotor functions and is repeated twice. Participants are asked to press the mouse key repeatedly as fast as they can for 12 s.

Catch game. This test incorporates reaction time, hand–eye coordination, and planning. Participants are required to "catch" a "falling" object (a rectangle) by moving a "paddle" horizontally using the right and left mouse keys. The "falling" rectangle increases its speed on every consecutive trial.

Visual spatial imagery. Computer-generated three-dimensional scenes are shown in which a red pillar is located differently in every scene. Participants are asked to select one out of the four scenes that corresponds to the correct vantage point of the pillar.

Verbal memory. Ten pairs of words are presented after which participants are shown a target word and four words of which one is from the original list. Four consecutive recognition trials are presented during the "learning phase". After a 10-min filled delay, participants are presented with an additional recognition phase.

Nonverbal memory. Eight images are presented (e.g., a key pointing upward) followed by a recognition phase in which each of the initially presented images is presented together with the same image in three different orientations (the same key pointing up left, diagonally, or right). Four consecutive recognition trials are presented during the learning phase. After a 10-min filled delay, participants are presented with an additional recognition phase.

Verbal functions. Participants are presented with pictures of items. Following each presentation, participants are presented with four words and are requested to select the word that rhymes with the name of the object in the picture.

Procedure

Participants signed informed consent following a general explanation regarding the procedure. All participants completed a short general personal information sheet and were administered the MINI. The OCD participants were also administered the Y-BOCS and BDI-II. Following the interview, all participants took the Mindstreams computerized neuropsychological battery using the same laptop computer.

Statistical Analysis

In order to examine the differences between the groups on neuropsychological domain-scaled scores, we conducted eight univariate analyses of variance (ANOVAs). To avoid inflation of Type I error, we used an α of 0.00625 (0.05/8) for each test. We used the same approach in examining differences in neuropsychological performance on individual subtests comprising the domain index scores (i.e., dividing the 0.05 significance level by the number of subtests comprising each domain). We conducted Pearson's zero-order correlation analyses to examine associations between OC symptom severity and neuropsychological performance within the OCD group. We used partial correlation with control for depressive symptom severity. Due to technical difficulties, we were unable to obtain BDI-II scores from three participants. Consequently, correlation analyses within the OCD groups are based on 27 participants. We did not employ alpha correction for correlation analyses in line with recent arguments that alpha corrections might inflate Type II errors, particularly in the context of correlation analyses in which the significance level is highly dependent on the sample size (O'Keefe, 2003; Weber, 2007).

Results

Demographic and clinical characteristics are presented in Table 1, which shows that there were no significant differences between the OCD and the control groups in age and years of education. The BDI-II scores within the OCD group (also displayed in Table 1) represent minimal severity, which is accounted for by the small number of depressed participants in the OCD group. In order to examine the impact of depressive symptom severity on neuropsychological performance within the OCD group, we correlated the BDI-II score with the eight neuropsychological indexes (Composite Performance Index, Attention, Executive Functions, Information Processing Speed, Motor skills, Verbal Function, Memory, and Visual-Spatial Orientation indexes). None of the correlations were statistically significant (rs = 0.012–0.298). To examine the potential effect of comorbid disorders on neuropsychological performance within the OCD group, we conducted univariate ANOVA on the domain indexes with comorbidity as the independent variable. No significant difference was found on any of the indexes between participants with and without Depression. In fact, performance was very similar between these subgroups. The same null finding was obtained when examining all other comorbid axis I disorders (Dysthymia, Social phobia, Panic Disorder, and Generalized Anxiety Disorder). In the same vein, no significant differences were found on any of the neuropsychological domain indexes between unmedicated OCD participants and those taking SSRIs or antipsychotic medication. These results are consistent with those reported in other studies (Mataix-Cols, Alonso, Pifarre, Menchon, & Vallejo, 2002). No significant correlations were found between age of onset and any neuropsychological domain indexes.

As presented in Table 2, a series of univariate ANOVAs corrected for inflation of Type I error ($\alpha = 0.00625$) showed that the OCD group's domain index scaled scores were significantly lower than the control group's across all domains, including Composite Performance Index, the Attention, Executive Functions, Information Processing Speed, Motor skills, Verbal Function, Memory, and Visual-Spatial Orientation indexes. Differences between the control and the OCD groups on all domain indexes were highly robust with Cohen's d effect size coefficients ranging between 1.0 and 1.92. To examine the differences in performance on individual test parameters, we compared the two groups on the raw scores of every component comprising each domain. As presented in Table 3, the OCD group scored lower on all test parameters when an uncorrected alpha level was used. After controlling for inflation of Type I error, differences on three subtest variables were no longer significant: the standard deviation of reaction time on the Go-NoGo test ($p = .016$), the Staged Information Processing test accuracy ($p = .011$), and the delayed verbal memory accuracy test ($p = .02$). Effect sizes across all 21 tests, ranged from medium to large with Cohen's d effect size coefficient ranging from 0.57 to 1.38. Specifically, large effect sizes were obtained in the Executive Functions, Information Processing Speed, and Visual-Spatial domain indexes.

