Published in final edited form as:

Psychiatry Res. 2009 December 30; 170(2-3): 282–285. doi:10.1016/j.psychres.2008.12.003.

Indices of Orbitofrontal and Prefrontal Function in Cluster B and Cluster C Personality Disorders

Anthony C. Ruocco^{*}, Michael S. McCloskey, Royce Lee, and Emil F. Coccaro

Department of Psychiatry, University of Chicago Medical Center, Chicago, IL, USA

Abstract

Neuropsychological studies implicate disruption of frontal systems in personality disorders. Few studies have examined the performance of Cluster B and Cluster C personality disorder patients on tests of orbitofrontal (OFC) and prefrontal (PFC) cortex function. Patients carrying diagnoses of either Cluster B (n=56) or Cluster C (n=19) personality disorders were compared with healthy control subjects (n=61) on the Iowa Gambling Task and University of Pennsylvania Smell Identification Test. They also completed the Wechsler Abbreviated Scale of Intelligence as a control for general intellectual ability. On the gambling task, Cluster B and Cluster C patients made more disadvantageous decisions during certain portions of the task but overall did not differ from healthy controls. Whereas no appreciable differences in olfactory identification performances were detected between patient and healthy control groups, IQ was higher for controls and was related to Cluster B patients' lower educational levels. Overall, there was limited evidence for neurocognitive inefficiency for personality disorder groups on tests sensitive to OFC and PFC function. The present study is among the first to report neurocognitive findings for the full range of Cluster B personality disorders and any Cluster C personality disorder.

Keywords

borderline personality disorder; olfaction; Iowa Gambling Task; prefrontal cortex; orbitofrontal cortex

1. Introduction

Personality disorders are severe psychiatric conditions characterized by long-standing and pervasive difficulties in two or more domains of function to include affect, cognition, impulse control, and interpersonal relations. Personality disorders affect between 9 and 15% of the United States population and they are associated with significant social, emotional, and physical disability (Grant et al., 2004; Lenzenweger et al., 2007). Whereas personality disorders are among the most chronic and financially burdensome of the psychiatric disorders (Comtois et al., 2003), relatively little is understood regarding their neurobiological bases.

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^{*}Corresponding author and reprint requests: Anthony C. Ruocco, Ph.D., Department of Psychiatry, University of Chicago Medical Center, 5841 S. Maryland Ave., MC 3077, Chicago, IL 60637, Phone: 312.355.0340, Fax: 312.413.8837, anthony.ruocco@gmail.com.

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Emerging evidence relates neuropsychological deficit to some personality disorders, namely borderline (Ruocco, 2005a), antisocial (Morgan and Lilienfeld, 2000), and schizotypal (Vogtmaier et al., 1997). The nature of these deficits suggests a disruption of frontal-limbic systems, findings which converge with structural and functional neuroimaging studies of several Cluster B personality disorders (Ruocco, 2005b). Affected structures often include the prefrontal (PFC) and orbitofrontal (OFC) cortices, anterior cingulate, hippocampus, and amygdala (McCloskey et al., 2005). Diffuse and variable cognitive inefficiencies are typical of the neuropsychological profiles for the few personality disorders which have been examined, most notably borderline personality disorder (BPD). Neuropsychological deficits tend to be more pronounced on tests of executive function which involve planning abilities (e.g., Tower of London), as well as visual memory tests which may be additionally impacted by patients' poor organization skills (Ruocco, 2005a). Inefficiencies are also apparent in several other cognitive domains, including attention, working memory, verbal memory, cognitive flexibility, and visuospatial abilities, although findings are not consistent across studies. Whereas the bulk of the evidence links these deficits to frontal lobe dysfunction, far less attention has been paid to specific functions of the OFC and PFC as they relate to the personality disorders. In light of the role that these regions play in social cognition, affect regulation, and impulsivity, there is good reason to suspect involvement of these regions, especially the OFC, in personality disturbance (Berlin et al., 2005; Franken et al., 2008; Kringelbach and Rolls, 2004).

The present study is the first to our knowledge which examines the performance of both Cluster B (antisocial, borderline, histrionic, narcissistic) and Cluster C (avoidant, dependent, and obsessive-compulsive) personality disorders on neurocognitive measures of OFC and PFC function, contrasting the performances of these patient groups on tests of olfactory identification and decision-making (i.e., gambling) with healthy control participants. As a control for general cognitive ability, patients also completed brief intellectual assessment. We hypothesized that personality disorder patients would perform more poorly than healthy controls on tests of OFC and PFC functions, with the Cluster B group possibly demonstrating the greatest deficit. We are unaware of any neuropsychological studies of Cluster C patients; however, there is correlational evidence of an association between neuropsychological deficit and Cluster C personality traits in patients with closed head injury (Ruocco and Swirsky-Sacchetti, 2007). Thus, we hypothesized that Cluster C patients would perform at a level intermediate to that of Cluster B patients and healthy controls on the neurocognitive measures employed in the present study.

