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Neurocognitive Function in Pediatric Obsessive-Compulsive Disorder

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Abstract

Objectives—The small body of neuropsychological research in pediatric OCD yields inconsistent results. A recent meta-analysis found small effect sizes, concluding that pediatric OCD may not be associated with cognitive impairments, stressing the need for more research. We investigated neuropsychological performance in a large sample of OCD youth, while assessing potential moderators.

Methods—Participants with OCD (n=102), and matched controls (n=161) were thoroughly screened and blindly evaluated for comorbidities, and completed a neuropsychological battery assessing processing-speed, visuospatial abilities (VSA), working memory (WM), nonverbal memory (NVM), and executive functions (EF).

Results—Compared to controls, youth with OCD exhibited underperformance on tasks assessing processing-speed. On tests of VSA and WM, underperformance was found only on timed tasks. There were no differences on NVM and EF tasks. Notably, the OCD group's normalized scores were in the normative range. Test performance was not associated with demographic or clinical variables.

Conclusions—OCD youth exhibited intact performance on memory and EF tests, but slower processing-speed, and underperformance only on timed VSA and WM tasks. While the OCD group performed in the normative range, these findings reveal relative weaknesses that may be overlooked. Such oversight may be of particular importance in clinical and school settings.

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Keywords

Neuropsychological tests; executive functions; processing speed; comorbidity; children

Introduction

Obsessive-Compulsive Disorder (OCD) is a burdensome disorder with a worldwide prevalence rate of 1-3% (Ruscio et al. 2010). Research suggests that the onset of OCD has a bimodal distribution pattern (Geller 2006), with the first peak in pre-adolescents and a second in early adulthood. Indeed, clinically significant OCD can be traced to childhood in nearly half of adult OCD patients. A large body of imaging research reveals neurobiological abnormalities in OCD (Melloni et al. 2012), generally depicting resting state frontostriatal hyperactivation. However, in contrast to the relative consistency observed in results from imaging studies, (Chamberlain et al. 2005), neuropsychological findings are notoriously inconsistent (Abramovitch and Cooperman 2015). Indeed, in a comprehensive meta-analysis of 115 studies examining neuropsychological functioning in adult OCD patients, Abramovitch and colleagues (Abramovitch et al. 2013) found significant heterogeneity across studies that was not accounted for by any potential moderator. In terms of effect sizes, meta-analyses of neuropsychological test performance in adults with OCD found small to moderate effect sizes, particularly in the domains of processing speed, non-verbal memory, and executive functions (Abramovitch, Abramowitz and Mittelman 2013, Shin et al. 2014, Snyder et al. 2014).

Despite the extensive research conducted in adults with OCD, far fewer investigations have examined neuropsychological test performance in pediatric OCD samples. This small corpus of research reveals even greater inconsistency than seen in the results of adult OCD research. In one of the first studies investigating neuropsychological test performance in pediatric OCD, Behar and colleagues (Behar et al. 1984) compared 16 adolescents diagnosed with OCD with 16 matched non-psychiatric controls. The authors found a higher number of errors on planning tasks (i.e., the Money's Road Map Test and the Stylus Maze Learning Test), but no difference on tests of verbal memory, processing speed, or on the Copy and Memory sections of the Rey-Osterrieth Complex Figure test (RCFT), assessing visuospatial functions and non-verbal memory, respectively. In a later study, Beers and colleagues (1999) administered a comprehensive neuropsychological test battery and found no difference between the 21 pediatric OCD patients and 21 matched controls. In fact, OCD patients in this study outperformed controls on tests of verbal fluency and the Stroop word and color trials. In a more recent study, Andres et al. (Andres et al. 2007) administered a large battery of neuropsychological tests to 35 children and adolescents with OCD and matched controls. Children with OCD demonstrated poorer performance on tests of verbal and non-verbal memory, as well as on tests of executive function (i.e., the Stroop test and the Wisconsin Card Sorting Test - WCST). Other studies reported reduced performance on tests of executive functions in pediatric OCD patients as compared to controls, but not on the RCFT or tests of attention (Shin et al. 2008). Similarly, Orenstein and colleagues (Ornstein et al. 2010) reported deficient performance among pediatric OCD participants on tests of planning and cognitive flexibility, but not on tasks of response inhibition and memory. In order to systematically examine this small body of literature, Abramovitch and colleagues conducted a meta-analysis of 11 neuropsychological studied in pediatric OCD (Abramovitch et al. 2015). The authors reported effect sizes ranging between 0.04 - 0.40 with an overall weighted small effect size of 0.27, and interpreted these small effect sizes as suggesting that pediatric OCD may not be associated with major impairments in cognitive abilities. Of note, similar to the vast majority of adult neuropsychological studies, reports regarding an association between neuropsychological functioning and symptom severity in pediatric OCD are scarce (Abramovitch et al. 2012). In fact, little is known about clinical moderators of cognitive function in pediatric OCD, presumably due to the small sample sizes ranging between n=14 to 35 (Abramovitch, Abramowitz, Mittelman, Stark, Ramsey and Geller 2015).

