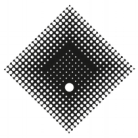
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Mapping the links between sexual addiction and gambling disorder: A Bayesian network approach

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ABSTRACT

Contemporary literature and recent classification systems have expanded the field of addictions to include problematic behaviours such as gambling and sexual addiction. However, conceptualisation of behavioural addictions is poorly understood and gender-based differences have emerged in relation to how these behaviours are expressed. The current research conducted partial-correlation and Bayesian network analyses to assess the symptomatic structure of gambling disorder and sexual addiction. Convenience community sampling recruited 937 adults aged 18 to 64 years (315 females, $M_{age} = 30.02$; 622 males, $M_{age} = 29.46$). Symptoms of problematic behaviours were measured using the Online Gambling Disorder Questionnaire (OGDQ) and the Bergen Yale Sex Addiction Scale (BYSAS). Results indicate distinct gender-based differences in the symptom networks of sexual addiction and gambling disorder, with a more complex network observed amongst men for both conditions. Addiction salience, withdrawal and dishonesty/deception were important components of the addictive network. Interpersonal conflict was more central for women while intrapsychic conflict a more prominent issue for men. Differences in the two symptom networks indicate separate disorders as opposed to a single underlying construct. Treating practitioners and community initiatives aimed at addressing sexual addiction and disordered gambling should consider gender, when designing educational or therapeutic interventions.

1. Introduction

Addiction is a pattern of repetitive engagement in a behaviour, with diminished capacity to reduce or control participation, leading to significant functional impairment or distress (Grant et al., 2010; Hakami et al., 2021). While addiction to psychoactive substances has long been established, behaviour-based addictions have been acknowledged by the Diagnostic and Statistical Manual of Mental Disorders (DSM; American Psychiatric Association, 2013) since only the fifth edition. However, taxonomy and aetiology of so called 'behavioural addictions' are poorly understood, resulting in controversy and debate regarding applicable theoretical models. For example, Petry et al. (2018) explains that while formal diagnosis of behavioural forms of addiction aids in prevention, treatment, and a reduction in morbidity, the fine line between habit formation, neurobiological abnormality, and potential minimisation of pronounced mental disorders such as schizophrenia is questionable, due to the poor introduction of behavioural addiction constructs. Therefore, some scholars have legitimately expressed concerns regarding over-pathologizing common, everyday behaviours (Billieux et al., 2015; Kardefelt-Winther et al., 2017), while others argue the merits of addiction being viewed as a specific brain disease (Pickard et al., 2015; Valkow and Koob, 2015; West and Brown, 2013). Meanwhile, the syndrome model of addiction (Shaffer et al., 2004, 2018) suggests the specific object of desire (i. e. the internet in the online addictions) is merely a manifestation of an underlying addictive disease (Gomez et al., 2022). The latter theory may help explain frequent co-occurrence of addictive disorders, or the phenomenon of cross-addiction, where one form of addiction is substituted with another (i.e. addiction hopping; Zarate et al., 2022). Indeed, cross-addiction occurs frequently when in recovery, or if access to the original addictive substance or behaviour is otherwise restricted (Carnes et al., 2004; Weiss, 2018).

According to Griffiths (2005), the following six components are (or should be) shared by all behaviours considered addictions: salience - the activity dominates the individual's thoughts, such that engaging in the behaviour becomes the most important activity in the individual's life; mood modification - the subjective experience of engagement in the

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activity, often referred to as a 'buzz' or 'high'; tolerance - where the individual needs to use more or spend more time engaged in the activity to receive the same feeling (e.g. gratification initially and reduced negative feelings later on; Gomez et al., 2022); withdrawal - unpleasant feeling state or physiological effect when the behaviour is suddenly stopped or reduced; conflict - interpersonal or intrapsychic conflict related to engagement in the activity; and relapse - returning to previous patterns of engagement after a period of abstinence, despite often consciously aiming the opposite. While these components are observed across the spectrum of addictive disorder(s), both behavioural and substance-based, the study of non-substance-based addictions provides opportunity to better understand issues related to addictive psychological processes, in isolation of the direct physical effect substances have on neurological structure and functioning (Petry, 2015). To address this recommendation, the present study will emphasize the links between gambling disorder (i. e. a formally recognised addiction type) and sexual addiction (a proposed, yet still debated type; Zarate et al., 2022).

1.1. Gambling disorder

Excessive gambling as a psychological phenomenon was first described in literature in 1914, attributed at the time to psychosexual and Oedipal conflicts (von Hattinger, as cited in Hunt and Blaszczynski, 2019). Prior to the current classification of gambling disorder (GD) as addiction, third and fourth editions of the DSM categorised 'pathological gambling' as an impulse control disorder. As understanding and conceptualization of GD has evolved, a multitude of screening tools have been developed, each emphasizing different behavioural components of the disorder (e.g. mood modification, withdrawal, functional impairment), varying the criteria for the determination of disordered gambling behaviour (Hodgins et al., 2011). Moreover, while the terminology 'problem gambling' and 'gambling disorder' are often used interchangeably within literature, discrimination should be made between the clinically symptomatic nature of gambling disorder as an addiction, versus the subjective judgement of harm described by the concept of problem gambling (Hunt and Blaszczynski, 2019). Nonetheless, a recent systematic review indicates the prevalence of disordered gambling globally to fall between 0.4 and 5.8% dependent upon geographic location and measurements used to assess disordered behaviour (higher prevalence generally noted in North American, Asian and African nations; Calado and Griffiths, 2016). The diversity of the prevalence rates reported should of course be viewed in relation to the methodological variations, the discrepancies and the deficits of the measurements employed (Otto et al., 2020). Taking these into consideration, it is understood that three to four times as many people experience problems at a sub-clinical level (Abbott, 2020), while more than one third of people experiencing problems with gambling indicate a high state of distress (Rockloff et al., 2020).

1.2. Sexual addiction

As with the evolution of GD, many labels have been used to describe excessive and problematic sexual behaviour including sex addiction, hypersexuality, sexual impulsivity, and sexual compulsivity to name a few (Zarate et al., 2023). Within this context, and while earlier versions of the DSM validated sexual addiction as a sexual disorder, the fourth edition removed the term 'addiction' due to a lack of empirical research and consensus in how to best conceptualise the behaviour (Kafka, 2010). While contention exists whether hypersexual behaviour is more accurately categorised as a disorder of impulse control or a compulsive behaviour (Kor et al., 2013; Walton et al., 2017), the concept of addiction includes a behavioural pattern with capacity to incorporate either, or both, compulsive and impulsive urges, (Giugliano, 2009). Nevertheless, other studies argue that: a) an addiction tends to be pleasure seeking, at least when it starts, in contrast with compulsive behaviours, which are harm/distress avoidant and; b) impulse control and compulsive disorders are ego-dystonic, while addictions can be initially ego-syntonic (Stavropoulos et al., 2016). Within the context of such discussions in the literature, recent changes to the International Statistical Classification of Diseases and Related Health Problems (11th ed.; ICD-11; World Health Organisation, 2019) include compulsive sexual behaviour disorder as an impulse control disorder, reflecting a rather conservative categorisation while still acknowledging problematic hypersexual behaviour (Kraus et al., 2018). Although the ICD-11 stops short of describing the disorder as an addiction per se, described characteristics tend to align with those of addictive disorder as defined in the DSM-V.

Such inconsistent terminology and classification may enhance stigmatisation of population groups at higher risk for disordered sexual behaviour (e. g. same-sex orientated males; Jaspal and Jaspal, 2019). Since diagnostic criteria remain uncertain, and unanimously accepted information cannot be disseminated to the public to improve awareness or understanding, it is likely that instead of acknowledging the behaviour as a condition, this may be misinterpreted as a manifestation indicative of a specific group (Hall, 2014; Lindsay et al., 2020). This could hamper the development of evidence-based intervention (Kingston and Firestone, 2008), whilst resulting in inconsistent measurement of the effected populations, with prevalence reported to fall anywhere between 3 and 10%, largely dependent upon criteria used to assess disorder, and the populations assessed (Brewer and Tidy, 2017). Despite this, contemporary neurobiological and neuropsychological findings support that excessive sexual behaviour falls within the bounds of addictive disorder (Carnes and Love, 2017). Moreover, progression often conforms to the addictive cycle, with successful treatment relying upon addiction-based modalities (Garcia and Thibaut, 2010; Rosenberg et al., 2014). As such, the current study will incorporate the various labels and operationalise such behaviour through the lens of behavioural addiction.

1.3. Sex, gambling and gender

Evidence suggests sexual addiction (henceforth SA) and GD share similar psychological and biological processes (Rosenberg et al., 2014), including reward system activation (Fujiwara et al., 2022). Links have been demonstrated by the onset of hypersexual behaviour and disordered gambling reported amongst Parkinson's patients treated with dopamine agonists (Bostwick et al., 2009). Furthermore, performance on the Iowa Gambling Task suggests a particular propensity for risk-taking amongst hypersexual men (Mulhauser et al., 2014). Indeed, similarities between SA and GD have been reported elsewhere relating to risk-taking and personality domains such as sensation seeking (Farre et al., 2015; Zuckerman, 2007), history of childhood trauma or neglect (Miller, 2010) and higher rates of suicidal ideation and attempt, when compared to other forms of addiction (Valenciano-Mendoza et al., 2021). Moreover, comorbidity between GD and SA has been reported to fall between 9.4% and 30.9% (Derbyshire and Grant, 2015), with Grant and Steinberg (2005) reporting disordered sexual behaviours manifesting prior to gambling problems in 70% of individuals meeting criteria for both.

