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Research paper

The joint role of impulsivity and distorted cognitions in recreational and problem gambling: A cluster analytic approach

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ABSTRACT

Background and aims: The Pathways Model (Blaszczynski & Nower, 2002) posits that problem gambling is a heterogeneous disorder with distinct subgroups (behaviorally conditioned gamblers, emotionally vulnerable gamblers, and antisocial-impulsivist gamblers). Impulsivity traits and gambling-related cognitions are recognized as two key psychological factors in the onset and maintenance of problem gambling. To date, these constructs have been explored separately, and their joint role in determining problem gambling subtypes has received little attention. The goal of our study was to identify subgroups of gamblers based on impulsivity traits and gambling-related cognitions, and to determine whether this approach is consistent with the Pathways model.
Methods: Gamblers from the community ($N = 709$) and treatment-seeking pathological gamblers ($N = 122$) completed questionnaires measuring gambling habits, disordered gambling symptoms, gambling-related cognitions, and impulsivity traits.
Results: Cluster analyses revealed that three clusters globally aligned with the pathways proposed by Blaszczynski & Nower (2002). Two other clusters emerged: (1) impulsive gamblers without cognitive-related cognitions; and (2) gamblers without impulsivity or gambling-related cognitions. Gamblers with both heightened impulsive traits and gambling-related cognitions had more severe problem gambling symptoms.
Conclusion: We successfully identified, based on an *a priori* theoretical framework, different subtypes of gamblers that varied in terms of problem gambling symptoms and clinical status. The diversity of the cluster profiles supports the development of personalized prevention strategies and psychological interventions.

1. Introduction

Gambling disorder has been classified as an addictive disorder in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013), and the eleventh revision of the International Classification of Diseases (World Health Organization, 2019). To date, no single etiological model convincingly explains the considerable heterogeneity (e.g., variation in symptoms or psychiatric comorbidities) that is observed in people with gambling problems (Blaszczynski, 1999; Milosevic and Ledgerwood, 2010). In light of such findings, research devoted to the subtyping of problem gambling has emerged (Blaszczynski and Nower, 2002; Milosevic and Ledgerwood, 2010), and has resulted in important avenues to improve conceptualization, prevention, and treatment of problem gambling.

The dominant model to describe this heterogeneity is the Pathways Model (Blaszczynski and Nower, 2002), which posited three routes that

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can lead to distinct subtypes of problem gamblers. According to Blaszczynski and Nower, some key environmental factors (e.g., increased availability or accessibility) and learning processes (classical and operant conditioning) are involved in all forms of problem gambling, while certain traits (e.g., impulsivity, diminished executive control) and other forms of psychopathology (e.g., mood or anxiety disorders) can result in distinct vulnerabilities to problem gambling. The first pathway is labeled *behaviorally conditioned* problem gamblers. For this subtype, gambling behavior is initiated for recreational and/or social purposes, and associative processes (e.g., behavioral conditioning) and gambling-related cognitive beliefs and distortions (e.g., illusion of control) serve to escalate problematic behavior. Importantly, this subtype cannot be traced back to specific personality profiles or any pre-existing psychopathology. This pathway is associated with the best prognosis (Blaszczynski and Nower, 2002). The second pathway corresponds to *emotionally vulnerable* problem gamblers: individuals with premorbid psychological distress (e.g., mood and/or anxiety disorders, traumatic history) for whom the primary function of gambling is coping and escape (i.e., negative reinforcement). The third pathway was labeled *antisocial-impulsivist* problem gamblers, sharing the characteristics of the two first subtypes but displaying heightened impulsivity and impaired executive control, underpinned by frontal lobe dysfunction and impulsive psychopathology (ADHD, antisocial personality disorder). It was postulated that this last subtype would present the greatest challenges for treatment and would be associated with the poorest prognosis.

The Pathways Model attributes a pivotal role to two psychological constructs that have been extensively linked to problem gambling in past research, namely (1) dysfunctional gambling-related cognitions and (2) impulsivity traits. Indeed, according to Blaszczynski and Nower (2002), maladaptive gambling-related cognitions are a pre-requisite to *any* form of problem gambling, whereas impulsivity traits are specifically associated with the last and most severe pathway, i.e. the antisocial-impulsivist subtype.

1.1. Gambling-related cognitions and problem gambling

A large body of research has examined gambling-related cognitions and supports their role in the onset and maintenance of problem gambling (Raylu and Oei, 2002). Specific cognitive distortions have been identified in past studies (Fortune and Goodie, 2012; Toneatto, 1999, 1997), including: (1) beliefs that one can directly influence gambling outcomes (e.g., via rituals or superstitious items); (2) interpretative biases that promote persistent playing despite losses (e.g., explaining away of losses); and (3) erroneous cognitions related to prediction (e.g., gambler's fallacy). Across many studies, cognitive distortions assessed via self-report questionnaires are elevated in groups with gambling problems (Marmurek et al., 2014; Michalczuk et al., 2011; Navas et al., 2017). These variables also predict problem gambling severity (Cunningham et al., 2014). According to the Pathways Model, gambling distortions arise as a direct consequence of gambling experience and associative learning, and are thus present within all three subtypes of problem gamblers.

A further set of items that are considered under the rubric of gambling-related cognitions pertains to beliefs about the self in relation to gambling: gambling expectancies that typically relate to coping and escape (i.e., negative reinforcement) or enhancement and excitement (i.e., positive reinforcement) (e.g., Stewart et al., 2008), and gambling-related metacognitions (e.g., perceived uncontrollability of gambling behaviors) (Raylu and Oei 2002). Previous studies confirm the impact of gambling expectancies in the etiology of gambling disorders (MacLaren et al., 2015; Marmurek et al., 2015; Michalczuk et al., 2011). Preliminary evidence also supports the role of dysfunctional metacognitions in gambling disorder (Caselli et al., 2018; Spada et al., 2015). Within the Pathways Model, gambling expectancies could differentially relate to the *emotionally vulnerable* pathway. Crucially, although gambling distortions and beliefs are central to the Pathways Model, no past studies have considered these constructs as core variables in subtyping problem gamblers.