A number of problems arise from the small sample sizes characteristic of this body of literature that may not only reduce power and limit generalizability, but also limit examination of confounds, mediators, and moderators. Secondly, these studies used a large number of partially intercorrelated outcome measures, which demands correction for multiple comparisons. A number of studies that did not employ an alpha correction for multiple comparison could produce an inflated Type I error that may in part, account for this inconsistency. Clinical factors such as medication status and age of onset may have also confounded these studies results (Andres, Boget, Lazaro, Penades, Morer, Salamero and Castro-Fornieles 2007, Ornstein, Arnold, Manassis, Mendlowitz and Schachar 2010). Notably, meta-analytic reviews found that these factors do not moderate neuropsychological test performance in adult OCD samples (Abramovitch, Abramowitz and Mittelman 2013, Shin, Lee, Kim and Kwon 2014). In addition, it has been hypothesized that alterations in neuromaturation processes in preadolescent youth with OCD is reflected in different pathophysiology (Fitzgerald et al. 2011) in preadolescent and post-adolescent OCD, with differing neuropsychological profiles. Finally, the majority of youth with OCD are diagnosed with at least one additional DSM comorbid condition (Boileau 2011) and several prevalent comorbid conditions in OCD may be independently associated with neuropsychological deficits (e.g., ADHD, chronic tic disorder, depression), that may potentially confound findings of altered neuropsychological test performance. However, several studies investigating neuropsychological functioning in pediatric OCD either excluded patients with secondary comorbid psychiatric conditions (e.g., Andres, Boget, Lazaro, Penades, Morer, Salamero and Castro-Fornieles 2007), or included a sample size that did not permit comprehensive analysis of the impact of comorbid conditions on neuropsychological functioning. To our knowledge, no study to date has performed a comprehensive examination of the impact of different comorbid conditions on neuropsychological performance in pediatric OCD.

In light of the paucity of studies, their inconsistent results, and small sample sizes, the primary aim of the present study was to examine neuropsychological functioning across major domains of interest in a large sample of youth with OCD. The secondary aim was to examine several potential moderating factors (i.e., OCD severity, age of onset, medication status, depression, and current age), including an examination of the potential moderating effect of comorbid diagnoses. Based on clinical experience and limited evidence from the extant and inconsistent literature, we hypothesized that the OCD group would underperform the control group on several outcome measures, particularly measures of processing speed, executive functions (other than inhibitory control), and visuospatial functions.

