J Gambl Stud
https://doi.org/10.1007/s10899-018-9758-y

ORIGINAL PAPER

In Search of Executive Impairment in Pathological Gambling: A Neuropsychological Study on Non-treatment Seeking Gamblers

Alexandros Kapsomenakis[1,2,5] · Panagiotis G. Simos[3] · Georgios Konstantakopoulos[4] · Dimitrios S. Kasselimis[3,5]

Abstract Pathological gambling is characterized by a persisting maladaptive and recurrent behavior with severe social and psychological consequences. There is evidence of strong comorbidity with psychiatric manifestations as well as cognitive mainly involving executive functions. This study aimed to investigate impairment in executive functions and working memory, and personality traits in a sample of Greek gamblers. Twenty-four men involved in various gambling activities were recruited from ecological settings as probable pathological gamblers. They were assessed with a comprehensive neuropsychological battery involving several executive tasks, the Zuckerman–Kuhlman Personality Questionnaire, the Hospital Anxiety Depression Scale, and the Difficulties in Emotion Regulation Scale. An age- and education-level matched group of 21 men without history of habitual gambling served as controls. As a group, gamblers displayed significantly lower scores on indices of inhibition, decision making and self-reported emotional awareness, and scored higher on impulsivity/sensation seeking personality traits. Notably, gamblers scored similarly or significantly higher on measures of verbal and visuospatial working memory, cognitive flexibility, processing speed, verbal fluency, and sustained attention. Overall, we argue that gamblers do present with specific cognitive deficits, but there is no evidence for a generalized executive impairment, and further stress the importance of investigating cognitive, personality, and psychiatric aspects of gambling on the basis of an ecologically valid sampling.

✉ Alexandros Kapsomenakis
kapsomenakis.a@gmail.com

[1] School of Psychological, Social and Behavioural Sciences, Faculty of Health and Life Sciences, Coventry University, Coventry, UK

[2] Department of Psychology, Aegean College, Athens, Greece

[3] Department of Psychiatry, School of Medicine, University of Crete, Heraklion, Greece

[4] Department of Psychiatry, School of Medicine, National and Kapodistrian University of Athens, Athens, Greece

[5] Department of Neurology, School of Medicine, Eginition Hospital, National and Kapodistrian University of Athens, 74 Vas. Sofias Av., 11528 Athens, Greece

Published online: 17 February 2018

Keywords Gambling · Personality dimensions · Psychopathology · Executive functions · Working memory

Introduction

Pathological gambling (PG) is an addictive disorder characterized by a persistent maladaptive and recurrent behavior with severe social and psychological effects (American Psychiatric Association 2000). From a clinical perspective, PG is connected with high levels of co-morbidity with a variety of disorders (Kessler et al. 2008; Petry et al. 2005). There is growing consensus that traits related to impulsivity and sensation (novelty) seeking are most intimately linked with gambling (Bagby et al. 2007). Zuckerman who introduced the concept of the impulsive-sensation seeking, considered gamblers as the prototypical sensation seeker (Zuckerman 1994), while personality dimensions in general have been examined as an important aspect of several theoretical frameworks which aim to explain the underlying mechanisms of gambling (e.g. Blaszczynski and Nower 2002; Brewer and Potenza 2008). Although pathological gambling is often viewed as an impulse control disorder, the impulsiveness may be caused by negative affect and gambling impulses might be an attempt to escape from anxiety and depression (Turner et al. 2008). Notably, impulsivity in PG has been associated with deficits in planning, decision making, inhibition and cognitive flexibility (Brevers et al. 2012; Odlaug et al. 2011).

Several studies indicate a general trend towards Executive Functions (EF) impairment in PG. Specifically, PG performance in various neuropsychological tasks compared to non-PG, revealed impairment in planning (Goudriaan et al. 2006; Ledgerwood et al. 2012) cognitive flexibility (Goudriaan et al. 2006; Odlaug et al. 2011), and behavioral inhibition (Goudriaan et al. 2006; Grant et al. 2012; Kalechstein et al. 2007; Odlaug et al. 2011; Potenza et al. 2003; Roca et al. 2008). Other studies found deficits in episodic and working memory, as well as verbal fluency in PG (Leiserson and Pihl 2007; Roca et al. 2008; Zhou et al. 2016). Finally, performance on the Iowa Gambling Task (IGT), which was designed to assess decision making capacity under ambiguity and risk, is impaired in PG (see Brevers et al. 2012; Goudriaan et al. 2006; Ledgerwood et al. 2012, among others). Brain imaging data appear to be consistent with these findings, revealing aberrant patterns of hemodynamic responses in prefrontal cortices in PG (for a review, see Grant et al. 2016). Given that the lateral prefrontal cortices has a central role in the neural substrate of EFs and working memory (Wager and Smith 2003; Zakzanis et al. 2005), taken together this evidence points to a dysexecutive cognitive basis for PG, possibly attributed to lateral prefrontal dysfunction (for a review, see van Holst et al. 2010).

