Roles for alexithymia, emotion dysregulation and personality features in gambling disorder: a network analysis

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Abstract

Background and aims: Although there is a growing interest in exploring the specific role of both emotional regulation processes and alexithymia in gambling disorder (GD), evidence remains scarce. In order to delve deeper into the complex interactions between these factors, the present study aimed at exploring a network of the core GD-related features, including GD symptomatology and severity, emotion dysregulation, alexithymia, and personality features. **Materials and methods:** The sample included *N* = 739 treatment-seeking patients with GD (691 men and 48 women), aged 18 to 78 years (mean age=39.2, SD=13.2). The DSM-5 diagnostic criteria were assessed in, and the South Oaks Gambling Screen, Difficulties in Emotion Regulation Scale (DERS), and Temperament and Character Inventory-Revised were administered to, participants. A network analysis was conducted to reveal inter-relationships between these elements. **Results:** Three nodes related to emotion dysregulation showed the most critical position in the whole network of the present study: “lack of emotional awareness”, “non-acceptance of emotional responses”, and “difficulties engaging in goal-directed behaviors”. When analyzing emotional dysregulation using the different DERS subscales, two independent clusters were identified. One cluster encompassed alexithymia dimensions ("lack of awareness" and "lack of clarity"), while the other cluster included all other emotion-dysregulation dimensions. **Discussion and conclusions:** Identification of the emotion-dysregulation- and GD-related features with the highest centrality/linkage may be particularly useful for developing valid measurement tools and precise management plans for individuals with GD.

Keywords: Gambling Disorder; Alexithymia; Emotion Regulation; Personality

1. INTRODUCTION

Alexithymia has been described as difficulties involving awareness, explicit identification, and description of one's feelings (Nemiah et al. 1976). Although multiple theoretical models have been proposed to conceptualize alexithymia, the Toronto framework is arguably the one with greatest consensus (Bagby et al. 1986). This theoretical model suggests that alexithymia is composed of several factors: an externally-oriented cognitive style (i.e., the tendency to avoid internal thoughts associated with affect and focus on superficial information), low emotional awareness (i.e., difficulty in identifying feelings), and difficulties describing feelings through words (Bagby et al. 1986).

Alexithymia has been considered a potential relatively stable personality feature found in both general and clinical populations, with severity ranging from low to high (Hogeveen and Grafman 2021; Luminet et al. 2021). Alexithymia may be associated with deficits in the automatic processing and regulation of emotional inputs at both neurobiological and behavioral levels (Donges and Suslow 2017). Therefore, an association between alexithymia and emotional dysregulation has been described. More specifically, alexithymia may involve alterations in the process of emotional regulation (i.e., inflexibility in the management of emotions), which may lead to somatic and mental disorders (Panayiotou et al. 2021). Consequently, both alexithymia and impaired emotional regulation have been considered as transdiagnostic clinical features found in multiple mental disorders such as autism (Cai et al. 2018; Kinnaird et al. 2019), depression (Joormann and Stanton 2016; Li et al. 2015), anxiety (Sloan et al. 2017; Terasawa et al. 2021), eating disorders (Prefit et al. 2019; Westwood et al. 2017), and substance and behavioral addictions (Honkalampi et al. 2022; Marchetti et al. 2019; Mestre-Bach, Fernández-Aranda, et al. 2020; Velotti et al. 2021; Wilcox et al. 2016).

Regarding addictive disorders, alterations in the processing of negative feedback have been reported, which may in part explain why individuals with addictions continue to engage in maladaptive behaviors despite the negative consequences (Castelluccio et al. 2014; Morie et al. 2014, 2022). In addition, individuals with addictions often show reductions in physiological responses, especially

reward deficits, that may lead to seeking of rewards linked to their addictive behaviors (Diekhof et al. 2008).

In the specific case of gambling disorder (GD), the presence of both alexithymia and emotion-regulation impairments has been described (Marchetti et al. 2019; Velotti et al. 2021). GD is characterized by a recurrent and persistent pattern of maladaptive gambling behavior that leads to clinically significant distress (American Psychiatric Association 2013). Considering GD as a heterogeneous disorder, alterations in emotional regulation, as well as high levels of impulsivity and the presence of gambling-related cognitive distortions, have been identified as some potentially relevant variables in the development and maintenance of GD (Ruiz de Lara et al. 2019). Specifically, alterations in emotional regulation have been associated with several GD-related features. In addition, problems in emotional regulation, together with other clinical features such as maladaptive personality features, poor cognitive reappraisal, and gambling motives, may predict GD severity (Marchica et al. 2020; Mestre-Bach et al. 2021; Rogier et al. 2020), although varying levels of impairment in emotional regulation have been described in individuals with GD (Jara-Rizzo et al. 2019). For example, considering gender, it has been suggested that men show a greater difficulty in accepting negative emotional states and, consequently, an exacerbation of nonacceptance of GD (Velotti et al. 2021). In view of the emotional regulation process, in the case of GD, difficulties have been described at multiple stages: (a) identification of one's emotional state, (b) selection of emotion regulation strategies, and (c) implementation of these strategies (Rogier and Velotti 2018), with a reported tendency for emotional suppression in individuals with GD (Velotti et al. 2021).

Alexithymia is related to emotional dysregulation processes and may be key in the evolution of GD. Alexithymia has been linked to greater GD severity and may show interactive mechanisms with cognitive, psychiatric and psychopathological features (Marchetti et al. 2019). Previous studies have suggested that alexithymia could impact executive function and memory, which may lead individuals to minimize the consequences associated with their behavior (Battista et al. 2021). Furthermore, regarding affect-dysregulation theoretical models, individuals with GD and high alexithymia levels

may use gambling as a coping strategy in order to avoid negative emotions and increase emotional arousal (Marchetti et al. 2019).