We calculated Pearson's correlation coefficients to assess the association between OC symptom severity and neuropsychological test performance. As presented in Table 4, the Y-BOCS total score correlated negatively and significantly with the

Table 2. Differences in neuropsychological domain indexes scaled score between OCD and control groups

Domain Index[a]	OCD ($N = 30$)		HC ($N = 30$)		$F(1, 58)$	Effect size Cohen's d
	SD	Mean	*SD*	Mean		
Composite Performance Index[b]	86.73	11.58	104.68	6.36	33.757***	2.00
Executive functions	87.29	14.86	104.38	9.10	25.541***	1.39
Attention	86.25	16.93	104.89	8.09	17.477***	1.40
Information Processing Speed	85.72	16.13	104.18	11.28	9.497***	1.33
Motor Skills	94.25	11.74	106.86	7.58	20.230***	1.28
Verbal Function	82.29	27.44	106.29	9.60	10.174***	1.17
Memory	84.38	19.56	100.53	9.58	8.471***	1.05
Visuospatial	88.11	21.04	105.60	12.90	11.953***	1.00

Notes: HC = healthy controls; OCD = obsessive-compulsive disorder.
[a]Scores are scaled according to Wechsler indexes (Mean = 100, $SD = 15$).
[b]Composite Performance Index N = General index representing overall neuropsychological performance.

Table 3. Differences between the OCD and control groups on neuropsychological domain subtests raw scores

Domain subtests	OCD ($N = 30$)		HC ($N = 30$)		$F(1, 58)$	Significance	Effect size Cohen's d
	Mean	*SD*	Mean	*SD*			
Executive functions							
Go-NoGo composite Score[a]	19.73	5.32	25.14	2.50	25.532	<.0001	1.30
Stroop composite Score	17.93	8.75	25.85	6.71	15.473	<.0001	1.02
Catch game total score	849.73	141.37	938.30	84.03	8.700	.005	0.76
Attention							
Go-NoGo RT (ms)	488.59	114.18	389.44	39.50	18.790	<.0001	1.16
Go-NoGo RT SD (ms)	130.77	119.62	68.52	18.88	7.396	.009	0.73
Stroop RT level 2 (ms)	519.73	168.98	388.97	87.49	14.168	<.0001	0.97
Staged info. RT 1.2 (ms)	618.65	146.75	474.40	71.72	23.397	<.0001	1.25
Staged info. accuracy 2.3 (%)	73.57	24.98	85.00	13.83	4.731*	.034	0.57
Information Processing Speed							
Staged info. composite score 1.1	14.89	3.93	18.66	2.51	19.572	<.0001	1.14
Staged info. composite score 1.3	15.74	3.91	20.50	2.89	28.639	<.0001	1.38
Staged info. composite score 2.1	7.98	2.18	10.23	1.77	18.596	<.0001	1.13
Staged info. composite score 2.2	10.47	2.65	13.09	2.23	16.619	<.0001	1.07
Motor skills							
Finger tap inter-tap interval (ms)	195.79	45.56	171.43	25.28	6.507	.013	0.66
Finger tap inter-tap interval SD (ms)	39.76	13.71	24.00	14.95	17.768	<.0001	1.10
Catch game time to first move (ms)	462.50	136.00	386.77	65.11	7.569	.008	0.71
Verbal functions							
Rhyming accuracy (%)	82.12	19.73	95.10	8.29	11.034	.002	0.86
Memory							
Verbal memory accuracy (%)	84.87	19.59	95.43	6.22	7.929	.007	0.73
Delayed Verbal memory accuracy (%)	85.00	21.46	95.00	7.77	5.762*	.02	0.62
Non-verbal memory accuracy (%)	72.50	22.25	91.90	6.74	20.890	<.0001	1.18
Delayed Non-verbal memory Accuracy (%)	76.97	27.48	95.53	8.83	12.413	.001	0.91
Visuospatial							
Visuospatial accuracy (%)	62.90	24.24	85.77	13.43	20.421	<.0001	1.17

