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ORIGINAL PAPER

Cognitive Deficits in Executive Functions and Decision-Making Impairments Cluster Gambling Disorder Subtypes

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Abstract To identify Gambling Disorder (GD) subtypes, in a population of men seeking treatment for GD, according to specific executive function domains (i.e., cognitive flexibility, inhibition and working memory as well as decision making) which are usually impaired in addictive behaviors. A total of 145 males ranging from 18 to 65 years diagnosed with GD were included in this study. All participants completed: (a) a set of questionnaires to assess psychopathological symptoms, personality and impulsivity traits, and (b) a battery of neuropsychological measures to test different executive functioning domains. Two clusters were identified based on the individual performance on the neuropsychological assessment. Cluster 1 [$n = 106$; labeled as Low Impaired Executive Function (LIEF)] was composed by patients with poor results in the neuropsychological assessment; cluster 2 patients [$n = 46$; labeled as High Impaired Executive Function (HIEF)] presented significantly higher deficits on the assessed domains and performed worse than the ones of LIEF cluster. Regarding the characterization of these two clusters, patients in cluster 2 were significantly older, unemployed and registered higher mean age of GD onset than patients in

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cluster 1. Additionally, patients in cluster 2 also obtained higher psychopathological symptoms, impulsivity (in both positive and negative urgency as well as sensation seeking) and some specific personality traits (higher harm avoidance as well as lower self-directedness and cooperativeness) than patients in cluster 1. The results of this study describe two different GD subtypes based on different cognitive domains (i.e., executive function performance). These two GD subtypes display different impulsivity and personality traits as well as clinical symptoms. The results provide new insight into the etiology and characterization of GD and have the potential to help improving current treatments.

Keywords Gambling disorder · Subtypes · Executive function · Decision-making · Cognitive flexibility · Personality

Introduction

Gambling disorder (GD) is a prevalent and highly heterogeneous condition characterized by persistent and recurrent maladaptive patterns of gambling behavior that leads to impaired functioning (APA 2013). It is widely known that impulse control deficits play an important role in the development and maintenance of this disorder (Ledgerwood et al. 2009; Petry 2001). For instance, patients with GD usually display impaired response inhibition and poor self-regulation (Goudriaan et al. 2006). These impulse control deficits are thought to be related to some underlying impairments in executive functions (EF; Hinson et al. 2003). which are high-level cognitive processes implicated in the formation of successful goal-directed behaviors (Lezak 2012). Among the EF deficits that patients with GD present, deficits in planning (Goudriaan et al. 2006), working memory and decision-making (Ledgerwood et al. 2012) are highlighted. Additionally, poor decision making patterns in GD seem to be characterized by deficits in immediate/delayed reinforcements and reward/punishment as well as myopia for the future and poor cognitive flexibility (Ochoa et al. 2013). Notably, a previous study in GD that we conducted with adults we found that difficulties on decision making are extensive to both the learning process and the whole decision making performance when assessed with the Iowa Gambling Task (IGT; Mallorquí-Bagué et al. 2016).

Patients diagnosed with GD also suffer from severe emotional distress (Stoltenberg et al. 2008; Williams et al. 2012; Wong et al. 2013) and present very specific personality traits such as impulsivity (Norbury and Husain 2015), sensation seeking as well as high reward and punishment sensitivity (Hodgins and Holub 2015; Jiménez-Murcia et al. 2016; Lorains et al. 2011; Mestre-Bach et al. 2016). These characteristic features, together with the previously mentioned neuropsychological deficits, contribute to the development and maintenance of the GD (Alvarez-Moya et al. 2011; Grant et al. 2016). Additionally, these factors (i.e., EF and decision-making impairments and, sensation seeking-impulsivity) also play an important role in the treatment outcome and the likelihood of relapses (Alvarez-Moya et al. 2011; Jiménez-Murcia et al. 2016; Ramos-Grille et al. 2015) as well as in the treatment drop-out rates (Norbury and Husain 2015; Smith et al. 2010). However, although EF deficits frequently underlie addictive behaviors, little research has specifically focused on exploring the neuropsychological deficits involved in GD. Future research on this area would be especially relevant for these patients' treatment outcome (Leblond et al. 2003).