1.2. Impulsivity and problem gambling

It is well established that problem gamblers have higher levels of impulsivity than matched control participants (Blaszczynski et al., 1997; Forbush et al., 2008; Slutske et al., 2005), and that impulsivity predicts the severity of problem gambling symptoms (e.g., Lightsey and Hulsey, 2002; Steel and Blaszczynski, 1998). Heightened impulsivity has been linked in clinical gamblers to a poorer treatment response (Maccallum et al., 2007) and a higher likelihood of drop out from psychotherapy (Leblond et al., 2003). Existing evidence indicates that impulsivity plays an etiological role in the severity of problem gambling, which is consistent with the argument that the *antisocial-impulsivist* pathway displays the most disabling symptoms and poorest prognosis (Blaszczynski and Nower, 2002). Nevertheless, previous case-control studies examining impulsivity have generally considered overall group differences, and most have ignored the possible presence of low-impulsive gamblers within these groups. In a study of treatment-seeking pathological gamblers by Billieux et al. (2012a), only a subgroup of patients displayed marked self-control deficits (i.e., elevated impulsivity, poor inhibitory control, compromised delay discounting), in line with an *antisocial-impulsivist* subtype.

Existing studies have also failed to conceptualize impulsivity as a multi-dimensional construct (Dawe et al., 2004; Evenden, 1999; Rochat et al., 2018). The UPPS-P Impulsivity model (Cyders and Smith, 2008; Whiteside and Lynam, 2001) divides impulsivity into five dimensions informed by personality theory: (1) positive and (2) negative urgency refer to the tendency to engage in rash actions when experiencing intense positive and negative affect, respectively; (3) lack of premeditation refers to the inability to think and reflect on the consequences of actions; (4) lack of perseverance refers to the inability to remain focused on a boring or difficult task; and (5) sensation seeking refers to the tendency to enjoy and pursue activities that are exciting and potentially dangerous. Several studies have related UPPS-P dimensions to aspects of problem gambling. Notably, in community gamblers, negative consequences resulting from gambling were predicted by high urgency and low premeditation, while sensation seeking predicted gambling game preferences and gambling frequency (Blain et al., 2015; Cyders and Smith, 2008; Smith et al., 2007). Two case-control studies in treatment-seeking groups corroborated increases in negative urgency and reduced premeditation (Billieux et al., 2012a; Michalczuk et al., 2011). Urgency also predicted the tendency to gamble for coping purposes (Canale et al., 2015; Devos et al., 2017), which might suggest that some aspects of emotionally-laden impulsivity underlie the *emotionally vulnerable* pathway to problem gambling. These findings suggest that impulsivity is not uniquely linked to the *antisocial-impulsivity* pathway and calls for a more nuanced exploration of the links between impulsivity-related constructs and the Pathways Model.

1.3. Current study

Past studies mainly subtyped gambling and problem gambling based on: (1) personality traits (Álvarez-Moya et al., 2010; Moon et al., 2016; Studer et al., 2016; Suomi et al., 2014); (2) gambling motives (Stewart et al., 2008; Stuart et al., 2008), (3) comorbid states (Moon et al., 2016; Studer et al., 2016; Suomi et al., 2014); (4) demographic factors and symptom severity (Chamberlain et al., 2017; Lee et al., 2008; Li et al., 2015; Turner et al., 2006), (5) type and frequency of gambling habits (Challet-Bouju et al., 2015; Heiskanen and Toikka, 2016), or (6) gambling cognitions (Yakovenko et al., 2016). With respect to the Pathways Model, past studies have supported the existence of an *emotionally vulnerable* type, by showing that a subgroup of problem gamblers is characterized by emotional instability and comorbid emotional

disorders (Álvarez-Moya et al., 2010; Moon et al., 2016; Suomi et al., 2014; Turner et al., 2008). Studies have also validated the *antisocial-impulsivist* pathway by identifying a subgroup with heightened impulsivity traits and comorbid impulse control disorders (Álvarez-Moya et al., 2010; Moon et al., 2016; Chamberlain et al., 2017). However, among these studies, none has measured gambling cognitions, which are a key construct in the Pathways Model. To our knowledge, the only subtyping study that conjointly measured impulsivity and gambling cognitions is Turner et al. (2008), which relied on a small sample ($N = 141$) and did not incorporate gambling expectancies or mood-related impulsivity (urgency).

The present study sought to subtype gamblers in relation to gambling-related cognitions and impulsivity traits, testing key tenets of the theoretical framework provided by the Pathways Model (Blaszczynski and Nower, 2002). Although some past studies considered impulsivity variables in cluster generation (Lee et al., 2008; Moon et al., 2016), none have comprehensively measured gambling-related cognitions (e.g., some studies only focused on gambling distortions). We predicted a differential impact of these constructs on problem gambling subtypes. For example, the urgency facet of impulsivity may be linked to the *emotionally vulnerable* pathway rather than the *antisocial-impulsivist* pathway. Our design included both gamblers from the community and treatment-seeking problem gamblers recruited through specialized outpatient centers for behavioral addictions. Current clustering studies have tended to rely on community samples, which limits generalization to clinical populations. Indeed, the Pathways Model was initially developed to account for clinically relevant gambling behaviors (Blaszczynski and Nower, 2002, p. 487). Thus, we decided in the current study to include gamblers across the continuum of severity, including treatment-seeking gambling disorder patients to ensure a sufficient number of observations at pathological levels.