Although GD and SA share similarities, symptomology and predisposing factors appear differently for men and women. For example, higher prevalence has been reported amongst men for SA (Öberg et al., 2017), GD (Merkouris et al., 2016) as well as co-occurrence of both disorders (Grant and Steinberg, 2005). Indicatively, concerning GD, gender differences have been reported in relation to betting preferences; men tend to prefer games perceived as skilful such as poker or sports-betting; women prefer games of chance, such as lotteries and poker machines (Baggio et al., 2018). Amongst gamblers, gender differences have been observed in neurocognitive domains such as attentional bias (Mallorqui-Bague et al., 2021), explaining why men are more likely to respond to gambling-related stimuli (Zakiniaeiz and Potenza, 2018). Moreover, men report more frequent comorbidity with substance

use disorders (Merkouris et al., 2016). Conversely, *telescoping* - a phenomenon where the activity is engaged later in life, with levels of engagement rapidly becoming disordered - is more common amongst women (Merkouris et al., 2016; Zakiniaeiz and Potenza, 2018). In that line, some argue that men tend to be at higher risk across the addictive spectrum, except maybe addictions related to food, partially due to gender specific socialization practices, which discourage them from expressing their feelings as indicative of being less maculine, thus pushing them to addiction-induced mood-modification (Stavropoulos et al., 2013). For individuals afflicted with SA, gender differences have been observed relating to comorbid psychopathologies including ADHD, depression and anxiety (Kürbitz and Briken, 2021), as well as personality traits (Slutske et al., 2013), with males displaying higher levels of neuroticism (Shimoni et al., 2018). Additionally, men are reported to engage more frequently with pornography and masturbation than women, who are more likely to exclusively seek physical sexual encounters with higher numbers of opposite sex partners (Brewer and Tidy, 2017; Öberg et al., 2017). Given the relationship between SA and GD, together with gendered differences in how these behaviours manifest, deeper understanding of the symptomatic network is warranted. Adding to insight already provided by studies which assess comorbidity at the construct level, network perspectives may inform strategies for earlier detection and more effective, gender-specific treatment of one or both disorders.

1.4. Network analysis and the Bayesian network model

As opposed to latent construct models, network theory in psychopathology is grounded in the idea that interactions amongst symptoms or elements give rise to episodes of mental disorder (McNally, 2021). Network analysis explores the relationships between symptoms of a disorder, attempting to identify specific relationships which act to sustain or maintain the given disorder, or create 'bridges' between comorbid conditions (Borsboom, 2017). Network graphs consist of nodes, representing the symptom or scale item being measured; and edges, which represent the statistical relationship between the nodes. Identification of symptoms which are central provides better understanding of psychopathological conditions, also offering insight towards targeted intervention and prevention strategies (Fried et al., 2017). However, identifying central symptoms is not enough as we do not understand whether those symptoms are more likely to activate, or *be activated by* other symptoms in the network (McNally, 2021).

While partial correlation networks reveal the joint probability distribution amongst nodes (Borsboom et al., 2021), Bayesian networks are probabilistic models which predict the direction and magnitude of relationships between nodes in the network (Briganti et al., 2021). Where a relationship exists between two nodes, a directed acyclic graph (DAG) demonstrates whether symptom A is more likely to activate symptom B or vice versa. A DAG highlights the conditional dependence of two nodes in a network indicating that the presence of a descendant node is more likely given the presence of a parent node (McNally et al., 2022). Where nodes are separated by other nodes within the DAG, this indicates they are independent in probability after controlling for other symptoms or variables within the network (Briganti et al., 2021). Partial correlation and Bayesian network approaches complement each other, providing different perspectives on relationships between symptoms of mental disorders, not dissimilar to the way in which the mean and median provide separate characterisations of central tendency (McNally et al., 2022).

1.5. Research aim

Previous research has explored comorbidity and gender differences of SA and GD, however little research has investigated these disorders from a symptom network perspective. Only one study has analysed the network structure in relation to gambling and gender differences (Baggio et al., 2018). However, the screening tool used to assess the symptoms of gambling, the Problem Gambling Severity Index, is designed to measure difficulties related to problem gambling, such as social and financial implications; it falls short in assessing gambling as a pathological construct or addiction per se (Petry, 2015). Given the association between GD and SA, together with gender-based expressions of disorder, the current study aimed to analyse the network structure and centrally positioned symptoms of both GD and SA as they relate to gender. Additionally, the study will report, by way of DAGs, the most probable direction of symptom activation. Identification of central symptoms and activation sequences within these symptom networks adds to theoretical understanding of behavioural addiction, and may inform effective and targeted intervention strategies by practitioners in the field of addiction treatment.

2. Method

2.1. Participants

Participants were recruited by way of convenience sampling through links placed on social media, online forums and Victoria University, and Australian Psychological Society websites. Voluntary participation was open to English speaking adults in the general community. Participants were provided a plain language information statement outlining the nature of the study prior to digitally obtaining consent. Participants completed a battery of self-report measures including the measures described below, as well as demographic information. Data were captured using Qualtrics (2022) and all participant identifying information (e.g. IP address) was excluded to ensure privacy.

The initial sample included responses from 968 adults, however, considering the focus of this study, 31 participants who identified as gender diverse were excluded from the final analysis. A total of 937 participants were included in the final sample. Participants were aged 18 to 64 years ($M = 29.65$, $SD = 9.45$), consisting of 315 females (33.6%; $M_{age} = 30.02$, $SD = 10.39$) and 622 males (66.4%; $M_{age} = 29.46$, $SD = 8.93$). The majority of participants identified as white (61.2%). Most participants had completed high school or above (88.4%) with the majority having completed at least some tertiary education (62.8%). Collectively, almost half of participants were engaged in either full-time employment (34.6%) or study (14.4%), while 19.2% reported they were unemployed. Full descriptive data is included in Supplementary Table 1.

2.2. Materials

2.2.1. Online gambling disorder questionnaire (OGD-Q)

As understanding and classification of GD has evolved, elements within screening tools have measured the construct in various ways (Petry, 2015). The Online Gambling Disorder Questionnaire (OGD-Q; González-Cabrera et al., 2020) was used to assess risk of GD since it is a recent measure, most closely aligned with diagnostic criteria of GD as currently described by the DSM-V (Montiel et al., 2021). The OGD-Q consists of 11 items (for example, "do you feel nervous, irritated, or angry when trying to reduce or stop gambling?") measured on a five-point Likert scale (1 = never, 5 = every day). Higher scores indicate increased risk of GD. GD is endorsed if a person scores on four or more items for a twelve-month duration. Within the current sample, the instrument demonstrated excellent internal consistency (Cronbach's α - 0.95; McDonald's ω = 0.96).

2.2.2. Bergen Yale sex addiction scale (BYSAS)

The Bergen-Yale Sex Addiction Scale (BYSAS; Andreassen et al., 2018) was utilised as a measure of SA within the current study. The BYSAS consists of six items (such as "used sex/masturbation to forget/escape personal problems") on a five-point Likert scale (0 = very rarely, 4 = very often). Higher composite scores indicate a higher risk of SA, with endorsement of SA reliant upon scoring three or higher on at

least three scale items. Within the current sample, the instrument demonstrated good internal consistency (Cronbach's α = 0.83; McDonald's ω = 0.89).

Items contained within both scales endorse Griffith's (2005) six components of addiction (i.e. salience, mood modification, tolerance, withdrawal, conflict, and relapse). Table 1 displays scale items and the associated component under Griffiths' model.

2.3. Procedure

All statistical analyses and graphical outputs were generated using R Studio (R Core Team, 2022). The Powerly package for R (Constantin et al., 2021) was used to determine the recommended sample size with acceptable statistical power for a Gaussian graphical model with 17 nodes (n = 309, 95% CI = 298–319, 1-β = 0.8, sensitivity = 0.6). Data were screened (MCAR = 0.12%) and Predictive Mean Matching (PMM) with 50 iterations was used to impute data for missing values using the *mice* package in R (Van Buuren and Groothuis-Oudshoorn, 2011).

2.3.1. Non-directed partial correlation network

The first stage of analysis followed the structure outlined by Epskamp et al. (2018) and involved calculating a Gaussian graphical model to estimate and evaluate the network using the *bootnet* package in R (Epskamp and Fried, 2015). Least Absolute Shrinkage and Selection Operator (LASSO) regularisation method was used employing Extended Bayesian Information Criterion (EBIC). This process reduces the likelihood of reporting false edges by estimating a sparse network and reducing trivial coefficients to exactly zero (Tibshirani, 1996). Higher centrality values suggest the importance of the symptom in the overall network with strength centrality and expected influence of particular relevance to psychological networks (McNally et al., 2022). Bridge centrality refers to the importance of the node in activating symptoms across disorders. Stability of centrality indices were assessed by *case-dropping subset bootstrapping* in which the Correlation Stability Coefficient should not fall below 0.25, ideally remaining above 0.5 (Epskamp et al., 2018). The resulting network and centrality indices were plotted using the *qgraph* package in R (Epskamp et al., 2012). Invariance between male and female network structure and global strength was assessed using random permutation testing via the *network comparison test* package in R (van Borkulo et al., 2022).

2.3.2. Bayesian network (directed acyclic graph)

The second stage of analysis involved learning the Bayesian network structure in order to produce a DAG representing directional probability of relationships within the network model. This was accomplished following the Bayesian network modelling procedures recommended by Briganti et al. (2021), utilising the *bnlearn* package in R (Scutari, 2010). A hill climbing algorithm computed goodness of fit by adding and removing edges and calculating scores based on Bayesian Information Criterion (BIC). Edges which appear more frequently between nodes are assigned greater scores for strength and directional probability. Non-parametric bootstrapping computed 5000 iterations to obtain a stable network structure, the network was then averaged while retaining only the relationships appearing in 85% of the models produced. Although statisticians have devised more sensitive methods for retaining edges (Nagarajan et al., 2013; Scutari, 2010), a significance threshold of 0.85 results in a sparser network, depicting only the most legitimate edges in the model (Briganti et al., 2021; McNally et al., 2017). The final DAG depicts the directional probability where direction of the relationship between the nodes was determined to occur in more than 50% of cases sampled. Graphic visualisations were produced using the package *bnviewer* (Fernandes, 2019).

Table 1
- Scale item descriptions and associated component as related to Griffiths' (2005) component model of behavioural addiction.

