Technology in Society 67 (2021) 101740

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

A network perspective on the relationship between gaming disorder, depression, alexithymia, boredom, and loneliness among a sample of Chinese university students

Li Li [a,*], Zhimin Niu [a], Mark D. Griffiths [b,**], Wen Wang [c], Chunying Chang [d], Songli Mei [e]

[a] School of Humanities and Social Sciences, Gannan Medical University, Ganzhou, China
[b] International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK
[c] Department of Education, Xi'an University, Xi'an, China
[d] Mental Health Education Center, Jiangxi College of Applied Technology, Ganzhou, China
[e] School of Public Health, Jilin University, Changchun, China

Abstract

Background and aims: Based on previous research, it was hypothesized that negative affect (e.g., depression, anxiety, and loneliness) and low level of emotion regulation (i.e., alexithymia) are risk factors for internet gaming disorder (IGD). Research utilizing a network analysis approach to psychopathology has increased rapidly, and is used to examines the pattern of interactions between causal factors of mental health disorders. Previous research has investigated the relationship between gaming disorder (GD), depression, alexithymia, boredom, and loneliness by pair-wise correlation and correlation of three or four variables. However, to date, network analysis has rarely been utilized to examine the relationship between the aforementioned multi-variables. Therefore, the present study used network analysis to examine the relationship between GD, depression, alexithymia, boredom, and loneliness among a sample of Chinese university students.

Methods: A sample comprising 1635 Chinese university students (913 males)

completed a survey including the Gaming Disorder Test, Patient Health Questionnaire, and Toronto Alexithymia Scale, alongside single-item measures of loneliness and boredom.

Results: Depression, alexithymia, boredom, and loneliness were significantly and positively associated with GD. Loneliness and boredom had the closest edge intensity, and loneliness was the strongest central node in the domain-level network. The facet-level and the item-level networks analysis also showed that GD was connected with depression, alexithymia, boredom, and loneliness. The domain-level network comparison test (NCT) showed the global strengths had significant difference among gender group (males = 1.90 vs. females = 1.77, p = 0.013).

Conclusions: The findings indicate that there is a close relationship between GD, depression, alexithymia, boredom, and loneliness. Negative affect and low emotion regulation may induce or worsen GD, resulting in a vicious cycle. Practitioners developing interventions to overcome GD should consider aspects aimed at adjusting and improving negative emotion, especially loneliness and related negative affect as well as facilitating positive emotion.

Keywords: gaming disorder; depression; alexithymia; boredom; loneliness; network analysis

1. Introduction

1.1 Gaming disorder

Gaming disorder (GD) has been defined as a pattern of persistent gaming behavior that takes place predominantly either online or offline, and comprises impaired control, increasing priority of gaming over other activities, continuation and/or escalation of gaming, as well as demonstrable distress and/or significant impaired everyday social functioning [1]. Recently, a systematic review and meta-analysis of 53 studies (including one from China, the country where the present study was carried out) reported that the global prevalence of gaming disorder was 3.05%, which decreased to 1.96% after considering more stringent random sampling [2]. The prevalence of problematic online gaming has been reported to range from 3.5%-17% in China [3]. A recent study reported that the prevalence of GD was 8.3% among a sample of Hong Kong adult gamers [4].

Some studies have reported that the interaction of internal and external factors may facilitate the development of GD, including deficient emotional regulation and impulsive decision-making, as well as a poor family environment and poor social skills [5]. Alexithymia as a type of emotional dysregulation may explain engagement in and maintenance of online gaming [6,7]. Based on self-determination theory [8], the motivation to engage in online gaming may be to meet individuals' psychological needs (i.e., autonomy, relatedness, and competency) and to escape negative affect (e.g., loneliness and boredom). Boredom may result from an external environment without autonomy [9], and is regarded as one of risk factors of problematic

smartphone use [10]. Loneliness and boredom as types of negative affect are usually directly or indirectly associated with GD [11-13]. In addition, gaming-related factors, such as gaming genre, game time, and gaming characteristics, as well as gaming motivation may also be involved in the development and maintenance of GD [14-18]. One study also reported that game-related smartphone use and entertainment may predict smartphone addiction and poor academic performance among undergraduate students [19]. Some scholars have indicated that adolescents and emerging adults may be more likely to develop GD than cohorts of other ages [20,21]. While males are more likely than females to experience GD, the gender gap may be decreasing [22,23]. GD has been found to be related to personality traits, including high impulsivity [24-26], high aggressiveness [27,28], and high neuroticism [29,30]. Moreover, neurobiological features (e.g., reward circuitry involving dopaminergic and neurotransmitter pathways) have been studied widely as one of risk factors for GD [31-34].