However, a closer look at the literature reveals a number of potential weaknesses in this notion. Firstly, there is evidence against a *generalized* executive impairment in PG (Manning et al. 2013). Secondly, several studies have a number of methodological limitations. Sampling bias, mainly due to inclusion of treatment-seeking patients only, may provide non-representative groups (Lorains et al. 2011). Additionally, it has been argued that the majority of pathological gamblers seek treatment for a co-morbid disorder rather than gambling per se (Winters and Kushner 2003). Moreover, small sample size prevents the use of parametric statistics and limits generalizability of results, whereas Type I error may be inflated when complex multivariate analyses are conducted. Finally, a large proportion of the relevant studies lack a thorough neuropsychological assessment, thus drawing conclusions on the basis of limited data. The above limitations stress the need for further studies

utilizing comprehensive cognitive batteries on representative, unbiased, ecological samples of pathological gamblers. The present study aims to investigate personality traits, cognitive impairment, and signs of psychopathology in a non-treatment-seeking PG sample.

Method

Participants

Non-treatment seeking adults with mixed gambling history were recruited from booking agencies, private clubhouses, and casinos in Chalkida, Korinthos, and Athens. A letter of invitation containing general information about the study and contact details of the first author was distributed in gambling spots, after approval was acquired by the manager of each spot. Prospective participants were then personally informed regarding the goals and procedures of the study by AK. Upon agreement to participate they were briefly interviewed using a structured health and gambling history questionnaire using the South Oaks Gambling Screen (SOGS; Lesieur and Blume 1987). Inclusion criteria were: a score higher than four on SOGS (indicating "probable pathological gambling") and at least 1 year (12 months) of gambling activity.

Based on the characteristics of the final study group candidates for the control group were men aged 30–68 years with 6–23 years of formal education. They were recruited following convenient sampling methodology from the broader region of Attica and were eligible to participate if they scored zero points on SOGS. Additional exclusion criteria for both groups included history of learning disability, psychiatric or neurological disorder, or traumatic brain injury (defined by loss of consciousness > 20 min). Moreover, all participants were evaluated by an experienced psychiatrist (GK) to confirm or exclude the diagnosis of PG and identify other comorbid mental disorders according DSM-5 diagnostic criteria (American Psychiatric Association 2013). Of 86 persons invited to participate, 35 candidates for the group of gamblers and 6 for the control group were excluded or refused to participate. All PG individuals participating in our study were non-professional gamblers.

The final sample consisted of 24 men aged 30–68 years with 6–23 years of formal education, displaying mixed gambling activity and SOGS ranging from 5 to 18 points (mean = 9.75, SD = 4.13), 4 to 53 years of gambling activity (mean = 22.87, SD = 12.51), and 2 to 7 days/week gambling frequency (mean = 5.54, SD = 1.74). They reported betting between to 10 and 2000 € per day (Mean = 427, SD = 535) and the highest amount of money played within a day ranging between 50 and 10.000 € (Mean = 2605, SD = 2973). The control group constituted of 21 healthy men with no problematic/pathological gambling history (SOGS score = 0). Four of our controls have never gambled, while the rest have occasionally bought lottery tickets (usually in case of jackpots), placed a bet on major sport events, or played cards in New Year's Eve. By design the two groups were matched on age and years of formal schooling. Demographic characteristics and health-related behaviors are presented in Table 1. A list of games played by each PG individual is shown in Table 2.

Measurement Tools

Patients were assigned to the study groups based on their scores on the SOGS (Lesieur and Blume 1987) and a semistructured clinical interview. SOGS is a widely used tool for

Table 1 Sociodemographic characteristics and health-related behaviors for each group of participants

	Gamblers		Controls		*p*
	Mean	SD	Mean	SD	
Age	45.5	10.6	44.7	11.8	.6[a]
Education	14.58	4.17	14.9	3.95	.8[a]
Marital status (N)					
Single	10		11		.7[b]
Married	8		5		
Divorced/widowed	6		5		
Financial status (N)					
Poor	3		7		.2[b]
Fair	9		5		
Good	12		9		
Smoking (%)					
Yes	67%		43%		.1[b]
Alcohol (N)					
Occasionally	6		8		.2[b]
Moderate	10		11		
Heavy	8		2		
History of substance use					
Yes	25%		29%		.8[b]

[a]Independent samples *t* test

[b]Chi square

the screening of problematic and probable pathological gambling. It consists of 20 items, in their majority answered with a yes or no, where a score of 5 or more is typically used to indicate a probable pathological gambler.

Persons who agreed to participate and met the inclusion/exclusion criteria of the study were administered a battery of the following neuropsychological tests to assess relevant cognitive functions. The *Memory Impairment Screen*, a short screening tool for assessing memory (Buschke et al. 1999), an experimental continuous performance task used for assessing sustained attention, the *Trail Making Test*, used as a measure of EF (Zalonis et al. 2008), a *digit span* task was used as a measure of verbal working memory (Simos et al. 2011), the *Corsi block-tapping task* (Corsi 1972), for accessing visual working memory, the *Iowa Gambling Task* (IGT; Bechara et al. 1994) served as a measure of decision making under ambiguity and risk, the *Stroop Colour-Word test* adapted in Greek (Zalonis et al. 2009) was used to access inhibition, the *Comprehension of Instructions in Greek* (Simos et al. 2014) was used to assess auditory comprehension of complex commands, the *Symbol Digit Modality Test* (Constantinidou et al. 2014) was used as a measure of processing speed, and finally the *Controlled Oral Word Fluency* (Kosmidis et al. 2004) provided a measure of semantic memory and recall capacity through phonetic or semantic category cues.