Another factor that has been associated with GD, alexithymia, and emotional regulation are personality features. Individuals with GD have shown higher levels of neuroticism compared to those with recreational gambling, as well as lower levels of agreeableness and conscientiousness (Whiting et al. 2019). In addition, an early age of onset of GD onset has been associated with higher levels of novelty-seeking and lower levels of self-directedness (Jiménez-Murcia et al. 2010; Odlaug et al. 2013). These personality features, as well as low cooperativeness and higher self-transcendence and harm avoidance have been linked to more severe GD (Pettorruso et al. 2021). Potentially maladaptive personality traits (e.g. impulsivity, lack of perseverance, and suspiciousness) have been linked to GD severity and emotion dysregulation may explain, at least partially, these associations (Rogier et al. 2020). Finally, alexithymia has been associated with potentially maladaptive personality features in individuals with GD, especially elevated levels of sensation-seeking, aggressiveness, and impulsivity (Marchetti et al. 2019).

Although there is interest in exploring the specific role of emotional regulation processes, alexithymia, and personality features in GD, evidence remains scarce. In order to investigate further, the present study aimed at exploring the network (structure) of the core GD-related features, including GD symptomatology and severity, emotion dysregulation, alexithymia, and personality features. Moreover, the current study sought to identify network nodes with the highest centrality and linkage capacity, and the existence of empirical modules-clusters of symptoms. For this purpose, a network-based analysis was used, a promising approach to reveal inter-relationships among elements and to analyze the structures of identified associations (Granero et al. 2021).

2. MATERIALS AND METHODS

2.1.Participants and procedure

The study sample included 739 (691 male and 48 female) consecutive treatment-seeking adults with a GD diagnosis recruited from the Behavioral Addictions Unit within the Department of Psychiatry

of a University Hospital between March 2015 and November 2019. This public hospital is certified as a tertiary care center (high specialization) for the treatment of psychological addictive behaviors and oversees the treatment of patients with very complex cases. Diagnoses were determined by psychologists and psychiatrists with >20 years of clinical experience in both the assessment and treatment of GD. Both diagnosis and evaluation were conducted prior to treatment initiation.

Only adult patients (18+ years) who sought treatment for GD as their primary mental health concern were included. The exclusion criterion was the presence of disorders (such as organic mental disorder, intellectual disability, or neurodegenerative disorder) that did not allow for completing the assessments.

2.2.Measures

2.2.1. DSM-5 Criteria (American Psychiatric Association 2013)

Participants were diagnosed with GD if they met DSM-5 criteria (American Psychiatric Association 2013). The DSM requires meeting four of nine inclusionary criteria for a diagnosis of GD (American Psychiatric Association 2013).

2.2.2. *South Oaks Gambling Screen (SOGS)* (Lesieur and Blume 1987)

The SOGS is a self-report tool with 20 items originally designed with the aim to identify the presence of probable, problematic and non-problematic gambling. It has also been used as a measure of the problem-gambling severity. The version used in this work (Spanish adaptation) had shown good psychometric indexes (Echeburúa et al. 1994). The internal consistency in this study was adequate (α=0.74).

2.2.3. *Difficulties in Emotion Regulation Scale (DERS)* (Gratz and Roemer 2004)

This is a self-report tool was developed to assess emotional dysregulation, with 36 items structured in six first-order factors: (a) “lack of emotional awareness” (difficulties attending to emotional states), (b) “lack of emotional clarity” (difficulties related to recognizing emotional experiences), (c) “non-acceptance of emotional responses” (the tendency to experience negative secondary emotional responses), (d) “difficulties engaging in goal-directed behaviors” (difficulties accomplishing tasks in

the presence of intense emotional states), (e) "limited access to emotion regulation strategies" (this dimension reflects the belief that there is little that can be done to effectively regulate emotions when experiencing upset), and "impulse control difficulties" (difficulties in regulating one's behavior under negative emotional states). The present study used the Spanish version of the questionnaire, which has demonstrated good psychometrical indexes (Wolz et al. 2015). The internal consistency in the current sample ranged from α=0.74 ("lack of emotional awareness") to α=0.90 ("non-acceptance of emotions"). In the present study, "lack of emotional awareness" and "lack of emotional clarity" were considered dimensions of alexithymia.

2.2.4. *Temperament and Character Inventory-Revised* (TCI-R) (Cloninger et al. 1994)

This self-report was originally developed to assess personality features, based on the Cloninger's personality multidimensional model. It includes 240 items structured in seven factors [4 dimensions assessing temperament (novelty seeking, harm avoidance, reward dependence, and persistence), and 3 assessing character (self-directedness, cooperation, and self-transcendence)]. The Spanish version used in this work has demonstrated adequate psychometric indexes (mean Cronbach's α=0.87) (Gutiérrez-Zotes et al. 2004). The internal consistency in the study sample was in the adequate to good range (from α=0.71 for novelty seeking to α=0.88 for self-directedness).

2.2.5. *Other variables*

Other sociodemographic and gambling-related variables were measured with a semi-structured interview. These measures included, among other variables, the socio-economic status index according to the Hollingshead's scale (based on employment status, participants' level of education and occupational prestige) (Hollingshead 2011).

2.3.Statistical analysis

Network analysis was conducted with Gephi 0.92 for Windows (Bastian et al. 2009) (available at http://gephi.org). This software is specifically developed for exploring and visualizing networks within data sets, with the advantages of powerful spatialization processing and ability to compute

centrality, density, and modularity-clustering. A network approach uses common elements of graph theory to reveal and visualize underlying structures of inter-relationships: a) nodes (symptoms and other correlates, including sociodemographic-clinical features), which are represented through circles; and b) edges (relationships between variables), which are represented as connecting lines (Borgatti et al. 2009). The effect size of the edges/associations can be calculated using several statistical procedures, such as the partial correlations matrix (this was the method employed in this manuscript, to avoid biases due to the impact of possible confounding variables) (Bringmann et al. 2013; Clifton and Webster 2017; Hevey 2018). This approach was used to identify the symptoms/features with the higher relevance ("central nodes") in a GD profile (Fried et al. 2017; Fried and Cramer 2017), as well as features with the highest linkage capacity ("transition/bridge" nodes, that facilitate the paths between the structures) (Braun et al. 2018; Cramer et al. 2010).