1.2 Depression

Depression manifests itself in negative mood states (e.g., feeling sad, irritable, and empty) or as loss of pleasure, which accompanies other cognitive, behavioral, or neuro-vegetative symptoms, as well as marked distress or significant impaired social functioning [1]. Depression is associated with various addictive behaviors, including gaming disorder [20,35-38], problematic smartphone use [39-41], and gambling disorder [42,43].

Some studies have also indicated that depression is the most frequently comorbid

condition for GD [44,45]. There are several similarities in symptoms between depression and GD, including impaired social functioning (e.g., maladaptive interpersonal relationship, poor educational and/or occupational performance), fatigue, sleep problems, and anhedonia [36,46]. GD may facilitate the onset of depression in specific contexts [47,48]. Longitudinal research has indicated that the level of depression may also predict the severity of GD [49], which indicates reciprocal relationship between GD and depression.

1.3 Alexithymia

Alexithymia is considered as a personality construct, in which individuals are unable to identify, differentiate, describe, and express emotion [50,51]. Some scholars indicate that there are close connections between alexithymia and other conditions, such as autism, chronic pain, type-2 diabetes, and inflammatory bowel disease [52-55]. In addition, in a literature review, a strong relationship between alexithymia and depression, self-harm, and aggression was reported [56].

Some studies also claim that alexithymia is also closely related to addictive disorders, including problematic alcohol use, problem gambling, and internet addiction [57-60]. Lyvers et al. suggested that alexithymia is often observed among individuals with drug abuse [61]. Over the past decade, the relationship between alexithymia and GD has attracted the attention of researchers in the field of behavioral addiction. Bonnaire, and Baptista reported that alexithymia, depression, and anxiety were all associated with internet gaming disorder (IGD) among male participants [62]. In contrast, only depression was associated with IGD among

females. Evren et al. also reported a significant correlation between alexithymia and IGD, especially in two dimensions: “difficulty identifying feelings” (DIF) and “externally oriented thinking” (EOT) [63].

1.4 Boredom

Boredom has different definitions depending on different individuals and contexts [64]. Boredom may be described as a negative emotion, dysphoric experience or state, which comprises an expected and a perceived inner conflict [65-67]. Stimulus factors of boredom include repetition, lack of novelty, and monotony [68]. Boredom is widely associated with social and psychological problems [64]. Todman indicated that sustained boredom may increase risk-taking and substance-seeking behaviors, disturb positive mood, give rise to distractibility, decrease cognitive efficiency, and demonstrate highly generalized uninterest [69]. Moreover, some scholars have demonstrated that boredom is associated with depression, delinquency, substance abuse, hyperactivity, inattention, and smartphone addiction [70-72].

According to the China Internet Network Information Center [73], the proportion of adolescents playing online games was 61% among Chinese internet users. In China, increasing numbers of adolescents play online videogames due to boredom proneness [74]. Boredom proneness may be considered as a risk factor for internet-communication disorder [67]. A Taiwanese survey reported that boredom during leisure time may increase Internet addiction and that effective time management decreases boredom experience [75]. In addition, Chou, Chang and Yen also indicated that boredom (and more specifically a lack of external stimulation) was significantly

associated with internet addiction, especially that related to online gaming [76]. Individuals with gaming disorder often experience boredom, sadness, and/or irritability [77,78].

1.5 Loneliness

Loneliness is often considered as a negatively emotional and social isolating state. Loneliness is associated with other negative emotions and actions, such as depression, pessimism, shyness, hostility, alienation, and social withdrawal [79]. Chronic loneliness may potentially impact on health, such as cardiovascular activation and sleep dysfunction [80]. Loneliness has been found to be closely related to depression among older aged individuals and adolescents [81,82] as well as excessive using technology and insomnia among children [83]. In addition, loneliness is associated with substance and alcohol abuse and behavioral addictions such as internet addiction and problem gambling [84-86].