The Greek adaptation of *Zuckerman–Kuhlman Personality Questionnaire* (*ZKPQ*; Hyphantis et al. 2013) was employed to assess relevant personality dimensions, namely Impulsive Sensation Seeking, Neuroticism-Anxiety, Aggression-Hostility, Activity, and

Table 2 Games played by PG individuals

No.	Sport events	Casinos/clubhouses				Lotteries	Keno	Horce races	Dog races	Cards	Poker	Stockmarket	Dices	Random bettings
		Roulette	Slot machines	Blackjack	Poker									
PG 1	+	+	+	+	−	+	+	+	+	+	−	+	−	+
PG 2	+	+	+	+	−	+	+	+	+	+	+	+	+	+
PG 3	+	+	+	+	−	−	−	+	+	+	+	+	−	−
PG 4	−	+	+	+	−	−	−	−	−	+	+	−	+	+
PG 5	+	+	+	+	−	−	−	+	−	+	−	+	+	+
PG 6	−	+	+	−	−	+	+	−	−	+	−	−	+	−
PG 7	−	+	+	+	+	+	+	−	−	+	+	−	−	−
PG 8	+	+	+	−	−	+	+	+	+	+	−	−	−	−
PG 9	+	+	−	−	−	+	+	−	−	−	−	−	−	−
PG 10	−	+	+	+	+	−	−	−	−	−	−	+	−	−
PG 11	+	+	+	+	−	−	+	+	+	−	−	+	−	+
PG 12	+	+	+	+	−	+	+	−	−	−	−	−	−	−
PG 13	−	+	+	+	−	+	−	−	−	−	−	−	+	−
PG 14	+	+	+	+	−	+	+	+	+	−	−	−	−	−
PG 15	+	−	−	−	−	+	+	−	−	+	−	−	+	−
PG 16	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PG 17	−	−	−	−	−	+	+	−	−	−	−	−	−	−
PG 18	+	+	+	+	−	+	+	+	+	+	+	−	+	−
PG 19	+	+	+	−	−	+	+	+	+	+	−	−	−	−
PG 20	+	−	−	−	−	+	+	−	−	+	−	−	−	−
PG 21	−	+	+	+	−	+	+	−	−	−	−	+	−	−
PG 22	+	+	+	+	−	+	+	−	−	−	−	−	+	−
PG 23	+	+	+	+	−	−	+	−	−	+	−	−	−	−
PG 24	+	−	−	−	−	+	+	−	−	−	−	−	−	−

+ indicates "yes" and − indicates "no"

Sociability. There is also a 10-item scale of "infrequency" consisting of 10 items (aiming to detect lying or carelessness in answering), with a suggested cut-off of three points.

The *Hospital Anxiety Depression Scale* (HADS; Zigmond and Snaith 1983; Greek adaptation by Michopoulos et al. 2008), was used as a measure of anxiety and depressive symptoms severity. The *Difficulties in Emotion Regulation Scale* (DERS; Gratz and Roemer 2004), adapted by Mitsopoulou and colleagues (Mitsopoulou et al. 2013) was employed to assess impaired regulation of emotions. It consists of 36 questions answered in a 5-point scale, which correspond to six factors: (a) Non-Acceptance of Emotions; (b) Difficulties Engaging in Goal-Directed Behavior; (c) Impulse Control Difficulties; (d) Reduced Emotional Awareness; (e) Reduced Access to Emotion Regulation Strategies; (f) Reduced Emotional Clarity.

Clinical Assessment

Psychiatric evaluation confirmed that all participants of the study group suffered from gambling disorder according DSM-5 criteria. Moreover 8 (33.3%) of them also had alcohol use disorder and 2 (8.3%) had another (and other than nicotine) substance use disorder. None of the controls had any substance related disorder other than nicotine dependence. 4 participants (16.6%) of the study group suffered an anxiety disorder and 3 (12.5%) from a depressive disorder, while in the control group 2 (9.5%) participants had an anxiety and 2 (9.5%) a depressive disorder. Qualitative information derived by the clinical interviews are presented in Table 3.

Statistical Analysis

In order to investigate normality and due to small N (< 50), Shapiro–Wilk tests were conducted. Homogeneity of variance was assessed with Levene's test. Normality and/or Homogeneity of variances were violated in Memory Impairment Screen, Corsi block-taping backward condition, Comprehension of Instructions in Greek, Controlled Oral Word Fluency, HADS anxiety subscale, the "Sociability" factor of the ZKPQ, and "Non-Acceptance of Emotions", "Difficulties Engaging in Goal-Directed Behavior", and "Reduced Emotional Clarity" factors from the Emotional Regulation Scale. For the aforementioned tests, where the assumptions for parametric statistics were violated, non-parametric Mann–Whitney U-tests were implemented to compare scores between gamblers and controls. For the remaining tests, where assumption of normality and homogeneity of variances were fulfilled, independent samples *t* tests were conducted. Group comparisons on the frequency of impaired performance as indicated by a standard (z) score < -1.5, or "abnormal" score on HADS were performed through the Chi square test. The α level was set at .05. All analyses were performed with IBM Statistical Package for the Social Sciences (SPSS) 17.0 for Windows.