2. Method

2.1. Participants and procedure

The community sample was recruited through advertisements on social networks (e.g., Facebook, Linkedin) and research-related networks (e.g., university websites and volunteer pools). Participants were requested to complete an online survey and informed that the study aimed to increase scientific knowledge on gambling behaviors. Inclusion criteria were French fluency, being at least 18 years old, and reporting at least monthly gambling involvement. All participants gave their consent before starting the online survey. Anonymity and confidentiality were guaranteed; personal data and the Internet Protocol address were not recorded. The study protocol for the community gamblers was approved by the ethical committee of the Psychological Sciences Research Institute of the Université catholique de Louvain (Belgium), and the ethical committee of Geneva University Hospitals (Switzerland). In total, 709 participants (506 men) completed the online survey; socio-demographic variables are reported in Table 1. The online survey started with several items measuring socio-demographic variables and gambling preferences (type and frequency of gambling). Then, participants completed the following questionnaires (in the same order): the short UPPS-P Impulsive Behavior Scale (UPPS-P; Billieux et al., 2012b), the Gambling-Related Cognitions Scale (GRCS; Raylu and Oei, 2004), and the Problem Gambling Severity Index (PGSI; Ferris and Wynne, 2001). The PGSI was used because this instrument is considered the "gold standard" for modern assessment of problem gambling severity (Caler et al., 2016). A subgroup of the community gamblers ($n = 400$) completed the short version of the Depression Anxiety Stress Scale (DASS-21; Lovibond and Lovibond, 1995). See Table 2 for a description of all the constructs measured and internal reliability coefficients.

Treatment-seeking gamblers ($n = 122$; 109 male) were enrolled in special treatment programs targeting pathological gambling, at the Department of Addictology and Psychiatry of Nantes University Hospital (France, $n = 22$) or the National Problem Gambling Clinic in London (UK, $n = 100$) (see Table 1). They completed a paper and pencil version of the research protocol at treatment initiation. All patients fulfilled the DSM-IV-TR criteria for pathological gambling. Patients provided written informed consent, and the protocol was approved by the local Research Ethics Committee of Nantes and the Cambridge Local Research Ethics Committee.

Table 1
Socio-demographics variables of the two samples and the overall.

	Range	Community sample ($n = 709$) M (SD)	Clinical sample ($n = 122$)	Both samples ($n = 831$)
Age	18–95	32.37 (12.03)	38.22 (11.63)	33.26 (12.15)
Nbr of school years	7–25	15.78 (2.49)	14.09 (1.88)	15.69 (2.49)
Countries		%		
	Belgium	42.9%		36.6%
	Switzerland	39.5%		33.7%
	France	14.2%	18%	14.9%
	England	1.4%	82%	12%
	Elsewhere	2%		2.8%
Professional status				
	Students	29.1%	3.3%	25.3%
	Employed	27.1%	69.7%	33.3%
	Unemployed	2.4%	18%	4.7%
	Retired	1.6%	1.6%	1.6%
	Self-employed	0.4%	7.4%	1.4%
	No answer	39.5%		33.7%

Participants were asked a series of questions about their frequency of engagement in different forms of gambling (in the online survey: lottery, scratch cards, poker, online poker, slot machines, sport betting, others ; the treatment seeking survey included some additional forms including Fixed Odds Betting Terminals). In the online survey of the community gamblers (options: no, several times a year, once a month, several times a month, once a week, several times a week, daily), gamblers reported engaging in at least one form once a month (61.4%), several times a month (1.8%), once a week (13.1%), more than once a week (8.7%), and daily (0.4%). The treatment-seeking gamblers (options: not at all, less than weekly, more than weekly) reported gambling more than weekly (77.9%) or less than weekly (3.2%). Information on gambling frequency was unavailable for 23 (18.9%) participants. From their gambling frequency scores, we coded each participant as preferring skill-based games (e.g., sports betting, poker), chance-based games (e.g. slot machines, scratchcards), or engaging with 'both' forms. In the community sample, 39.9% preferred skill games, 28.8% preferred chance games, and 31.2% played both forms (gambling preferences were unavailable for one participant). In the treatment-seeking sample, most (67.2%) played both forms, with 11.5% preferring games of chance and 2.5% preferring games of skill (2.5%).

Symptoms of disordered gambling were assessed with the PGSI, with scores ranging from 0 to 27 ($M = 5.32$, SD = 6.96). The cut-offs proposed by Ferris and Wynne (2001) were applied: 'non-problem gambling' (PGSI = 0) in 25.2% of the sample, 'low risk gambling' (PGSI = 1–2) in 26.8%, 'moderate risk gambling' (PGSI = 3–7) in 24.5%, and 'high risk problem gamblers' (PGSI > 7) in 23.2%, which comprised all the treatment-seeking group. The PGSI was unavailable for three participants.

2.2. Data analytic strategy

Data clustering techniques were used to identify subgroups of

Table 2
Questionnaire variables used in the survey.