Node/ Item number	Scale Item	Associated Component[a]	Brief description
BYSAS items			
S1	Spent a lot of time thinking about sex/masturbation or planned sex	Salience	Spend time thinking about sex
S2	Felt an urge to masturbate/ have sex more and more	Tolerance	Increased sexual urges
S3	Used sex/masturbation in order to forget/escape from personal problems	Mood modification	Use sex to escape
S4	Tried to cut down on sex/ masturbation without success	Relapse	Unsuccessful attempts to reduce
S5	Become restless or troubled if you have been prohibited from sex/masturbation	Withdrawal	Restless or troubled if prohibited
S6	Had so much sex that it has had a negative impact on your private relationship, economy, health and/or job/studies	Conflict	Sex has negative impact on life
OGD-Q items			
G1	Do you feel the need to spend more and more money to get the high you desire?	Tolerance	Gamble more money to achieve same high
G2	Do you feel nervous, irritated or angry when trying to reduce or stop gambling?	Withdrawal	Irritated or angry when trying to reduce
G3	Have you tried to control, reduce or stop gambling and have not been able to do so?	Conflict: Intrapsychic[b]	Unsuccessful attempts to reduce
G4	Have you ever felt that gambling has had negative consequences at a personal, social, family, or academic/ work level, and you have still continued to gamble?	Conflict: interpersonal	Continue despite negative consequences
G5	Do you often think about gambling, for example, remembering past bets, planning your next bets, thinking about ways to make more money gambling, reliving some moments related to gambling, etc.?	Salience	Spend time thinking about gambling
G6	Do you bet or gamble when you feel sad, anxious, or guilty, in order to feel better or to stop thinking about how you feel?	Mood modification	Use gambling to escape
G7	Do you feel like you have little control over gambling (e.g., gambling more than you would like, spending more money than you would like, gambling in places where you shouldn't do that, not being able to stop gambling when you want to)?	Conflict: Intrapsychic	Have little control over gambling
G8	After losing money on a bet or in gambling, do you usually gamble again to try to get that money back?	Gambling[c]	Chasing losses
G9	Do you lie to others to conceal how much time you gamble or how much you actually spend on gambling?	Gambling[c]	Lie about gambling

(*continued on next page*)

Table 1 (*continued*)

Node/ Item number	Scale Item	Associated Component[a]	Brief description
G10	Have you ever asked someone for money to improve or overcome the bad economic situation that gambling has caused you?	Gambling[c]	Borrow money due to gambling
G11	Have you felt that you prioritized gambling over other areas of your life that had been more important before (e.g., studying, hanging out with friends, sleeping less if you gamble at night, etc.)?	Salience	Prioritise gambling over other aspects of life

[a] Component as associated with Griffith's component model of addiction (2005).
[b] Although labelled under Conflict, this item is identical in nature to the item for relapse as included in the BYSAS.
[c] Item is specific to gambling disorder and does not fit criteria for Griffiths' model.

3. Results

3.1. Partial correlation networks – Gaussian graphical model

Case-dropping subset bootstrap assessed stability of the estimated network indicating a high level of correlation between bootstrap samples and original values. The CS coefficient for strength was observed at 0.59 and for expected influence at 0.67. Results are displayed in Fig. 1. Network comparison tests confirmed invariance between male and female network structure ($M = 0.26$, p=.48) and invariant global strength ($S = 0.02$, p=.93).

Networks for GD and SA are displayed separately for male and female participants in Fig. 2a and Fig. 2b respectively. Of 136 possible edges, the male network displayed 73 non-zero edges, while 58 were observed for the female network. The vast majority of relationships were positive. The clustering of nodes suggests that SA and GD are distinct constructs, however connection between the nodes of each disorder appear differently for the male and female subgroups.

The strongest edge weights for both genders appear between time spent thinking about sex (S1) and increased sexual urges (S2). Table 2 displays the top ten ranking edge weights across the network. Not surprisingly, edge weights were strongest within rather than between disorders. All edge weights between disorders were small in magnitude, the largest coefficient observed at 0.14 between G11 and S6, a relationship observed only within the female network model. A full edge weight correlation matrix is included in Supplementary materials. Complete network output is included in Supplementary materials 2.

Fig. 3a displays centrality plots by gender. Increased sexual urges (S2) and becoming irritated when reducing gambling (G2) were prominent across both networks, with gambling despite negative consequences (G4) displaying the strongest number of connections in females, whereas using gambling to escape (G6) was a more central feature within the male network. Clear distinctions emerged between centrality metrics across genders for gambling more to experience the same high (G1), gamble despite negative consequences (G4), and unsuccessful attempts to reduce sex (S4). Nodes acting to bridge the two disorders also appeared differently for males and females as highlighted in Fig. 3b. Tables displaying centrality indices are included in Supplementary Materials.

3.2. Directed acyclic graph (Bayesian approach)

DAGs highlighting directional relationships between symptoms of SA and GD are displayed in Fig. 4a and 4b for male and female networks respectively. With significance threshold set at 0.85, there is no observable relationship between disorders for either the male or the female network. A greater number of influential relationships were found in the male network displaying 23 directed arcs, whereas 14 arcs were observed within the female network. Interestingly, sexual relapse (S4) was observed to lead to sexual withdrawal (S5) within the female network (Strength (S) > 0.99, Direction (D) = 0.93), however this relationship was reversed in the male network (S > 0.99, D = 0.59). Table 3 presents estimated strength and direction of relationships

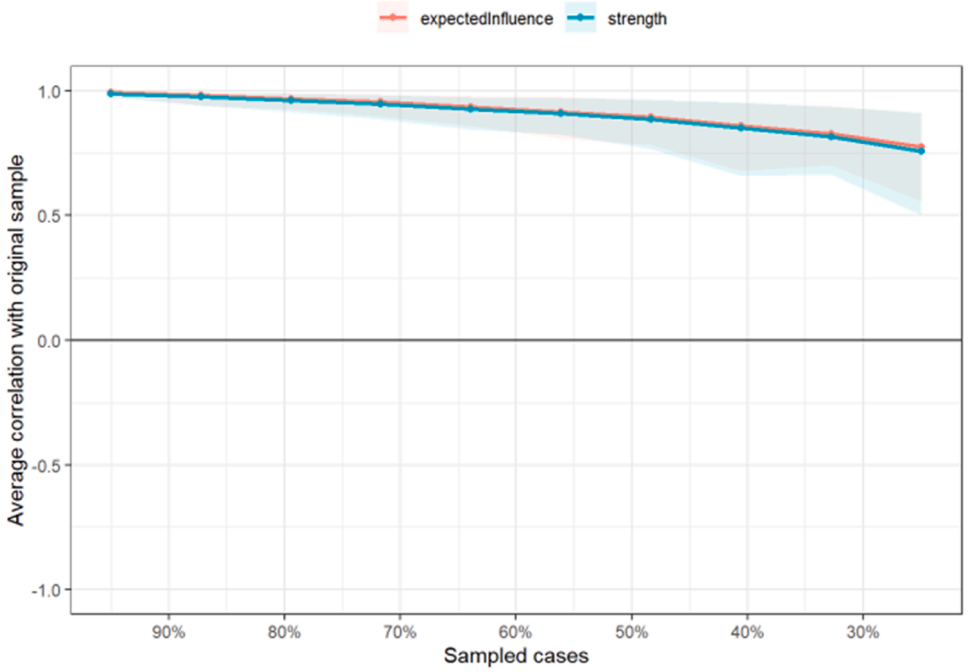

Fig. 1. Case-dropping subset bootstrap. Results indicate correlation between bootstrapped data and original observations for strength and expected influence as cases are progressively dropped from the sample.

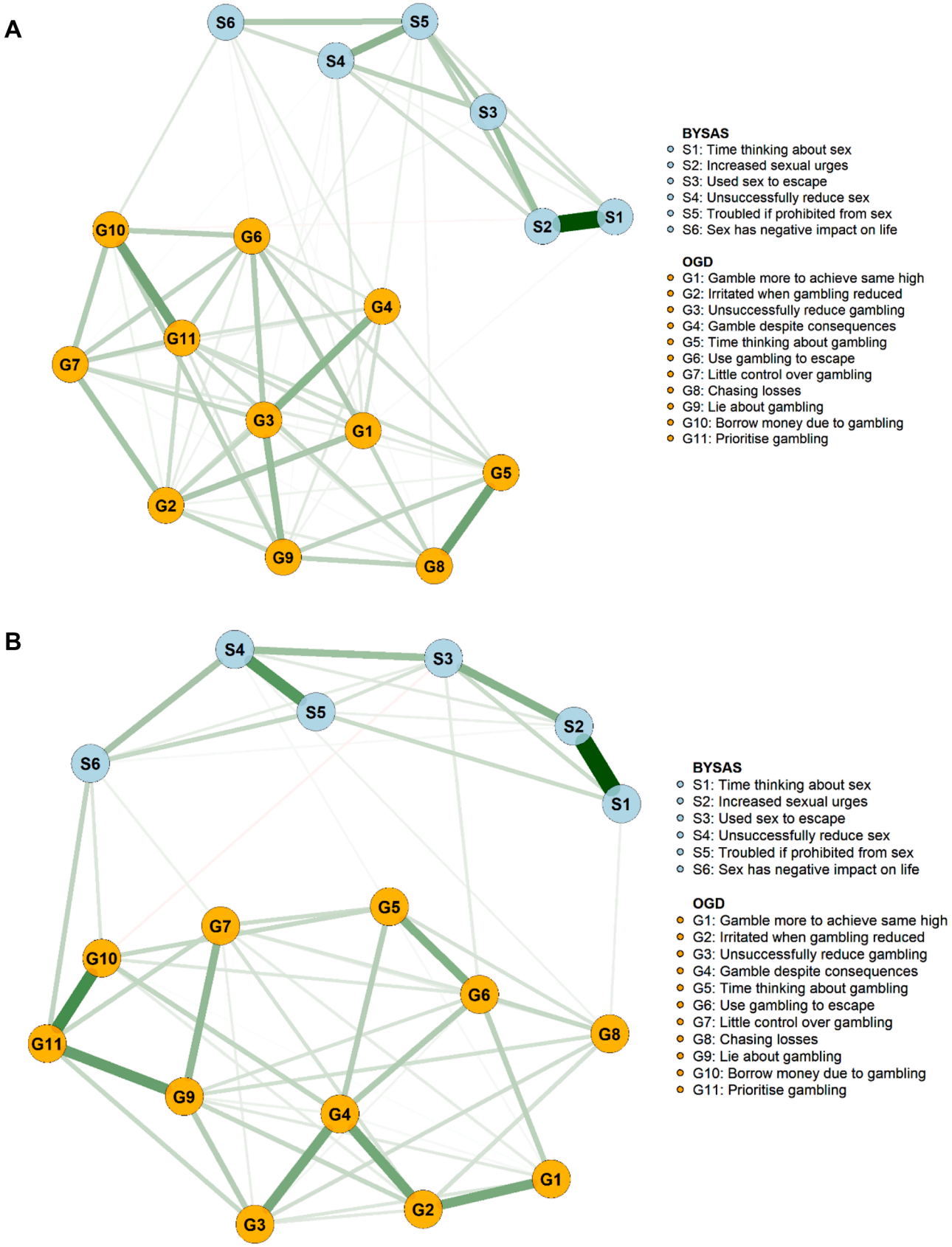

Fig. 2. **a.** Male partial correlation network displaying symptoms of gambling disorder and sex addiction. **b.** Female partial correlation network displaying symptoms of gambling disorder and sex addiction.