Some scholars suggest that online gaming is characterized by novelty, interactivity and virtuality, which may contribute to socialization and help avoid loneliness [87]. Therefore, loneliness and depression are often related to gaming motivation [21]. Lemmens, Valkenburg, and Peter reported loneliness to be one of the risk factors may significantly predict pathological gaming [88]. Pathological gaming was reported to trigger feelings of loneliness among Pakistan adolescents [89]. A cross-sectional study from Korea indicated there was a reciprocal relationship between loneliness and pathological gaming [90]. Moreover, loneliness may predict depression via GD and generalized pathological internet use (GPIU) [91].

2. Theoretical background

2.1 Related theories on the relationship between GD and depression, alexithymia, boredom, and loneliness

There are related theories on the relationship between GD and depression, alexithymia, boredom, and loneliness. Self-determination theory has highlighted the importance of psychological need satisfaction and negative outcomes (e.g., poor sleep and various addictive behaviors) arising from need dissatisfaction [8]. Daily frustration of basic psychological needs and stronger gaming motivations may lead to GD [92]. Online gaming (e.g., Massively Multiplayer Online Role Playing Games [MMORPGs] and Multiplayer Online Battle Arena [MOBA] games) engaged in as a form of self-compensation may alleviate negative affect and/or help in escaping real life issues, as well as facilitating feelings of achievement and belonging [93], while excessive gaming activities may further lead to GD among a minority of individuals. In addition, some variables may interact and demonstrate a reciprocal relationship, which may better explain the occurrence and progression of psychiatric disorders including behavioral addictions. In Billieux's pathway of problematic mobile phone use, it was posited that the reciprocal influence between negative affect and impulsivity may cause problematic mobile phone/smartphone use. In turn, negative outcomes from excessive or uncontrolled mobile phone use also may increase negative affect (depression, anxiety, loneliness, boredom, and even alexithymia) and increase impulsive behavior via applications on the mobile phone (e.g., playing online games and SNS use) [94]. Moreover, the Interaction of Person-Affect-

Cognition-Execution (I-PACE) model also posited that addictive behaviors (such as problematic gaming) develop as a consequence of the interactions between multi-variables as well as addictive behaviors being further intensified due to negative affect and cognitive responses [32].

2.2 Network analysis

Network analysis approaches have been used widely in both natural sciences and social sciences over the past two decades [95]. In psychological and psychiatric settings, network analysis is used to explore and verify the basic assumptions and explanatory models of mental health disorders. Compared to correlation analysis, the advantage of network analysis lies in its graphic visualization, which may describe the relationship between causal variables more intuitively and is characterized by nodes and edges utilizing graph theory. Network analysis may also better explain the causal interaction of an episode of a mental health disorder and track the time change of nodes and edges as opposed to unclear latent variables analysis [96]. For instance, a close connection between childhood trauma and positive and negative psychotic symptoms was found in a longitudinal network analysis study [97]. Another study found that the traits of callousness and interpersonal manipulation were reported to be core traits in a network analysis of dark personality [98]. Network analysis has also been used to visualize the structure of other psychiatric or related diseases (e.g., smartphone addiction and competitive state anxiety) [99-102].

2.3 The present study

Although the relationship between GD, depression and/or alexithymia has been

studied utilizing correlation analysis or latent class analysis, the utilization of network analysis has rarely been used and is a new perspective for better understanding the relationships between GD, depression, alexithymia, boredom and loneliness. Therefore, network analysis was utilized in the present study to better explain the relationship between these variables among a sample of Chinese university students. Moreover, a visual relational graph may contribute to examining the theoretical links between GD, depression, alexithymia, boredom, and loneliness. In addition, the invariance of network connectivity between gender can also be compared by the structure and global strength of the network.

3. Methods

3.1 Participants and procedure

A cross-sectional (convenience sampling) design was utilized to collect the data. The inclusion criteria were (i) being Chinese, (ii) being aged 18 years of age or older, and (iii) having played videogames in the past year. The sample comprised 1918 university students from Liaoning and Jiangxi provinces of China. A *Wenjuanxing* online survey was completed by all participants to gain course credit. A total of 283 participants who did not play videogames in the past year were excluded from the analysis (i.e., they answered 'no' to the question "Have you played any videogame in the past year?" in the online survey) resulting in 1635 participants remaining for data analysis (913 males, 55.8%). The mean age of participants was 19.7 years (SD = 1.5, aged 17 to 25 years).