Given that GD is a highly heterogeneous condition with frequently poor treatment outcomes, several authors have suggested the necessity of classifying GD into subtypes (Milosevic and Ledgerwood 2010). Consequently, the term GD subtypes emerged with

some studies describing different GD clusters according to different personality and psychopathological patterns as well as the individual motivation for gambling (Heiskanen and Toikka 2016; Moon et al. 2016). However, despite the role that EFs play in addictive behaviors and specifically in GD, no previous studies have explored GD subtypes according to the severity of these neuropsychological deficits. The characterization of GD based on different cognitive patterns could enhance the current knowledge on this condition and help targeting the best treatment approach for each patient.

The aim of this study is to identify specific GD subtypes according to different domains of EFs (including cognitive flexibility, inhibition and working memory as well as decision making) in a population of men seeking outpatient treatment for GD. Additionally, we also aim to characterize the resulting subtypes by exploring and comparing their sociodemographic variables, comorbid clinical symptoms, as well as personality and impulsivity traits.

Methods

Sample

The sample consists of 145 male participants diagnosed with GD, according to the DSM-5 criteria (APA 2013). All participants were consequently referred to the hospital for problematic gambling and were assessed by a senior clinician specialized on behavioral addictions. All participants gave written signed informed consent and received no additional compensation for being part of the study. In accordance with the Helsinki Declaration of 1975 as revised in 1983, the Ethics Committee of the institution involved in the project approved the study. Exclusion criterion were: (1) history of chronic medical illness or neurological condition that might affect cognitive function; (2) brain trauma, learning disability or intellectual disabilities; (3) age under 18 or over 65 (adults not older than 65 to discard neuropsychological deficits associated with age). Given that GD is more prevalent among men than women and that there are substantial differences described between sexes (Granero et al. 2009), only males diagnosed with GD were included in this study.

Clinical and Neuropsychological Assessment

For the purpose of this study, all participants fulfilled self-reported questionnaires for exploring psychopathological symptoms as well as personality and impulsivity traits. Participants also completed a set of neuropsychological tests for assessing different EF domains, including cognitive flexibility, inhibition and working memory as well as decision making. Table 1 and 3 contains the internal consistency (Cronbach's alpha, α) for the psychometrical measures obtained in the present sample, which achieved values into the range adequate to excellent.

Self-Reported Measures of Impulsivity, Personality and Psychopathological State

The UPPS-P Impulsivity Scale (Whiteside et al. 2005) is a 59-item questionnaire to assess five different features of impulsive behavior: Negative Urgency, Lack of Perseverance, Lack of Premeditation, Sensation Seeking and Positive Urgency. The UPPS-P has

Table 1 Descriptive

	Total ($n = 152$)		Cluster 1 ($n = 106$)		Cluster 2 ($n = 46$)				
	n	%	*n*	%	*n*	%	χ^2	*df*	*p*
Origin									
Spanish	145	95.4	103	97.2	42	91.3	2.51	1	.113
Education level									
Primary	76	50.0	50	47.2	26	56.5	1.48	2	.478
Secondary	61	40.1	44	41.5	17	37.0			
University	15	9.9	12	11.3	3	6.5			
Civil status									
Single	51	33.6	33	31.1	18	39.1	2.76	2	.252
Married—in couple	78	51.3	59	55.7	19	41.3			
Divorced—separated	23	15.1	14	13.2	9	19.6			
Employment									
Employed	80	52.6	65	61.3	15	32.6	10.61	1	**.001***
Smoker	91	59.9	59	55.7	32	69.6	2.58	1	.108
Alcohol use-abuse	33	21.7	21	19.8	12	26.1	0.74	1	.389
Other drugs use-abuse	13	8.6	7	6.6	6	13.0	1.70	1	.192