Results

As a group Pathological Gamblers performed worse than the comparison group on IGT, $t(43) = 2.137$, $p = .038$, and the Stroop Color-Word interference index, $t(41) = -2.386$, $p = .022$ (see Table 2). However, they scored higher than controls on several tests: Digit Span Forward, $t(43) = 2.147$, $p = .037$, Corsi block-taping test Forward, $t(43) = 3.395$,

Table 3 Behaviors and harmful consequences related to gambling

Psychosocial aspects	Divorced due to gambling	16.6%
	Ended a relation due to gambling	20.8%
	Serious marriage/relationship issues	25%
	Gambling effect on sexual life	50%
	Socialised/friendship with other gamblers	87.5%
	Lost a close person due to gambling	66.6%
	Lost time work/studies in order to gamble	62.5%
	Occupation relevant to gambling	29.2%
	In debt for significant period of time due to gambling.	83.3%
Habits	Heavy smokers	66.6%
	Heavy alcohol Drinkers	33.3%
	Regular Substance users	8.3%
	Higher use when gambling	87.5%
Attitudes	Easily bored	58.3%
	High level of risk-taking	70.8%
	Involvement in illegal/criminal activities	50%
	Lying about gambling	70.8%
Behaviour related to the game	Not setting time-money limits	83.3%
	Reported loss of sense of time	66.6%
	Comes back the next day	91.6%
	Admitting PG	37.5%
	Repeated and unsuccessful attempts to quit	33.3%
	Develop strategies to keep limits	20.8%

$p = .001$, and Reverse, $U = 155.500$, $z = -2.246$, $p = .025$, Symbol Digit Modality Test, $t(43) = 2.439$, $p = .019$, and the semantic subscale of Controlled Oral Word Fluency, $U = 142.000$, $z = -2.312$, $p = .021$.

Moreover, Gamblers scored higher on the ZKPQ Impulsive/Sensation Seeking, $t(43) = 2.164$, $p = .036$, and the Aggression-Hostility scales, $t(43) = 2.268$, $p = 0.028$. They also scored higher on the DERS Reduced Emotional Awareness scale, indicating reduced self-reported capacity to become conscious of their emotions, $t(42) = 2.024$, $p = .049$. No other group comparisons approached significance. Scores for the two groups on the psychometric tools are shown in Table 4.

Discussion

Our findings confirmed the expected characteristics of the present sample of non-treatment seeking gamblers, namely more frequent choices on the "disadvantageous" decks on the Iowa Gambling Task (e.g., Weller et al. 2010, 2011), and higher rates on impulsivity/sensation seeking (Bagby et al. 2007; Odlaug et al. 2013). However, contrary to the often-reported conclusion that gamblers demonstrate a "dysexecutive syndrome", we failed to reproduce such findings. In our study, gamblers performed lower than controls on a single task (Stroop-color Word) and scored higher than the former group on several other tasks of

Table 4 Scores for the two groups on the psychometric tools

Variable	Gamblers		Controls		*p*
	Mean	SD	Mean	SD	
MIS	7.13	1.15	6.86	1.24	.427[a]
DSF	18.83	2.62	16.86	3.54	.037[b]
DSB	15.00	3.38	13.38	3.93	.144[b]
CBF	9.88	1.51	8.33	1.53	.001[b]
CBB	9.29	1.94	8.10	1.70	.025[a]
SNST	38.00	10.33	45.90	11.32	.022[b]
TMT-A	37.96	11.93	39.33	14.28	.727[b]
TMT-B	62.21	17.67	65.76	18.37	.512[b]
SDMT	47.71	8.97	41.71	7.28	.019[b]
CIG	10.46	2.54	11.81	1.81	.075[a]
CPT	49.38	8.85	44.19	9.96	.071[b]
IGT	52.17	9.71	45.05	12.60	.038[b]
HADS-A	6.04	4.46	5.90	4.19	.936[a]
HADS-D	5.25	3.49	4.95	3.47	.776[b]
ZKPQ-IMPss	53.72	16.92	40.60	23,73	.036[b]
ZKPQ-Nanx	40.78	22.98	32.83	24.11	.264[b]
ZKPQ-AggHost	51.96	22.66	36.13	24.13	.028[b]
ZKPQ-Act	54.41	21.75	52.67	19.57	.781[b]
ZKPQ-Sy	40.68	21.51	47.33	16.68	.196[a]
COWF-S	65.54	10.45	58.75	10.76	.021[a]
COWF-P	39.67	7.92	37.30	10.95	.153[a]
DERS-Ac	13.74	4.82	12.10	3.73	.308[a]
DERS-G	13.70	3.65	13.14	2.94	.554[a]
DERS-I	15.17	4.57	13.67	3.02	.209[b]
DERS-S	18.83	6.46	17.29	4.21	.359[b]
DERS-C	10.04	3.84	8.19	2.93	.113[a]
DERS-Aw	15.04	3.97	12.52	4.29	.049[b]