From October 2020 to December 2020, participants were recruited from three

universities (655, 568 and 412 participants, respectively) in Jiangxi and Liaoning provinces. The participants were informed the study purpose and took approximately five minutes to complete the survey.

3.2 Measures

Sociodemographic and gaming variables

Sociodemographic data was collected included participants' gender, age, grade, residential status, whether children had more than six months in the care of someone other than their parents, family structure. Gaming variables comprised how many years they had been gaming, how many days a week they spent gaming, and how many hours they spent gaming on weekdays and weekends.

Gaming disorder

The Gaming Disorder Test (GDT) which was originally developed using British and Chinese samples was used to assess the severity of gaming disorder [103]. The GDT has four items assessing impaired control over gaming, increasing priority to gaming, continuation or escalation of gaming, and marked distress or significant impairment in personal, family, social, educational, occupational or other important areas of functioning [1]. A five-point Likert scale from 1 (*never*) to *5* (*very often*) is used to rate all items. Higher scores indicate a greater risk of gaming disorder. The Cronbach's alpha and McDonald's ω were 0.84 and 0.85 in the present study.

Depression

The nine-item Patient Health Questionnaire-9 (PHQ-9) was used to assess depression and was developed using items from the fourth edition of the Diagnostic

and Statistical Manual of Mental Disorders [104] and is a popular depression screening instrument [105]. The PHQ-9 has been validated among Chinese people [106]. Items (e.g., *"Little interest or pleasure in doing things"*) assessing major depressive disorder (MDD) are rated on five-point Likert scale from 0 (*"not at all"*) to 4 (*"nearly every day"*). Higher scores indicate higher severity of depression. The Cronbach's alpha and McDonald's ω were 0.88 and 0.88 in the present study.

Alexithymia

The 20-item Toronto Alexithymia Scale (TAS-20) [107] was used to assess alexithymia, and has been validated into Chinese [108]. The TAS-20 comprises three factors: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally-oriented thinking (EOT). Each item is assessed on a five-point Likert scale from 1 ("*totally disagree*") to 5 ("*totally agree*"). Higher total scores indicate greater difficulty in expressing feelings. The Cronbach's alpha and McDonald's ω of the total TAS-20 were 0.92 and 0.92 in the present study. The Cronbach's alpha and McDonald's ω were 0.9 and 0.9 for DIF, 0.67 and 0.70 for DDF, and 0.81 and 0.81 for EOT in the present study.

Loneliness

Loneliness was assessed using a single item (*"I felt lonely much of the time over the past month"*) modified from the Center for Epidemiologic Studies Depression Scale (CES-D) concerning loneliness [109]. The item is assessed on a five-point Likert scale from 1 ("*not at all"*) to 5 ("*always"*). A higher score represents a higher lonely feeling. One-week test-retest reliability of the loneliness item in the present study was .89 for

96 university students. Single-item measures have been shown to be as effective as multiple-item measures in previous research [110,111].

Boredom

Boredom was assessed using a single item (*"I felt bored much of the time over the past month"*) modified from a previous study [112]. The item is assessed on a five-point Likert scale from 1 ("*not at all"*) to 5 ("*always"*). A higher score represents a higher level of boredom. One-week test-retest reliability of the boredom item in the present study was 0.9 for 96 university students.

3.3 Statistical analysis

Descriptive statistics and Pearson's correlations were calculated using SPSS 25. Network analysis, Cronbach's alpha, McDonald's ω and Bayesian correlation were performed using JASP (Jeffrey's Amazing Statistics Program). The network comparison test (NCT) on gender was conducted using the R package [113].