2. Methods and Materials

Participants were 166 individuals recruited as part of ongoing research studies on personality dysfunction at the University of Chicago Medical Center. Written informed consent was obtained from all participants. Participants were excluded if they reported lifetime bipolar or psychotic disorder, or traumatic head injury with loss of consciousness. All participants passed a urine drug screen. Participants completed a clinical interview conducted by trained doctoral level diagnosticians. Axis I and Axis II disorders were assessed using DSM-IV criteria via the Structured Clinical Interview for DSM-IV and the Structured Interview for Disorders of Personality, respectively. Diagnoses were confirmed using a "best estimate procedure" in which the written diagnostic report and raw interview data were reviewed by a multidisciplinary committee of psychiatrists, psychologists, and diagnosticians who were blind to the study hypotheses (Klein et al., 1994).

Participants were assigned to Axis II groups only if they had one or more diagnosis within one Axis II cluster and no diagnoses in any other cluster. Based on these criteria, eight participants were identified from Cluster A, 56 from Cluster B, and 19 from Cluster C. Because of the small number of participants in the Cluster A group, these participants were excluded from

subsequent analyses. Participants in the Cluster B group carried diagnoses of borderline (71%), antisocial (45%), narcissistic (26%), and histrionic (7%) personality disorders. The Cluster C group had diagnoses of obsessive-compulsive (70%), avoidant (35%), and dependent (5%), personality disorders. Sixty-one healthy control participants who did not meet criteria for any Axis I or Axis II disorders were also examined. Table 1 displays demographic characteristics and diagnostic features of the patient groups and healthy controls.

Participants were administered two neurocognitive measures of frontal lobe function. The first, the University of Pennsylvania Smell Identification Test (UPSIT) (Doty et al., 1995), is a 40-item multiple choice test of smell identification linked to functioning of the OFC. The second test, the Iowa Gambling Task (IGT) (Bechara et al., 1996), is considered a test of decision-making, in which participants must select among four decks of cards (two decks each with advantageous or disadvantageous results) over 100 trials, learning through experience which decks provide the greatest likelihood of reward. There is some controversy regarding which frontal systems mediate performance on the IGT. Some evidence suggests the involvement of both the ventromedial and dorsolateral prefrontal cortices, the former associated with reversal learning and the latter working memory (Farah and Fellows, 2005), whereas other studies implicate specific involvement of the OFC (Bechara et al., 1996). As a control for general intelligence, the Wechsler Abbreviated Scale of Intelligence (WASI) was administered, yielding a full scale intelligence quotient (IQ) as an estimate of overall intellectual abilities.

3. Results

3.1 Preliminary Analyses

It is possible that analyzing personality disorders by grouping them into clusters may overlook potential heterogeneity within the groups. To explore any possible differences between personality disorder diagnoses within each cluster, preliminary analyses were conducted comparing the most prevalent personality disorders within Cluster B (BPD, 71%) and Cluster C (obsessive compulsive personality disorder [OCPD], 70%). The performance of BPD and non-BPD Cluster B personality disorder subjects was compared on the IGT, UPSIT, and WASI. Results showed that the two groups did not differ on any measure (all $p > .27$). We found the same pattern of non-significant results when we compared OCPD and non-OCPD cluster C subjects on the IGT, UPSIT or WASI (all $p > .25$). These analyses suggested that there was not a large degree of variation across disorders within each cluster on the neurocognitive tasks.

3.2 Primary Analyses

Groups did not differ in terms of age, gender, or ethnicity (all $p > .10$); however, there was a significant difference with regard to educational level (see Table 1). Distributions of scores on the IGT and UPSIT were non-normal. Analyses using transformed data, parametric, and non-parametric tests did not change the pattern of results. For the purposes of simplicity, results of parametric analyses are presented. WASI and UPSIT scores are presented in Table 1. With regard to intellectual abilities, a one-way analysis of variance (ANOVA) demonstrated a main effect of Group on Full Scale IQ, $F(2, 136) = 7.79, p < .001$. Post-hoc Tukey tests showed Cluster B patients had a lower IQ than healthy controls. As education level is known to significantly influence intelligence test scores, and Cluster B patients had lower levels of academic attainment than healthy controls, education was examined as a covariate. The effect of Group on IQ was no longer significant ($F < 1$) when education level was included as a covariate. A one-way ANOVA examining olfactory identification performance on the UPSIT revealed no main effect of Group, $F(2, 84) = .82, p = .44$.