MIS memory impairment screen, *DSF* digit span forward, *DSB* digit span backward, *CBF* Corsi block forward, *CBB* Corsi block backward, *SNST* stroop neuropsychological screening test, *TMT-A* trail making test-form A, *TMT-B* trail making test-form B, *SDMT* symbol digit modality test, *CIG* comprehension of Instructions in Greek, *CPT* continuous performance task, *IGT* Iowa gambling task, *HADS-A* Hospital Anxiety Depression Scale-Anxiety, *HADS-B* Hospital Anxiety Depression Scale-Depression, *ZKPQ-IMPss* Zuckerman–Kuhlman Personality Questionnaire-Impulsive-sensation seeking; *ZKPQ-Nanx* Zuckerman–Kuhlman Personality Questionnaire-Neuroticism-Anxiety, *ZKPQ-AggHost* Zuckerman–Kuhlman Personality Questionnaire-Aggression-Hostility, *ZKPQ-Act* Zuckerman–Kuhlman Personality Questionnaire-Activity, *ZKPQ-Sy* Zuckerman–Kuhlman Personality Questionnaire-Sociability, *COWF-S* semantic subscale of the Controlled Oral Word Fluency, *COWF-P* phonemic subscale of the Controlled Oral Word Fluency, *DERS-Ac* Difficulties in Emotion Regulation Scale-Acceptance, *DERS-G* Difficulties in Emotion Regulation Scale-Goals, *DERS-I* Difficulties in Emotion Regulation Scale-Impulse, *DERS-S* Difficulties in Emotion Regulation Scale-Strategies, *DERS-C* Difficulties in Emotion Regulation Scale-Clarity, *DERS-Aw* Difficulties in Emotion Regulation Scale-Awareness

[a]Mann–Whitney U-test

[b]Independent samples *t* test

Immediate/Working memory (Digits forward, Corsi block-tapping task), attentional control (Symbol Digit Modality Test) and verbal fluency. These results are discussed in turn below.

Executive Capacity Among Gamblers

As a group gamblers made significantly more frequent choices on the "disadvantageous" decks in the Iowa Gambling Task, indicating deficits in decision making under ambiguity and risk. With respect to the plethora of the conducted research (Weller et al. 2010, 2011), here we should make a note of an interesting observation during the administration of the tool: the dramatic majority of our gamblers commented in their choices on the disadvantageous decks (e.g. "you took them, you will give them back") and continued in a maladaptive way to choose the certain decks in a chase of their losses. We therefore argue that IGT cannot be considered as a conventional cognitive task, since an emotional component may be involved. This is further discussed below.

Performance of the gambling group on the Stroop test reveals impaired inhibition. This finding is in accordance with several recent studies (Kertzman et al. 2006, 2011). The well-defined gambling behavior is attributed—at least in part—to deficient cognitive mechanisms related to cognitive flexibility, inhibition, and control under interference conditions.

Beyond the aforementioned possible interpretation, the EF negative results should be further discussed. A comprehensive study of previous research unveils a blurry and inconclusive image, possibly due to taxonomical bias. Impulse disorders are thought to be connected with the prefrontal cortex which is considered to be the neurobiological substrate of executive functions. Specifically, studies suggest that there are profile similarities regarding EF among PG patients and patients with frontal lesions (see van Holst et al. 2010). However, there are several issues on EF testing. The interpretation of the widely used IGT is severely questioned. A recent review (Toplak et al. 2010) indicates that IGT is dissociated from EF and WM, while the somatic marker hypothesis clearly states the emotional bias in poor decision making (Bechara and Damasio 2005; Damasio et al. 1996). Brand and colleagues (Brand et al. 2007) claim that IGT provides indications for impaired decision making under ambiguity and risk, rather than poor decision making due to an EF deficit; at the same time other studies support that IGT should be used only as a complementary tool toward the assessment of EF (Lehto and Elorinne 2003).

Furthermore, careful examination of the extant literature reveals several pieces of evidence that contradicts the "general dysexecutive syndrome" notion. The majority of recent studies reveal isolated EF deficits (i.e. in cognitive flexibility, inhibition, planning tasks), while other EF components and WM remain intact (Ledgerwood et al. 2012). Some of these studies feature notable methodological limitations and include treatment seeking gamblers, a significant percentage of whom may seek treatment for other co-morbid pathologies, and therefore may not be representative of the entire population of pathological gamblers (Lorains et al. 2011; Slutske 2006; Winters and Kushner 2003). Beyond the problem of non-representativeness, treatment-seeking gamblers are often receiving pharmacological augmentation, which could affect aspects of cognition, and, consequently, their performance on neuropsychological tasks, as noted in Grant and colleagues (Grant et al. 2012). One study conducted in PG selected from an ecologic setting (Roca et al. 2008) was characterized by a very small sample (N = 11) and therefore its results should be interpreted with caution and generalization is implausible. Our study is also characterized by several limitations, however our gambling group could be considered as ecologically valid, constituted of non-treatment seeking gamblers involved in strategic-type games, and the participants in the control group was matched according to age, gender, and education.

Working Memory Among Gamblers

Previous studies also failed to note deficits in spatial or verbal WM (e.g., Goudriaan et al. 2006). Similarly, Lawrence and colleagues (Lawrence et al. 2009) did not find any significant differences on the Digit Span Forward and Backward or the CANTAB spatial WM test (which is very similar to the Corsi block-tapping task used in the present study) between controls and 21 non-treatment seeking gamblers.