Notes: HC = healthy controls; ms = milliseconds; RT = response time; Stroop level 2 = choice reaction time, selecting color named by a word in white letter-color; Staged info.: 1.1 = staged information processing task low load low speed; 1.2 = low load medium speed; 2.1 = medium load low speed; 2.2 = medium load medium speed.
[a]All composite scores are calculated: (accuracy/reaction time) × 100.
*Not significant after alpha correction for multiple univariate analyses (0.05/the number of domain subtests).

neuropsychological Composite Performance Index ($r = -.400$, $p = .039$, Figure 1a), the Executive Functions Index ($r = -.565$, $p = .002$, Figure 1b), and the Verbal Functions Index ($r = -.389$, $p = .045$). The Y-BOCS Obsession scale was significantly negatively correlated with the Executive Functions Index ($r = -.511$, $p = .006$) and the Verbal Functions

Table 4. Y-BOCS and neuropsychological domain index zero-order and partial correlation coefficients controlling for depressive symptom severity, within the OCD group

	Composite Performance Index	Attention	Executive Functions	Information Processing Speed	Motor Skills	Verbal Functions	Memory	Visuo-Spatial
Y-BOCS Total Score	−.400* (−.391*)	−.262 (−.238)	−.565** (−.527**)	−.077 (−.083)	−.197 (−.181)	−.389* (−.399*)	−.174 (−.172)	−.009 (−.035)
Y-BOCS Obsessions	−.355 (−.344)	−.238 (−.214)	−.511** (−.472*)	−.030 (−.028)	−.118 (−.099)	−.474** (−.485**)	−.115 (−.110)	.082 (.061)
Y-BOCS Compulsions	−.243 (−.232)	−.100 (−.142)	−.454* (−.432*)	−.179 (−.188)	−.232 (−.222)	.112 (−.110)	−.144 (−.141)	.012 (−.002)

Notes: Y-BOCS = Yale-Brown Obsessive Compulsive Scale; OCD = obsessive-compulsive disorder. Partial correlations controlling for BDI-II scores are in parenthesis.
*$p < .05$.
**$p < .01$.

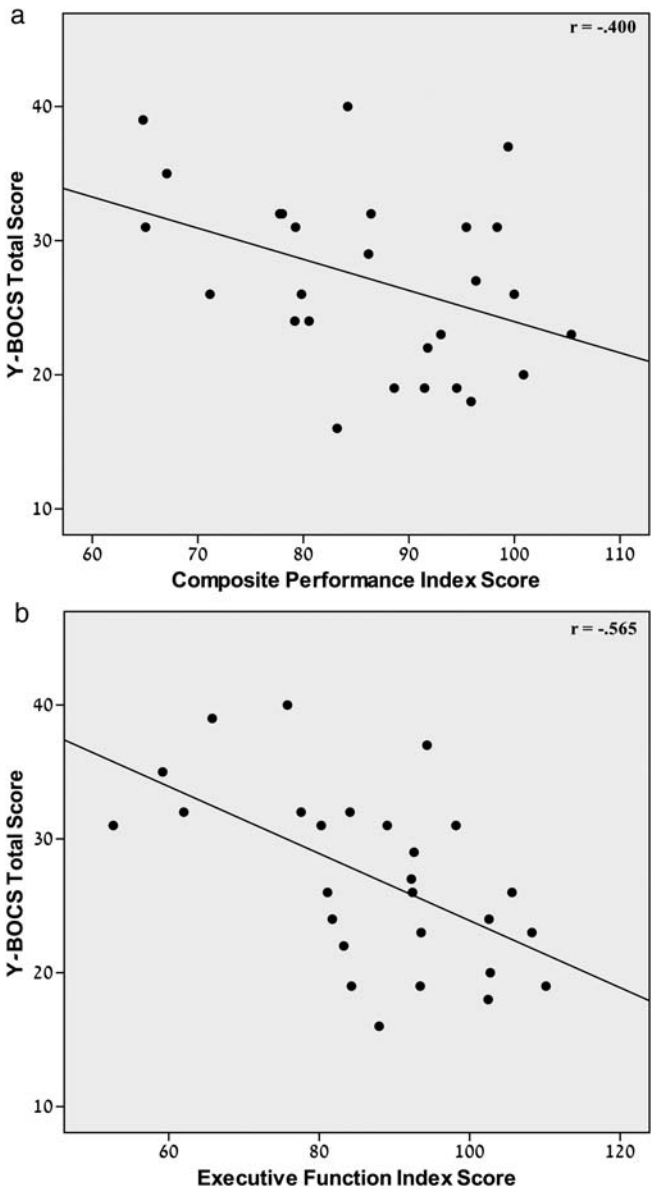

Fig. 1. Association of the Y-BOCS total score with (a) the Composite Neuropsychological Performance index score and (b) the Executive Functions index score within the OCD group.