Method

Participants

The OCD group (*n* = 102; see Table 1. for demographic information) was recruited as part of a large family study (NIMH K08MH01481, PI DG) via referral to the Pediatric OCD Program at Massachusetts General Hospital in Boston. Fifteen percent of patients were ascertained directly through advertising and direct clinician referrals to the research study and 85% were patients referred to the OCD clinic. Inclusion criteria were age between 6-17, a primary diagnosis of OCD and basic English proficiency. We excluded potential participants if they had a major sensorimotor handicap (deafness, blindness), an eating disorder, psychosis, autism, pervasive developmental disorder, or full scale IQ less than 80. The control group (n=161) derived from a sample of identically designed contemporaneous case-control family studies of male and female youth with and without attention-deficit hyperactivity disorder (ADHD) ascertained from psychiatric and pediatric settings. Detailed study methodology is reported elsewhere (Biederman et al. 2002, Rosenbaum et al. 2000). Briefly, these studies ascertained families on the basis of a case (ADHD) or control (non-ADHD) children aged 6-17 years at time of ascertainment and included 242 control cases with their 737 first-degree biological relatives, respectively. The same pool of trained raters interviewed them with a similar assessment battery thus avoiding a cohort effect. For this comparison a random sample of biological siblings of the *non-ADHD* control cases were selected as matched to the OCD baseline sample on age and gender. For the present study, we excluded control participants with a lifetime or current diagnosis of OCD. Other disorders were not excluded to provide a “normal” control sample representative of community rates of disorders rather than a “super-normal control” group with all disorders screened out that may yield results that are not generalizable due to poor ecological validity. Rates of *lifetime* DSM diagnosis in the control sample were as follows: Major depressive disorder (n=7, 4.3%), bipolar disorder I (n=1, 0.6%), bipolar disorder II (n=1, 0.6%), dysthymia (n=3, 1.8%), panic disorder (n=2, 1.2%), agoraphobia (n=6, 3.7%), simple phobia (n=13, 8%), social phobia (n=7, 4.3%), anorexia nervosa (n=1, 0.6%), ADHD (n=26, 16%), and conduct disorder (n=5, 3.1%).

Clinical and diagnostic measures—Psychiatric assessments were made using the Kiddie SADS-E (Epidemiologic Version; Orvaschel and Puig-Antich 1987) and were based on blind independent interviews with the patients' mothers and direct interviews with the patients. Identically trained raters who were blind to the clinical status of the subjects evaluated participants of both groups. A diagnostic review team blindly weighed each source of information from direct and indirect Kiddie SADS-E to yield diagnoses using a Best Estimate method described by Leckman et al. (Leckman et al. 1982) as well as clinical judgment based on the information provided in each report. Diagnoses were considered definite only if DSM IV criteria (APA 2000) were met to a degree that would be considered clinically meaningful. Discrepancies between parents and children were resolved using both reports and a consensus algorithm that included the more severe rating from either source.

Next, an experienced child psychiatrist (DAG) clinically interviewed children and adolescents of all ages, administered the Children's Yale-Brown Obsessive Compulsive Scale (CY-BOCS; Scahill et al. 1997) and the Yale Global Tic Severity Scale (YGTSS; Leckman et al. 1989) where indicated, and resolved any discrepancies in parent and child reports in favor of the informant deemed most reliable. Thus, final Best Estimate diagnoses used data from all sources. Age at onset was determined by the age at which symptoms were estimated to be clinically impairing. This was defined by overall daily symptom presentation greater than one hour (indicated by a CYBOCS score ≥2, items 1&6), subjective distress greater than mild (indicated by a CYBOCS score ≥2, items 3&8), and functional impairment of at least moderate degree (≥2 on CYBOCS, items 2&7)"

Neurocognitive measures—To increase validity and facilitate replicability, a battery of gold standard neuropsychological tests was selected. The tests have been validated in numerous languages and are commonly used in pediatric and adult OCD studies facilitating comparison with previous investigations. The neuropsychological domains and tests were:

Intellectual ability: To control for intelligence we administered the Wechsler Intelligence Scale for Children – 3rd edition Vocabulary subtest (WISC-III; Wechsler 1991), a reliable estimate of general intellectual potential (Lezak et al. 2012).

Processing Speed: The WISC-III subtests comprising the processing speed index (i.e., Digit Symbol Coding and Symbol Search) were used to assess processing speed.

Visuospatial Abilities: To assess visuospatial abilities we used the Rey-Osterrieth Complex Figure Test (RCFT; Osterrieth 1944) Copy accuracy score, and the WISC-III Block Design subtest scaled score.

Working memory: The WISC-III Arithmetic and Digit Span scaled scores were selected for the assessment of working memory.

Non-verbal Memory: For the assessment of non-verbal memory, the RCFT Delayed accuracy score was used.

Executive Functions: The Stroop test (Stroop 1935) was used to assess response inhibition/interference control. We used the Golden (1978) administration and scoring procedures where *t* scores were calculated for each of the three Stroop trials (i.e., Color, Word and Color-Word) as well as for the interference index. Cognitive flexibility/set shifting were assessed using the computerized version of the WCST (Harris 1990). Finally, the RCFT Copy and Delayed organization scores were computed using the Developmental Scoring System for the RCFT (DSS-ROCF; Bernstein and Waber 1996).

