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Neurocognitive profile associated with borderline personality disorder: building specific indices of executive function

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ABSTRACT

Introduction. The objective of this work is the creation of specific indices of the different executive functions (EF), which allow a more complete understanding of the executive performance associated with borderline personality disorder (BPD) and not through isolated tests.

Methodology. 118 patients with BPD and 81 controls were evaluated with a neuropsychological battery. Three indices of attention, memory and FE were created. The tests that make up the executive domain were grouped into four different executive indices: cognitive flexibility, planning, working memory, and response inhibition. The batteries for each domain were compared through the standardized batteries of the tests that comprised them.

Results. The results showed differences in the memory, attention, and EF indices, as well as in the different executive indices of cognitive flexibility, planning, working memory, and response inhibition, between BPD patients and controls.

Conclusions. This study has allowed the creation of four executive indexes, being the first to do so. These results established a neurocognitive profile of BPD characterized by executive-specific impairment of cognitive flexibility, planning, working memory, and response inhibition. These findings support that patients with BPD will benefit from the application of neuropsychological programs, especially focused on improving a certain EF, and lay the foundations for the investigation of the relationship between these specific executive deficits and certain clinical characteristics of BPD, such as different types of Impulsive behavior and different mentalization errors.

Keywords. Borderline personality disorder, neuropsychology, executive functions, impulsivity

Perfil neurocognitivo asociado al trastorno límite de personalidad: creación de índices específicos de función ejecutiva

RESUMEN

Introducción. El objetivo de este trabajo es la creación de índices específicos de las distintas funciones ejecutivas (FE), que permitan comprender de forma más completa y no mediante pruebas aisladas el rendimiento ejecutivo asociado al trastorno límite de la personalidad (TLP).

Metodología. 118 pacientes con TLP y 81 controles fueron evaluados con una batería neuropsicológica. Se crearon tres índices de atención, memoria y FE. Las pruebas que forman el índice ejecutivo se agruparon en cuatro índices ejecutivos diferentes: flexibilidad cognitiva, planificación, memoria de trabajo e inhibición de respuesta. Las puntuaciones para cada dominio se obtuvieron a través de las puntuaciones estandarizadas de las pruebas que los componían.

Resultados. Los resultados mostraron diferencias significativas en los índices de memoria, atención y FE, así como en los diferentes índices ejecutivos de flexibilidad cognitiva, planificación, memoria de trabajo e inhibición de respuesta, entre los pacientes con TLP y los controles.

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Actas Esp Psiquiatr 2023;51(5): 220-28 | ISSN: 1578-2735

Conclusiones. Este estudio ha permitido la creación de cuatro índices ejecutivos, siendo el primero hasta la fecha en hacerlo. Estos resultados establecen un perfil neurocognitivo del TLP caracterizado por un deterioro ejecutivo específico de la flexibilidad cognitiva, la planificación, la memoria de trabajo y la inhibición de la respuesta. Estos hallazgos avalan que los pacientes con TLP podrían beneficiarse de la aplicación de programas neuropsicológicos, especialmente enfocados en mejorar determinadas FE, y sientan las bases para la investigación de la relación entre estos déficits ejecutivos específicos y ciertas características clínicas del TLP, como diferentes tipos de comportamiento impulsivo y diferentes errores de mentalización.

Palabras clave. Trastorno límite de la personalidad, neuropsicología, funciones ejecutivas, impulsividad

INTRODUCTION

Borderline Personality Disorder (BPD) is a severe and persistent mental disorder characterized on affective instability and impulsive behaviors, that affects to self-image, interpersonal relationships, affectivity and behavior[1].

Different studies have focused on the neuropsychological alterations related to borderline personality disorder, confirming the evidence that patients with BPD show significant neurocognitive deficits, in comparison with other psychiatric disorders and with control subjects[2].The cognitive disfunction of this disorder seems to affect mainly functions of prefrontal areas involve in the processing and management of information and in the regulation of complex behavioral responses, so it could play an important role in clinical manifestations of borderline disorder, such as emotional instability and impulsive behaviors[2,3].