Nodes analyzed in the study were the nine DSM-5 criteria for GD, six DERS scales and the personality profile (measured with the TCI-R). The initial data structure for the network study resulted in 24 nodes and 276 potential nodes, most of them with very low weights (partial correlations around 0). To simplify this initial complex structure, edges with $p < 0.10$ were excluded, resulting in a final structure with 210 edges (around 76% of all potential connections).

Several indexes may be used to assess the relevance (prominence) and linkage (interconnection) capacity of the nodes (Epskamp et al. 2018). In this work, the measure of the node-level relevance within the network was valued with the eigenvector centrality, calculated from the weighted sum of centrality measures of all the nodes connected to a specific node (this is an indicator of the total amount of direct links with the other nodes). High eigenvector centrality indicates that the information contained in a concrete node is highly valuable for the whole graph. The node-level linkage was measured with the betweenness centrality, a measure of the mediational role of each node in the whole network (and calculated from the number of shortest paths [between any couple of nodes in the graph] that passes through the target node). High betweenness centrality indicates short average distance between a node with respect to all other nodes, and therefore a large capacity to provide relevant

changes in other parts of the network, and also high vulnerability to be impacted by modifications in any part of the graph.

Gephi automatically identifies empirical clusters of nodes (also named as communities or modules in Gephi) (Blondel et al. 2008), and groups nodes that are highly interconnected among themselves and poorly connected with nodes outside the cluster.

3. RESULTS

3.1.Descriptive characteristics of the sample

Table 1 displays the frequency distributions for the study variables. Most participants were men, were single or married, had low educational levels, were employed and held mean-low to low social positions. Mean age of onset of GD was 28.2 years (SD=11.5) and mean duration of GD was 5.5 years (SD=6.1). Non-strategic forms of gambling were preferred (lotteries, bingo and slot-machines). The percentage of participants who reported gambling-related debts was 63%. The prevalence of individual DSM-5 criteria for GD ranged between 60.2% (preoccupations with gambling) and 90.8% (attempts to reduce/stop gambling without success).

--- Insert Table 1 ---

3.2.Network analysis

Figure 1 visually displays the identified network (the complete statistics for the project-analysis are included in Table S1, supplementary material). Different colors were used to highlight nodes according to specific dimensions (personality, emotional regulation and GD measures), and also for differentiating positive versus negative weights of the edges. Figure S1 (supplementary material) includes the specific paths of the two core factors of alexithymia: “lack of awareness” and “lack of clarity.”

--- Insert Figure 1 ---

Figure 2 displays the bar charts with the nodes ordered according to the eigenvector centrality and the betweenness centrality. Three nodes containing information regarding the emotion-dysregulation capacity occupied the most critical position in the whole network (highest eigenvector centrality):

"lack of emotional awareness", "non-acceptance of emotional responses", and "difficulties engaging in goal-directed behaviors." The nodes with the highest linkage capacity were the fourth DSM-5 criterion for GD "preoccupation with gambling", and the TCI-R "novelty seeking" measure. These two variables achieved the highest "control" over the graph, since they were inter-connected with the largest volume of information.

--- Insert Figure 2 ---

Five modularity latent classes (clusters of nodes) were identified (Figure 3 shows the nodes grouped into each modularity class). Cluster 1 (C1) grouped all GD-related measures (DSM-5 criteria, gambling-related debts and problem-gambling severity). The DERS subscales were distributed in two differentiated clusters: Cluster C2 included "awareness" and "clarity", and Cluster C3 the remaining emotional dysregulation factors. The personality scores measured with the TCI-R were also distributed in two clusters: Cluster C4 grouped reward dependence and cooperativeness, while Cluster C5 included the remaining personality factors.

--- Insert Figure 3 ---

4. DISCUSSION

The present study explored the network structure of the core GD features, including GD severity, personality features and aspects of emotional dysregulation including those related to alexithymia. Three nodes related to alexithymia and emotion dysregulation showed the most critical position in the identified network. These nodes included "lack of emotional awareness," "non-acceptance of emotional responses," and "difficulties engaging in goal-directed behaviors." "Lack of emotional awareness" has been understood as difficulties attending to and acknowledging emotions (Gratz and Roemer 2004). This factor played an essential role in the network, in line with previous findings that suggested that it was crucial in relating to GD severity (Williams et al. 2012). This difficulty in identifying emotions would fall under the first phase of proposed emotional regulation processes ("identification of emotional state"), and it has been suggested that in the case of GD, it could involve: (a) under-representation of negative emotional states; (b) over-valuations of negative emotions

leading to expressive suppression; (c) over-valuations of escape-based strategies leading to experimental avoidance; and/or (d) poor valuations of a valid output signal for action (Rogier and Velotti 2018). Moreover, these difficulties in acknowledging emotional states coincide with the construct of alexithymia (Velotti et al. 2021). Alexithymia tends to be quite common in individuals with GD (with prevalence estimates of 34-67% in clinical samples with GD) and may relate to GD severity (Marchetti et al. 2019; Noël et al. 2018). It has been hypothesized that difficulties in realizing, understanding and using appropriately one's emotions may be related to disadvantageous decision-making (Olsen et al. 2015) and hinder impulse control toward gambling behavior in individuals with GD (Marchetti et al. 2019). In addition, gambling behavior may be acting as an external regulator of undifferentiated negative emotions (Di Trani et al. 2017). Potentially, these processes may underlie both substance and behavioral addictions. Individuals with addictions may experience intense negative emotions that they do not know how to identify and interpret, so they may avoid them and engage in maladaptive addictive behaviors as self-regulation strategies.