Procedure

For all participants, a parent/legal guardian signed an informed consent. As this study was part of a larger family study, each family received monetary reimbursement. The present study was approved by the Massachusetts General Hospital Institutional Review Board, in accordance with the declaration of Helsinki. All clinical and neuropsychological measures were administered in a uniform fashion for all participants according to standard published guidelines. Raters completed training pertaining to neuropsychological administration and scoring by an experienced neuropsychologist (PhD level) and clinical ratings by an experienced child psychiatrist (DAG). In addition, quality control measures were taken to assure accurate administration, scoring, and data integrity as follows. Bachelor's level test administrators observed Ph.D. level examiners administrating a neuropsychological test battery, then administered tests under direct supervision until assessment competence and testing scores matched PhD level supervisors' scores a minimum number of times, before being permitted to administer tests independently. All neuropsychological tests were administered in a single 2-3 hour session.

All data was entered independently by two research assistants and then checked for congruence errors before analyses.

Data analysis

In order to examine differences in neuropsychological test performance between the control and OCD groups, univariate analyses of variance (ANOVA) were used. In addition, ANOVAs were used in the examination of the potential confounding impact of medication and comorbidity. Age, estimated IQ and gender were used as covariates (ANCOVA) when differences on these variables were detected. Pearson correlations were computed to assess the impact of continuous variables on neuropsychological performance. Group differences on nominal variables were analyzed using Pearson's χ^2 test. In order to correct for multiple comparisons, a conservative *p* value of 0.01 was used. We chose this common method (instead of methods such as Bonferroni correction) because some tests/domains had only one outcome measure, yet others had numerous variables analyzed. Using the conservative *p* value of 0.01 value across all analyses provided an equal probability threshold for multiplicity correction.

Results

No significant differences were found between the groups on age, gender, and estimated IQ (Table 1). The average CY-BOCS scores (M=20.9, Table 1) reflect moderate degree of OCD symptom severity.

Neuropsychological test performance

Results of individual comparisons on test performance are presented in Table 2. Compared to controls, the OCD group scored significantly lower on tests assessing processing speed, namely, the Digit Symbol Coding test ($F(1, 261) = 34.83$, $p < .001$, Cohen's $d=.72$), and the Symbol Search test ($F(1, 166)= 9.65$, $p=.002$, $d=.50$). For visuospatial ability, the OCD group scored significantly lower on the Block Design test ($F(1, 261)= 50.75$, $p <.001$, $d=.91$) but not on the RCFT Copy trial ($F(1, 159) = 1.11$, $p=.29$, $d=.16$). In the domain of working memory, the OCD group performed significantly worse than the control group on the Arithmetic test ($F(1, 261)= 13.90$, $p <.001$, $d =.46$), but there was no significant difference on the Digit Span test ($F(1, 261)= 0.59$, $p=.44$, $d=.10$). Within the domain of executive functions, no significant differences were found on all Stroop and WCST outcome measures (all *p*'s > .05, *d* range .01 - .26). No significant difference was found on the RCFT Copy Organizational Score (F(1, 161)= 1.30, p=.26, d=.18). In contrast, the OCD group scored lower on the RCFT Delayed Organizational Score (F(1, 160)= 5.81, p=.02, d=.18). However, given the conservative significance threshold determined for the present study (p <.01), the results of this analysis did not cross significance threshold. Similarly, the OCD sample scored lower on the RCFT Delayed Recall phase (F(1, 159)= 4.59, p=.03, d=.34), but this difference was deemed insignificant.

Analysis of potential moderators

Symptom severity—Pearson's correlation analyses were conducted between the CY-BOCS total score and neuropsychological outcome measures. A significant negative correlation was found between the CY-BOCS total score and the Arithmetic scaled score (r=-.27, p=.006). The direction of this correlation implies that greater OCD severity is associated with worse test performance. No significant correlations were found between the CY-BOCS total score and any of the other neuropsychological outcome measures.