However, despite of the confirmation of these cognitive alterations in BDP, there is still no agreement to establish a specific neuropsychological profile for these patients. The most consistent results show a deficit in executive functions in patients with BDP, although different studies show alterations in different domains of executive function[2,4,5,6].

Executive Functions (EF) are commonly conceptualized inn terms of cognitive processes that enable future, goal-directed actions, planning processes, working memory, inhibitory control and cognitive flexibility[7,8,9]. Some studies[2,4,6] have shown significant deficits in both decision making and cognitive flexibility and planification in these patients. In contrast, some authors have related such deficits to problems in inhibitory control[10] while others find that working memory is the most affected domain, with the inhibitory response remaining unchanged[11].

However, all studies of executive deficit in BPD until now, have focused on the results of isolated tests, within complex neuropsychological batteries, that measured certain EF, but no global study of performance in the different domains that make up executive functions in borderline personality disorder has been conducted so far.

Along with difficulties in executive function tasks, a worse performance with respect to the control group has also been found in BPD patients in the functions of attention, memory and processing speed[2,5,6].

According to Ruocco[6], deficits shown in the domains of attention, cognitive flexibility, and processing speed suggest a frontal lobe dysfunction, while deficits in learning and memory imply a frontotemporal deficit in BPD patients.

Therefore, despite the effort of neuropsychological research in the last two decades, there is still a significant lack of concordance regarding the cognitive impairment associated with BPD. Ruocco[6] explains this lack of concordance to the sample size, insufficient at the statistical level in many of the investigations. However, more current studies such as Kalpakci et al.[12] explain this lack of consistency to the heterogeneous nature of this disorder. According to these authors, those patients with more externalizing symptoms, such as impulsive behaviors, than internalizing ones, such as emotional lability or lack of identity, will have greater difficulties in behavioral control and, therefore, worse performance in executive functions.

Therefore, the aim of this work is to confirm the neuropsychological deficits related to borderline personality disorder observed in previous works, as well as the investigation of a specific neuropsychological profile associated with BPD through the study of the different cognitive domains, and of the creation of specific indices of the different executive functions, which allow the understanding of said executive performance in a more complete way, and not through isolated tests.

MATERIAL AND METHODS

Participants

The studied sample consists of 118 patients diagnosed with borderline personality disorder as primary diagnosis,

according to DSM-V criteria[1] and had to have moderate-severe severity (CGI (Clinical Global Impression) > 4) and moderate dysfunctionality (GAF (Global Assessment Functionally) < 65) to enter the study. Patients were recruited from the Personality Disorders Day Hospital of the Hospital Clínico San Carlos.

Patients were excluded from the study if they present the following criteria:

1) had a neurological or medical disease that could affect brain functions;

2) had an IQ < 85;

3) had suffered from schizophrenia, schizophreniform disorder or bipolar disorder during their lifetime; 4) had a major depressive episode or a substance use disorder that could affect neuropsychological performance at the time of the study.

The sample of control participants consisted of a group of 81 persons with characteristics of sex, age and educational level similar to those of the patients. The controls were healthy, with no medical or neurological disease and IQ > 85 and were recruited through advertisements in different social settings.

All patients and controls received detailed information about the study and signed written informed consent prior to their participation in the research. The clinical research study was approved by the Clinical Research Ethics Committee of the Hospital Clínico San Carlos.

Instruments

The collection of clinical variables was performed by experienced psychiatrists and psychologists at the beginning of the study. All patients and controls were interviewed with the Structural Interview for Personality Disorders (SCID-II[13]), with the aim of confirming the diagnosis of BPD in patients and ruling it out in control subjects. Severity was measured with the Clinical Global Scale for Personality Disorders (CGI-BPD[14]) and chronicity was assessed with the Global Assessment of Functioning Scale (GAF[15]). Anxious-depressive symptoms were assessed through the Hamilton Anxiety Rating Scale (HARS[16]) and the Montgomery-Asberg Depression Scale (MADRS[17]), respectively.

Subjects were assessed with a comprehensive neuropsychological battery based on previous studies of cognitive functions in BPD patients[18,19]. The battery consisted of several tests assessing three different domains: attention, memory, and executive function. The different domains were carried out using the same methodology as Pascual et al.[20].