IGT trials were divided into 4 successive 25-trial ranks. Performance on the IGT was analyzed using a 3 (Group) $\times$ 4 (Card Rank) repeated measures analysis of covariance. Education, IQ,

and number of Axis I disorders were entered as covariates. Results for the IGT are displayed in Figure 1. The number of disadvantageous choices made by participants on the IGT declined over the course of the task, $F(3, 387) = 2.78, p = .04$; however, there was no main effect of Group ($F < 1$), and no Group $\times$ Card Rank effect, $F = 1.31, p = .25$. Post-hoc exploratory analyses based on visual inspection of the graphed results revealed a significant difference between Cluster B patients and healthy controls in the number of disadvantageous choices made during the final card rank, the advantage to the latter, $t(116) = 2.47, p = .02$. Cluster C patients made more disadvantageous decisions than healthy controls during the second quarter of cards on the IGT, $t(78) = -2.30, p = .02$.

4. Discussion

The present study examined performances on tests of OFC and PFC function in patients with Cluster B and Cluster C personality disorders and healthy controls. This is the first study to our knowledge which examines neurocognitive function in the full range of Cluster B personality disorders and any Cluster C personality disorder. We hypothesized that patients with personality disorders would perform less efficiently than healthy controls on measures of OFC and PFC function (i.e., olfaction, gambling) in the context of relatively equivalent general intellectual ability. Our hypotheses, however, were only partially supported.

With regard to OFC function, personality disorder patients did not differ from healthy controls in olfactory identification performance as assessed by the UPSIT. The results were not entirely surprising given equivocal findings in previous investigations involving other personality disorder populations (Compton and Chien, 2008; Mohr et al., 2001). One possible factor which may account for these negative findings is the birhinal mode of administration employed in the present study. Unirhinal administration of these tests may yield more promising findings given preliminary evidence which links specific personality trait dimensions (i.e., social introversion, submissiveness) to right unirhinal olfactory identification and threshold sensitivity deficits in schizophrenia patients and healthy controls (Ruocco and Moberg, 2006).

Personality disorder groups generally did not differ from healthy controls on the IGT, the exception being more disadvantageous choices made by Cluster B and Cluster C personality disorder patients compared with healthy controls during the fourth and second quarters of the IGT, respectively. The overall results may be interpreted as unexpected given positive findings in one study involving borderline personality disorder patients, who were found to perform poorer than healthy controls on the IGT (Haaland and Landro, 2007). That investigation, however, was based upon a sample of 20 BPD patients, seven of whom carried diagnoses of another personality disorder which was unspecified. The present study had several advantages over the Haaland and Landro investigation. First, these findings are based on a substantially larger sample size. Second, the present study had the advantage of accounting for Axis II comorbidity by amalgamating patients solely carrying diagnoses of either Cluster B or Cluster C personality disorders, rather than focusing strictly on one of the Axis II diagnoses (i.e., BPD). Comorbid Axis I diagnoses were also controlled for statistically. An alternative approach to addressing the problem of comorbidity is to implement a dimensional assessment of personality disorder. This approach may help to clarify the relationship between symptom domains (e.g., affective lability, impulsivity) and performance on decision-making and olfactory identification tests, overcoming some of the limitations imposed by categorical diagnoses which often yield significant diagnostic heterogeneity within personality disorder clusters. Future studies would benefit from a dimensional measurement of personality disorder to avoid these difficulties and further these findings.

These preliminary results suggest that Cluster B and Cluster C personality disorder groups may possess some mild difficulties with reversal learning on the IGT. Thus, it is possible that these patients have a selective difficulty with flexible learning, particularly in situations which present salient reward and punishment contingencies. It is unclear, however, the extent to which working memory abilities may have impacted these findings. Based on these results, *a priori* hypotheses may be tested in future studies which incorporate other measures of reversal learning and working memory to determine whether Cluster B and Cluster C personality disorder patients show a selective deficit in any one (or both) of these cognitive domains. Indeed, it is possible that these patients demonstrate deficits associated with certain frontal systems which are independent of deficits in other functionally related regions or circuits (e.g., Martino et al., 2007). It should be noted, however, that these results may also be affected by poor effort on the cognitive measures, as there is evidence that some personality disorders (i.e., antisocial) may be more likely to demonstrate suboptimal performance on neuropsychological symptom validity measures (Delain et al., 2003). In addition to possible difficulties with reversal learning, poor effort may also partly explain the drop-off in performance of Cluster B patients during the final portion of the IGT.