Comorbid Conditions—The prevalence of comorbid conditions is presented in Table 3. In order to assess the potential impact of comorbid disorders on neuropsychological test performance (for tests where a significant difference was found between the groups), we examined the impact of (1) the presence of a comorbid condition, (2) functional impairment severity of the comorbid diagnosis using the K-SADS (i.e., mild, moderate and severe), and (3) the number of comorbid conditions. In order to allow sufficient statistical power, these factors were analyzed only for comorbid conditions that were identified in at least 20% of patients (i.e., major depressive disorder [MDD], simple phobia, generalized anxiety disorder [GAD], attention deficit/hyperactivity disorder [ADHD], Tic disorders and Tourette's syndrome and, oppositional defiant disorder [ODD], see Table 3). For the purpose of this analysis we combined the Tourette's syndrome and chronic tic disorder conditions into one group (henceforth termed TS). For all analyses, we first examined differences in gender, age and estimated IQ. In cases where the groups (e.g., OCD+MDD vs OCD-MDD) differed on these factors, an ANCOVA was conducted, controlling for the relevant factors.

No significant differences were found between the OCD subgroups with vs. without these comorbid disorders on all outcome measures (see supplementary materials for effect sizes of these comparisons). Similarly, comparisons between degrees of severity of functional impairment between sub-samples diagnosed with these comorbid conditions yielded no significant difference on any of the neuropsychological outcome measures. To examine the impact of the number of comorbid conditions, Pearson's correlation analyses were conducted with neuropsychological outcome measures. These analyses yielded no significant associations between the number of comorbid conditions and any of the neuropsychological outcome measures. In light of a significant correlation we found between the number of comorbid conditions and the total CY-BOCS score, (r = .29, p = .003), we conducted a subsequent Pearson's partial correlation analysis, controlling for OCD severity. The result of this analysis revealed similar null findings.

Medication Status—Sixty percent of the OCD sample was receiving medication at time of testing. To assess the impact of medication status on neuropsychological functioning, we compared medicated and unmedicated participants with OCD on neuropsychological outcome measures where differences between the groups were identified. The medicated OCD group (n=61, M=11.84, SD=2.88) was found to be older than the unmedicated OCD group (n=41, M=10.59, SD=3.2), F(1, 100)=4.222, p=0.04). In addition, the unmedicated group had a higher prevalence of males (75%) than the medicated group (50%; χ^2 (1)=6.321, p=.012). Subsequent ANCOVAs (controlling for gender and age) yielded no significant differences between medicated and unmedicated OCD patients on all relevant neuropsychological outcome measures (all p's < .05).

Age of Onset—Age of OCD onset was found to be significantly correlated only with the organization score on the RCFT copy trial (r=.27, p=.016), suggesting that later onset is associated with a better organizational score. However given our correction for multiplicity (significance threshold of p=0.01), this association did not reach statistical significance. Finally, research suggests that preadolescence and adolescent OCD may differ in terms of pathophysiology (Fitzgerald, Welsh, Stern, Angstadt, Hanna, Abelson and Taylor 2011, Rosenberg and Keshavan 1998). In order to examine whether these age groups differ in terms of neuropsychological functioning, we conducted a ANCOVAs comparing neuropsychological outcome measures between patients older (n=66) or younger (n=76) than 12 years of age while controlling for age. This analysis yielded no significant difference between the groups.

Discussion

In light of inconsistent reports regarding neuropsychological functioning in pediatric OCD the present study aimed to compare a large, well characterized sample of pediatric OCD patients with matched controls. A second aim of the study was to examine the potential confounding impact of comorbid conditions, and clinical and demographic correlates on neuropsychological functioning.

Our results suggest that youth with OCD demonstrate reduced neuropsychological tests performance on tests measuring processing speed as well as on tasks of visuospatial abilities and working memory. While OCD youth underperformed compared to the control group on the Block Design subtest assessing visuospatial abilities, they did not underperform on a test of visuospatial abilities in which time does not count toward scoring (i.e., RCFT copy). Thus, given that the Block Design test also assesses motor ability, and more importantly is a timed test, their slower processing speed may have contributed to reduced performance. Similarly, in the working memory domain, OCD youth underperformed compared to the control group on the Arithmetic subtest, but did not differ on the Digit Span subtest. Whereas the latter is an untimed test, the former is a timed test that requires manipulating information in working memory. Therefore, this may also point to reduced performance associated with processing speed in the OCD youth when compared to the controls. These results imply that processing speed may be a central point of weakness in youth with OCD that underlies underperformance on tests assessing other domains. This notion has been suggested by others (Bedard et al. 2009, Burdick et al. 2008), arguing that processing speed deficits may underlie underperformance in tests of executive function in adult OCD, but to our knowledge this is the first study to demonstrate this effect in youth with OCD. Notably, we did not find performance differences in the domain of non-verbal memory and executive functions between youth with OCD and HC.