	α	Mean	SD	Mean	SD	Mean	SD	F	*df*	*p*
Age (years-old)		39.93	10.01	38.50	9.65	43.24	10.15	7.50	1;150	**.007***
GD onset (years-old)		25.08	9.29	23.66	8.84	28.35	9.59	8.56	1;150	**.004***
Duration of GD (years)		4.87	5.19	4.94	5.02	4.70	5.62	0.06	1;150	.801
SOGS total score	.754	11.01	3.07	11.23	3.09	10.50	3.00	1.73	1;150	.191
DSM-5 criteria: total	.799	7.10	1.87	7.10	1.88	7.09	1.86	0.00	1;150	.981

SD standard deviation

*Bold: significant comparison (.05 level). α: Cronbach's alpha in the sample

satisfactory psychometric properties in terms of both convergent and discriminatory validity (Cyders and Smith 2008; Lynam et al. 2007; Smith et al. 2007, 2011). Adequate psychometric properties are demonstrated in the Spanish adaptation of the scale (Verdejo-García et al. 2010).

The Symptom Checklist-90-R (SCL-90-R; Derogatis 1977) is a 90-item questionnaire to measure psychological and psychiatric symptoms through nine dimensions: somatization, obsession-compulsion, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation and psychoticism. The questionnaire has demonstrated satisfactory psychometric properties in a Spanish sample (Derogatis and González de Rivera y Revuelta 2002).

The Temperament and Character Inventory-Revised (TCI-R; (Cloninger 1994; adapted to Spanish population by Gutiérrez-Zotes et al. (2004) is a 240-item questionnaire to asses four dimensions of temperament (harm avoidance, novelty seeking, reward dependence and persistence) and three character dimensions (self-directedness, cooperativeness and self-transcendence). The scales in the Spanish revised version showed adequate internal consistency (Cronbach's alpha α mean value of 0.87).

Neuropsychological Assessment

The Iowa Gambling Task (IGT; Bechara et al. 1994; Bechara et al. 2000) is a computerized task to evaluate decision-making, risk and reward as well as punishment value. The participant has to select 100 cards from four decks (A, B, C and D) and after each card selection an output is given either a gain or a loss of money. Participants are instructed that the final aim of the task is to win as much money as possible. This test is scored by subtracting the amount of cards selected from decks A and B from the amount of cards selected from decks C and D. Decks A and B are not advantageous as the final loss is higher than the final gain; however, decks C and D are advantageous since the punishments are smaller. Higher scores point to better performance while negative scores point to persistently choosing disadvantageous decks.

The Wisconsin Card Sorting Test (WCST; Grant and Berg 1948) is a task for assessing cognitive flexibility and inhibition control. It is compound by 4 stimulus cards and 128 response cards showing different shapes, colors and numbers of figures in each one. The participant has to match response cards with the stimulus cards in a way that it seems justifiable before receiving the feedback: correct or incorrect. After ten sequential correct answers the categorization criteria changes. The number of complete categories, the percentage of perseverative errors and the percentage of non-perseverative errors are recorded.

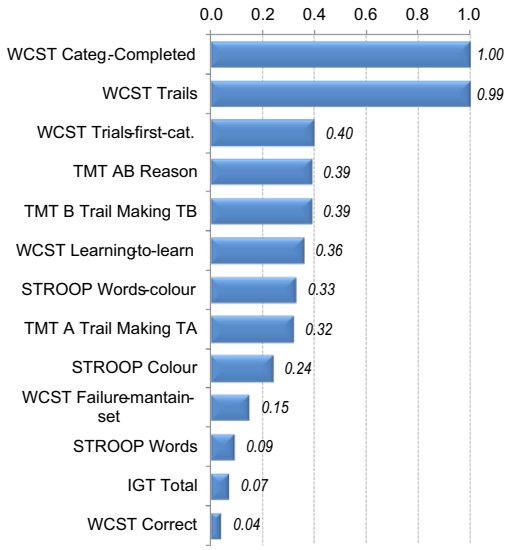
The Stroop Color and Word Test (SCWT; Golden 1978) consists of three different lists. To begin with a *word list* containing the names of colors printed in black ink. After that a *color list* that comprises letter Xs printed in color. Finally, a *color-word list* constituted of names of colors in a color ink that does not match the written name. Three final scores are obtained based on the number of items that the participant is able to read on each of the three lists in a time of 45 seg. The interference score enables the assessment of individual's cognitive flexibility and reaction to cognitive pressures.