Questionnaire	Scale	Scale description	Representative item	Reliability coefficient (α)
UPPS-P Impulsive Behavior Scale	Urgency	The tendency to engage in rash actions when experiencing negative or positive affect.	When I am upset I often act without thinking	.86
	Lack of premeditation	The tendency to think and reflect on the consequences of an act before engaging it	My thinking is usually careful and purposeful	.84
	Lack of perseverance	The ability to remain focused on a task that may be boring or difficult	I finish what I start.	.86
	Sensation seeking	The tendency to enjoy and pursue activities that are exciting and an openness to trying new experiences that may or may not be dangerous	I sometimes like doing things that are a bit frightening	.82
Gambling-Related Cognitions Scale (GRCS)	Interpretative bias	The tendency to reframe gambling outcomes in a way that would encourage continued gambling despite losses	Relating my winnings to my skill and ability makes me continue gambling	.88
	Predictive control	The perceived ability to predict gambling outcomes	When I have a win once, I will definitely win again	.73
	Illusion of control	The perceived ability to control gambling outcomes	Praying helps me win	.77
	Gambling expectancies	Positive or negative reinforcement values of gambling (e.g., promoting excitement or relieving boredom)	Having a gamble helps reduce tension and stress	.70
	Perceived inability to stop gambling	Perception that it is not possible to stop or control one's gambling	I'm not strong enough to stop gambling	.66
Problem Gambling Severity Index (PGSI)	Problem gambling symptoms	Symptoms of disordered gambling	Have you gone back on another day to try to win back the money you lost?	.92
Depression Anxiety Stress Scale (DASS-21)	Depression	Symptoms reflecting depression	I was unable to become enthusiastic about anything	.90
	Anxiety	Symptoms reflecting anxiety	I felt scared without any good reason	.77
	Stress	Symptoms reflecting stress	I found it hard to wind down	.85

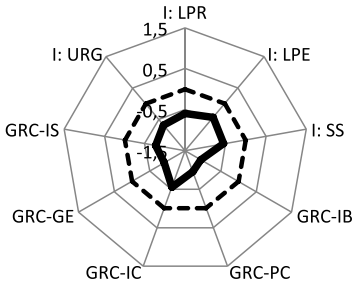
gamblers. The variables used for the data analysis comprised psychological factors that were used to generate the clusters (impulsivity and gambling-related cognitions) and the external correlates that were used to ascertain the validity and specificity of the identified clusters (socio-demographic, gambling preferences and problem gambling symptoms, psychopathological symptoms). Following established guidelines in cluster analysis (Hair et al., 2010), a combination of hierarchical and non-hierarchical procedures were used. First, a hierarchical cluster analysis was conducted. All variables were Z-transformed, so that each variable contributes equally to the cluster formation. The hierarchical cluster analysis was computed using Ward's method with the squared Euclidian distance measure, the most commonly used distance measure (Yim and Ramdeen, 2015). Inspection of the agglomeration schedule, dendrogram, and scree plot (Yim and Ramdeen, 2015) indicated that a five-cluster solution offered the best account of the data, although we also computed the four- and six-cluster solutions (see results section). Cluster memberships were then determined with a non-hierarchical K-means cluster analysis computed to identify an optimal five-factor solution. Variable selection is a critical part of cluster analysis because of the descriptive nature of this statistical approach. First, the variables used for cluster generation were determined, recognizing the trade-off between parsimony and available evidence from the literature: the UPPS-P Impulsive Behavior questionnaire (Billieux et al., 2012b) was used to measure impulsivity facets, and the GRCS (Raylu and Oei, 2004) was used to measure gambling-related cognitions. We grouped negative and positive urgency as a single dimension reflecting mood-related impulsivity, because (1) recent data questions the usefulness of distinguishing these constructs (Berg et al., 2015) and (2) the correlation between the two variables was $r = 0.56$ ($p < .0001$). The five subscales of the GRCS were selected (interpretative bias, predictive control, illusion of control, perceived inability to stop gambling, gambling expectancies), given the distinct predictions for gambling-related cognitions as outlined in the introduction.

External correlates were then considered in relation to the clusters generated: (1) socio-demographic variables (age, gender), (2) gambling activities (types of games), (3) problem gambling symptoms (PGSI; Ferris and Wynne, 2001), and (4) emotional distress (DASS-21; Lovibond and Lovibond, 1995). Parametric (ANOVA) and non-parametric (K independent samples Kruskal–Wallis) tests were used to compare the clusters on the external variables. Post-hoc tests were computed using Neuman–Keuls (parametric) and Chi-Squared (non-parametric) analyses. All analyses were considered statistically significant at $p < .05$. Pairwise treatment of missing data was applied.

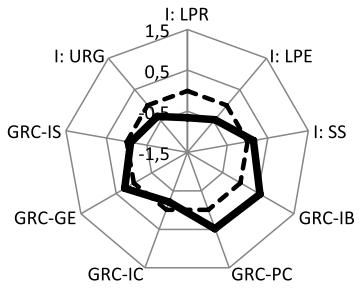
3. Results

The five cluster profiles are illustrated in Fig. 1. Cluster 1 (25.99% of the sample) was characterized by low impulsivity and few gambling-related cognitions. Cluster 2 (25.03%) comprised gamblers with low impulsivity and a high level of specific gambling cognitions, namely interpretative bias, predictive control, and gambling expectancies. Cluster 3 (20.58%) comprised gamblers with high levels of all impulsivity facets but low levels of all types of gambling-related cognitions. Cluster 4 (14.32%) was characterized by a combination of elevated gambling cognitions (perceived inability to stop gambling, gambling expectancies, interpretative bias) and high impulsivity (urgency, lack of premeditation, lack of perseverance). Cluster 5 (14.08%) displayed the highest scores on all types of gambling cognitions except for the perceived inability to stop gambling subscale, and this cluster also presented with the highest levels of urgency and sensation seeking.