1. Attention index.

This index was calculated by summing the standardized scores obtained from the Symbol Digit Modality Test (SDMT[21]) to assess sustained attention and the standardized inverse values of the Trail Making Test (TMT-A[22]) requiring visual scanning and divided attention.

2. Memory index.

It was calculated by means of the standardized scores of the Buschke Selective Reminding Test[23], which measures delayed and immediate verbal memory.

3. Executive Index.

This index was obtained by averaging the standardized scores of different tests: Verbal Phonological Fluency Task (FAS[24]), which assesses verbal fluency; Trail Making Test (TMT-B[22]), which assesses cognitive flexibility; Direct and Inverse Digit Tests[23], which measures working memory; Letters and Numbers Subtest of the WAIS-IV[25], which measures working memory; Stroop Test[26], which assesses inhibitory control; and Wisconsin Card Sorting Test (WCST[27]), which measures abstraction, cognitive flexibility, concept elaboration and planning ability.

Finally, the tests that made up the executive domain were grouped into four different indexes according to the function assessed: cognitive flexibility, planning, working memory and response inhibition. These domains were carried out using again the methodology previously used by Pascual et al.[20], grouping them based on the function described by the author of each test.

a. Cognitive flexibility index.

This index was calculated by averaging the standardized scores of different tests: Phonological Verbal Fluency Task (FAS[24]), Semantic Verbal Fluency Task or Semantic Categorical Evocation of Animals[28] and the inverse values of the Trail Making Test (TMT- B[22]).

b. Planning index.

This index was calculated by means of the standardized scores of the Wisconsin Card Sorting Test (WCST[27]).

Actas Esp Psiquiatr 2023;51(5): 220-28 | ISSN: 1578-2735

c. Working memory index.

This index was calculated by averaging standardized scores from different tests: Direct and Reverse Digit Tests[23] and the Letters and Numbers Subtest of the WAIS-IV[25].

d. Response inhibition index.

This index was calculated by averaging the standardized scores from different tests: Stroop Test (Golden, 1978) and Wisconsin Card Sorting Test (WCST[27]).

Statistical analysis

Statistical analysis was performed using the IBM SPSS Statistics package (IBM Corporation, Armonk, New York, USA) version 23.0. Quantitative variables were expressed as mean and standard deviation (SD), or median for continuous variables with skewness. Qualitative variables were described with absolute and relative frequency (percentage). Comparison of quantitative variables between the 2 study groups was performed using Student's t-test for symmetrical variables. Univariate factorial analysis of variance was performed to adjust the quantitative variables between the 2 study groups for the effect of age. The linear correlation between quantitative variables that were symmetrically distributed was assessed using Pearson's correlation coefficient, or the nonparametric coefficient (Spearman's rho) if any variable did not follow a normal distribution. In all hypothesis contrasts, the null hypothesis was rejected with a type I error or α error less than 0.05.

Table 1 Sociodemographic data and functionality of the BPD and control groups

		BDP (n = 118)	Controls (n = 81)
Age (mean)		28.76	33.94
Sex (percentaje)	Male	22.9	12.3
	Female	77.1	87.7
Marital status (percentaje)	Single/Separates	73.3	35.8
	Married/Couple	26.7	64.2
Current activity (percentaje)	Unemployed	73.3	11.1
	Studying	15.5	8.6
	Working	11.2	90.2
Educational level (percentaje)	Secondary education/ Professional training	76.1	77.8
	Higher education	23.9	22.2
Pharmacological Treatment (percentaje)	Antidepressants	75.4	0
	Antipsychotics	50.9	0
	Antiepileptics	40.4	0
	Benzodiazepines	60.5	0
CGI (M)		5.17 (DT±0.830)	
GCS (M)		59.58 (DT±6.800)	

CGI= Clinical Global Scale for Personality Disorders score; GCS= Global Assessment of Functioning Scale score.

RESULTS

Table 1 shows the sociodemographic and functionality variables of patients and controls. Differences in these variables were analyzed between the two study groups and the results showed significant differences in age, marital status and current activity (p = 0.000, p = 0.000 and p = 0.000, respectively), showing how the control subjects were older, had a higher % marital status of married/partnered and higher work functionality.