The Trail Making Test (TMT; Reitan 1958) consists of 25 circles spread out over two sheets of paper (Parts A and B). The participant is told to connect these circles drawing a line between consecutive numbers (part A) and alternating numbers and letters following a sequential order (part B). The task assesses visual conceptual and visual-motor tracking, entailing motor speed, attention and the capacity to alternate between cognitive categories (set-shifting). Each part is scored according to the time spent to complete the task.

The digits backward task of the Wechsler Memory Scale-Third Edition (WMS-III; Wechsler 1997) consists of two lists of digits presented verbally by the examiner. The participant is asked to repeat the digits in the same order (first list) and in reverse order (second list). Verbal working memory is assessed trough Digits Backward Task due to internal manipulation of mnemonic representations of verbal information is required in the absence of external cues.

Statistical Analysis

Statistical analysis was carried out with SPSS20 for Windows. Empirical clusters were explored through TwoStep-Clustering-Component, entering as indicators the main neuropsychological measures of the study (see Fig. 1). This procedure uses an algorithm which has (at least) two desirable features that differentiate it from other traditional clustering techniques: (a) it can handle both the categorical and the continuous variables; and (b) it automatically determines the optimal number of clusters by comparing the values of the model-choice criterion across different clustering solutions. The TwoStep-Clustering



	Centroids		
	C1	C2	Total
WCST Categories Completed	5.8	3.5	5.1
WCST Trails	92.1	120.4	100.7
WCST Trials First Cat.	15.4	36.8	21.9
TMT_AB Reason	66.0	110.6	79.5
TMT_B Trail Making TB	67.0	111.6	80.5
WCST Learning to learn	0.1	-4.3	-1.2
STROOP words-colour	45.5	36.2	42.7
TMT_A Trail Making TA	25.7	37.8	29.4
STROOP colour	72.4	62.6	69.4
WCST Failure to maintain set	0.6	1.1	0.8
STROOP words	101.8	93.1	99.1
IGT-total	10.0	1.4	7.4
WCST Correct	71.3	68.7	70.5

Fig. 1 Summary for the clustering: relative importance of each indicator and centroids

operates in two steps: (1) subjects are pre-clustered into many small sub-clusters according to a sequential clustering approach; (2) the resulting sub-clusters are considered as inputs and grouped into the desired number of clusters according to the agglomerative hierarchical clustering method. By default, this procedure uses a combination of Schwarz Bayesian Information Criterion and log-likelihood distance when autodetermining the final number of clusters. Also, it automatically chooses as the most optimal solution the one that presents a reasonably large ratio of Schwarz Bayesian Information Criterion change and a large ratio of distance measures.

The comparison among the derived empirical clusters for the studied variables (sociodemographic, clinical and personality measures) was carried out with Chi square tests (χ^2) for categorical factors and analysis of variance (ANOVA) for quantitative measures. Partial correlations measured the association between impulsivity with the psychopathological and cognitive profile.

In order to avoid potential biases in the results due to confounding variables both the comparison between clusters and the partial correlations included the following statistical covariates: years of age, years of education and depressive symptoms scores. These variables are strongly associated—reported in the scientific literature—with the explored neuropsychological measures. In addition, Finner's correction was used to control increase in the Type-I error due to multiple statistical comparisons (Finner 1993). Finner's procedure was included into the familywise error rate stepwise procedures, which is more preferable than the classic Bonferroni correction since it offers more powerful tests.

Results

Characteristics of the Sample

Table 1 includes the descriptive variables of the sample. Most of the participants were Spanish (95.4%), had primary (50.0%) or secondary studies (40.1%), were married or living with a partner (51.3%) and were employed (52.6%). The mean age of the sample was of 39.9 years-old (SD = 10.1) and patients' mean age of gambling behavior onset was 25.1 years-old (SD = 9.29) with a mean of 4.9 years (SD = 5.2) of disordered gambling. Regarding substances consumption, around 60.0% of the sample smoked tobacco regularly, 21.7% reported alcohol use-abuse and 8.6% recognized the usual use of other drugs.