The fact that the present sample of gamblers scored higher on certain cognitive tasks, could be explained as gradual development of strategies through their chronic gambling activity. For example, performance on Symbol Digit Modality Test is an indication for an advantageous information processing speed. Performance on Controlled Oral Word Fluency may indicate improved retrieval strategies, especially since language per se is unlikely to be affected by gambling behavior. Superiority in WM measures could be also explained in the same framework of developing mnemonic strategies used in several games. In any case, this is an over-reaching hypothesis and cannot be based solely on a single study. Thus, we do not suggest this explanation as a robust interpretation schema, but rather as a potential rationale of a working hypothesis.

Personality Traits and Psychoemotional Characteristics in PG

Individual scores suggest the presence of notable individual variability within the PG group. The higher rates according to Aggression-Hostility, may be an indication for the existence of "antisocial, impulsivist problem gamblers" (Blaszczynski and Nower 2002) among our sample. Further examination under the prism of taxonomical models is recommended for a potential identification—classification within our experimental group.

Results derived from DERS indicate significant differences between groups, particularly on the awareness factor. Lack of emotional awareness could be an indication of pathology. In this context, impaired emotional awareness could be related to alexithymia and dysthymia (Battersby et al. 2006; Bonnaire et al. 2013).

No significant differences were found between our two groups with regard to HADS. This is in contrast with the general consensus, according to which, pathological gamblers often demonstrate high rates of anxiety and depression. Additionally, the proportion of participants identified with anxiety or depression symptoms in our PG group was relatively low. This could be attributed to the aforementioned bias with regard to inclusion of participants in the majority of the relevant studies: as discussed above, pathological gamblers often seek treatment due to a co-morbid psychiatric disorder.

Strengths and Limitations–Suggestions for Future Research

A strength of this study is that we measured non treatment seeking pathological gamblers, and varied degree of severity. As stated above, the majority of the available literature refers to treatment-seeking gamblers, among which there is a significant proportion seeking treatment for other co-morbid pathologies, and thus receiving psychiatric medication, which in turn has a potential effect on cognitive and behavioral aspects. Given the scarcity of studies involving PG selected from ecological settings, we argue that our findings, derived from an ecologically valid, non-treatment seeking gambling group could aid in further elucidating the cognitive profile of PG individuals. However there are certain practical and methodological limitations which could be set as guidelines for future studies. First our study

recruited a relatively limited number of participants. Even if similar studies also use small samples (in several cases they include fewer PG individuals compared to the present study; e.g. Cavedini et al. 2002; Lawrence et al. 2009; Roca et al. 2008) our preliminary analyses dictated the use of non-parametric statistics for several variables, thus not allowing us to generalize our results.

Our study, similarly to other relevant studies, does not include women. Female players contacted with us in order to participate in the study reported single gambling activity in "non-strategic" types of game like slot machines or Keno. Only three female gambles reported mixed gambling activity. This potential subgroup was considered as small in order to be included in the current study. Impulsivity may be related more strongly to male pattern gambling (games that require skill), but that warrants examination in future studies. Our sample was habitants of urban areas near the capital of Greece (wider areas of Athens, Chalkida and Korinthos). Therefore, the results of this study could not be considered to be representative of the gambling population in Greece.

The participants were categorized as "mixed" (involves more than one type of games) gamblers who, based on their self-reports, are following strategies. "Strategic" players expected to be more organized, to elaborate problem solving skills, and follow strategies during game. However, future studies should focus on collecting larger samples, in order to perform within group analyses, among the different types of gamblers—something that was beyond the scope of this study.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

American Psychiatric Association. (2000). *DSM-IV-TR*. Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Bagby, R. M., Vachon, D. D., Bulmash, E. L., Toneatto, T., Quilty, L. C., & Costa, P. T. (2007). Pathological gambling and the five-factor model of personality. *Personality and Individual Differences, 43*(4), 873–880.

Battersby, M., Tolchard, B., Scurrah, M., & Thomas, L. (2006). Suicide ideation and behaviour in people with pathological gambling attending a treatment service. *International Journal of Mental Health and Addiction, 4*(3), 233–246.

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior, 52*(2), 336–372.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*(1), 7–15.

Blaszczynski, A., & Nower, L. (2002). A pathways model of problem and pathological gambling. *Addiction, 97*(5), 487–499.

Bonnaire, C., Bungener, C., & Varescon, I. (2013). Alexithymia and gambling: A risk factor for all gamblers? *Journal of Gambling Studies, 29*(1), 83–96.

Brand, M., Recknor, E. C., Grabenhorst, F., & Bechara, A. (2007). Decisions under ambiguity and decisions under risk: Correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. *Journal of Clinical and Experimental Neuropsychology, 29*(1), 86–99.

Brevers, D., Cleeremans, A., Goudriaan, A. E., Bechara, A., Kornreich, C., Verbanck, P., et al. (2012). Decision making under ambiguity but not under risk is related to problem gambling severity. *Psychiatry Research, 200*(2–3), 568–574.

Brewer, J. A., & Potenza, M. N. (2008). The neurobiology and genetics of impulse control disorders: Relationships to drug addictions. *Biochemical Pharmacology, 75*(1), 63–75.