Table 2
Top ten edge weights across male and female networks of sex addiction and gambling disorder.

Top 10 edge weights – Female network			Top 10 edge weights – Male network		
Edge between		$r_{partial}$	Edge between		$r_{partial}$
S1	S2	.60	S1	S2	.59
G10	G11	.41	G5	G8	.32
S4	S5	.37	G10	G11	.31
G9	G11	.34	S4	S5	.25
G2	G4	.31	G3	G4	.25
G1	G2	.30	G3	G9	.23
G3	G4	.30	S2	S3	.21
G5	G6	.27	S5	S6	.19
S2	S3	.26	G1	G2	.19
G7	G9	.25	G2	G7	.19

between male and female networks. Supplementary Material 3 includes complete Bayesian network output.

4. Discussion

The present study is the first of its kind aiming to analyse the network structure of relationships between symptoms of SA and GD as they related to gender, in a large, normative, community sample. The study further pioneered in aiming to analyse the probable direction of relationships observed within the SA-GD network, in an attempt to understand symptom activation sequences of these two forms of behavioural addiction(s). To the authors' knowledge, this is the first study to assess the specific network structure of GD and SA together, and to employ an advanced Directed Acyclic Graph Bayesian Network to: a) analyse symptomatic relationships amongst these disorders, whilst taking into consideration one's gender; and b) investigate directional relationships between self-report measures of SA and GD within the general population. Findings generate significant new knowledge regarding the links between SA and GD symptoms, which generate potentially significant practice implications.

4.1. Sexual and gambling addictions

While some overlap occurred between symptoms of SA and GD within the partial correlation network, edge weight coefficients were weak, and network structures revealed the two disorders are indeed distinct constructs. This was reaffirmed by Bayesian modelling in which no relationship was observed between symptoms of the two disorders utilising conservative thresholds (relationships detected in at least 85% of observations). These results suggest that GD and SA are contingent upon symptomatic relationships unique to the behaviour of concern, rather than forming different behavioural manifestations of the same underlying construct (i.e. general addictive inclinations). These findings seem at odds with a syndromic model of addiction which hypothesises a singular addiction with various chemical and behavioural expressions (Grant et al., 2012; Shaffer et al., 2004, 2018; Gomez et al., 2022). Moreover, these findings reinforce the importance of properly understanding the symptomatic structure of distinct types of addiction(s), as well as legitimate inclusion criteria for the categorisation of behavioural addiction, in order to avoid a false widening of the addictive spectrum (Billieux et al., 2015; Kardefelt-Winther et al., 2017; Zarate et al., 2022).

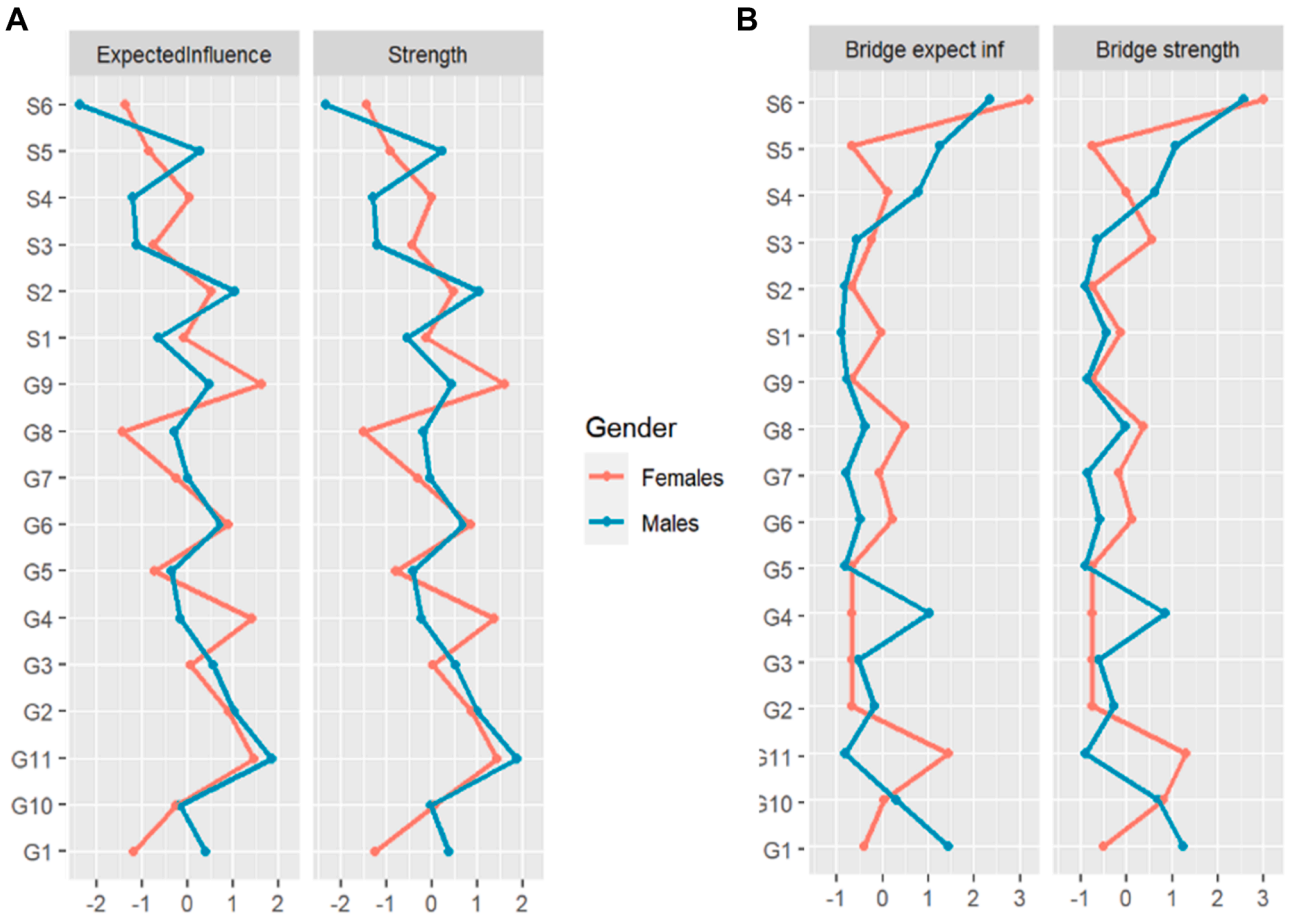

Fig. 3. a. Centrality metrics for the network depicting standardised measures for strength and expected influence separated by gender. **b**. Centrality metrics for bridge symptoms within the network depicting standardised measures for strength and expected influence separated by gender.

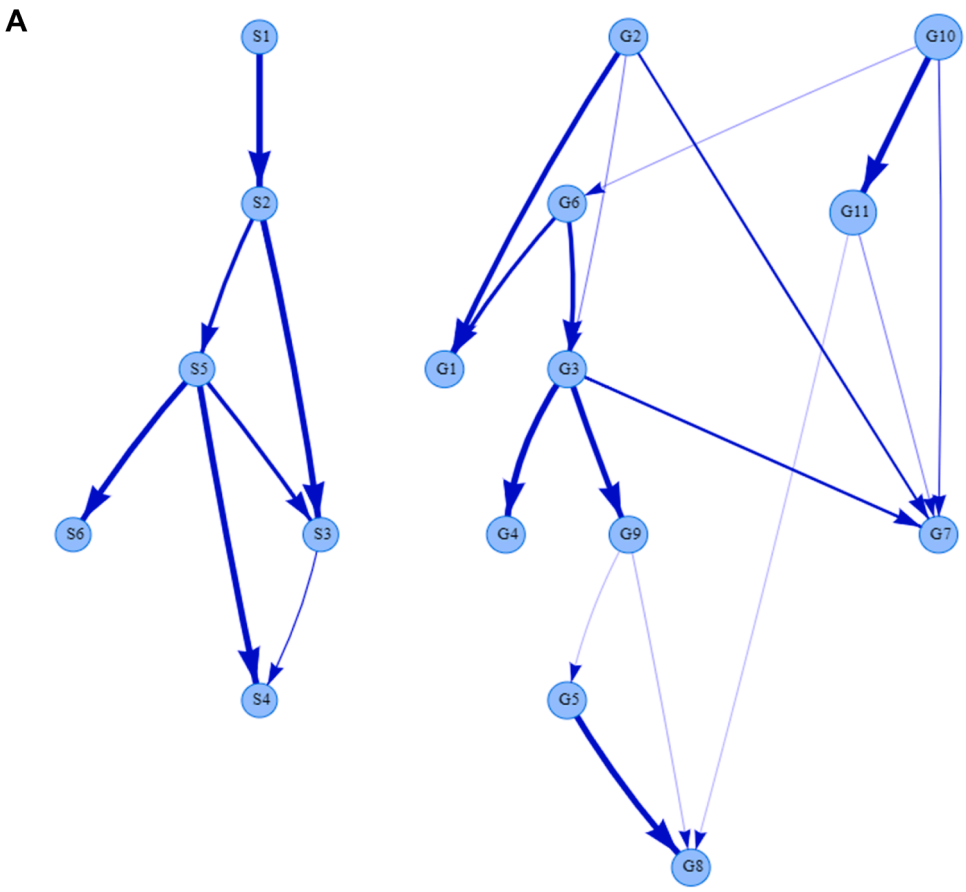

Fig. 4. a. Directed Acyclic Graph (DAG) representing directed relationships between gambling and sex addiction with threshold set at 0.85 for males. **b**. Directed Acyclic Graph (DAG) representing directed relationships between gambling and sex addiction with threshold set at 0.85 for females.