Clusters Composition and Comparison

The two-cluster option was selected as being the most optimal and it was the one auto-determined as the most appropriate by the TwoStep-Clustering procedure. The Silhouette's index (a validity measure of consistency within clusters, which can be interpreted as the level of cohesion/separation for the empirical derived groups; Rousseeuw 1987) was into the fair range (average Silhouette = 0.45, suggesting reasonable evidence of cluster structure in the data). The comparison between the largest cluster size (n = 106, 69.7%) and the smallest (n = 46, 30.3%) yielded a ratio of 2.30.

The bar-graph represented in the left panel of Fig. 1 represents the relative importance of each indicator in the clustering procedure, which in this study reports how well each neuropsychological measure can differentiate the derived empirical clusters (the higher the importance measure, the less likely it is that the variation of the variable between clusters is random and the more likely it is that it is due to some underlying difference). In this study the WCST categories completed and WCST trails achieved the highest relative importance for clustering, while the poorest relevance was obtained for STROOP words, IGT total and WCST correct. The table included in the right panel of Fig. 1 contains the centroids for the indicators in the clustering, which summarizes the clusters patterns for this set of variables.

Cluster 1 (n = 106, 69.7% of the sample) is characterized by more effective executive function compared to the other group, and it has been labeled as Low Impaired Executive Function (LIEF). Cluster 2 (n = 46 patients, 30.3% of the sample) is characterized by including the participants with poorer results in the neurological measures of the study, and it has been labeled as High Executive Function Impairment (HIEF).

Tables 1, 2 and 3 contain the comparison between the empirical clusters for all the variables of the study. Patients into Cluster 2-HIEF were older (mean age was 43.2 compared to 38.5 for participants in Cluster 1-LIEF) and registered higher mean age for the onset of the GD (28.4 compared to 23.7) (Table 1). The comparison of the neuropsychological domains adjusted by the covariates age, years of education and depression levels (Table 2), supported the worse state for Cluster 2-HIEF in almost all the measures. And related to other clinical variables (Table 3) adjusted by age, Cluster 2-HIEF obtained higher psychopathological levels (higher means for all the SCL-90R scales, except for hostility), higher scores in the personality traits harm avoidance and self-transcendence, lower mean in the self-directedness trait and higher impulsivity levels in the positive urgency scale.

Table 2 Comparison between clusters in neuropsychological and impulsivity measures: ANOVA adjusted by age, years of education and SCL-90R depression score

	Cluster 1 ($n = 106$)		Cluster 2 ($n = 46$)		$F_{1;147}$	p	$\|d\|$
	Mean	SD	Mean	SD			
Trail Making Test							
Part A	25.99	8.82	33.69	18.75	15.71	**< .001***	**0.53**†
Part B	67.56	22.79	97.58	67.50	25.82	**< .001***	**0.60**†
Part A/B	66.56	22.79	96.58	67.50	25.82	**< .001***	**0.60**†
Iowa Gambling Task							
Total raw scores	9.24	22.48	3.76	23.10	1.49	.225	0.24
Wisconsin Card Sorting Test							
Total response errors	18.55	10.61	53.32	23.27	103.31	**< .001***	**1.92**†
Perseverative errors	8.73	4.77	25.24	14.83	66.46	**< .001***	**1.50**†
Conceptual level responses	66.75	6.40	52.46	24.72	19.35	**< .001***	**0.79**†
Number of categories completed	5.75	0.39	3.57	2.06	92.62	**< .001***	**1.48**†
Trials to complete 1st category	15.91	5.86	34.76	35.01	25.87	**< .001***	**0.75**†
Failure to maintain set	0.59	0.67	1.20	1.25	11.60	**.001***	**0.61**†
Stroop							
Word reading	101.10	20.00	94.79	18.98	2.70	.103	0.32
Color naming	72.24	11.05	64.41	14.28	11.52	**.001***	**0.61**†
Color/Word naming	44.96	9.18	38.72	10.49	12.02	**.001***	**0.63**†
Interference	4.35	7.83	1.36	5.77	1.09	.305	0.43
Digit scores							
Forward scores	8.15	1.71	8.05	1.17	0.08	.781	0.07
Backward scores	6.49	1.28	5.66	1.45	7.38	**.008***	**0.61**†