Index ($r = -.474$, $p = .012$). Y-BOCS Compulsion scale was negatively and significantly correlated only with the Executive Functions Index ($r = -.454$, $p = .017$).

In order to control for the potentially confounding effects of depressive severity, we re-calculated all the above coefficients while partialling out the BDI-II scores. As presented in Table 4, these partial correlations were nearly identical to the zero-order correlations, indicating no confounding effects of depression.

Discussion

The first aim of this study was to compare neuropsychological functioning between individuals with OCD and matched controls. In line with our principal hypothesis, OCD participants performed significantly worse on all neuropsychological domains (Composite Neuropsychological Performance Index, Attention, Executive Functions, Information Processing Speed, Motor Skills, Verbal Functions, Memory, and Visual Spatial Orientation). Moreover, the OCD group performed significantly worse than controls on all the individual parameters in all domains, including parameters from the Mindstreams' Stroop test, Go-NoGo, Staged Information Processing Test, Finger Tapping test, Rhyming Test, Verbal Memory Test, Non-Verbal Memory Test, and Visual Spatial Imagery Test. These results signify a wide-ranging neuropsychological impairment in OCD. Consistent with previous studies (Burdick et al., 2008; Penades et al., 2005; Rao et al., 2008), depressive symptom severity was not associated with neuropsychological performance.

As discussed above, the majority of neuropsychological studies implicate neuropsychological deficits in OCD, especially in the executive function domain. Nevertheless, it has been noted that "the overall conclusions are notoriously divergent" (Bedard et al., 2009). In the present study, we gave careful consideration to the criticism concerning confounding variables and alternative explanations for the inconsistent results in this field, including matching for age and education, strict inclusion and exclusion criteria, statistical corrections, analyzing performance on neuropsychological domains as well as individual tests, and examining the impact of comorbidities and medication. In addition, we used a well-validated computerized neuropsychological battery in order to improve accuracy in measuring response time, taking into account speed versus accuracy tradeoff. While not directly examined in this study, we believe that the use of a computerized neuropsychological battery also minimizes examinee–examiner interactions, which may affect neuropsychological performance by reducing anxiety. As previously noted, this may be especially important in the case of individuals with OCD who are reported to utilize reassurance seeking as the most common strategy to reduce obsessive thoughts and images (Freeston & Ladouceur, 1997). Indeed, research suggests that reassurance seeking is reinforces by temporary reduction in anxiety (Parrish & Radomsky, 2006). Thus, neuropsychological test performance in OCD may be relatively unstable as symptoms may be exacerbated or alleviated in different settings, especially under test conditions while interacting with examiners. Specifically, it is possible that the anxiety-reducing effect inherent to these situations and the variability in examinee–examiner interactions may potentially impact neuropsychological performance and may have contributed to the inconsistent results presented in neuropsychological literature in OCD. We believe that employing these methods enabled us to obtain a more objective neuropsychological profile of individuals with OCD.

More generally, there are good reasons to believe that neuropsychological deficits in OCD are largely influenced by situational or state factors (beyond the influence of depression). The neuropsychological findings in OCD are more variable than those in other neuropsychiatric disorders (e.g., ADHD, Schizophrenia), which is consistent with the possibility that neuropsychological functioning in OCD is influenced by various "state" factors such as obsessive preoccupation, anxiety, parameters of the test situation, and so on. Furthermore, a trait interpretation of these findings is undermined by the association between OC symptoms and neuropsychological impairments, which indicates that the impairment is not determined by having the "trait" of OCD but by the severity of the symptoms (i.e., the state), as also found in other studies (Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003; Segalas et al., 2008; Tallis, 1997; Tallis, Pratt, & Jamani, 1999). In the same vein, research shows that neuropsychological performance in OCD significantly improves upon successful behavioral treatment (Kuelz et al., 2006). These findings further undermine a trait account of these deficits.

Our results are in accord with numerous studies suggesting an overall neuropsychological deficit in OCD, especially in executive functions, memory, psychomotor, and verbal functions (Aycicegi et al., 2003; Bannon et al., 2002; Bucci et al., 2007; Chamberlain et al., 2005, 2006; Deckersbach et al., 2002; Greisberg & McKay, 2003; Harris & Dinn, 2003; Hartston & Swerdlow, 1999; Kuelz et al., 2004, 2006; Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003; Muller & Roberts, 2005; Penades et al., 2005; Purcell et al., 1998; Rao et al., 2008; Savage et al., 2000; Segalas et al., 2008; van den Heuvel et al., 2005).