4.2. Interrelationships between symptoms and the role of gender

Differences were observed between male and female networks in terms of network sparsity and specific relationships considering symptoms of SA and GD. Overall, females displayed sparser relationships for both partial correlation and Bayesian network models considering both disorders. However, for men, a more complex symptom network acts to sustain both SA and GD. These findings may shed light onto the higher prevalence of both disorders reported amongst men (Grant and Steinberg, 2005; Merkouris et al., 2016; Öberg et al., 2017). Alternatively, a simplified network structure may explain why women are observed to move through the various stages of addiction, from first exposure to dependence, more quickly than men (Becker and Koob, 2016). Moreover, Becker et al. (2016) report that women are more susceptible to relapse and addictive engagement following stress related cues, particularly when there is a history of trauma, while men are more susceptible to stimuli-related cues such as imagery or paraphernalia. Speed of dependency and stress-related engagement in females have been replicated in animal studies of substance addiction, indicating differences in addictive tendency between men and women may be based in both biology as well as psychosocial factors (Becker and Koob, 2016; Becker et al., 2016).

Time spent thinking about sex (i.e. salience) led to increased sexual urges (i.e. tolerance) across both genders and this represented the strongest edge weight observed within the partial correlation model. However, no direct link was established between salient features of gambling and gambling tolerance. In development of the BYSAS, Andreassen et al. (2018) identified local dependence between these two scale items which may explain the strength of relationships detected. Subjective appraisal of these scale items might result in similar responses amongst participants, if increased time spent thinking about sex is interpreted as synonymous with increased urges to have sex. Moreover, more frequent desires for sexual activity do not necessarily indicate an increase in intensity of sexual behaviour. Interestingly, increased sexual urges led to using sex to escape from personal problems, resulting in an inability to reduce sexual behaviour across both genders.

Strong relationships were observed between borrowing money and prioritising gambling over other life aspects/domains, however the directional probability was only marginally in favour of borrowing money as the parent node. A further similarity between men and women suggests that gambling tolerance was an end result of using gambling to escape, as well as experiences of gambling withdrawal. Griffiths (1993) first associated tolerance with increased excitement in gamblers by comparing heart rates of regular and non-regular gamblers. Alternative views suggest that increased bet sizes could be more closely associated with chasing losses as a behavioural strategy to recover from gambling debts (Blazzczynski et al., 2008; Lee et al., 2020). The current study found very little association between tolerance and chasing losses and suggests that tolerance is more closely associated with mood modification. However, chasing losses resulted from addiction salience amongst men, chasing losses was also observed to follow from deception about gambling behaviour. Moreover, women were more likely to perceive a lack of control over gambling or prioritise gambling over other aspects of life following dishonesty about their gambling behaviour. Lying to conceal gambling behaviour causes significant harm to marital and interpersonal relationships of gambling addicts (Hunt and Blaszczynski, 2019); Dąbrowska and Wieczorek (2020) suggest that this dishonesty may result from internalised stigma. Sociocultural factors may well

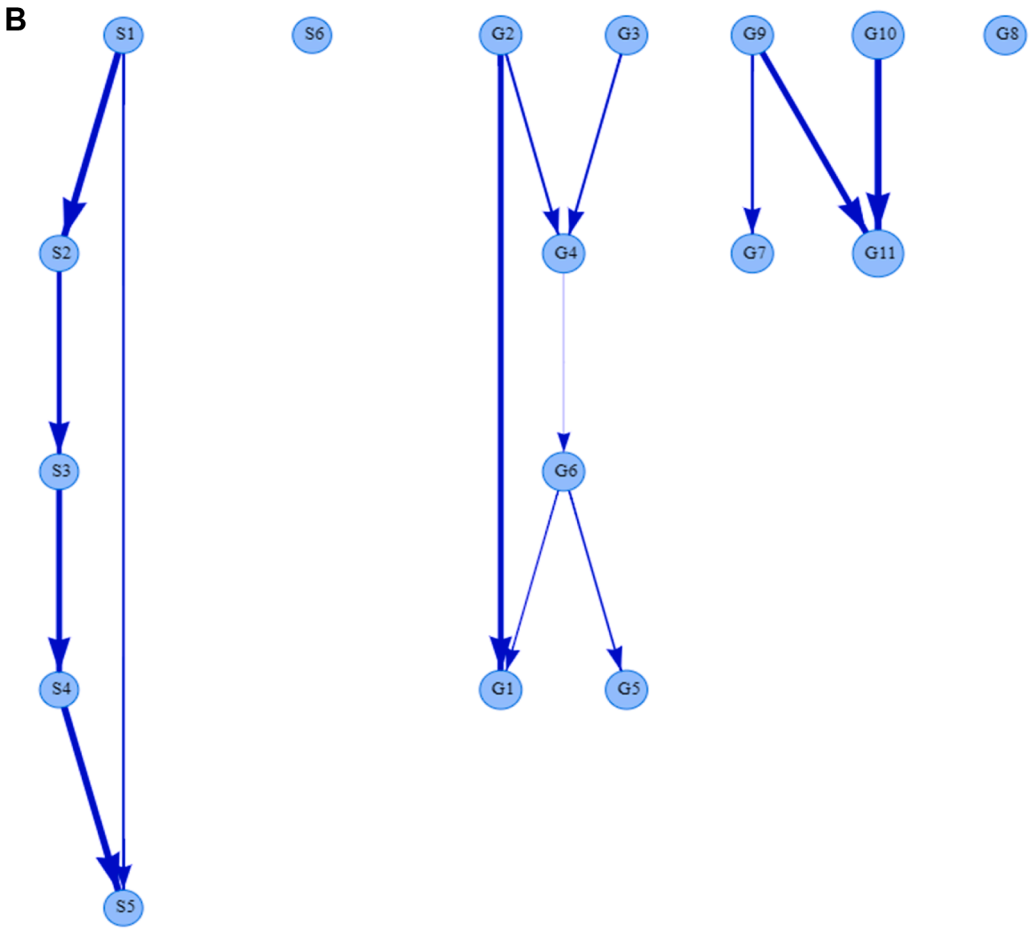

Fig. 4. (*continued*).

contribute to higher stigmatisation of women experiencing problems with addiction or engagement with addictive-type behaviour (Becker et al., 2016), explaining why women were observed to use dishonesty in relation to gambling prior to experiencing a lack of control. Nonetheless, the current study supports links between dishonesty and intrapsychic conflict, suggesting direct connection with an inability to control gambling behaviour, resulting in the reinforcement of addiction salience. Moreover, some men may chase losses in an attempt to cover up dishonesty about gambling engagement. While deception was not emphasized in the context of SA, the current study indicates that deception is a central feature of the addictive cycle amongst gamblers, a feature which acts to reinforce addictive salience and perceived control over behaviour.

Withdrawal was a further component presenting unique relationships with symptoms of each disorder dependent upon gender. While withdrawal led to an increased tolerance for gambling across both genders, women were found to continue gambling despite negative consequences to personal, social and familial relationships when withdrawal was present. For men, withdrawal led to a lack of control over gambling behaviour. These findings highlight that in relation to GD, withdrawal is more likely to result in interpersonal conflict for women, and intrapsychic conflict for men. This subtle nuance might be relevant when providing support or therapeutic modalities aimed at dealing with withdrawal. For instance, men may benefit from an approach aimed more exclusively at improving control and decision making related to their gambling behaviour, while women may need additional support in restoring or improving interpersonal relationships to avoid continued gambling as a form of escape. In relation to SA, withdrawal was presupposed by symptoms associated with salience and relapse for women, showing no further influence on other symptoms. The male network displayed a more complex relationship for withdrawal, which was presupposed only by increased sexual urges, yet led to conflict, relapse and using sex as a means of escape amongst men.

4.3. Implications

The current research has practical implications for addiction diagnosis/classification, and treatment. From a diagnostic/classification perspective, relationship pathways between similar components of addiction were demonstrated to be unique to the individual disorder, confirming the importance of accurate diagnostic criterion for individual addictive behaviours, instead of employing general addiction definitions/constructs. From a treatment perspective, findings suggest that interventions targeting salient features of behavioural addiction, such as cognitive-based therapies, may be effective in disrupting the addictive network and promoting recovery. In that context, public awareness and education regarding behavioural forms of addiction can help reduce associated stigma and allow for honest discussion of one's addictive experience. Group-based therapies may foster promotion of honesty through discussion and understanding of shared experiences. Moreover, gender differences in network structures suggest the importance of gender-specific treatment approaches, with interventions focusing more on intrapsychic processes for men and interpersonal factors for women. Such insights can guide the development of more effective and tailored interventions for individuals struggling with SA, GD, and potentially, other addictive behaviours.

Table 3
Estimated strength and directional probability between symptoms of sex addiction and gambling disorder within male and female networks.