All data of the variables under investigation were continuous variables rated on five-point Likert scales. Therefore, the data were acceptable for using network analysis [114]. Network was estimated using EBICglasso model, which was a least absolute shrinkage and selection operator (LASSO) [115] regularization based on the Extended Bayesian Information Criterion (EBIC) [116]. The tuning parameter of 0.5 was selected for the EBICglasso to ensure a higher specific and sensitive network. Nodes (study variables) and edges (correlation between two nodes) comprise network system. The centrality of codes was calculated including betweenness (degree of connectivity), closeness (the distance centrality), and strength (degree

centrality) [114]. Node centrality stability was calculated using correlation stability coefficient (*CS*-coefficient, at least 0.25 and more than 0.5 is preferable for interpretability and stability) [117]. Positive partial correlations are displayed through blue lines. More saturated and thicker edges indicate stronger relationship between variables. Edge stability was estimated using bootstrapping (1000 times) with 95% confidence intervals, which indicated higher stability based on fewer overlaps. The network comparison test (NCT) was conducted for comparing network structure and global network strengths between gender.

3.4 Ethics

The study was examined and approved by research team's University Research Ethics Committee. Informed consent was provided by all participants.

4. Results

4.1 Descriptive statistics and correlation analyses

Approximately one-quarter of participants (24.4%, males = 180, females = 219) reported no indicators of GD at all (e.g., all answers to all items relating to gaming disorder were "never"). The proportion of participants who endorsed (i.e., responded 'often' or 'very often') for one indicator was 5.8% (males = 66, females = 29), for two indicators was 1.6% (males = 22, females = 4), for three indicators was 0.5% (males = 8, females = 0), and for all four indicators was 0.9% (males = 12, females = 2). The present study did not distinguish between GD and non-GD gamers as the GDT does not have a validated cut-off score. Descriptive statistics are shown in Table 1. Comparison of the study variables between gender are shown in Appendix

S1. Depression, alexithymia, boredom and loneliness were significantly and positively associated with GD (all *p*-values <. 01, Appendix S2). All of log (BF10) were more than 3, which further verified the statistically significant correlations between GD, depression, alexithymia, boredom, and loneliness.

4.2 EBICglasso network analysis for the total sample

The EBICglasso domain-level network including GD, depression, alexithymia, boredom, and loneliness for the total sample are shown in Figure 1A. Nodes boredom and loneliness had the strongest edge intensity (*r* = 0.528). Depression had a direct association with alexithymia (*r* = 0.291) and loneliness (*r* = 0.266). GD had a small direct association with alexithymia (*r* = 0.122), boredom (*r* = 0.153), depression (*r* = 0.126), and loneliness (*r* = 0.069) (Appendix S3). The *CS*-coefficients of GD, depression, alexithymia, boredom, and loneliness were 0.49, 0.84, 0.62, 0.77, and 0.95, respectively (Appendix S4). The node centrality was stable and interpretable in the network. The indices of node were described by betweenness, closeness, and strength (degree) for the total sample in Appendix S5. Loneliness was the most central node (betweeness = 1.565, closeness = 1.131, strength = 1.229).

Facet-level and Item-level GD, depression, alexithymia, boredom, and loneliness data are shown in Figure 1B and 1C. The network analysis showed that GD was connected with depression, alexithymia, boredom, and loneliness. In the facet-level network, the boredom and loneliness nodes had stronger edge intensity (*r* = 0.506) (Appendix S6). Facet GD4 (significant impaired everyday social functioning; "*I have experienced significant problems in life [e.g., personal, family, social, education,*

occupational] due to the severity of my gaming behavior.") had the highest level of strength centrality (1.068). In the item-level network, nodes A1 ("*I am often confused about what emotion I am feeling*") and A2 ("*I have physical sensations that even doctors don't understand*") had the strongest edge intensity (*r* = 0.525). The boredom and loneliness nodes also had stronger edge intensity (*r* = 0.449). Item A19 (*"I find examination of my feelings useful in solving personal problems"*) had the highest level of strength centrality (2.278) in alexithymia, and items A2 (*"It is difficult for me to find the right words for my feelings"*) and A13 ("I don't know what's going on inside me") also had higher strength centrality (1.321 and 1.203). In addition, items D2 (*"Feeling down, depressed, or hopeless"*) and D9 (*"Thoughts that you would be better off dead or of hurting yourself in some way"*) had higher level of strength centrality (1.352 and 1.283) in depression (Appendix S7 -S10).