Buschke, H., Kuslansky, G., Katz, M., Stewart, W. F., Sliwinski, M. J., Eckholdt, H. M., et al. (1999). Screening for dementia with the memory impairment screen. *Neurology, 52*(2), 231.

Cavedini, P., Riboldi, G., Keller, R., D'Annucci, A., & Bellodi, L. (2002). Frontal lobe dysfunction in pathological gambling patients. *Biological Psychiatry, 51*(4), 334–341.

Constantinidou, F., Zaganas, I., Papastefanakis, E., Kasselimis, D., Nidos, A., & Simos, P. G. (2014). Age-related decline in verbal learning is moderated by demographic factors, working memory capacity, and presence of Amnestic mild cognitive impairment. *Journal of the International Neuropsychological Society, 20*(8), 822–835.

Corsi, P. M. (1972). *Human memory and the medial temporal region of the brain*. Unpublished doctoral dissertation. McGill University, Montreal, Canada.

Damasio, A. R., Everitt, B. J., & Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex [and Discussion]. *Philosophical Transactions of the Royal Society B: Biological Sciences, 351,* 1413–1420.

Goudriaan, A. E., Oosterlaan, J., De Beurs, E., & Van Den Brink, W. (2006). Neurocognitive functions in pathological gambling: A comparison with alcohol dependence, Tourette syndrome and normal controls. *Addiction, 101*(4), 534–547.

Grant, J. E., Odlaug, B. L., & Chamberlain, S. R. (2016). Neural and psychological underpinnings of gambling disorder: A review. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 65,* 188–193.

Grant, J. E., Odlaug, B. L., Chamberlain, S. R., & Schreiber, L. R. N. (2012). Neurocognitive dysfunction in strategic and non-strategic gamblers. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 38*(2), 336–340.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation. *Journal of Psychopathology and Behavioral Assessment, 26*(1), 41–54.

Hyphantis, T., Antoniou, K., Floros, D. G., Valma, V., Pappas, A. I., Douzenis, A., et al. (2013). Assessing personality traits by questionnaire: Psychometric properties of the Greek version of the Zuckerman–Kuhlman personality questionnaire and correlations with psychopathology and hostility. *Hippokratia, 17*(4), 342.

Kalechstein, A., Fong, T., Rosenthal, R., Davis, A., Vanyo, H., & Newton, T. (2007). Pathological gamblers demonstrate frontal lobe impairment consistent with that of methamphetamine-dependent individuals. *Journal of Neuropsychiatry and Clinical Neuroscience, 19*(3), 298–303.

Kertzman, S., Lidogoster, H., Aizer, A., Kotler, M., & Dannon, P. N. (2011). Risk-taking decisions in pathological gamblers is not a result of their impaired inhibition ability. *Psychiatry Research, 188*(1), 71–77.

Kertzman, S., Lowengrub, K., Aizer, A., Nahum, Z. Ben, Kotler, M., & Dannon, P. N. (2006). Stroop performance in pathological gamblers. *Psychiatry Research, 142*(1), 1–10.

Kessler, R. C., Hwang, I., LaBrie, R., Petukhova, M., Sampson, N. A., Winters, K. C., et al. (2008). DSM-IV pathological gambling in the National Comorbidity Survey Replication. *Psychological Medicine, 38*(9), 1351–1360.

Kosmidis, M. H., Vlahou, C. H., Panagiotaki, P., & Kiosseoglou, G. (2004). The verbal fluency task in the Greek population: Normative data, and clustering and switching strategies. *Journal of the International Neuropsychological Society, 10*(2), 164–172.

Lawrence, A. J., Luty, J., Bogdan, N. A., Sahakian, B. J., & Clark, L. (2009). Problem gamblers share deficits in impulsive decision-making with alcohol-dependent individuals. *Addiction, 104*(6), 1006–1015.

Ledgerwood, D. M., Orr, E. S., Kaploun, K. A., Milosevic, A., Frisch, G. R., Rupcich, N., et al. (2012). Executive function in pathological gamblers and healthy controls. *Journal of Gambling Studies, 28*(1), 89–103.

Lehto, J. E., & Elorinne, E. (2003). Exploratory factor analysis of the Wechsler Abbreviated Scale of Intelligennce (WASI) in adult standardization and clinical samples. *Applied Neuropsychology, 10*(4), 252–256.

Leiserson, V., & Pihl, R. O. (2007). Reward-sensitivity, inhibition of reward-seeking, and dorsolateral prefrontal working memory function in problem gamblers not in treatment. *Journal of Gambling Studies, 23*(4), 435–455.

Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry, 144*(9), 1184–1188.

Lorains, F. K., Cowlishaw, S., & Thomas, S. A. (2011). Prevalence of comorbid disorders in problem and pathological gambling: Systematic review and meta-analysis of population surveys. *Addiction, 106*(3), 490–498.

Manning, V., Teoh, H. C., Guo, S., Wong, K. E., & Li, T.-K. (2013). Executive functioning in Asian pathological gamblers. *International Gambling Studies, 13*(3), 403–416.

Michopoulos, I., Douzenis, A., Kalkavoura, C., Christodoulou, C., Michalopoulou, P., Kalemi, G., et al. (2008). Hospital Anxiety and Depression Scale (HADS): validation in a Greek general hospital sample. *Annals of General Psychiatry, 7*(1), 4.