		Probable influence (female)		Probable influence (male)	
Parent node (from)	Descendant node (to)	Strength	Direction	Strength	Direction
Similar between male and female networks					
S1 - time thinking about sex	S2 – increased sexual urges	>0.99	0.80	>0.99	0.61
G10 – borrow money for gambling	G11 – prioritise gambling	>0.99	0.52	>0.99	0.54
S3 – use sex to escape	S4 – sexual relapse	0.98	0.59	0.89	0.54
G2 – gambling withdrawal	G1 – gambling tolerance	0.97	0.72	0.98	0.58
S2 – increased sexual urges	S3 – use sex to escape	0.96	0.79	>0.99	0.72
G3 – unable to control gambling	G4 – negative consequences from gambling	0.91	0.54	>0.99	0.85
G6 – use gambling to escape	G1 – gambling tolerance	0.89	0.56	0.94	0.56
Observed only within female network					
G9 – lie about gambling	G11 – prioritise gambling	0.99	0.64		
G9 – lie about gambling	G7 – lack of control over gambling	0.91	0.68		
G2 – gambling withdrawal	G4 – negative consequences from gambling	0.91	0.59		
S1 - time thinking about sex	S5 – sexual withdrawal	0.90	0.85		
G6 – use gambling to escape	G5 – time thinking about gambling	0.89	0.57		
G4 – negative consequences from gambling	G6 – use gambling to escape	0.85	0.74		
Observed only within male network					
G5 – time thinking about gambling	G8 – chasing losses			>0.99	0.62
G3 – unable to control gambling	G9 – lie about gambling			0.99	0.61
S5 – sexual withdrawal	S6 – sex has negative impact on life			0.99	0.70
G6 – use gambling to escape	G3 – unable to control gambling			0.96	0.501
S5 – sexual withdrawal	S3 – use sex to escape			0.95	0.58
S2 – increased sexual urges	S5 – sexual withdrawal			0.95	0.58
G3 – unable to control gambling	G7 – lack of control over gambling			0.92	0.53
G2 – gambling withdrawal	G7 – lack of control over gambling			0.91	0.61
G10 – borrow money for gambling	G7 – lack of control over gambling			0.89	0.60
G2 – gambling withdrawal	G3 – unable to control gambling			0.87	0.63
G11 – prioritise gambling	G7 – lack of control over gambling			0.87	0.67
G10 – borrow money for gambling	G6 – use gambling to escape			0.87	0.59
G9 – lie about gambling	G8 – chasing losses			0.86	0.67
G9 – lie about gambling	G5 – time thinking about gambling			0.86	0.67
G11 – prioritise gambling	G8 – chasing losses			0.86	0.82

4.4. Future research

While this study provides valuable insights, there are several avenues for future research. First, refining the diagnostic criteria, particularly for SA, is essential to accurately capture unique features and interrelationships of behavioural disorders and correctly estimate the population proportions of those impacted. Longitudinal studies can provide insight into the dynamic nature of addictive behaviours and their developmental trajectories. Qualitative research may complement quantitative analyses by exploring the lived experiences and subjective perspectives of individuals with SA and GD. For example, recent research has highlighted strong associations between disordered gambling and hedonic dysregulation (Velotti et al., 2021). That is, unlike in alcohol and other substances where mood manipulation is used to avoid negative emotions, in gambling, and possibly other behavioural addictions, positive mood manipulation is more pronounced. Positive reappraisal of negative emotional cues, such as incurring a loss following a bet, may therefore act to reinforce continued gambling behaviour (Ruiz de Lara et al., 2019). Current gambling disorder measures and classifications are a step behind research and fail to ask about experiences of positive mood states and gambling engagement. Further research of positive mood modification may illuminate key distinctions between behavioural and psychoactive addictions.

In that line, deception was shown to reinforce addiction salience amongst gamblers. Research into substance-based addiction typically distinguishes between two forms of deceptive tendency; impression management – the desire to present oneself favourably; and self-deception – an unconscious tendency to enhance self-concept, such as with denial (Caputo, 2019). Further exploration into the use and role of deception may prove relevant for distinguishing between healthy coping and problematic behaviour in a range of proposed behavioural addictions.

Similarly, investigating the role of age may illuminate why women are observed to move through the cycles of addiction at a faster rate than men (Becker et al., 2016), or, why women are more commonly observed to develop problems with addictive behaviour later in life (Merkouris et al., 2016; Zakiniaeiz and Potenza, 2018). Additionally, examining cultural values and social factors, not considered here, may also provide a more comprehensive understanding of the complex interplay between addiction and its contexts. For example, further research may provide insight as to whether gender-based differences are based in biological mechanisms or due to systemic processes at a macro level. Finally, exploring other forms of behavioural and substance-based addictions within the same network model can offer expanded/deeper insights into co-occurring addictions and cross-addictive behaviours.

4.5. Limitations

Results of the current study should be interpreted with several limitations in mind. Findings from the current study suggest that individual scale items influenced the addictive model in different ways. However, it has been argued that equal weighting of scale items within measures used to assess behavioural addiction, may not accurately reflect the importance of individual items contained within the scale (Kardefelt-Winther et al., 2017). Moreover, the BYSAS assesses SA based solely on Griffith's (2005) component model of addiction, while the OGD-Q includes components of addiction, as well as other diagnostic criteria included in the DSM-V. As such, several scale items may be considered associated with the same theoretical construct component. For example, item six and eleven of the OGD-Q both measure aspects of salience; items three, four and seven relate to various forms of conflict (González-Cabrera et al., 2020; Stavropoulos et al., 2022). Node selection in the model could therefore be improved. Additionally, the OGD-Q incorporates several scale items which are distinct features of gambling addiction, including chasing losses, lying about gambling, and borrowing money. These items were influential in the overall model. A lack of consensus around diagnostic classification of SA makes it difficult to assess features which are unique to the disorder, or how these features

may influence the addictive cycle.

Secondly, while the goal of network analysis in psychological research is to identify potentially causal relationships which give rise to episodes of disorder (McNally et al., 2017), dynamic processes which play out on an individual level may not be appropriately theorised based on cross-sectional data (Forbes et al., 2019). Further, Bayesian network analysis incorporates a structure learning algorithm. As such, causal interpretation of the analysis is subject to strong assumptions (Briganti et al., 2021). Firstly, sufficiency assumes that all causes of the variable being measured are included in the model and there are no latent or confounding variables. The second, faithfulness, assumes a probabilistic dependence of all variables included in the model. Both assumptions are difficult to verify in psychological datasets, particularly given that psychological research often assumes the existence of a latent construct. The current analysis provides a probable perspective on the direction and influence of relationships amongst symptoms of SA and GD, with data derived from a particular group of participants at a given timepoint. Additionally, the sample primarily consisted of English speaking, Western adults, limiting generalisability of the results. Future studies should include more diverse samples, including clinical populations, to enhance the external validity of the findings.

Finally, the use of network analysis, and in particular, Bayesian network analysis is a relatively new approach to interpreting psychological data. The analysis interpreted in the current study was performed using conservative thresholds, however there is currently no recommendation for interpreting, with certainty, directional strength. For example, a directional relationship observed in 51% of cases, appears in the opposite direction in 49% of cases. Additionally, DAGs are incapable of detecting cyclic relationships and positive feedback cycles could exist amongst symptoms, acting to further sustain networks of addiction. While the current study provides insight to the most prominent relationships between symptoms of SA and GD, it may not fully explain relationships between all variables included in the model.

5. Conclusion

In conclusion, this study provides valuable insights into the network structures and gender differences of SA and GD. The findings emphasize the distinct nature of these addictive behaviours and underscore the importance of accurate diagnostic criteria and tailored treatment approaches. The implications of this research extend to addiction classification, intervention strategies, and public education. Future research should focus on refining diagnostic criteria, employing longitudinal and qualitative methodologies, and examining additional forms of addictive behaviours within the network model. By addressing these limitations and advancing our understanding of addictive networks, we can enhance addiction research, treatment outcomes, and support for individuals affected by SA, GD, and other addictive behaviours.

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Ethical standards – animal rights

All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Confirmation statement

Authors confirm that this paper has not been either previously published or submitted simultaneously for publication elsewhere.

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CRediT authorship contribution statement

Brian Hunt: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing – original draft. **Daniel Zarate:** Conceptualization, Data curation, Writing – review & editing. **Peter Gill:** Supervision, Writing – review & editing. **Vasileios Stavropoulos:** Funding acquisition, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors of the present study do not report any conflict of interest.

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Supplementary materials

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References

Abbott, M.W., 2020. The changing epidemiology of gambling disorder and gambling-related harm: public health implications. Public Health 184, 41–45. https://doi.org/10.1016/j.puhe.2020.04.003.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). doi:10.1176/appi.books.9780890425596.

Andreassen, C.S., Billieux, J., Griffiths, M.D., Kuss, D.J., Demetrovics, Z., Mazzoni, E., Pallesen, S., 2016. The relationship between addictive use of social media and video games and symptoms of psychiatric disorders: a large-scale cross-sectional study. Psychol. Addict. Behav. 30 (2), 252. https://doi.org/10.1037/adb0000160.

Baggio, S., Gainsbury, S.M., Starcevic, V., Richard, J., Beck, F., Billieux, J., 2018. Gender differences in gambling preferences and problem gambling: a network-level analysis. Int. Gambl. Stud. 18 (3), 512–525. https://doi.org/10.1080/14459795.2018.1495750.

Becker, J.B., Koob, G.F., 2016. Sex differences in animal models: focus on addiction. Pharmacol. Rev. 68, 242–263. https://doi.org/10.1124/pr.115.011163.

Becker, J.B., McClellan, M., Reed, B.G., 2016. Sociocultural context for sex differences in addiction. Addict. Biol. 21, 1052–1059. https://doi.org/10.1111/adb.12383.

Billieux, J., Schimmenti, A., Khazaal, Y., Maurage, P., Heeren, A., 2015. Are we overpathologizing everyday life? A tenable blueprint for behavioral addiction research. J. Behav. Addict. 4 (3), 119–123. https://doi.org/10.1556/2006.4.2015.009.

Blaszczynski, A., Walker, M., Sharpe, L., Nower, L.I.A., 2008. Withdrawal and tolerance phenomenon in problem gambling. Int. Gambl. Stud. 8 (2), 179–192. https://doi.org/10.1080/14459790802140007.

Borsboom, D., 2017. A network theory of mental disorders. World Psychiatry 16 (1), 5–13.

Borsboom, D., Deserno, M.K., Rhemtulla, M., Epskamp, S., Fried, E.I., McNally, R.J., Robinaugh, D.J., Perugini, M., Dalege, J., Costantini, G., Isvoranu, A.-M., Wysocki, A.C., van Borkulo, C.D., van Bork, R., Waldorp, L.J., 2021. Network analysis of multivariate data in psychological science. Nat. Rev. Methods Prim. (1), 1. https://doi.org/10.1038/s43586-021-00055-w.

Bostwick, J.M., Hecksel, K.A., Stevens, S.R., Bower, J.H., Ahlskog, J.E., 2009. Frequency of new-onset pathologic compulsive gambling or hypersexuality after drug treatment of idiopathic Parkinson disease. Mayo Clin. Proc. 84 (4), 310–316. https://doi.org/10.1016/S0025-6196(11)60538-7.