Our results are in accord with previous investigations that found reduced processing speed in youth with OCD compared to controls, but no difference (or a very small effect size) on tests of executive functions (Andres, Boget, Lazaro, Penades, Morer, Salamero and Castro-Fornieles 2007, Ornstein, Arnold, Manassis, Mendlowitz and Schachar 2010). For example Chang and colleagues (Chang et al. 2007) found comparable performance on the RCFT copy and executive function tests, but reduced performance on the Digit Symbol Coding tests in OCD youth compared to controls. Additionally, Shin and colleagues (2008) administered an extensive neuropsychological test battery and similar to our results, reported reduced performance in a group of 17 pediatric OCD patients on the WISC Arithmetic and Block Design but no differences on response inhibition indices (auditory and visual CPT), set shifting (Trail Making B), nonverbal memory (RCFT) and the RCFT organizational scores.

It is important to note that on the four subtests where the OCD group performed lower than controls, the WISC scaled scores were within the average range (WISC scaled scores for the OCD sample ranging from 9.25 – 11.15). Although effect sizes ranged from medium to large (Cohen's *d* ranging from, .46 - .91), our patient sample performed in the normal range. These results, observed in other neuropsychological investigations of pediatric OCD (Chang, McCracken and Piacentini 2007, Taner et al. 2011), suggest that this population may underperform compared to controls, but attribution of the term ‘impairments’ may be unsuitable. Nevertheless, given that relatively high estimated IQ of the OCD sample (110.1; 2/3 standard deviation above population mean), these factors may indicate a within-group relative weakness in this population. This has important implications, especially in school settings. Given that OCD youth may exhibit relative reduced processing speed, these children may not be able to fulfil their intellectual potential. More importantly, standard school or clinical assessments, where results are compared to norms, may fail to identify this weakness.

An examination of potential confounding factors (i.e., age of onset, OCD severity, depression severity, age, medication, individual comorbid diagnosis and the number of comorbid diagnosis) yielded no significant impact on neuropsychological test performance. The lack of association between neuropsychological functions and symptom severity has been reported in the majority of pediatric OCD (Andres, Boget, Lazaro, Penades, Morer, Salamero and Castro-Fornieles 2007, Beers, Rosenberg, Dick, Williams, O'Hearn, Birmaher and Ryan 1999, Behar, Rapoport, Berg, Denckla, Mann, Cox, Fedio, Zahn and Wolfman 1984, Shin, Choi, Kim, Hwang, Kim and Cho 2008) as well as adult OCD investigations (Abramovitch, Abramowitz and Mittelman 2013, Kuelz et al. 2004). However, whereas a recent study examining neuropsychological performance on tests of executive functions and memory in a large sample of youth with OCD found no association with symptom severity (Lewin et al. 2014), analysis of symptom dimensions in this sample suggested some specific associations between test performance and symptom dimensions (McGuire et al. 2014).

Comorbid diagnosis in pediatric OCD has been reported to result in increased functional impairments, increased OCD severity and reduced treatment response (Geller et al. 1996, Storch et al. 2010, Storch et al. 2008). Thus it may seem logical to assume that comorbidity affects neuropsychological functioning. However, lack of such association is the rule and not the exception in the vast majority of neuropsychological investigation in youth and well as in adults with OCD (Abramovitch, Abramowitz and Mittelman 2013, Abramovitch and Cooperman 2015). Furthermore, the lack of association between neuropsychological test performance and symptom severity may account for our findings regarding a lack of impact of psychiatric comorbidity on neuropsychological functioning. Similar to our results, comorbid ADHD was not found to influence neuropsychological test performance in a large sample of youth with OCD (McGuire, Crawford, Park, Storch, Murphy, Larson and Lewin 2014).