“Non-acceptance of emotional responses” has been understood as a “tendency to have negative secondary emotional responses to one’s negative emotions, or non-accepting reactions to one’s distress” (Gratz and Roemer 2004). This factor of emotional regulation was also central to the network analysis of the present study. Previous studies had highlighted that individuals with GD show difficulties in accepting their emotional states in a non-judgmental way and, on the contrary, often experience disappointment and shame (Jauregui et al. 2016; Rogier and Velotti 2018; Williams et al. 2012).

The dimension "engaging in goal-directed behaviors" was also identified as a central node of the network. This dimension encompasses difficulties in concentration and task accomplishment when experiencing negative emotions (Gratz and Roemer 2004). Individuals with GD often act impulsively when experiencing intense negative emotional states (Mestre-Bach, Fernández-Aranda, et al. 2020; Whiteside et al. 2005), or even positive emotional states, such as euphoria. Impulsive behaviors in these individuals are often the response to these emotions, which they may not know how to regulate.

In turn, elevated levels of impulsivity are associated with more severe GD (Mestre-Bach, Steward, et al. 2020; Steward et al. 2017). Therefore, it is possible that individuals with GD, when experiencing strong negative emotions, perform gambling behavior impulsively and consequently deviate from their goals. However, this finding or interpretation does not coincide uniformly with previous results. Rogier et al. (Rogier et al. 2020) observed that this dimension was the only one of the DERS in which individuals with GD presented similar levels to comparison subjects without GD. Therefore, this domain may be less associated with GD than other emotion-dysregulation dimensions. The authors (Rogier et al. 2020) interpreted the results taking into account the tendencies of individuals with GD to pursue goals through maladaptive gambling behaviors, for example by chasing losses. However, alternative explanations exist. For example, some individuals with GD may be able to identify emotions and find them annoying or distressing, and gambling behavior may follow. Alternatively, in some individuals alexithymia may be more of a maintenance factor that engages following gambling losses, and specific aspects may contribute differentially across time. Further research is needed to clarify the specific role of alexithymia and its components in GD.

The nodes with the highest linkage capacity were DSM-5 criterion “preoccupation with gambling” and the TCI-R “novelty seeking” dimension. Both variables achieved the highest “control” over the graph, since they were inter-connecting the largest volume of information. On the one hand, the high "control" of the diagnostic criterion of preoccupation with gambling does not coincide with previous studies. Some authors highlighted that some diagnostic criteria, such as preoccupation with gambling and chasing losses, were less associated with GD severity than were other criteria such as withdrawal, jeopardizing important matters, and needing financial assistance to resolve gambling-related financial concerns (Grant et al. 2017; Sleczka et al. 2015). Further studies are needed to clarify the specific weight of the preoccupation criterion in GD. On the other hand, high novelty seeking appears to be a characteristic feature of GD and a distinguishing feature between individuals with and without GD (Martinotti et al. 2006; Pettorruso et al. 2021). Moreover, it has been proposed as a predictor of GD severity (Jiménez-Murcia et al. 2021). This dimension is associated with high impulsivity (Nordin

and Nylander 2007), a feature also common in individuals with GD (Fineberg et al. 2014; Gullo and Potenza 2014).

When analyzing emotional dysregulation using the different DERS subscales, two independent clusters were identified. One cluster encompassed the dimensions "lack of awareness" and "lack of clarity," while the other cluster included all other dimensions. These results suggest that "lack of awareness" and "lack of clarity" may present unique characteristics in comparison with other dimensions associated with emotional dysregulation. These findings suggest that "lack of awareness" and "lack of clarity" may be dimensions that reflect alexithymia, a possibly separate entity but at the same time related to aspects of emotional dysregulation. These findings are in line with previous studies, which reported that both dimensions had distinct roles in terms of their associations with GD severity. More specifically, it was observed that both "lack of awareness" and "lack of clarity" were the only two DERS dimensions that appeared not to be significantly associated with GD severity (Jauregui et al. 2016; Mestre-Bach et al. 2021), nor with the other dimensions of the DERS (Vintró-Alcaraz et al. 2022).

Finally, considering the specific paths of the DERS dimensions associated with alexithymia ("lack of awareness" and "lack of clarity"), the network model indicated that these domains are associated with specific personality features, and not necessarily directly with GD severity (although they are linked to specific diagnostic criteria of GD, such as those involving GD-related debts). These findings partially coincide with what was proposed by Marchetti et al. (Marchetti et al. 2019) in their systematic review on alexithymia and GD. The authors suggested that alexithymia may be considered a multifaceted personality construct, which would explain its association with other personality traits. More specifically, the authors highlighted that alexithymia was related to a maladaptive personality profile, characterized by high impulsivity, sensation-seeking and aggressiveness. This would be consistent with, for example, the path found in the present study between "lack of awareness" and "novelty seeking." The authors also proposed that alexithymia could potentially increase both the risk

for GD and GD severity. Therefore, further research that more comprehensively explores the specific associations between alexithymia and GD is important.

4.1.Strengths, limitations and future studies

One strength of the study is the use of network analysis for modeling a relatively large number of nodes and edges, since this approach provides a realistic picture of the patients' clinical profile. Particularly relevant is the inclusion of the nine DSM-5 criteria for GD, and the observation that all these symptoms were grouped within the same modularity-class (this result provides new evidence regarding the validity for the conceptualization of this mental condition into the categorical taxonomy). Observing that the DSM-5 criterion 4 (excessive preoccupations with gambling) obtains the highest connectivity capacity (linkage) is also a strength (this is the first study identifying a "bridge" symptom in the DSM-5 criteria list for GD).