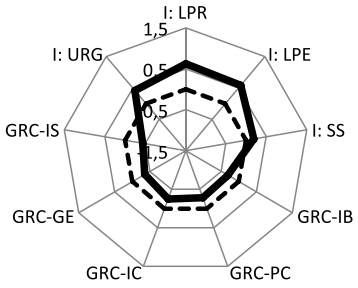
Although the hierarchical cluster analysis supported a five-cluster solution, we considered the non-hierarchical four- and six-cluster solutions (see https://osf.io/q2usd/). The four-cluster solution masked some important findings: although clusters 1 and 2 were similar to the five-cluster solution, the two other clusters were characterized by systematically elevated (Cluster 3) and very elevated (Cluster 4) scores



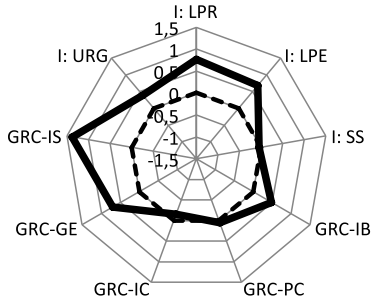
Cluster 1: Non-Impulsive gamblers without gambling-related cognitions



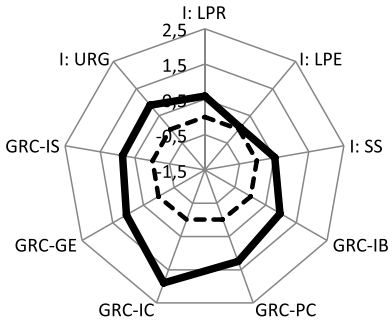
Cluster 2: Gamblers with skill-based cognitive distortions



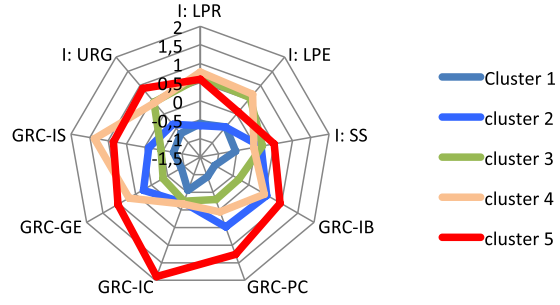
Cluster 3: Impulsive gamblers



Cluster 4: Impulsive emotional gamblers



Cluster 5: Impulsive gamblers with gambling-related cognitions



Visual comparison of the five clusters identified

Figuer 1. Clusters profiles based on impulsivity and cognitive distortions.
Note : I= Impulsivity traits, GRC= Gambling-Related Cognitions, URG= Urgency (UPPS-P), LPR= Lack of premeditation (UPPS-P), LPE= Lack of perserverance (UPPS-P), SS= Sensation seeking (UPPS-P), IB= Interpretative bias (GRCS), PC= Predictive control (GRCS), IC= Illusion of control (GRCS), GE= Gambling Expectancies (GRCS), IS= Inability to stop gambling (GRCS). Dashed lines refer to mean Z-scores of the entire sample. Bold lines refer to mean Z-scores for each specific cluster.

across all variables, and thus did not afford the clinically-plausible differentiation of the five-cluster solution. On the other hand, the six-cluster solution included two clusters that were barely differentiable.

As a reliability check, the cluster analysis was recomputed restricted to the community gamblers only (n = 709) (available from https://osf.io/q2usd/). The non-hierarchical K-means cluster analysis identified an optimal five-cluster solution, and the five profiles were very similar to those obtained in the full sample. The only slight differences that emerged were less marked impulsivity traits for Cluster 3 and less marked perceived inability to stop gambling in Cluster 4.

The descriptive statistics and statistical differences between clusters on the external variables are reported in Table 3. There were significant effects of cluster membership on all external variables. Clusters 1 and 4 were older than the other clusters. Women were more represented in Cluster 5 (42.7% of the females belonged to this Cluster). Emotional distress was higher in Clusters 4 and 5 compared to other clusters. Symptoms of disordered gambling were higher in Clusters 4 and 5. From the Ferris and Wynne (2001) cut-offs, the modal risk category in Cluster 1 was low risk, in Clusters 2 and 3 the modal risk category was moderate risk, and in Clusters 4 and 5 the modal risk category was high risk (i.e. likely) problem gambling. Table 4 summarizes the PGSI data and numbers of treatment-seeking cases per cluster. The correlation matrix between variables is available from https://osf.io/q2usd/.

Finally, in regard of gambling activities, Cluster 1 were significantly more likely to prefer games of chance than the other clusters; Cluster 2 were more likely to prefer games of skill; Cluster 3 were more likely to prefer either games of chance or skill, and Clusters 4 and 5 tended to have mixed gambling habits (i.e., they play *both* games of chance and skills), which might reflect higher gambling involvement and is consistent with their elevated levels of problem gambling.

4. Discussion

The aim of the current study was to identify theoretically sound and clinically valid clusters of gamblers based on impulsivity traits and gambling-related cognitions. The cluster analytic approach evidenced five distinct clusters of gamblers. Based on the levels of disordered gambling (measured with the PGSI; Ferris and Wynne, 2001) and the proportion of treatment-seeking cases within each cluster, Cluster 1 corresponded to non-risky gambling, Clusters 2 and 3 presented with moderate risky gambling, and Clusters 4 and 5 were associated with likely problematic gambling. These two last clusters (4 and 5) represented 28.4% of the pooled sample and 65.6% of the treatment-seeking cases. Three of our identified clusters can be linked to subtypes

Table 3
Descriptive statistics for the five clusters.