4.3 EBICglasso network analysis for males and females

There were ten non-zero edges in the male domain-level network and nine in the female domain-level network. Boredom and alexithymia had no connection among females and had a weak connection among males (Appendices S11). The edge of boredom and loneliness had the strongest intensity among both males (*r* = 0.526) and females (*r* = 0.528). Loneliness had the highest strength coefficient among both males (1.499) and females (1.201). The *CS*-coefficients of GD, depression, alexithymia, boredom, and loneliness among females and males were 0.4 and 0.59, 0.87 and 0.83, 0.58 and 0.68, 0.77 and 0.76, and 0.93 and 0.94, respectively (Appendices S12-S14). Standardized estimates of node strength centrality among male and female groups

are shown in Figure 2. The facet-level and item-level networks across gender are shown in Appendix S15-S17.

4.4 Comparison of network between males and females

The network comparison test (NCT) showed the domain-level network structure had no significant difference between males and females (M = 0.109, p = 0.396). The edge invariance test was not conducted to avoid an increased Type I error when the network structure is invariant (i.e., the NCT proved slightly too liberal for the edge strength test relative to the network structure invariance test) [118]. However, the global edge strengths had significant difference among gender group (males = 1.90 vs. females = 1.77, p = 0.013).

5. Discussion

The present study found that the prevalence of GD was 0.5% to 5.8% (i.e., endorsing one to four indicators on the GDT) among a sample of Chinese university students, which was similar to previous findings [2,3]. Males were significantly more likely than females to be classed as being at risk of GD, which was consistent with previous research on males' vulnerability to GD [119-121]. Bonnaire, and Baptista's study reported significant correlations between alexithymia, depression, anxiety, and internet gaming disorder (IGD), as well as indicating gender as an important risk factor in the relationship between the variables [62]. The significant and positive association between GD and depression, alexithymia, boredom, and loneliness was also verified by the results of the present study.

In the domain-level network analysis for the total sample of 1635 university

students, the boredom and loneliness nodes were found to have the strongest edge intensity. Moore and Schultz reported that adolescents often attributed loneliness to boredom [122], and these two variables have been identified as significant predictors of problematic internet use [123]. Social networking site gaming addicts have also been found to be lonely and bored in leisure time among college students [124]. In addition, the present study found that loneliness presented the highest node centrality in the network of relationship, and which indicated an important relationship with other variables. Loneliness was closely associated with other negative affect states (i.e., depression and boredom) and alexithymia [123-127]. Adolescents and young people engaging in playing videogames may be gaming to escape negative emotion including loneliness, boredom, and depression, which when played excessively lead to GD among a minority of individuals. Loneliness was also more closely associated with difficulty identifying feelings (DIF) than the other two factors of alexithymia. Among this sample of Chinese university students, a possible explanation may be a deficiency in self-consciousness which may lead to greater difficulty in identifying and distinguishing between feelings (i.e., loneliness and depression) and bodily sensations.

The node centrality stability of the male and female domain-level networks was acceptable given that the CS-coefficients were almost more than 0.5. The loneliness node also exhibited the highest strength centrality in different groups domain-level networks. Tras found that loneliness was a predictor of internet gaming disorder among Turkish adolescents [125]. Moreover, the resting-state functional

connectivity (rsFC) between the prefrontal cortex and supplementary motor area was reported to moderate the relationship between gaming craving (in internet gaming disorder) and negative affect (loneliness) [126]. Consequently, there was a bidirectional pathway between loneliness and GD. Greater loneliness may also predict greater depression [127-129]. In addition, alexithymia and interpersonal distrust interacted to predict social and family loneliness among British undergraduate students [130]. Therefore, loneliness is closely correlated with other negative emotions (i.e., boredom and depressive mood), alexithymia, and gaming disorder.

In the facet-level network, the boredom and loneliness nodes had stronger edge intensity, which verified the close relationship in the present network. Facet GD4 with the highest level of node strength centrality demonstrated that significant impaired everyday social functioning from GD was associated with negative affects (small edge weights). This result may indicate that GD is not influenced directly by negative affect and that GD originates from the interactions between predisposing variables, affective and cognitive responses to specific stimuli, and inhibitory control and decision-making [31]. As Billieux [94] and others have theorized, negative affect and personality traits as well as low self-esteem interact and all can play a role in addictive and impulsive behaviors, poor self-control, maladaptive emotion regulation, and distorted cognitions.