IQ for Cluster B personality disorder patients, though in the average range, was lower than that of controls, suggesting perhaps a relative inefficiency in general cognitive ability among Cluster B patients. This decrement in intellectual function was associated with a lower educational level for Cluster B patients. These results may indicate that differences in IQ for Cluster B patients may be an artifact of education, and/or it may suggest that patients with lower IQ may seek out and achieve lower levels of educational attainment. The causal links among educational attainment and intellectual function in this personality disorder sample are unclear but warrant further investigation.

The study findings are limited by our relatively small sample size for Cluster C personality disorders. Whereas we had the advantage of categorizing patients by parsing them into meaningful groupings with similar symptomatologies, sample size restrictions and the pervasive comorbidity of personality disorders within each cluster precluded examination of cognitive functioning for each personality disorder. Nevertheless, the sample of patients included in the present study may be more representative of the typical Cluster B and Cluster C patients who present with several comorbid Axis I and Axis II disorders. Replication using larger samples with fewer comorbid Axis I conditions is needed to confirm and extend our findings, particularly given that various Axis I disorders have been associated with inefficient performance on the IGT (see, for example, Bechara et al., 2001). Overall, our findings suggest that some Cluster B and Cluster C patients may possess subtle frontal system inefficiencies associated with poorer performance during certain portions of the IGT, although it is unclear the extent to which these result from reversal learning and/or working memory deficits. Olfactory identification, on the other hand, appeared relatively intact compared with healthy comparison groups, although this ability represents only one aspect of OFC function. It is important to note the possibility that more dramatic cognitive deficits may become manifest in personality disorder patients under specific conditions (e.g., heightened negative affectivity, interpersonal distress) which may exacerbate any underlying cognitive vulnerabilities. Finally, these findings provide further evidence for possible neurocognitive inefficiency associated with Cluster B and Cluster C personality disorders, potentially involving disruption of frontal systems.

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Figure 1. Performance of healthy controls, Cluster B and Cluster C personality disorder patients on the Iowa Gambling Task

Note: Estimated marginal means covarying for education, IQ, and number of Axis I disorders. Error bars represent standard error of the mean.

* $p = .02$

Table 1

Demographic characteristics, diagnostic status, and neurocognitive performances of personality disorder groups and healthy controls.

	Cluster B (<i>n</i> = 56)	Cluster C (<i>n</i> = 19)	Healthy Control (<i>n</i> = 61)
Age ^a M (SD)	35.8 (10.1)	35.7 (8.9)	32.5 (9.0)
Gender ^b <i>n</i> (%)			
Male	30 (54)	12 (63)	32 (52)
Female	26 (46)	7 (37)	29 (48)
Education ^c <i>n</i> (%)			
Some high school	6 (11)	0 (0)	0 (0)
High school degree	9 (16)	3 (16)	6 (10)
Some college	21 (38)	8 (42)	10 (16)
College degree	14 (25)	6 (32)	35 (57)
Graduate degree	6 (11)	2 (11)	10 (16)
Ethnicity ^d <i>n</i> (%)			
Caucasian	30 (54)	12 (63)	37 (61)
African-American	15 (27)	5 (26)	11 (18)
Asian/Pacific Islander	1 (2)	0 (0)	4 (7)
Hispanic	10 (18)	2 (11)	4 (7)
Native American	(0) 0	0 (0)	3 (5)
Other	(0) 0	0 (0)	2 (3)
Axis I Diagnoses <i>n</i> (%)			
Mood Disorder, Current	16 (29)	3 (16)	0 (0)
Anxiety Disorder, Current	20 (36)	5 (26)	0 (0)
Alcohol Dependence, Past	15 (27)	2 (11)	0 (0)
Other Substance Dependence, Past	19 (34)	2 (11)	0 (0)
Full Scale IQ ^e	117.2 (13.1)	107.0 (15.2)	108.5 (16.3)
UPSIT raw score ^f	36.6 (2.8)	35.3 (6.1)	35.9 (2.4)

Note: UPSIT = University of Pennsylvania Smell Identification Test, IQ = Intelligence Quotient

^a $F(2,135) = 2.02, p = .14$

^b $\chi^2(2) = .70, p = .71$

^c $\chi^2(8) = 24.3, p < .01$

^d $\chi^2(10) = 13.4, p = .20$

^e $F(2, 136) = 7.79, p < .001$

$$f_F(2, 84) = .82, p = .44$$