Variable Cluster profile	Cluster 1 (N = 216, 25.99%) Non-impulsive gamblers without gambling-related cognitions M (SD)	Cluster 2 (N = 208; 25.03%) Gamblers with skill-based cognitive distortions M (SD)	Cluster 3 (N = 171, 20.58%) Impulsive gamblers M (SD)	Cluster 4 (N = 119, 14.32%) Impulsive emotional gamblers M (SD)	Cluster 5 (N = 117, 14.08%) Impulsive gamblers with gambling-related cognitions M (SD)	Statistic test	*p*	η^2
Urgency	8.27 (2.10)	9.06 (1.86)[a]	10.96 (2.09)[a,b]	10.93 (2.00)[a,b]	12.15 (2.08)[a,b,c,d]	99.68	<.001	.326
Lack of premeditation	6.16 (1.73)	6.01 (1.62)	9.11 (1.97)[a,b]	9.45 (2.21)[a,b]	9.02 (1.89)[a,b]	146.43	<.001	.415
Lack of perseverance	6.40 (2.08)	6.37 (1.98)	8.99 (2.47)[a,b]	9.27 (2.32)[a,b]	7.70 (2.54)[a,b,c,d]	65.28	<.001	.240
Sensation seeking	9.35 (2.38)	11.23 (2.55)[a]	11.36 (2.61)[a]	10.71 (2.82)[a]	12.24 (2.64)[a,b,c,d]	29.87	<.001	.126
Interpretative bias	7.56 (4.11)	17.45 (3.86)[a]	12.16 (4.34)[a,b]	17.01 (4.52)[a,c]	19.98 (3.69)[a,b,c,d]	256.12	<.001	.554
Predictive control	10.56 (3.84)	20.81 (5.04)[a]	15.31 (5.19)[a,b]	17.76 (5.49)[a,b,c]	26.32 (5.02)[a,b,c,d]	239.24	<.001	.537
Illusion of control	4.81 (1.84)	6.42 (3.03)[a]	6.22 (3.06)[a]	6.64 (2.77)[a]	16.25 (3.96)[a,b,c,d]	330.58	<.001	.616
Gambling expectancies	7.56 (3.12)	13.58 (3.99)[a]	10.42 (3.47)[a,b]	15.81 (4.2)[a,b,c]	17.61 (3.78)[a,b,c,d]	194.62	.<001	.485
Inability to stop gambling	6.44 (2.67)	11.37 (5.42)[a]	8.86 (3.72)[a,b]	22.31 (5.70)[a,b,c]	18.51 (7.08)[a,b,c,d]	273.87	<.001	.326
External Correlates								
Age	38.33 (13.67)	30.87 (10.03)[a]	31.35 (10.29)[a]	35.29 (11.78)[b]	29.05 (12.15)[a,d]	17.50	<.001	.082
Gender (M/F)	150/66	175/32[a]	125/46[b]	98/19[a,c]	67/50[a,b,c,d]	37.36	<.001	
PGSI	1.71 (4.21)	3.50 (3.90)[a]	4.73 (6.86)[a]	11.74 (7.96)[a,b,c]	9.57 (7.89)[a,b,c]	73.39	<.001	.256
Dass21-Depression (n = 400)	3.16 (3.55)	3.27 (4.19)	4.22 (4.94)	6.54 (5.69)[a,b]	6.12 (5.27)[a,b]	7.76	<.001	.073
Dass21-Anxiety (n = 400)	2.28 (2.55)	2.62 (2.90)	2.87 (3.23)	4.93 (2.23)[a,b,c]	5.77 (4.19)[a,b,c]	18.20	<.001	.156
Dass21-Stress (n = 400)	4.88 (4.14)	5.88 (4.34)	6.25 (4.70)	8.61 (4.69)[a,b]	9.89 (4.11)[a,b,c]	17.48	<.001	.150

Note. Three participants did not mention their gender.
[a] Statistically significant in comparison to cluster 1
[b] Statistically significant in comparison to cluster 2
[c] Statistically significant in comparison to cluster 3
[d] Statistically significant in comparison to cluster 4

Table 4
The number of gamblers depending on the PGSI cut-off by cluster, the total number and percentage of PG in treatment by cluster and clusters differences (post-hoc tests) on theses variables.

PGSI cut-off	Cluster 1 (N = 216, 25.99%) Non-impulsive gamblers without gambling-related cognitions N(% in the cluster)	Cluster 2 (N = 208; 25.03%) Gamblers with skill-based cognitive distortions N(% in the cluster)	Cluster 3 (N = 171, 20.58%) Impulsive gamblers N(% in the cluster)	Cluster 4 (N = 119, 14.32%) Impulsive emotional gamblers N(% in the cluster)	Cluster 5 (N = 117, 14.08%) Impulsive gamblers with gambling-related cognitions N(% in the cluster)	Statistic test	p
						333.395	< 0.0001
PGSI = 0	119 (55.1)	36 (17.3)[a]	44 (25.7)[a]	4 (3.4)[a,b,c]	6 (5.1)[a,b,c]		
Low risk (1–2)	66 (30.6)	69 (33.2)	54 (31.6)	13 (10.9)[a,b,c]	20 (17.1)[b]		
Moderate risk (3–7)	16 (7.5)	82 (39.4)[a]	42 (24.6)[a,b]	32 (26.9)[a,b]	33 (27.4)[a,b]		
High risk (> 7)	13 (6)	21 (10.1)	31 (18.1)[a]	70 (58.8)[a,b,c]	57 (49.6)[a,b,c]		
Number (%) in treatment-seeking group	13 (10.7)	5 (4.1)	24 (19.7)[a,b]	50 (41)[a,b,c]	30 (24.6)[a,b,c,d]	272.140	< 0.0001
Gambling preferences:						132.368	< 0.0001
Games of chance (lottery, scratch cards, slot)	94 (44.1)	24 (11.6)[a]	49 (29)[a,b]	17 (15.9)[a,c]	34 (30.6)[a,b,d]		
Games of skills/strategy	79 (37.1)	107 (51.7)[a]	55 (32.5)[b]	38 (35.5)[b]	7 (6.3)[a,b,c,d]		
Both types of games	40 (18.8)	76 (36.7)[a]	65 (21.5)[a]	52 (48.6)[a,b]	70 (63.1)[a,d]		