SD standard deviation. $|d|$ Cohen's-*d* measuring effect size

*Bold: significant comparison (.05 level). †Bold: effect size into the moderate ($|d| > 0.50$) to high range ($|d| > 0.80$). *p* value includes Bonferroni–Finner correction for multiple statistical comparisons

As a synthesis of the comparison between the empirical clusters, Fig. 2 includes the radar-chart with the standardized mean scores (to allow easier interpretation) for the main variables with differences between the groups.

Association Between the Variables of the Study

Supplementary Table 4 includes the partial correlations (adjusted by the academic years and the depression levels) measuring the association between GD severity (SOGS total and DSM-5 criteria), global psychopathological state (SCL-90R GSI) and neuropsychological performance with impulsivity (UPPS-P) and personality (TCI-R) measures. Results have been obtained stratified for each empirical cluster subsample.

For the Cluster 1-LIEF, GD severity positively correlated with impulsivity levels (sensation seeking, positive and negative urgency) and with novelty seeking trait, while GD severity negatively correlated with self-directedness. A similar pattern was obtained for the psychopathological level: the worse the state the higher the impulsivity levels and

Table 3 Clinical comparison between clusters in the GD related variables: ANOVA adjusted by age

	α	Cluster 1 ($n = 106$)		Cluster 2 ($n = 46$)		$F_{1;149}$	p	$\|d\|$
		Mean	SD	Mean	SD			
SCL-90-R								
Somatization	.906	0.71	0.68	1.16	0.90	9.67	**.002***	**0.56**†
Obsessive–compulsive	.864	1.09	0.74	1.13	0.83	0.14	.713	0.05
Interpersonal sensitivity	.862	0.88	0.70	1.30	0.89	8.46	**.004***	**0.53**†
Depressive	.885	1.44	0.75	1.83	0.84	6.81	**.010***	**0.52**†
Anxiety	.876	0.81	0.62	1.27	0.85	12.16	**.001***	**0.62**†
Hostility	.840	0.82	0.77	1.15	0.87	4.69	**.032***	0.40
Phobic anxiety	.760	0.30	0.47	0.64	0.67	10.67	**.001***	**0.58**†
Paranoid	.795	0.76	0.65	1.27	0.88	13.79	**< .001***	**0.66**†
Psychotic	.809	0.77	0.61	1.12	0.80	7.39	**.007***	**0.51**†
GSI score	.976	0.91	0.56	1.32	0.74	11.94	**.001***	**0.62**†
TCI-R								
Novelty seeking	.742	108.97	14.01	109.61	14.80	0.06	.812	0.04
Harm avoidance	.819	98.62	15.19	107.51	17.58	8.32	**.005***	**0.54**†
Reward dependence	.821	99.19	15.49	96.60	16.16	0.72	.396	0.16
Persistence	.880	111.41	19.07	109.34	20.03	0.30	.584	0.11
Self-directedness	.881	133.10	21.56	124.47	22.14	4.19	**.042***	0.39
Cooperativeness	.840	132.77	15.86	125.90	18.04	5.06	**.026***	0.40
Self-Transcendence	.839	60.60	13.82	65.62	16.06	3.20	.076	0.34
UPPS-P								
Lack premeditation	.878	23.89	6.28	25.67	7.04	1.88	.173	0.27
Lack perseverance	.788	21.86	5.33	22.27	5.57	0.14	.712	0.08
Sensation seeking	.813	26.84	8.28	29.85	6.38	4.00	**.048***	0.41
Positive UR	.932	29.93	10.43	37.63	9.06	13.19	**< .001***	**0.79**†
Negative UR	.874	31.73	8.03	36.41	6.70	8.39	**.004***	**0.63**†