The present study had certain limitations. First, the sample included was not gender-balanced. Future studies could include a higher proportion of women with GD and compare whether the network paths may differ by gender. Second, the sample was composed exclusively of treatment-seeking patients with GD, so generalization to other populations, such as individuals with GD who do not seek treatment, should be made with caution. Third, emotion dysregulation, alexithymia and personality features were explored using self-report instruments, which in most cases may be associated with biases and may not capture the full complexity of the constructs assessed. Future studies could include other types of assessment, such as behavioral tasks, in order to have a more comprehensive perspective of these factors. Finally, two dimensions of the DERS were used to assess domains theoretically linked to alexithymia, and no use was made of specific psychometric tools directly assessing the construct, such as the Toronto Alexithymia Scale. In addition, the DERS focuses on the emotional regulation of negative emotions, and it has been suggested that dysregulation of positive emotions may play an essential role in GD (Rogier and Velotti 2018). Therefore, future studies should explore positive emotions and their relationships to GD, alexithymia, and personality features.

5. CONCLUSIONS

The two dimensions of alexithymia assessed by network analysis, "lack of awareness" and "lack of clarity," seem to constitute a distinct cluster in relation to the other emotional dysregulation dimensions of the DERS. Alexithymia may be associated with certain personality features and other dimensions of emotional dysregulation. However, no clear association was observed between the proxy measures of alexithymia and GD severity, although there is a clear association with certain gambling-related features, such as the presence of gambling-related debts. Further studies are needed to clarify the specific role of alexithymia in the development and maintenance of GD. Identification of the GD-related features with the highest centrality/linkage may be particularly useful for developing valid measurement tools and precise management plans for individuals with GD.

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Table 1 Descriptive of the variables of the study *(n=739)*

Sociodemographic		*n*	*%*
Gender	Female	48	6.5%
	Male	691	93.5%
Marital status	Single	407	55.1%
	Married	249	33.7%
	Divorced	83	11.2%
Education	Primary	374	50.6%
	Secondary	287	38.8%
	University	78	10.6%
Employed	Unemployed	259	35.0%
	Employed	480	65.0%
Social position	High	20	2.7%
	Mean-high	45	6.1%
	Mean	78	10.6%
	Mean-low	281	38.0%
	Low	315	42.6%
GD profile		*Mean*	*SD*
Age (years)		39.25	13.18
GD Onset (years)		28.21	11.53
GD Duration (years)		5.47	6.05
		n	*%*
Type	Non-strategic	322	43.6%
	Strategic	248	33.6%
	Mixed	169	22.9%
Debts	No	274	37.1%
	Yes	465	62.9%

GD DSM-5 criteria	*n*	*%*
A1: Gambling with increasing amounts of money	507	68.6%
A2: Restless-irritable when stopping gambling	602	81.5%
A3: Repeated efforts to control-stop gambling	671	90.8%
A4: Preoccupied with gambling	445	60.2%
A5: Often gambles when feeling distressed	494	66.8%
A6: Chasing one's losses	658	89.0%
A7: Lies to conceal the extent of gambling	690	93.4%
A8: Has lost relationships, job, education due to gambling	611	82.7%
A9: Gambling-related financial issues	585	79.2%
GD severity symptoms: SOGS total *(mean – SD)*	10.99	3.31
Emotion regulation: DERS scales	*Mean*	*SD*
Non-acceptance of emotions	16.22	7.00
Difficulties with directed behaviors	13.89	4.85
Impulse control difficulties	13.55	5.65
Lack of emotional awareness	16.99	4.89
Limited access to emotions	18.98	7.83
Lack of emotional clarity	12.04	4.34
Personality: TCI-R scales	*Mean*	*SD*
Novelty seeking	110.77	13.13
Harm avoidance	99.73	18.11
Reward dependence	96.62	14.47
Persistence	108.54	19.35
Self-directedness	128.80	22.12
Cooperativeness	130.06	16.38
Self-transcendence	61.47	14.35

Note: SD: standard deviation; GD: gambling disorder; DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; SOGS: South Oaks Gambling Screen; TCI-R: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale.

Figure 1 Visualization of the network

Note. Positive edges are represented by blue lines, and negative edges are plotted in brown-ochre. The thicker the edge, the stronger the connection weight. Nodes are plotted in colors depending on the dimension: personality (purple), emotion regulation (green) and GD-related measures (orange). GD: gambling disorder; DSM: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; SOGS: South Oaks Gambling Screen; TCI: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale.

Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9, as listed below), GD symptom severity (GD.sogs), GD related debts (GD.debts), TCI.novelty (novelty seeking), TCI.harm (harm avoidance), TCI.reward (reward dependence), TCI.persist (persistence), TCI.selfdirect (self-directedness), TCI.coopera (cooperativeness), TCI.selftrans (selftranscendence), DERS.accept (lack of acceptance of emotions), DERS.directed (difficulties in directed behaviors), DERS.impul (impulse control difficulties), DERS.awaren (lack of emotional awareness), DERS.access (difficulties in access to emotions) and DERS.clarity (lack of emotional clarity). The DSM criteria for GD include as numbered below: [1] Needs to gamble with increasing amounts of money in order to achieve the desired excitement; [2] Is restless or irritable when attempting to cut down or stop gambling; [3] Has made repeated unsuccessful efforts to control, cut back, or stop gambling; [4] Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble); [5] Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed); [6] After losing money gambling, often returns another day to get even (“chasing” one’s losses); [7] Lies to conceal the extent of involvement with gambling; [8] Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling; and [9] Relies on others to provide money to relieve desperate financial situations caused by gambling.