Note. Some missing data were present for PGSI scores (n = 3) and gambling activities (n = 24), so that the percentages in the table can sum to < 100%.
[a] Statistically significant in comparison to cluster 1.
[b] Statistically significant in comparison to cluster 2.
[c] Statistically significant in comparison to cluster 3.
[d] Statistically significant in comparison to cluster 4.

proposed by the Pathways Model (behaviorally conditioned gamblers, Cluster 2; emotionally vulnerable gamblers, Cluster 4; antisocial-impulsivist gamblers, Cluster 5). Using a data-driven approach, two further clusters emerged, one comprising impulsive gamblers without evident cognitive distortions (Cluster 3) and another displaying neither impulsivity nor gambling-related cognitions (Cluster 1). Crucially in our data, the gamblers who presented with both elevated impulsivity and gambling-related cognitions (Clusters 4 and 5) displayed more severe problem gambling symptoms.

The first cluster was labeled "Non-impulsive gamblers without gambling-related cognitions", as members of this cluster presented with the lowest scores in both impulsivity traits and gambling-related cognitions. Members of this cluster reported the lowest level of disordered gambling symptoms (55.1% of this cluster were PGSI = 0) and emotional distress. This cluster thus groups the largest proportion of participants having non-harmful gambling practices. From the spectrum of gambling involvement in our sample, such a cluster may be expected, and could be reasoned to fall outside the Pathways Model if these participants do not display the pathological features that the model aims to characterize. This cluster also comprises the highest proportion of gamblers preferring chance-based games, who may indeed be lottery gamblers, as this form of gambling is the highly prevalent in community samples and appears less risky than most other forms of gambling (e.g., Binde et al., 2017). Nevertheless, approximately 10% of the treatment-seeking gamblers were grouped in this cluster, which is perhaps surprising. It is possible that Cluster 1 incorporates gambling risk factors that are not necessarily linked with either impulsivity and/or gambling cognitions, for example Cluster A and C personality disorders (see Vaddiparti and Cottler, 2017, for a recent review on the links between gambling and personality disorders).

The second cluster was labeled "Gamblers with skill-based cognitive distortions". Members of this cluster are characterized by specific cognitive distortions pertaining to their personal capacity to control and predict gambling outcomes. These skill-related distortions are known to influence actual gambling patterns, and predicted gambling persistence on a laboratory slot-machine task (Billieux et al., 2012c). Cluster 2 comprised the highest proportion of gamblers favoring skill-based games, which are likely to appeal to gamblers with an interest in strategy and predictive control (Myrseth et al., 2010). This cluster presented with moderate risk of problem gambling, low level of emotional distress, and comprised the lowest proportion of treatment-seeking gamblers. This finding is in line with the view that gamblers who are only characterized by cognitive distortions are less likely to develop severe gambling problems (Moon et al., 2016; Nower et al., 2013). Our results are also consistent with the prediction of the Pathways Model that "behaviorally conditioned problem gamblers" are those with the lower functional impairment, accounting for their lower level of treatment seeking. Yet, from a public health perspective, low and moderate risk gambling are responsible for much of the aggregate burden of harm associated with gambling (Browne et al., 2016).

The third cluster was labeled "Impulsive gamblers" and members of this cluster were primarily characterized by elevated urgency, low perseverance, and low premeditation, in comparison to Clusters 1 and 2. Similar to Cluster 2, members of this cluster were characterized by moderate risk of problem gambling and low emotional distress, but a larger proportion of treatment-seeking gamblers fell in Cluster 3. The impulsive traits characterizing this cluster (high urgency, low perseverance, low premeditation) may promote risky patterns of gambling via compromised inhibitory control (Johnson et al., 2016; Wilbertz et al., 2014) and hazardous decision-making (Billieux et al., 2010), which are both central in the etiology of gambling disorder (Goudriaan et al., 2004). Case-control studies also demonstrate heightened impulsivity on these specific components in patients with gambling disorder (Billieux et al., 2012a; Michalczuk et al., 2011). Importantly, Cluster 3 indicates that gambling-related cognitions are not necessarily present in people with hazardous gambling (see Toneatto

et al., 1997). In the Pathways Model, dysfunctional gambling cognitions are supposed to be present in all problem gamblers (Blaszczynski and Nower 2002), an assumption that is questioned by Cluster 3 in the present study.

The fourth cluster was labeled "Impulsive emotional gamblers" and could be linked to the second pathway described by Blaszczynski and Nower (2002). This cluster presents with a combination of elevated impulsivity traits (high urgency, low premeditation, low perseverance) and specific gambling-related cognitions including gambling expectancies and meta-cognitive beliefs about inability to control gambling. This cluster recorded the highest mean PGSI score and included the highest proportion of treatment-seeking cases (41%), as well as displaying elevated emotional distress. The observed combination of emotion-laden impulsivity (i.e. urgency trait) and gambling expectancies is consistent with previous research showing that gambling can constitute a maladaptive and unregulated coping mechanism (Canale et al., 2015; Devos et al., 2017), and more generally that "emotional gambling" plays a pivotal role in the development of gambling disorder (Jacobs, 1986). Our findings are also in line with Moon et al. (2016) who reported that emotional gamblers presented with more severe symptoms. Nevertheless, to assert that this cluster equates to the "emotionally vulnerable" pathway, further evidence of affective disturbance is required (e.g., scales measuring emotion regulations strategies). Finally, it is worth noting that the pronounced dysfunctional meta-cognitive belief identified in this cluster call for a more comprehensive exploration of metacognition in gambling disorder (Spada et al., 2015).