Beers and colleagues suggested that the lack of significant neuropsychological impairments in pediatric OCD may be due to the fact that these children are examined "*early in the illness*" (Beers, Rosenberg, Dick, Williams, O'Hearn, Birmaher and Ryan 1999). Similarly, discussing their results, Ornstein and colleagues (2010) concluded that, "*The isolated deficits … may indicate emerging impairment that…possibly represent an ongoing process*" (Ornstein, Arnold, Manassis, Mendlowitz and Schachar 2010). However, no longitudinal neuropsychological study has investigated such a progression. Neuromaturational delay in youth could mean that adults with OCD may exhibit more robust or better defined impairments. In addition, higher order executive functions, which develop after the age of 12, may continue to develop until early adulthood (McCann and Roy-Byrne 2004, Rosenberg and Keshavan 1998). Our results did not reveal any association between age and neuropsychological performance, or a difference between pre and post adolescents on neuropsychological measures. Only a longitudinal study can demonstrate the maturational deficit hypothesis in the transition from childhood into adulthood. This line of research is particularly important given that approximately 60% of children diagnosed with OCD remit into adulthood, but research into cognitive functioning among remitted versus persistent OCD is non-existent.

The present study holds several strengths. The central strengths are the large sample size that allows for reliable analysis of the impact of comorbid conditions and a statistically sound sample size to outcome measures ratio. In addition, the present study employed a rigorous screening and diagnostic processes including 'blind' assessors, as well as a correction for multiple comparisons. A limitation of the present study is the lack of a continuous measurement of depression severity. However, a psychometrically sound ordinal measure (K-SADS) was used to assess three degrees of depression severity. Finally, we excluded any OCD diagnosis, but some control participants had lifetime psychiatric diagnoses (other than OCD). While this may pose a potential limitation, the rates of lifetime diagnosis in the control sample were representative of the rates in the general population, increasing ecological validity and facilitating generalizability of our results. Indeed, the vast majority of neuropsychological studies utilized 'healthy' controls, which do not represent the general population. Moreover, the control group's standard score across neuropsychological tests were in the normative or higher average range. Notably, although the control group's performance was within the normative range across tests, it is theoretically possible that past diagnosis of certain disorders may be associated with reduced neuropsychological test performance in some individuals (even in participants that do not meet current criteria for any DSM disorder). However, even in such a case -which theoretically reduces the probability of rejecting the null hypothesis - results pertaining to performance difference between the clinical and control groups found in this study may be more reliable and may facilitate generalizability. Finally, although medication status has been assessed and analyzed in the present investigation, different classes of medications (e.g., SSRIs, neuroleptics) could have a potential differential effect on neuropsychological test performance. However, direct examinations (e.g., Mataix-Cols et al., 2004), as well as a meta analytic investigations (Abramovitch et al., 2013; Snyder et al., 2015) in adults with OCD found no significant impact of medication on cognitive performance (regardless of medication class).

Conclusion

In a large sample of youth with OCD that were compared to a matched control sample, patients exhibited reduced performance on neuropsychological tests involving processing speed, and on tasks of working memory and visuospatial functioning that incorporate time as part of the tests score. Comparable performance was found on measures of executive functions, memory or visuospatial organization (that was not timed). However, objectively, OCD patients performed within a normative range, warranting clinicians and educators to pay careful attention to these relative weaknesses that may not be identifiable in standard tests that lack a peer group comparison, and that may hinder fulfillment of the full intellectual potential in this population. Finally, consistent with findings in adult OCD, neuropsychological performance was not associated with any demographic or clinical indices, including comorbid conditions and medication status.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic and clinical characteristics of the OCD and control groups.