In the item-level network, the boredom and loneliness nodes also had stronger edge intensity. Item A19 (externally-oriented thinking) had the highest level of

strength centrality in alexithymia, and items A2 (difficulty describing feelings) and A13 (difficulty identifying feelings) also had higher strength centrality. These findings verified that the core characteristics of alexithymia included difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally-oriented thinking (EOT). In addition, items D2 (*"Feeling down, depressed, or hopeless"*) and D9 (*"Thoughts that you would be better off dead or of hurting yourself in some way"*) had higher level of strength centrality in depression, which may determine the core symptoms of depression. Item Gd4 (significant impaired everyday social functioning) had the highest level of strength centrality in GD which may be considered as the most important aspect when making a clinical diagnosis.

The structure of domain-level networks as a whole were found to be identical among males and females which demonstrated the invariance of the network structure across gender. However, the overall level of connectivity was unequal across gender. Males manifested higher connectivity coefficients between GD and other variables than females. The edge connectivity coefficients of alexithymia with boredom and depression were also higher in the male network. The edge connectivity coefficients of loneliness with boredom, depression, and alexithymia were also higher in the female network. These results suggest that males are more vulnerable to gaming disorder and that GD is closely related to multiple negative emotions. Levant proposed the "normative male alexithymia hypothesis" which posits higher levels of alexithymia among males due to gender role socialization adherence (i.e., all action and no talk) [131]. Carpenter and Addis also indicated that

males exhibited higher alexithymia than females. However, this was not found in the present study [132]. Only the global strength was different between males and females, which may indicate gender moderates the interaction between alexithymia and multiple negative emotions.

Several limitations should be considered in the present study. Firstly, the use of cross-sectional data cannot be used to observe continuous changes and cannot determine cause-effect relationship between the study variables. Secondly, the survey comprised self-report data which is subject to various methods biases (e.g., motivation preference and social desirability). Thirdly, the data collection adopted convenience sampling which lacks representativeness. Fourth, apart from gender, sociodemographic variables except gender were not fully investigated in relation to their impact on GD in the present study. In future studies, more representative sampling (in relation to sociodemographic and gaming variables), longitudinal network analysis, and more objective research methods (e.g., fMRI studies and clinical diagnosis of GD) are recommended. Fifth, the present study did not distinguish between GD and non-GD gamers as the GDT does not have a validated cut-off score. Like most of the 30+ scales that have been developed to assess disordered gaming [133], the higher the GDT score, the greater the risk that the individual is experiencing disordered gaming. Those who score high on the GDT may or may not have gaming disorder. Gaming disorder can only be diagnosed via a clinical interview and no scale used in any epidemiological survey study can confirm the presence of gaming disorder in any individual.

6. Conclusions

The relationships between gaming disorder (GD), depression, alexithymia, boredom, and loneliness were examined using network analysis. The results indicated that loneliness was the core node in the domain-level relationship network between GD, depression, alexithymia, boredom, and loneliness. The global strength of network demonstrated significant gender differences among a sample of Chinese university students. The findings suggest a new perspective in the regulation of negative emotion and prevention of GD that will aid both future research and clinical practice.

Availability of data and materials

The datasets supporting the conclusions of this article are available from the corresponding author upon reasonable request.

Competing interests

There are no financial or non-financial competing interests. None of the research staff received incentives for recruiting participants or for any other purpose directly associated with the study.

Consent for publication

Not applicable.

References

1. World Health Organization, 6C51 Gaming disorder, (2019). Retrieved March 16, 2021 from: ICD-11 for mortality and morbidity statistics https://icd.who.int/browse11/l-m/en#/http%3a%2f%2fid.who.int%2ficd%2fentity%2f1448597234
2. M.W. Stevens, D. Dorstyn, P.H. Delfabbro, D.L. King, Global prevalence of gaming disorder: A systematic review and meta-analysis, Aust NZ J Psychiat. Advance online publication. (2020) 0004867420962851. doi.org/10.1177/0004867420962851.
3. J. Long, T. Liu, Y. Liu, W. Hao, P. Maurage, J. Billieux, Prevalence and correlates of problematic online gaming: A systematic review of the evidence published in Chinese, Curr Addict Rep. 5 (2018) 359-371.
4. H.Y. Wang, C. Cheng, New perspectives on the prevalence and associated factors of gaming disorder in Hong Kong community adults: A generational approach, Comput Hum Behav. 114 (2021) 106574.
5. F.W. Paulus, S. Ohmann, A. von Gontard, C. Popow, Internet gaming disorder in children and adolescents: a systematic review, Dev Med Child Neurol. 60 (2018) 645-

659.