The second aim of this study was to explore the association between OC symptom severity and neuropsychological performance in OCD. In line with our predictions, we found medium to strong negative correlations between symptom severity (particularly obsessions) and performance on the Composite Neuropsychological Performance Index, Executive Functions Domain Index, and the Verbal Functions Domain Index. These correlations, which virtually remained unchanged after controlling for depressive symptom severity, corroborate the notion that OC symptoms—associated with abnormal brain activity—may have a

secondary impact on cognitive functioning. Whereas only few studies examined the association between symptom severity and neuropsychological deficits in OCD, their results are generally in agreement with ours (Lacerda, Dalgalarrondo, Caetano, Haas, et al., 2003; Segalas et al., 2008; Tallis, 1997; Tallis et al., 1999).

Neuropsychological deficits, especially in executive functions, are characteristically associated with damage or "hypoactivity" in certain brain regions. In OCD, in contrast, executive function deficits are concomitant with abnormal "hyperactivation" of prefrontal (and frontostriatal regions). We suggest that our findings of a strong association between OC symptom severity and neuropsychological dysfunction support the view that neuropsychological deficits in OCD should be understood as epiphenomena. Specifically, we hypothesize that the hyperactivation of the frontostriatal network in individuals with OCD reflects hypercontrol that is manifested in an obsessional thoughts overflow. This in turn causes "flooding" of the executive control system and consumes valuable resources that are needed for normal cognitive functioning.

The model described above is consistent with the view that individuals experiencing anxiety and depression pay a "cognitive price" for emotionally loaded thoughts. For example, depressed individuals are believed to display "capacity reduction" and difficulty in allocating attention to external stimuli (Gotlib, Roberts, & Gilboa, 1996; Hartlage, Alloy, Vazquez, & Dykman, 1993). With regard to anxiety disorders, it has been suggested that high levels of anxiety "consume" working memory capacities during task performance due to irrelevant processing of intrusive information (Eysenck, 1992; Gotlib et al., 1996). Recently, Boyer and Lienard (2006) suggested that "flooding of the working memory" occurs in individuals with OCD as a result of constant preoccupation with and attempt to control fragmented lower-level gestures. Such "cognitive price" is supported by ERP studies examining error and action monitoring, which consistently find an association between error-related negativity, deficient performance on cognitive tasks, and OC symptom severity (Endrass, Klawohn, Schuster, & Kathmann, 2008; Gehring, Himle, & Nisenson, 2000; Ursu, Stenger, Shear, Jones, & Carter, 2003). It should be noted, however, that correlation results do not necessary reflect causation. Although it is logical to hypothesize that an overflow of obsessive thoughts consumes neurocognitive resources needed for other cognitive task, there is also a possibility that individuals with OCD who are more cognitively impaired may be more likely to have more severe scores on the Y-BOCS.

Our study has some limitations. First, only male participants were included in this study, so our results should be replicated using a mixed-gender sample. Second, our sample size did not allow for analysis of OCD subtypes. Notably, our clinical sample did not include OCD hoarders—an OCD subtype that is thought to be associated with a different neuropsychological profile in comparison to all other subtypes (Pertusa et al., 2010). In addition, our comparisons of subgroups of OCD with and without comorbid axis I disorders and medication resulted in small sample sizes. Whereas the inclusion of participants that are not drug-naïve is a potential limitation, there was no indication of differences in neuropsychological performance between medicated and unmedicated participants. In addition, as noted previously, this issue was directly examined by Mataix-Cols and colleagues (2002) suggesting that SSRI medications did not have an impact on cognitive functions in their sample of OCD and concluded that "both SRI-medicated and SRI-free patients could be recruited, thus increasing the population available for study" (Mataix-Cols et al., 2002). Finally, based on the Y-BOCS mean score, our clinical sample is characterized with severe degree of illness. This degree of severity may not represent a typical group of OCD participants.

Conclusion

Our findings of wide-ranging impairments in neuropsychological functioning in OCD, which are correlated with OC symptom severity, are important in light of the mixed results in previous research examining neuropsychological performance in OCD and the paucity of research examining its clinical correlates. By considering reaction time/accuracy tradeoff and minimizing examiner–examinee interaction, the use of computerized neuropsychological battery may have enabled us to find more objective and accurate results. Our findings regarding the association between neuropsychological deficits and OC symptom severity, an area that has been relatively neglected, are encouraging and should be explored further.

Conflict of Interest

None declared.

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