Measure	**OCD (N = 102)**	**Controls (N = 161)**	***F*** **(1, 261)/** χ^2**(1)**	**Sig (*****P*****)**
Age *M (SD)*	11.39 (3.05)	11.61 (3.03)	0.34	.56
Gender N (% Males)	57 (55.9%)	92 (57.0%)	<.01	.98
Estimated IQ *M (SD)*[1]	110.07 (14.34)	112.18 (13.76)	1.41	.26
CY-BOCS total score *M (SD)*	20.88 (5.04)	-	-	-
CY-BOCS obsessions *M (SD)*	10.91 (2.71)	-	-	-
CY-BOCS compulsions *M (SD)*	9.88 (2.66)	-	-	-

[1]Estimated IQ (based on WISC Vocabulary test score); CY-BOCS, Children's Yale-Brown Obsessive Compulsive Scale

Table 2

Group comparison on neuropsychological measures

	OCD *M* (*SD*)	Controls *M* (*SD*)	OCD *N*	Controls *N*	*F(df)*	*Sig*	*Cohen's d*
Processing Speed							
Coding scaled score	9.25 (3.75)	11.66 (2.87)	102	161	34.83 (1, 261)	**<.00**	**0.72**
Symbol Search scaled score	10.23 (3.40)	11.80 (2.90)	102	66	9.65 (1, 166)	**<.01**	**0.50**
Visuospatial abilities							
RCFT copy accuracy	61.55 (4.28)	62.52 (7.36)	94	67	1.11 (1, 159)	.29	0.16
Block Design scaled score	10.76 (3.21)	13.70 (3.27)	102	161	50.75 (1, 261)	**<.00**	**0.91**
Working Memory							
Digit Span scaled score	10.68 (3.03)	10.39 (3.00)	102	161	0.59 (1, 261)	.44	0.10
Arithmetic scaled score	11.15 (3.36)	12.58 (2.83)	102	161	13.90 (1, 261)	**<.00**	**0.46**
Non-Verbal Memory							
RCFT delay accuracy	43.09 (10.64)	46.94 (12.11)	93	68	4.58 (1, 159)	.03	0.34
Executive Functions							
Stroop Word (t score)	46.91 (7.11)	46.98 (7.10)	99	78	.01 (1, 175)	.94	0.01
Stroop Color (t score)	43.70 (8.25)	42.23 (7.62)	99	78	1.47 (1, 175)	.23	0.19
Stroop Color-Word (t score)	45.20 (8.51)	45.87 (9.61)	99	77	.24 (1, 174)	.63	0.07
Stroop Interference (t score)	48.78 (6.36)	50.51 (7.27)	99	77	2.82 (1, 174)	.09	0.25
WCST Categories Completed	4.88 (1.69)	5.00 (1.56)	64	62	.19 (1, 124)	.67	0.07
WCST Percent Perseverative Errors	14.44 (9.75)	14.00 (6.71)	63	62	.09 (1, 123)	.77	0.05
WCST Trials to Complete 1st Category	24.19 (27.48)	18.66 (20.60)	64	62	1.62 (1, 124)	.20	0.23
WCST Failure to maintain set	.98 (1.15)	1.29 (1.27)	64	62	2.01 (1, 124)	.16	0.26
RCFT Copy Organization Score	8.27 (3.47)	8.93 (3.79)	95	68	1.30 (1, 161)	.26	0.18
RCFT Delayed Organization Score	6.57 (3.76)	8.04 (3.92)	94	68	5.81 (1, 160)	.017	0.38

OCD, obsessive-compulsive disorder; RCFT, Rey complex figure test; WCST, Wisconsin Card Sorting Test.

Table 3

Prevalence of lifetime comorbid disorders among 102 OCD youth.

Disorder	N	%
MDD Lifetime	46	45.1%
MDD Current	20	19.6%
Bipolar Disorder I	6	5.9%
Bipolar Disorder II	10	9.8%
Dysthymia	9	8.8%
Conduct Disorder	0	0%
Panic Disorder	12	11.8%
Social Phobia	15	14.7%
Simple Phobia	27	26.5%
GAD	44	43.1%
Anorexia	0	0%
PTSD	2	2.0%
ADHD	42	41.2%
TS/CTD	30	31.4%
PDD	4	3.9%
ODD	46	45.1%

MDD, Major Depressive Disorder; GAD, Generalized Anxiety Disorder; PTSD, Post Traumatic Stress Disorder; ADHD, Attention Deficit/ Hyperactivity Disorder; TS, Tourette's Syndrome; CTD, Chronic Tic Disorder; PDD, Pervasive Developmental Disorder; ODD, Oppositional Defiant Disorder