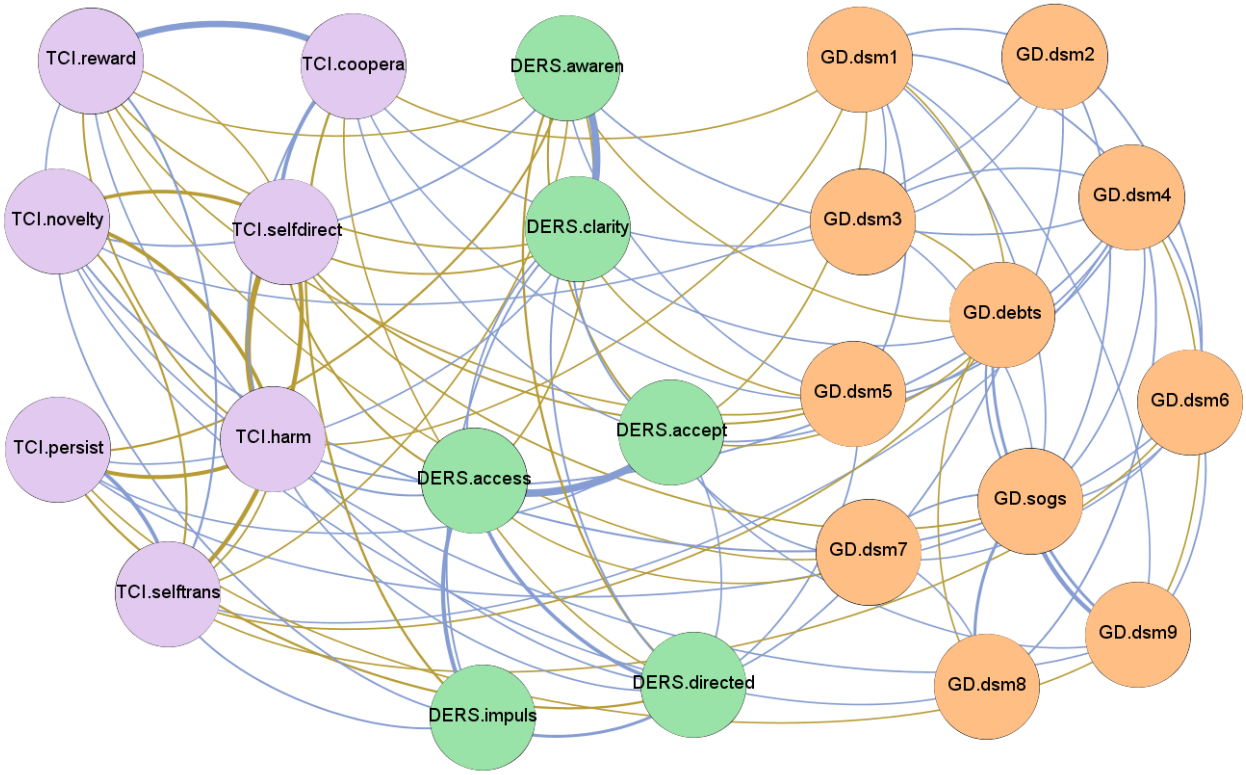

Figure 2 Relevance of centrality and linkage of the nodes

Note. GD: gambling disorder; DSM: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; SOGS: South Oaks Gambling Screen; TCI: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale.

Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9, as numbered below), GD symptom severity (GD.sogs), GD related debts (GD.debts), TCI.novelty (novelty seeking), TCI.harm (harm avoidance), TCI.reward (reward dependence), TCI.persist (persistence), TCI.selfdirect (self-directedness), TCI.coopera (cooperativeness), TCI.selftrans (selftranscendence), DERS.accept (lack of acceptance of emotions), DERS.directed (difficulties in directed behaviors), DERS.impul (impulse control difficulties), DERS.awaren (lack of emotional awareness), DERS.access (difficulties in access to emotions) and DERS.clarity (lack of emotional clarity). The DSM criteria for GD include as numbered below: [1] Needs to gamble with increasing amounts of money in order to achieve the desired excitement; [2] Is restless or irritable when attempting to cut down or stop gambling; [3] Has made repeated unsuccessful efforts to control, cut back, or stop gambling; [4] Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble); [5] Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed); [6] After losing money gambling, often returns another day to get even (“chasing” one’s losses); [7] Lies to conceal the extent of involvement with gambling; [8] Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling; and [9] Relies on others to provide money to relieve desperate financial situations caused by gambling.