α Cronbach's alpha in the sample, *SD*: standard deviation, *GD* gambling disorder, $|d|$ Cohen's-*d* effect size
*Bold: significant comparison (.05 level). †Bold: effect size into the moderate ($|d| > 0.50$) to high range ($|d| > 0.80$). p value includes Bonferroni–Finner correction for multiple statistical comparisons

the lower the self-directedness and the cooperativeness. Regarding associations for the neuropsychological performance, Trail Making Test Part B and Part A/B positively correlated with reward-dependence, while STROOP interference negatively correlated with impulsivity sensation-seeking, novelty seeking and persistence, and positively correlated with cooperativeness.

For the Cluster 2-HIEF, positive associations between GD severity with impulsivity and novelty seeking trait emerged, while negative associations between GD severity with self-directedness and cooperativeness traits were obtained. A worse psychopathological state was related to lower scores in the impulsivity sensation seeking and self-directedness scales and to higher scores in the impulsivity positive urgency and harm avoidance. For the neuropsychological performance, most associations emerged compared to those obtained

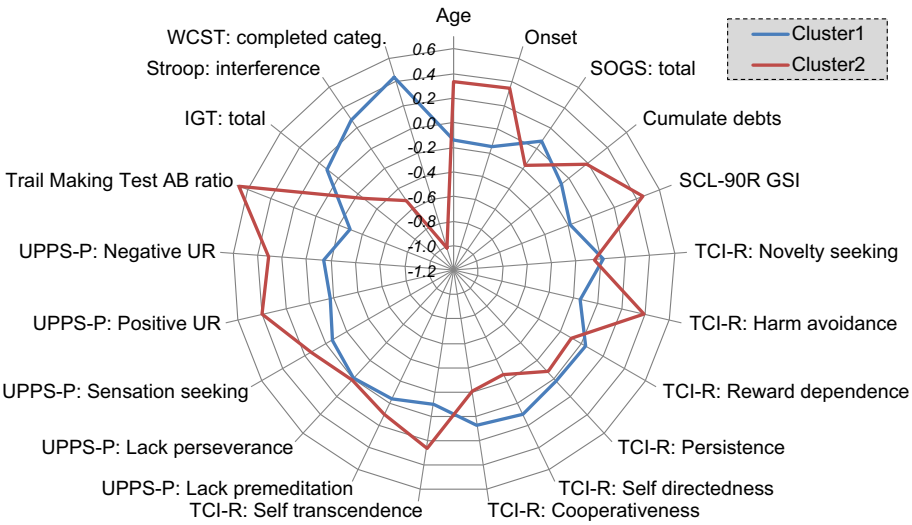


Fig. 2 Summary of the results: radar-chart

for the other Cluster. As a whole, results indicated that the poorest neurological scores were related to the highest scores in impulsivity and the most dysfunctional scores in the personality traits.

Discussion

This study has identified two different clusters relying on neuropsychological functions in a male sample with GD. The GD subtypes are differentiated by their executive function impairment but they also show marked disparities in their psychopathological symptoms, personality traits and impulsivity.

Specifically and compared to the cluster 1-LIEF, the cluster 2-HIEF emerges as a cluster with significantly more unemployment, older mean age and with a later onset of the condition. It also presents more executive function impairment (including poor inhibition, working memory and cognitive flexibility) and lower mean scores on the IGT total score than cluster 1-LIEF. Although group differences with the IGT are not statistically significant, it is important to note that a mean score below ten indicates deficits in the task (Bechara et al. 2002; Ochoa et al. 2013), which means that both groups would present impairments in decision-making as reported in previous studies conducted with individuals diagnosed with GD (Ledgerwood et al. 2012). However, while cluster 1-LIEF would almost reach the minimum score to be considered functional cluster, the cluster 2-HIEF would display a higher impairment. Besides, GD has also been associated with poor inhibition capability when measured through the STROOP or GO-noGO tasks (Kertzman et al. 2017), with deficits in working memory and with poor cognitive flexibility (Alvarez-Moya et al. 2011). In line with our results, working memory deficits assessed with the digit span task, were also reported in a recent study conducted by Zhou et al. (2016), where participants with GD obtained significantly lower backward scores than the healthy control group (HC). In this same study, impairments on cognitive flexibility emerged when