Brewer, G., Tidy, P., 2019. Sex addiction: therapist perspectives. Sex. Relatsh. Ther. 34 (1), 40–53. https://doi.org/10.1080/14681994.2017.1347618.

Briganti, G., Scutari, M., McNally, R.J., 2021. A tutorial on Bayesian Networks for psychopathology researchers. PsyArXiv. https://doi.org/10.31234/osf.io/h4vxa.

Calado, F., Griffiths, M.D., 2016. Problem gambling worldwide: an update and systematic review of empirical research (2000–2015). J. Behav. Addict. 5 (4), 592–613. https://doi.org/10.1556/2006.5.2016.073.

Caputo, A., 2019. Deceptive dynamics in drug addiction and their role in control beliefs and health status reporting: a study on people with substance use disorder in treatment. J. Drug Issues 49 (4), 575–592. https://doi.org/10.1177/0022042619853299.

Carnes, P.J., Murray, R.E., Charpentier, L., 2004. Addiction Interaction Disorder. In: Coombs, R.H. (Ed.), Handbook of Addictive Disorders: A practical Guide to Diagnosis and Treatment. John Wiley & Sons, Incorporated.

Carnes, S., Love, T., 2017. Separating models obscures the scientific underpinnings of sex addiction as a disorder. Arch. Sex. Behav. 46 (8), 2253–2256.

Constantin, M.A., Schuurman, N.K., & Vermunt, J. (2021). A general Monte Carlo method for sample size analysis in the context of network models. doi:10.31234/osf.io/j5v7u.

Dąbrowska, K., Wieczorek, Ł., 2020. Perceived social stigmatisation of gambling disorders and coping with stigma. Nordic Stud. Alcohol Drugs 37 (3), 279–297. https://doi.org/10.1177/1455072520902342.

Derbyshire, K.L., Grant, J.E., 2015. Compulsive sexual behavior: a review of the literature. J. Behav. Addict. 4 (2), 37–43. https://doi.org/10.1556/2006.4.2015.003.

Epskamp, S., Borsboom, D., Fried, E.I., 2018. Estimating psychological networks and their accuracy: a tutorial paper. Behav. Res. Methods 50 (1), 195–212. https://doi.org/10.3758/s13428-017-0862-1.

Epskamp, S., Cramer, A.O., Waldorp, L.J., Schmittmann, V.D., Borsboom, D., 2012. qgraph: network visualizations of relationships in psychometric data. J. Stat. Softw. 48, 1–18. https://doi.org/10.18637/jss.v048.i04.

Epskamp, S., & Fried, E. (2015). bootnet: bootstrap methods for various network estimation routines [R software package].

Farré, J.M., Fernández-Aranda, F., Granero, R., Aragay, N., Mallorquí-Bague, N., Ferrer, V., More, A., Bouman, W.P., Arcelus, J., Savvidou, L.G., Penelo, E., Aymamí, M.N., Gómez-Peña, M., Gunnard, K., Romaguera, A., Menchón, J.M., Vallès, V., Jiménez-Murcia, S., 2015. Sex addiction and gambling disorder: similarities and differences. Compr. Psychiatry 56, 59–68.

Fernandes, R. (2019). bnviewer: interactive Visualization of Bayesian Networks. R package version 0.1. 4.

Forbes, M.K., Wright, A.G., Markon, K.E., Krueger, R.F., 2019. The network approach to psychopathology: promise versus reality. World Psychiatry 18 (3), 272. https://doi.org/10.1002/wps.20659.

Fried, E.I., van Borkulo, C.D., Cramer, A.O.J., Boschloo, L., Schoevers, R.A., Borsboom, D., 2017. Mental disorders as networks of problems: a review of recent insights. Soc. Psychiatry Psychiatr. Epidemiol. 52, 1–10. https://doi.org/10.1007/s00127-016-1319-z.

Fujiwara, H., Tsurumi, K., Shibata, M., Kobayashi, K., Miyagi, T., Ueno, T., Oishi, N., Murai, T., 2022. Life habits and mental health: behavioural addiction, health benefits of daily habits, and the reward system. Front. Psychiatry 13, 813507. https://doi.org/10.3389/fpsyt.2022.813507.

Garcia, F.D., Thibaut, F., 2010. Sexual addictions. Am. J. Drug Alcohol Abuse 36 (5), 254–260. https://doi.org/10.3109/00952990.2010.503823.

Giugliano, J.R., 2009. Sexual addiction: diagnostic problems. Int. J. Ment. Health Addict. 7, 283–294. https://doi.org/10.1007/s11469-009-9195-3.

Gomez, R., Stavropoulos, V., Brown, T., Griffiths, M.D., 2022. Factor structure of ten psychoactive substance addictions and behavioural addictions. Psychiatry Res. 313, 114605 https://doi.org/10.1016/j.psychres.2022.114605.

González-Cabrera, J., Machimbarrena, J.M., Beranuy, M., Pérez-Rodríguez, P., Fernández-González, L., Calvete, E., 2020. Design and measurement properties of the Online Gambling Disorder Questionnaire (OGD-Q) in spanish adolescents. *J. Clin. Med.* 9 (120) https://doi.org/10.3390/jcm9010120.

Grant, J.E., Potenza, M.N., Weinstein, A., Gorelick, D.A., 2010. Introduction to behavioral addictions. Am. J. Drug Alcohol Abuse 36 (5), 233–241. https://doi.org/10.3109/00952990.2010.491884.

Grant, J.E., Schreiber, L.R.N., Harvanko, A.M., 2012. Neurobiology of addiction: support for a syndrome model of addiction. In: Shaffer, H.J., LaPlante, D.A., Nelson, S.E. (Eds.), APA Addiction Syndrome Handbook, Vol. 1. Foundations, Influences, and Expressions of Addiction. American Psychological Association, pp. 121–146. https://doi.org/10.1037/13751-006.

Grant, J.E., Steinberg, M.A., 2005. Compulsive sexual behavior and pathological gambling. Sex. Addict. Compulsivity 12 (2–3), 235–244. https://doi.org/10.1080/10720160500203856.

Griffiths, M., 1993. Tolerance in gambling: an objective measure using the psychophysiological analysis of male fruit machine players. Addict. Behav. 18, 365–372. https://doi.org/10.1016/0306-4603(93)90038-B.

Griffiths, M.D., 2005. A 'components' model of addiction within a biopsychosocial framework. J. Subst. Use 10 (4), 191–197. https://doi.org/10.1080/14659890500114359.

Hakami, A.Y., Ahmad, R.G., Alsharif, A., Ashqar, A., AlHarbi, F.A., Sayes, M., Khan, M.A., 2021. Prevalence of behavioral addictions and their relationship with stress and anxiety among medical students in saudi arabia: a cross-sectional study. Front. Psychiatry 1433.

Hall, P., 2014. Sex addiction - an extraordinarily contentious problem. Sex. Relatsh. Ther. 29 (1), 68–75. https://doi.org/10.1080/14681994.2013.861898.

Hodgins, D.C., Stea, J.N., Grant, J.E., 2011. Gambling disorders. Lancet 378 (9806), 1874–1884. https://doi.org/10.1016/S0140-6736(10)62185-X.

Hunt, C.J., Blaszczynski, A., 2019. Gambling disorder as a clinical phenomenon. Gambling Disorder. Springer, Cham, pp. 15–27. https://doi.org/10.1007/978-3-030-03060-5_2.

Jaspal, R., Jaspal, R., 2019. Stigmatised sexual behaviours. Soc. Psychol. Gay Men 117–136. https://doi.org/10.1007/978-3-030-27057-5_7.

Kafka, M.P., 2010. Hypersexual disorder: a proposed diagnosis for DSM-V. Arch. Sex. Behav. 39 (2), 377–400. https://doi.org/10.1007/s10508-009-9574-7.

Kardefelt-Winther, D., Heeren, A., Schimmenti, A., van Rooij, A., Maurage, P., Carras, M., Edman, J., Blaszczynski, A., Khazaal, Y., Billieux, J., 2017. How can we conceptualize behavioural addiction without pathologizing common behaviours? Addiction 112, 1709–1715. https://doi.org/10.1111/add.13763.

Kingston, D.A., Firestone, P., 2008. Problematic hypersexuality: a review of conceptualization and diagnosis. Sex. Addict. Compulsivity 15 (4), 284–310. https://doi.org/10.1080/10720160802289249.

Kor, A., Fogel, Y., Reid, R.C., Potenza, M.N., 2013. Should Hypersexual Disorder be Classified as an Addiction? Sex. Addict. Compulsivity 20 (1–2). https://doi.org/10.1080/10720162.2013.768132.

Kraus, S.W., Krueger, R.B., Briken, P., First, M.B., Stein, D.J., Kaplan, M.S., Voon, V., Abdo, C.H.N., Grant, J.E., Atalla, E., Reed, G.M., 2018. Compulsive sexual behaviour disorder in the ICD-11. World Psychiatry 17 (1), 109–110. https://doi.org/10.1002/wps.20499.

Kürbitz, L.I., Briken, P., 2021. Is compulsive sexual behavior different in women compared to men? J. Clin. Med. 10 (15), 3205. http://doi.org/10.3390/jcm10153205.

Lee, L., Tse, S., Blaszczynski, A., Tsang, S., 2020. Concepts and controversies regarding tolerance and withdrawal in gambling disorder. Curr. Opin. Behav. Sci. 31, 54–59. https://doi.org/10.1016/j.cobeha.2019.11.004.

Lindsay, B.L., Bernier, E., Szeto, A.C.H., 2020. An exploration on the public stigma of sexual addiction. Addict. Compul. 27 (3–4), 293–321. https://doi.org/10.1080/10720162.2021.1904471.

Mallorqui-Bague, N., Mestre-Bach, G., Lozano-Madrid, M., Granero, R., Vintró-Alcaraz, C., Fernández-Aranda, F., Gomez-Pena, M., Moragas, L., Del Pino-Gutierrez, A., Menchon, J.M., Jiménez-Murcia, S, 2021. Gender and gambling disorder: differences in compulsivity-related neurocognitive domains. Addict. Behav. 113, 106683 https://doi.org/10.1016/j.addbeh.2020.106683.