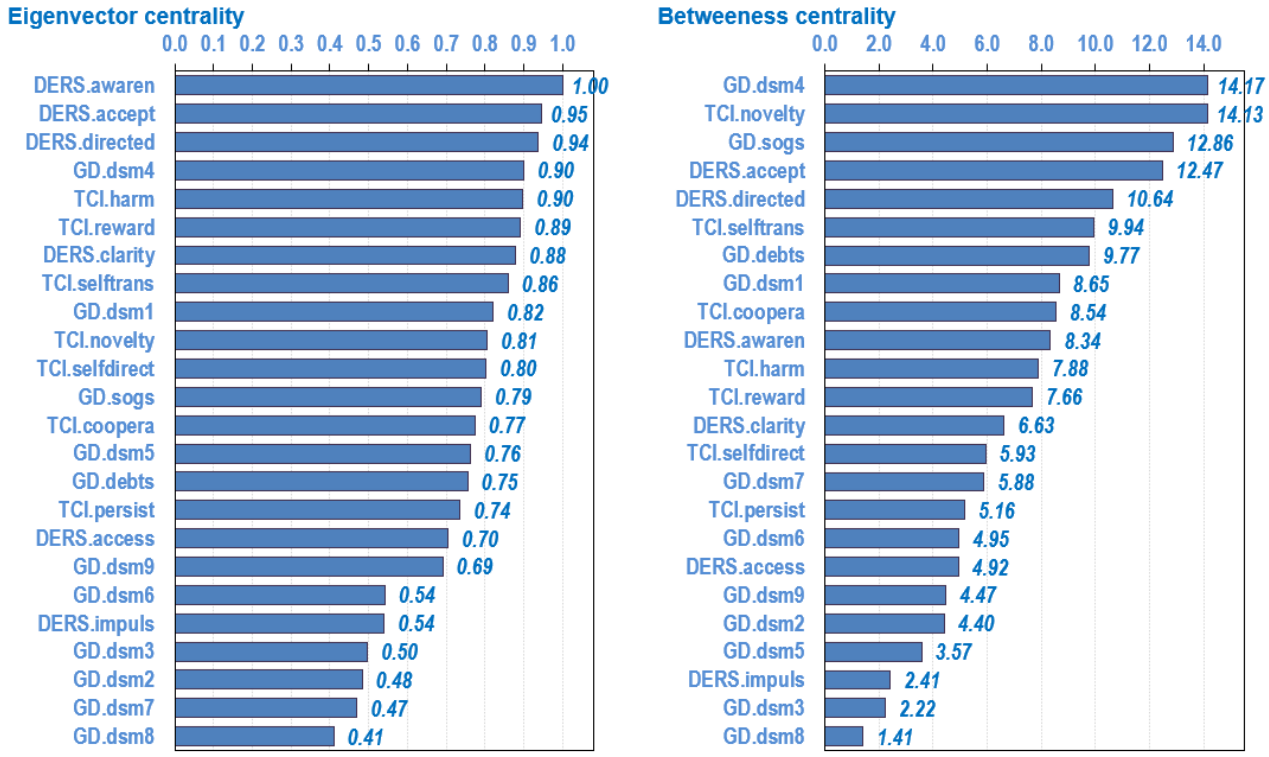

Figure 3 Network grouping the nodes within module-class-clusters

Note. Positive edges are represented by blue lines, and negative edges are plotted in brown-ochre. The thicker the edge, the stronger the connection weight. Nodes are plotted in colors depending on the dimension: personality (purple), emotion regulation (green) and GD-related measures (orange). GD: gambling disorder; DSM: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; SOGS: South Oaks Gambling Screen; TCI: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale.

Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9, as numbered below), GD symptom severity (GD.sogs), GD related debts (GD.debts), TCI.novelty (novelty seeking), TCI.harm (harm avoidance), TCI.reward (reward dependence), TCI.persist (persistence), TCI.selfdirect (self-directedness), TCI.coopera (cooperativeness), TCI.selftrans (selftranscendence), DERS.accept (lack of acceptance of emotions), DERS.directed (difficulties in directed behaviors), DERS.impul (impulse control difficulties), DERS.awaren (lack of emotional awareness), DERS.access (difficulties in access to emotions) and DERS.clarity (lack of emotional clarity). The DSM criteria for GD include as numbered below: [1] Needs to gamble with increasing amounts of money in order to achieve the desired excitement; [2] Is restless or irritable when attempting to cut down or stop gambling; [3] Has made repeated unsuccessful efforts to control, cut back, or stop gambling; [4] Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble); [5] Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed); [6] After losing money gambling, often returns another day to get even (“chasing” one’s losses); [7] Lies to conceal the extent of involvement with gambling; [8] Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling; and [9] Relies on others to provide money to relieve desperate financial situations caused by gambling.