completing the WCST: GD had significantly higher perseverative errors and failure to maintain set with significantly lower categories completed and lower conceptual level responses than HC (Zhou et al. 2016). Remarkably, the present study steps further and according to the results not all GD individuals present the same severity of neuropsychological impairments; instead they are presumably divided into two different neuropsychological functioning clusters. These findings support previous studies reporting the heterogeneity of this condition and the existence of different GD subtypes (Álvarez-Moya et al. 2010; Blaszczynski and Nower 2002; Milosevic and Ledgerwood 2010), but no previous studies explored neuropsychological domains of GD subtypes.

Concerning personality, impulsivity and comorbid psychological symptoms, cluster 2-HIEF emerges as the one that presents more relevant psychopathological symptoms and traits linked to maladaptive behaviors and emotional impairment. Notably it presents higher impairment in all the explored areas with the exception of Obsessive–compulsive symptoms. It also presents higher impulsivity for both positive and negative urgency as well as sensation seeking and, it displays specific personality traits: higher scores on harm avoidance with lower scores on self-directedness and cooperativeness. Similarly, studies exploring personality traits, comorbidities and impulsivity in GD individuals report higher levels of impulsivity in both negative and positive urgency, higher comorbid psychological simptomatology and specific personality traits when compared to HC (Savvidou et al. 2017). However, as previously stated, GD is a highly heterogeneous disorder and some studies have reported different GD subtypes differentiated by comorbidities in addition to clinical and personality variables (Heiskanen and Toikka 2016; Jiménez-Murcia et al. 2013; Suomi et al. 2014; Valleur et al. 2016). Of special relevance for its longitudinal design, it is the study conducted with a GD sample that described three clusters: behaviorally conditioned emotionally vulnerable and antisocial impulsivity (Ledgerwood and Petry 2010). Later this clusters were also found in non-treatment seeking problem gamblers (Moon et al. 2016). However, previous studies in GD subtypes are still not conclusive and none of them considered the role that cognitive impairments can play when establishing these subtypes.

The present study have the potential to improve current knowledge on GD subtypes and provides some relevant information by describing two different clusters with different neuropsychological impairments that also present different personality, impulsivity and comorbid psychological symptoms. However, the results of this study are constrained to some limitations. Firstly, the final sample is only constituted by males thus results cannot be extrapolated to females. It is important to note that up until now most of the studies have manly been conducted with male gamblers and that those studies that explored both sexes found numerous differences (i.e., insociodemographic variables, age of onset, duration of the gambling problem, type of game played as well as comorbidity with other substance use and mood disorders) (Bonnaire et al. 2017; Echeburúa et al. 2011; Ladd and Petry 2002; Moragas et al. 2015; Toneatto and Wang 2009). Thus, future studies should be conducted to explore if the described subtypes of the present study are also applicable to females. Secondly, this is a cross-sectional study and no causality can be driven from the results. Finally, cognitive performance can be directly linked to age and years of education and as we have an adult sample consecutively referred for treatment and preserved external validity we could only control for these variables during the statistical analysis.

Conclusion

Due to the observed GD heterogeneity, there is a need to better characterize this disorder and to better target individualities for improving current treatments. Previous literature describes GD-subtypes according to different personality, psychological symptoms and motivational factors. However, although cognitive deficits are known to have a pivotal role in the GD, to our knowledge no previous studies have explored GD subtypes according to different cognitive variables. The results of this study describe two different clusters based on different cognitive domains that also present different impulsivity and personality traits in addition to different clinical symptoms. These subtypes have the potential to be critical to advancing our understanding of the etiology and course of disordered gambling.

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Compliance with Ethical Standards

Conflict of interest All authors declare no conflicts of interest.

Ethical Approval All procedures were in accordance with the ethical standards of the Hospital Universitari Bellvitge institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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