First, a comparison of neuropsychological test scores between the BPD patient group and the control group was performed, adjusted for age (Table 2). The results showed significant differences in all the neurocognitive tests evaluated between both groups, with the BPD patients showing worse performance in all tests than the controls.

Hereafter, the different tests of this neuropsychological battery were then grouped into three different cognitive domains of attention, memory and executive function; and the differences between the two study groups were studied. The results showed significant differences in all these neuropsychological domains between BPD patients and controls (p = 0.001, p = 0.048 and p = 0.001, respectively), with BPD patients performing worse in the domains of attention, memory and executive function than controls (table 3).

A more specific study was also realized on the executive index, creating different indexes by dividing the EF into four functions: cognitive flexibility, planning, working memory and response inhibition, and analyzing the differences between the different groups. The results showed significant differences in all the executive functions evaluated (p=0.000, p=0.001, p=0.001 and

Table 2 Differences in neuropsychological test scores between the BPD patients and the age-matched control group

		GROUP	*M*	*SD*	*t- Test*	Signification
RLT		BPD	16.24	4.099	t = - 3.034	p < .001
		CONTROL	19.25	4.131		
RFT		BPD	11.91	3.309	t = 1.955	p < .001
		CONTROL	9.96	3.330		
RDT		BPD	14.41	1.876	t = - 0.810	p = .004
		CONTROL	15.22	1.884		
FAS		BPD	32.73	9.507	t = - 5.656	p < .001
		CONTROL	38.39	9.567		
Animals		BPD	17.73	4.499	t = - 3.472	p < .001
		CONTROL	21.20	4.527		
Keynum		BPD	46.33	11.043	t = - 15.082	p < .001
		CONTROL	61.41	11.106		
TMTA		BPD	37.31	13.106	t = - 0.300	p < .001
		CONTROL	27.64	9.831		
TMTB		BPD	84.04	32.600	t = - 0.427	p < .001
		CONTROL	55.05	21.632		
DSMT		BPD	42.51	10.762	t = - 11.446	p < .001
		CONTROL	53.96	10.827		
Direct Digits		BPD	8.37	2.067	t = - 1.488	p < .001
		CONTROL	9.86	2.079		
Inverse Digits		BPD	5.51	1.895	t = - 1.958	p < .001
		CONTROL	7.46	1.908		
Stroop		BPD	39.17	10.329	t = -1.522	p < .001
		CONTROL	45.77	10.386		
Letternum		BPD	8.16	2.520	t = - 2.755	p < .001
		CONTROL	10.92	2.529		
WCST	Nº Pers.Err	BPD	10.19	6.346	t = - 0.356	p < .001
		CONTROL	7.13	4.523		
	Compcat	BPD	5.38	1.121	t = - 0.546	p = .001
		CONTROL	5.92	1.128		

FRT= Buschke Selective Memory Test of Free Recall; FRT= Buschke Selective Memory Test of Facilitated Recall; DRT= Buschke Selective Memory Test of Deferred Recall; FAS= Phonological Verbal Fluency Task; Animals= Semantic Verbal Fluency Task or Semantic Categorical Evocation of Animals; Keynum= Keys and Numbers subtest of the Weschler Adult Intelligence Scale (WAIS IV); TMTA= Trace Test part A; TMTB= Trace Test Part B; DSMT= Digit Symbol Modality Test; direct digits= direct digits subtest of the Weschler Adult Intelligence Scale (WAIS IV); inverse digits= inverse digits subtest of the Weschler Adult Intelligence Scale (WAIS IV); Stroop= Stroop test; Letternum= letters and numbers subtest of the Weschler Adult Intelligence Scale (WAIS III); WCST= Wisconsin Card Sorting Test; Nº Pers.Err= number of perseverative errors of the Wisconsin Card Sorting Test; Compcat= completed categories of the Wisconsin Card Sorting Test.

Actas Esp Psiquiatr 2023;51(5): 220-28 | ISSN: 1578-2735

Table 3 Differences in neurocognitive domains between BPD patients and the age-matched control group.