McNally, R., Mair, P., Mugno, B., Riemann, B., 2017. Co-morbid obsessive–compulsive disorder and depression: a Bayesian network approach. Psychol. Med. 47 (7), 1204–1214. https://doi.org/10.1017/S0033291716003287.

McNally, R.J., 2021. Network analysis of psychopathology: controversies and challenges. Annu. Rev. Clin. Psychol. 17 (1), 31–53. https://doi.org/10.1146/annurev-clinpsy-081219-092850.

McNally, R.J., Robinaugh, D.J., Deckersbach, T., Sylvia, L.G., Nierenberg, A.A., 2022. Estimating the symptom structure of bipolar disorder via network analysis: energy dysregulation as a central symptom. J. Psychopathol. Clin. Sci. 131 (1), 86–97. https://doi.org/10.1037/abn0000715.

Merkouris, S.S., Thomas, A.C., Shandley, K.A., Rodda, S.N., Oldenhof, E., Dowling, N.A., 2016. An update on gender differences in the characteristics associated with problem gambling: a systematic review. Curr. Addict. Rep. 3, 254–267. https://doi.org/10.1007/s40429-016-0106-y.

Miller, R., 2010. The feeling-state theory of impulse-control disorders and the Impulse-Control Disorder Protocol. Traumatology (Tallahass Fla) 16 (3), 2–10. https://doi.org/10.1177/1534765610365912.

Montiel, I., Ortega-Barón, J., Basterra-González, A., González-Cabrera, J., Machimbarrena, J.M., 2021. Problematic online gambling among adolescents: a systematic review about prevalence and related measurement issues. J. Behav. Addict. 10 (3), 566–586. https://doi.org/10.1556/2006.2021.00055.

Mulhauser, K.R.W., Struthers, W.M., Hook, J.N., Pyykkonen, B.A., Womack, S.D., MacDonald, M., 2014. Performance on the Iowa gambling task in a sample of hypersexual men. Sex. Addict. Compul. 21 (2), 170–183. https://doi.org/10.1080/10720162.2014.908333.

Nagarajan, R., Scutari, M., Lèbre, S., 2013. Bayesian Networks in r. Springer. https://doi.org/10.1007/978-1-4614-6446-4.

Öberg, K.G., Hallberg, J., Kaldo, V., Dhejne, C., Arver, S., 2017. Hypersexual disorder according to the hypersexual disorder screening inventory in help-seeking swedish men and women with self-identified hypersexual behavior. Sex. Med. 5 (4), e229–e236. https://doi.org/10.1016/j.esxm.2017.08.001.

Otto, J.L., Smolenski, D.J., Wilson, A.L.G., Evatt, D.P., Campbell, M.S., Beech, E.H., Belsher, B.E., 2020. A systematic review evaluating screening instruments for gambling disorder finds lack of adequate evidence. J. Clin. Epidemiol. 120, 86–93. https://doi.org/10.1016/j.jclinepi.2019.12.022.

Petry, N., 2015. Behavioral Addictions: DSM-5® and Beyond. Oxford University Press.

Petry, N.M., Zajac, K., Ginley, M.K., 2018. Behavioral Addictions as Mental Disorders: to Be or Not To Be? Annu. Rev. Clin. Psychol. 14, 399–423. https://doi.org/10.1146/annurev-clinpsy-032816-045120.

Pickard, H., Ahmed, S.H., Foddy, B., 2015. Alternative models of addiction. Front. Psychiatry 6, 20. https://doi.org/10.3389/fpsyt.2015.00020.

Qualtrics. (2022). Qualtrics [computer software]. https://www.qualtrics.com.

R Core Team, 2022. R: a Language and Environment For Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from. https://www.Rproject.org/.

Rockloff, M., Browne, M., Hing, N., Thorne, H., Russell, A., Greer, N., Tran, K., Brook, K., Sproston, K., 2020. Victorian Population Gambling and Health Study 2018–2019. Victorian Responsible Gambling Foundation, Melbourne. Retrieved from. https://responsiblegambling.vic.gov.au.

Rosenberg, K.P., Carnes, P., O'Connor, S, 2014. Evaluation and treatment of sex addiction. J. Sex. Marital. Ther. 40 (2), 77–91. https://doi.org/10.1080/0092623X.2012.701268.

Ruiz de Lara, C.M., Navas, J.F., Perales, J.C., 2019. The paradoxical relationship between emotion regulation and gambling-related cognitive biases. PLoS ONE 14 (8), e0220668. https://doi.org/10.1371/journal.pone.0220668.

Scutari, M., 2010. Learning Bayesian networks with the BNLEARN package. J. Stat. Softw. 35 (3), 1–22. https://doi.org/10.18637/jss.v035.i03.

Shaffer, H.J., LaPlante, D.A., LaBrie, R.A., Kidman, R.C., Donato, A.N., Stanton, M.V., 2004. Toward a syndrome model of addiction: multiple expressions, common etiology. Harv. Rev. Psychiatry 12 (6), 367–374. https://doi.org/10.1080/10673220490905705.

Shaffer, H.J., Tom, M.A., Wiley, R.C., Wong, M.F., Chan, E.M., Cheng, G.L., Lo, C.K.M., Ma, E.K.Y., Wong, R.H.Y, Lee, M., 2018. Using the Syndrome Model of Addiction: a preliminary consideration of psychological states and traits. Int. J. Ment. Health Addict. 16, 1373–1393. https://doi.org/10.1007/s11469-018-9952-2.

Shimoni, L., Dayan, M., Cohen, K., Weinstein, A., 2018. The contribution of personality factors and gender to ratings of sex addiction among men and women who use the Internet for sex purpose. J. Behav. Addict. 7 (4), 1015–1021. https://doi.org/10.1556/2006.7.2018.101.

Slutske, W.S., Cho, S.B., Piasecki, T.M., Martin, N.G., 2013. Genetic overlap between personality and risk for disordered gambling: evidence from a national community-based Australian twin study. J. Abnorm. Psychol. 122 (1), 250. https://doi.org/10.1037/a0029999.

Stavropoulos, V., Alexandraki, K., Motti-Stefanidi, F., 2013. Flow and telepresence contributing to Internet abuse: differences according to gender and age. Comput. Human Behav. 29 (5), 1941–1948. https://doi.org/10.1016/j.chb.2013.03.011.

Stavropoulos, V., Gentile, D., Motti-Stefanidi, F., 2016. A multilevel longitudinal study of adolescent Internet addiction: the role of obsessive–compulsive symptoms and classroom openness to experience. Eur. J. Dev. Psychol. 13 (1), 99–114. https://doi.org/10.1080/17405629.2015.1066670.

Stavropoulos, V., Monger, K., Zarate, D., Prokofieva, M., Schivinski, B., 2022. Online gambling disorder questionnaire (OGD-Q): an item response theory examination. Addict. Behav. Rep. 16, 100449 https://doi.org/10.1016/j.abrep.2022.100449.

Tibshirani, R., 1996. Regression shrinkage and selection via the lasso. *J. R. Statist. Soc.* Ser. B (Methodol.) 267–288. https://doi.org/10.1111/j.2517-6161.1996.tb02080.x.

Valenciano-Mendoza, E., Fernández-Aranda, F., Granero, R., Gómez-Peña, M., Moragas, L., Mora-Maltas, B., Håkansson, A., Menchón, J.M., Jiménez-Murcia, S., 2021. Prevalence of suicidal behavior and associated clinical correlates in patients with behavioral addictions. Int. J. Environ. Res. Public Health 18, 11085. https://doi.org/10.3390/ijerph182111085.

van Borkulo, C.D., van Bork, R., Boschloo, L., Kossakowski, J.J., Tio, P., Schoevers, R.A., Borsboom, D., Waldorp, L.J., 2022. Comparing network structures on three aspects: a permutation test. Psychol. Methods. https://doi.org/10.1037/met0000476. Advance online publication.

Van Buuren, S., Groothuis-Oudshoorn, K., 2011. mice: multivariate Imputation by Chained Equations in R. J. Stat. Softw. 45 (3), 1–67. https://www.jstatsoft.org/v45/i03/.

Velotti, P., Rogier, G., Beomonte Zobel, S., Billieux, J., 2021. Association between gambling disorder and emotion (dys)regulation: a systematic review and meta-analysis. Clin. Psychol. Rev. Jul 87, 102037. https://doi.org/10.1016/j.cpr.2021.102037.

Volkow, N.D., Koob, G., 2015. Brain disease model of addiction: why is it so controversial? Lancet Psychiatry 2 (8), 677–679. https://doi.org/10.1016/S2215-0366(15)00236-9.

Walton, M.T., Cantor, J.M., Bhullar, N., Lykins, A.D., 2017. Hypersexuality: a critical review and introduction to the "Sexhavior Cycle. Arch. Sex. Behav. 46 (2017), 2231–2251. https://doi.org/10.1007/s10508-017-0991-8.

Weiss, R., 2018. When addictions merge. In: Birchard, T., Benfield, J. (Eds.), The Routledge International Handbook of Sexual Addiction. Routledge.

West, R., Brown, J., 2013. Theory of Addiction, 2nd ed. Wiley.

World Health Organisation (2019). International Statistical Classification of Diseases and Related Health Problems (11th ed.). https://icd.who.int/.

Zakiniaeiz, Y., Potenza, M.N., 2018. Gender-related differences in addiction: a review of human studies. Curr. Opin. Bahav. Sci. 23, 171–175. https://doi.org/10.1016/j.cobeha.2018.08.004.

Zarate, D., Ball, M., Montag, C., Prokofieva, M., Stavropoulos, V., 2022. Unravelling the web of addictions: a network analysis approach. Addict. Behav. Rep. 15, 100406 https://doi.org/10.1016/j.abrep.2022.100406.

Zarate, D., Tran, T.T.D., Rehm, I., Prokofieva, M., Stavropoulos, V., 2023. Measuring problematic sexual behaviour: an item response theory examination of the Bergen–Yale sex addiction scale. Clin. Psychol. 1–15.

Zuckerman, M., 2007. Sensation Seeking and Risky Behavior. American Psychological Association. https://doi.org/10.1037/11555-000.