Mitsopoulou, E., Kafetsios, K., Karademas, E., Papastefanakis, E., & Simos, P. G. (2013). The greek version of the difficulties in emotion regulation scale: Testing the factor structure, reliability and validity in an adult community sample. *Journal of Psychopathology and Behavioral Assessment, 35*(1), 123–131.

Odlaug, B., Chamberlain, S., Kim, S., Schreiber, L., & Grant, J. (2011). A neurocognitive comparison of cognitive flexibility and response inhibition in gamblers with varying degrees of clinical severity. *Psychological Medicine, 41*(10), 2111–2119.

Odlaug, B. L., Schreiber, L. R. N., & Grant, J. E. (2013). Personality dimensions and disorders in pathological gambling. *Current Opinion in Psychiatry, 26*(1), 107–112.

Petry, N., Stinson, F., & Grant, B. (2005). Comorbidity of DSM-IV pathological gambling and other psychiatric disorders: Results from the national epidemiologic survey on alcohol and related conditions. *Journal of Clinical Psychiatry, 66*(5), 564–574.

Potenza, M. N., Leung, H.-C., Blumberg, H. P., Peterson, B. S., Fulbright, R. K., Lacadie, C. M., et al. (2003). An FMRI Stroop task study of ventromedial prefrontal cortical function in pathological gamblers. *The American Journal of Psychiatry, 160*(11), 1990–1994.

Roca, M., Torralva, T., López, P., Cetkovich, M., Clark, L., & Manes, F. (2008). Executive functions in pathologic gamblers selected in an ecologic setting. *Cognitive and Behavioral Neurology, 21*(1), 1–4.

Simos, P. G., Kasselimis, D., Potagas, C., & Evdokimidis, I. (2014). Verbal comprehension ability in aphasia: Demographic and lexical knowledge effects. *Behavioural Neurology*. https://doi.org/10.1155/2014/258303.

Simos, P. G., Papastefanakis, E., Panou, T., & Kasselimis, D. (2011). *The Greek memory scale*. Rethymno: Laboratory of Applied Psychology, University of Crete.

Slutske, W. S. (2006). Natural recovery and treatment-seeking in pathological gambling: Results of two U.S. national surveys. *American Journal of Psychiatry, 163*(2), 297–302.

Toplak, M. E., Sorge, G. B., Benoit, A., West, R. F., & Stanovich, K. E. (2010). Decision-making and cognitive abilities: A review of associations between Iowa Gambling Task performance, executive functions, and intelligence. *Clinical Psychology Review, 30*(5), 562–581.

Turner, N. E., Jain, U., Spence, W., & Zangeneh, M. (2008). Pathways to pathological gambling: Component analysis of variables related to pathological gambling. *International Gambling Studies, 8*(3), 281–298.

van Holst, R. J., van den Brink, W., Veltman, D. J., & Goudriaan, A. E. (2010). Why gamblers fail to win: A review of cognitive and neuroimaging findings in pathological gambling. *Neuroscience and Biobehavioral Reviews, 34*(1), 87–107.

Wager, T., & Smith, E. (2003). Neuroimaging studies of working memory: A meta-analysis. *Cognitive, Affective, & Behavioral Neuroscience, 3*(4), 255–274.

Weller, J. A., Levin, I. P., & Bechara, A. (2010). Do individual differences in Iowa Gambling Task performance predict adaptive decision making for risky gains and losses? *Journal of Clinical and Experimental Neuropsychology, 32*(2), 141–150.

Weller, J. A., Levin, I. P., & Denburg, N. L. (2011). Trajectory of risky decision making for potential gains and losses from ages 5 to 85. *Journal of Behavioral Decision Making, 24*(4), 331–344.

Winters, K. C., & Kushner, M. G. (2003). Treatment issues pertaining to pathological gamblers with a comorbid disorder. *Journal of Gambling Studies, 19*(3), 261–277.

Zakzanis, K. K., Mraz, R., & Graham, S. J. (2005). An fMRI study of the trail making test. *Neuropsychologia, 43*(13), 1878–1886.

Zalonis, I., Christidi, F., Bonakis, A., Kararizou, E., Triantafyllou, N. I., Paraskevas, G., et al. (2009). The Stroop effect in greek healthy population: Normative data for the Stroop neuropsychological screening test. *Archives of Clinical Neuropsychology, 24*(1), 81–88.

Zalonis, I., Kararizou, E., Triantafyllou, N. I., Kapaki, E., Papageorgiou, S., Sgouropoulos, P., et al. (2008). A normative study of the trail making test A and B in Greek adults. *The Clinical Neuropsychologist, 22*(5), 842–850.

Zhou, Z., Zhou, H., & Zhu, H. (2016). Working memory, executive function and impulsivity in Internet-addictive disorders: A comparison with pathological gambling. *Acta Neuropsychiatrica, 28*(2), 92–100.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica, 67*(6), 361–370.

Zuckerman, M. (1994). Impulsive unsocialized sensation seeking: The biological foundations of a basic dimension of personality. In J. Bates & T. Wachs (Eds.), *APA science Vols. Temperament: Individual differences at the interface of biology and behavior* (pp. 219–255). Washington, DC: American Psychological Association.