	Group	*M*	*DT*	*t-Test*	*p-value*
Attention	BPD	- 1.124	1.146	*t* = -1.211	*p* < .001
	CONTROL	0.087	1.161		
Memory	TLP	- 0.164	0.692	*t* = - 0.204	*p* = .048
	CONTROL	0.040	0.702		
Executive Function	TLP	- 0.807	8.512	*t* = - 0.808	*p* < .001
	CONTROL	0.000	4.446		

Atención= puntuación del índice de atención; Memoria=puntua-Attention=attention index score; Memory=memory index score; Executive function=executive function index score.

p=0.001, respectively) between patients and controls, with BPD patients performing worse in each of the specific executive functions than controls (Table 4).

Finally, the relationship between the scores of the neuropsychological domains of attention, memory and executive functions and the scores of the Montgomery-Asberg Depression Scale (MADRS) and the Hamilton Anxiety Scale (HARS) in patients was analyzed. The results showed no significant correlations between the neurocognitive indices and the depression and anxiety scales.

Table 4 Differences in executive indices between BPD patients and the age-adjusted control group.

	GROUP	*M*	*SD*	*t-Test*	*Signification*
CF	BPD	- 1.266	1.168	*t* = - 1.281	*p* < .001
	CONTROL	0.015	1.179		
Plan	BPD	- 1.043	2.293	*t* = - 1.103	*p* = .001
	CONTROL	0.060	2.304		
WM	BPD	- 1.004	0.865	*t* = - 1.055	*p* < .001
	CONTROL	0.051	0.873		
RI	BPD	- 1.069	0.855	*t* = - 1.077	*p* < .001
	CONTROL	0.008	0.855		

CF= index of cognitive flexibility; Plan= index of planning; WM= index of working memory; RI= index of response inhibition.i

DISCUSSION

The results of this study show a global cognitive impairment associated with borderline personality disorder (BPD). Specifically, the results of this work showed how BPD patients presented significantly lower performance in the cognitive domains of attention, memory and executive function than control subjects. These results are consistent with those of Ruocco[29] study, which had a major influence on subsequent research on cognitive impairment associated with borderline personality disorder. Our findings, like Ruocco[6], showed a global deficit in neuropsychological functioning in BPD. Specifically, this author associated this impairment to a series of dysfunctions in the frontal lobe, parietal frontal area and frontotemporal area.

This global neuropsychological deficit associated with BPD would be behind certain clinical features of this disorder. For example, the biopsychosocial models of BPD by Jackson[30] and Linehan[31] support that many of the clinical features of borderline disorder, such as emotional instability or lack of identity, are caused by altered connections between the prefrontal cortex and other brain regions responsible for higher cognitive functions.

However, within this global cognitive impairment, the deficit associated with executive functions in borderline personality disorder stands out. For the complete and specific study of EF, four indexes were created to reflect performance in cognitive flexibility, planning, working memory and response inhibition. Thus, our results not only found worse performance in the domain of executive functions in general in BPD patients compared to controls, but more specifically, significant differences were found between both groups in the executive subdomains of cognitive flexibility, planning, working memory and response inhibition, with BPD presenting worse performance in all these subdomains compared to controls. These results group those of Piñeiro et al.[4], Arza et al.[2], Silbersweigy et al.[10] and Ruocco et al.[6], who found no concordance in the specific EFs to which such executive deficit was due, because these studies were based on performance in isolated neuropsychological tests, and not on performance in executive indices composed of different tests.

Our results, by showing a global impairment of these specific executive functions, lay the groundwork for the study of the relationship of different types of impulsive behaviors that could be associated with deficits in different executive function indices.

As well, this predominantly executive impairment supports the theory of Bateman and Fonagy[32], who focuses the clinical symptomatology of BPD on a deficit in mentalization. Impaired mentalization refers to an inability to identify mental states in oneself or others. Mentalization would therefore be related to theory of mind (ToM). Several studies in children[33], in adults[34] and in clinical populations[35] have found a direct relationship between EF and ToM. These works suggest that better performance in executive tasks is positively associated with better performance in ToM. Furthermore, ToM involves holding information in working memory and switching between self and other perspectives[36].