The last cluster identified was labeled "Impulsive gamblers with gambling-related cognitions" and corresponds to the third pathway proposed by Blaszczynski and Nower (2002). These gamblers were characterized by high impulsivity, and displayed the highest level of sensation seeking among all clusters. This cluster was also characterized by the most elevated gambling-related distortions (illusion of control, predictive control, interpretative bias). Similar to Cluster 4, this cluster demonstrated likely problem gambling on the PGSI, the second highest proportion of treatment-seekers (24.6%), and pronounced emotional distress. In contrast to the impulsive emotional gamblers (Cluster 4) who we regard as gambling for negative reinforcement (e.g., coping with distress), the high level of sensation seeking in Cluster 5 suggests an unregulated pursuit of positive reinforcement (e.g., stimulation, pleasure). Sensation seeking has been a critical construct in some models of gambling disorder (Brown, 1986), and it is likely that dysfunctional gambling cognitions in these gamblers could potentiate a loss of control by increasing their conviction in their ability to win. We note that the younger age in this cluster could account for the slightly lower proportion of treatment-seeking cases compared to Cluster 4; as financial problems tend to accumulate over years, older problem gamblers are likely to have had longer to engage with treatment services.

Some limitations should be mentioned. First, the community and treatment-seeking gamblers were recruited from different European jurisdictions, and there were some socio-demographic differences; we recognize that dominant gambling forms and legislation can vary by country (Hodgins and Petry, 2016). Overall, our analysis strategy prioritized representativeness across the gambling continuum (i.e., from sub-clinical to treatment-seeking cases) over demographic comparability. Second, there were some minor procedural differences between the two samples: i) the DASS was only available on a subgroup of the community sample, and so we used this measure as an external correlate to avoid biasing the cluster creation; ii) it was not possible to administer the online surveys in the treatment centres, and hence the community and clinical gamblers differed in the mode by which the surveys were completed; iii) the assessment of gambling frequency and preferred games differed slightly, precluding any detailed analysis of specific forms (e.g., lottery engagement in Cluster 1). Third, as the study consists in a cross-sectional design, the stability of the cluster identified should be further confirmed using longitudinal analyses. Fourth, the sample of community gamblers was self-selected, which may limit the generalizability of our findings. Fifth, for the sake of parsimony in generating the clusters, we did not differentiate positive and negative subscales of urgency, or positive- and negative- reinforcement aspects of gambling expectancies. Future studies could thus strengthen and refine our findings by taking into account these differences. Finally, additional measures could have helped to comprehensively capture other elements of the Pathways Model (e.g., a measure of antisocial personality in relation to the third pathway).

The current study tested some of the predictions of the Pathways Model by relying on a multi-dimensional assessment of impulsivity and gambling-related cognitions, as central constructs in the model. In terms of building theoretical knowledge, our data-driven results support the main tenets of the Pathways Model by identifying clusters that resemble its three postulated pathways, but also extend the Pathways Model by evidencing two further groups (Clusters 1 and 3), including a group of impulsive gamblers without evident gambling-related cognitions. We found two clusters (4 and 5) with high levels of problematic gambling, challenging the notion that the "antisocial-impulsivist" pathway is necessarily the most severe. From a clinical point of view, the current findings open up avenues for assessment and treatment of problem gambling, by emphasizing a highly heterogeneous condition. Our data call for treatment centers to implement assessment batteries that incorporate these psychological factors. Crucially, the heterogeneity of the psychological profiles identified supports the relevance of individualized treatment options targeting specific psychological dimensions. Such an approach would reduce the application of unnecessary modules of treatment (for a discussion, see Dudley et al., 2011). For example, focusing on cognitive distortions is generally a mandatory step of cognitive behavior therapy for gambling disorder (Fong, 2005; Rizeanu, 2014) but may not benefit Cluster 3 gamblers (who are only impulsive) or Cluster 4 gamblers (who present gambling expectancies and dysfunctional metacognitions rather than traditional cognitive distortions). A problem gambler with strong meta-cognitive beliefs regarding their control over gambling but without specific cognitive distortions, may derive little benefit from cognitive restructuring, but their psychological treatment could be augmented with interventions promoting meta-cognitive awareness (Rochat et al., 2018; Spada et al., 2015). Similarly, gamblers characterized by emotion-laden impulsivity and marked gambling expectancies could benefit of psychological interventions targeting specifically emotion-regulation skills, such as mindfulness-based approaches (Deplus et al., 2016; Griffiths et al., 2016), whereas problem gamblers presenting deficits limited to self-control would primarily benefit from techniques devoted to the optimization of voluntary control over behavior (Friese et al., 2011). To conclude, the present study identified theoretically informed and clinically meaningful subgroups of problem gamblers assuming a process-based approach. Indeed, our approach conceptualized psychological processes (e.g., individual differences in impulsivity traits and gambling cognitions) as causal factors used to create the clusters, whereas psychopathological symptoms were considered as external correlates used to establish the validity of the various clusters identified. Our approach clearly highlights some potential limitations of standard treatments approaches.

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CRediT authorship contribution statement

Mr. Gaëtan Devos: Conceptualization, Data curation, Formal analysis, Validation, Writing - original draft. **Luke Clark:** Data curation, Writing - review & editing. **Henrietta Bowden-Jones:** Data curation, Writing - review & editing. **Marie Grall-Bronnec:** Data curation, Writing - review & editing. **Gaëlle Challet-Bouju:** Data curation, Writing - review & editing. **Yasser Khazaal:** Data curation, Writing - review & editing. **Pierre Maurage:** Validation, Writing - review & editing. **Joël Billieux:** Conceptualization, Validation, Writing - original draft.

Declaration of Competing Interest

GD, HBJ, YK, PM and JB have no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found at https://osf.io/q2usd/

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