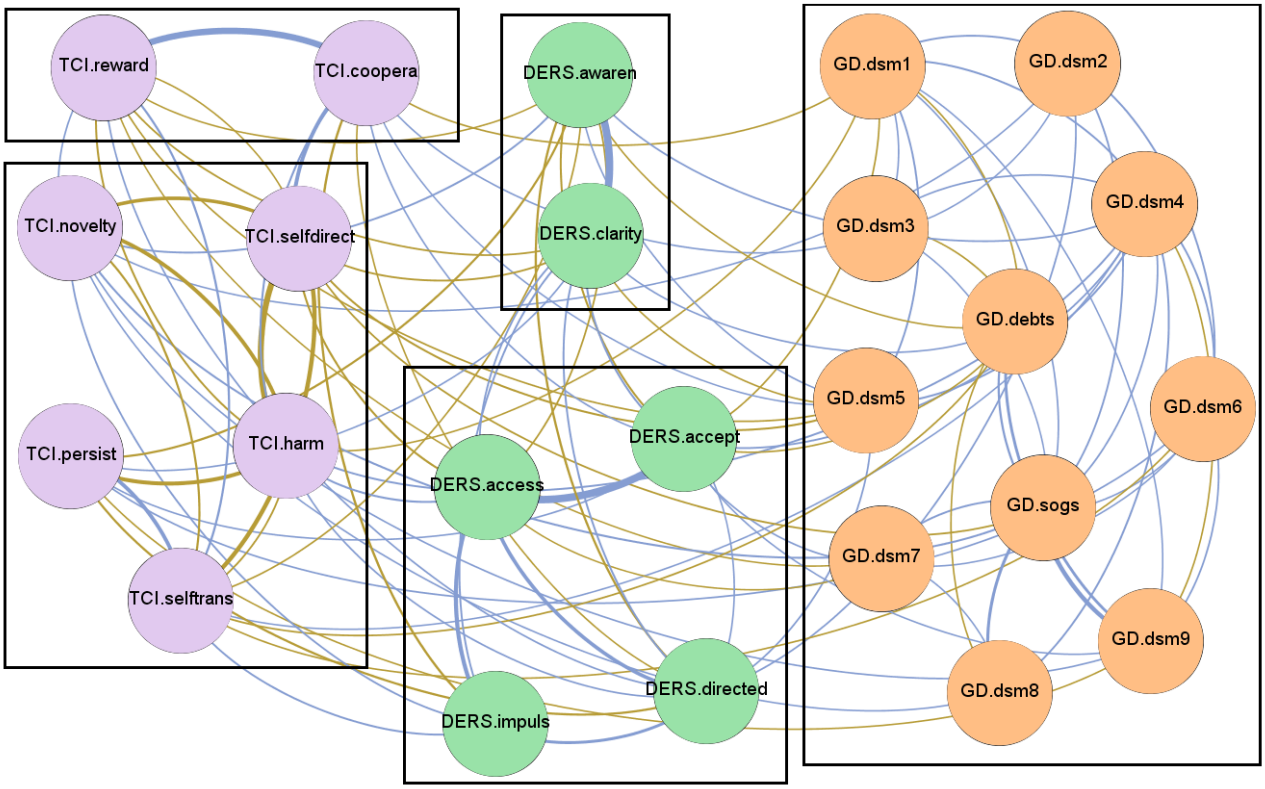

Table S1 (Supplementary) Results of the network

ID	Dimension	Label	Eigenvector Centrality	Authority	Closeness Centrality	Harmonic Closeness Centrality	Betweenness Centrality	Modularity Class	Clustering Coefficient	HUB	Number Triangles
GD.dsm1	Gambling	DSM-5 criterion 1	0.8215	0.2179	0.6389	0.7174	8.6511	1	0.4222	0.2179	19
GD.dsm2	Gambling	DSM-5 criterion 2	0.4832	0.1275	0.5750	0.6304	4.4024	1	0.3333	0.1275	5
GD.dsm3	Gambling	DSM-5 criterion 3	0.4971	0.1311	0.5476	0.6159	2.2212	1	0.5333	0.1311	8
GD.dsm4	Gambling	DSM-5 criterion 4	0.9001	0.2389	0.6571	0.7391	14.1699	1	0.3091	0.2389	17
GD.dsm5	Gambling	DSM-5 criterion 5	0.7628	0.2050	0.6053	0.6739	3.5668	1	0.5000	0.2050	14
GD.dsm6	Gambling	DSM-5 criterion 6	0.5418	0.1430	0.5750	0.6449	4.9508	1	0.3810	0.1430	8
GD.dsm7	Gambling	DSM-5 criterion 7	0.4701	0.1246	0.5750	0.6304	5.8805	1	0.2000	0.1246	3
GD.dsm8	Gambling	DSM-5 criterion 8	0.4095	0.1078	0.5227	0.5870	1.4083	1	0.4000	0.1078	4
GD.dsm9	Gambling	DSM-5 criterion 9	0.6907	0.1828	0.6053	0.6739	4.4669	1	0.4643	0.1828	13
GD.sogs	Gambling	SOGS: GD symptoms level	0.7902	0.2080	0.6571	0.7391	12.8592	1	0.3818	0.2080	21
GD.debts	Gambling	Debts related with GD	0.7550	0.2005	0.6216	0.6957	9.7694	1	0.3333	0.2005	12
DERS.accept	Emotions	DERS acceptance emotions	0.9463	0.2530	0.6571	0.7391	12.4692	2	0.3818	0.2530	21
DERS.directed	Emotions	DERS directed behaviors	0.9379	0.2524	0.6389	0.7319	10.6373	2	0.4364	0.2524	24
DERS.impuls	Emotions	DERS impulse control	0.5403	0.1453	0.5750	0.6304	2.4126	2	0.3333	0.1453	5
DERS.awaren	Emotions	DERS emotional awareness	1.0000	0.2684	0.6571	0.7391	8.3406	3	0.4364	0.2684	24
DERS.access	Emotions	DERS access emotions	0.7050	0.1897	0.5897	0.6667	4.9220	2	0.4286	0.1897	12
DERS.clarity	Emotions	DERS emotional clarity	0.8790	0.2367	0.6389	0.7174	6.6253	3	0.4667	0.2367	21
TCI.novelty	Personality	TCI-R novelty seeking	0.8060	0.2147	0.6389	0.7174	14.1345	4	0.2889	0.2146	13
TCI.harm	Personality	TCI-R harm avoidance	0.8979	0.2407	0.6389	0.7174	7.8813	4	0.3778	0.2407	17
TCI.reward	Personality	TCI-R reward dependence	0.8919	0.2398	0.6389	0.7174	7.6597	5	0.4667	0.2398	21
TCI.persist	Personality	TCI-R persistence	0.7359	0.1973	0.5750	0.6594	5.1626	4	0.4286	0.1973	12
TCI.selfdirect	Personality	TCI-R self-directedness	0.8032	0.2154	0.6216	0.6957	5.9336	4	0.4167	0.2154	15
TCI.coopera	Personality	TCI-R cooperativeness	0.7738	0.2076	0.5897	0.6812	8.5387	5	0.3889	0.2076	14
TCI.selftrans	Personality	TCI-R self-transcendence	0.8592	0.2298	0.6389	0.7174	9.9361	4	0.3556	0.2298	16

Note. GD: gambling disorder; DSM: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; SOGS: South Oaks Gambling Screen; TCI: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale. The DSM criteria for GD include as numbered above: [1] Needs to gamble with increasing amounts of money in order to achieve the desired excitement; [2] Is restless or irritable when attempting to cut down or stop gambling; [3] Has made repeated unsuccessful efforts to control, cut back, or stop gambling; [4] Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble); [5] Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed); [6] After losing money gambling, often returns another day to get even (“chasing” one’s losses); [7] Lies to conceal the extent of involvement with gambling; [8] Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling; and [9] Relies on others to provide money to relieve desperate financial situations caused by gambling.

Figure S1 (Supplementary). Main paths of "lack of awareness" and "lack of clarity"

Note. GD: gambling disorder; DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; TCI: Temperament and Character Inventory-Revised; DERS: Difficulties in Emotion Regulation Scale. The DSM criteria for GD include as numbered below: [1] Needs to gamble with increasing amounts of money in order to achieve the desired excitement; [2] Is restless or irritable when attempting to cut down or stop gambling; [3] Has made repeated unsuccessful efforts to control, cut back, or stop gambling; [4] Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble); [5] Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed); [6] After losing money gambling, often returns another day to get even ("chasing" one's losses); [7] Lies to conceal the extent of involvement with gambling; [8] Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling; and [9] Relies on others to provide money to relieve desperate financial situations caused by gambling.