Again, the global study methodology of specific executive functions performed in this study would allow investigating the association between different types of mentalization errors and the deficits found in different executive functions.

The origin of these neurocognitive alterations has not yet been determined at present, with some authors establishing a genetic component, especially in patients with borderline personality disorder with a more biological impulsivity, closer to neurodevelopmental disorders[6]. Thus, the study of the development of these cognitive functions from early ages would not only allow us to understand the characteristics of this process but would also facilitate the detection and prevention of common alterations in patients with characteristics similar to neurodevelopmental disorders.

These findings support the hypothesis that BPD patients could benefit from the application of neuropsychological rehabilitation programs targeted to the type and degree of neurocognitive difficulties.

For example, improving cognitive domains involved in social cognition such as attention, memory, executive control, and decision making would enhance the effectiveness of mentalization therapy[32]. Social cognition, through these cognitive processes, is implicated in the ability to understand one's own mind and the minds of others, guiding automatic and volitional behaviors[37]. Cognitive stimulation of attentional processes would also imply an improvement in the efficacy of third generation therapies, such as mindfulness. The standard procedure of dialectical-behavioral therapy (DBT[31]) consists of several types of interventions, including mindfulness training, which is considered a core intervention of DBT. Moreover, this type of DBT intervention has been confirmed as the most widely used by BPD patients[38].

The study is limited by the sociodemographic differences, such as age, found between the BPD patients and the control group, due to the difficulty in obtaining control subjects. Age is an important mediating variable in the cognitive deficit, affecting the performance of individuals in these tests directly. However, to reduce this limitation, statistical analyses were performed adjusting for age.

It is also important to highlight the consumption of medication by the patients. This type of medication intervenes on neuronal circuits that regulate thought and mood, producing undesirable effects in these areas. Specifically, some studies[39] have shown that antidepressant, antiepileptic drugs and benzodiazepines affect the performance of cognitive processes such as learning and memory. In addition, antipsychotic drugs have also shown an effect on attention and executive functions[40]. However, the withdrawal of these drugs entails serious clinical consequences so, in future studies, all data related to these drugs should be collected in detail to deduce their possible consequences through a more complete statistical analysis. To improve this limitation, the medication in the patients studied was limited to that necessary to obtain a moderate behavioral stability that would allow their psychological treatment in the Day Hospital, but in all cases we avoided studying patients who showed signs of sedation or slowing.

Finally, the sample was composed of patients with moderate-severe severity (CGI (clinical global impression) > 4) and high dysfunctionality (GAF (global assessment functionally) < 65). Therefore, the findings of our study cannot be generalized to all BPD patients as our patients were severely affected by the disorder and thus do not represent the average BPD population.

Conclusions

This work allows the specific study of executive functions in BPD through the creation of specific EF indexes composed of different tests, achieving a global study of each executive domain, and not through isolated tests as neuropsychological studies on BPD have done to date. The results of this study have made it possible to establish a neurocognitive profile of borderline personality disorder characterized by a global cognitive and executive impairment, establishing a generalized impairment in the functions of attention, memory and different executive functions such as cognitive flexibility, working memory, planning and response inhibition. This specific executive deficit associated with BPD patients highlights the importance of neuropsychological rehabilitation as part of a comprehensive treatment for this disorder characterized by its heterogeneity. Also, our results lay the groundwork for future studies on the understanding of the different types of impulsive behavior in BPD in relation to the deficits found in the different executive domains, as well as the relationship of these executive deficits with the

Actas Esp Psiquiatr 2023;51(5): 220-28 | ISSN: 1578-2735

difficulties in theory of mind, and therefore, the interpersonal instability, characteristic of this disorder.

Declaration of interest (disclosure) statement

This work was supported by the PI20/01471 project, integrated in the Plan National de I+D+I, AES 2020–2023; funded by the ISCIII and co-funded by the European Regional Development Fund (ERDF). "A way to make Europe"

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Actas Esp Psiquiatr 2023;51(5): 220-28 | ISSN: 1578-2735