6. S. Gaetan, V. Bréjard, A. Bonnet, Video games in adolescence and emotional functioning: emotion regulation, emotion intensity, emotion expression, and alexithymia, Comput Hum Behav. 61 (2016) 344-349.
7. A. Estévez, P. Jàuregui, I. Sànchez-Marcos, H. Lopez-Gonzàlez, M. Griffiths. Attachment and emotion regulation in substance addictions and behavioral addictions, J Behav Addict. 6 (4) (2017) 534-544.
8. E.L. Deci, R.M. Ryan, Motivation and self-determination in human behavior. NY: Plenum Publishing Co. (1985).
9. W. Hong, R.D. Liu, Y. Ding, R. Zhen, R. Jiang, X. Fu, Autonomy need dissatisfaction in daily life and problematic mobile phone use: the mediating roles of boredom proneness and mobile phone gaming, Int J Env Res Pub Health. 17(15)(2020) 5305.
10. A.J. Ksinan, J. Mališ, A.T. Vazsonyi, Swiping away the moments that make up a dull day: Narcissism, boredom, and compulsive smartphone use, Curr Psychol. 40(6)(2021) 2917-2926.
11. D. L.King, P. HDelfabbro, T. Zwaans, D. Kaptsis, Clinical features and axis I comorbidity of Australian adolescent pathological Internet and video game users, Aust NZ J Psychiat. 47(11)(2013) 1058-1067.
12. N. Maroney, B.J. Williams, A. Thomas, J. Skues, R. Moulding, A stress-coping model of problem online video game use. Int J Ment Health Addict. 17(4)(2019) 845-858.
13. E. Krossbakken, S. Pallesen, R.A. Mentzoni, D.L. King, H. Molde, T.R. Finserås, T. Torsheim, A cross-lagged study of developmental trajectories of video game

engagement, addiction, and mental health, Front Psychol. 9(2018) 2239.

14. D. King, E. Koster, J. Billieux, Study what makes games addictive, Nature. 573 (2019) 346.
15. D.L. King, P.H. Delfabbro, J.C. Perales, J. Deleuze, O. Király, E. Krossbakken, J. Billieux, Maladaptive player-game relationships in problematic gaming and gaming disorder: A systematic review, Clin Psychol Rev. 73 (2019) 101777.
16. M.D. Griffiths, F. Nuyens, An overview of structural characteristics in problematic video game playing, Curr Addict Rep. 4 (2017) 272-283.
17. S. Laconi, S. Pir, H. Chabrol, Internet gaming disorder, motives, game genres and psychopathology, Comput Hum Behav. 75 (2017) 652-659.
18. D. Westwood, M.D. Griffiths, The role of structural characteristics in video game play motivation: A Q-methodology study, Cyberpsych Beh Soc N. 13 (2010) 581-585.
19. G.A. Abbasi, M. Jagaveeran, Y.N. Goh, B. Tariq, The impact of type of content use on smartphone addiction and academic performance: Physical activity as moderator, Technol Soc. 64 (2021) 101521.
20. T.L. Burleigh, V. Stavropoulos, L.W. Liew, B.L. Adams, M.D. Griffiths, Depression, internet gaming disorder, and the moderating effect of the gamer-avatar relationship: An exploratory longitudinal study, Int J Ment Health Addict. 16 (2018) 102-124.
21. K. Kircaburun, Z. Demetrovics, M.D. Griffiths, O. Király, B. Kun, Ş.B. Tosuntaş, Trait emotional intelligence and internet gaming disorder among gamers: The mediating role of online gaming motives and moderating role of age groups, Int J Ment Health Addict. 18 (2020) 1446-1457.

22. J.E. Brand, J. Jervis, P.M. Huggins, T.W. Wilson, Digital Australia 2020, Eveleigh, NSW: IGEA. (2020). Retrieved March 16, 2021 from: https://igea.net/wp-content/uploads/2019/08/DA20-Report-FINAL-Aug19.pdf.
23. D.L. King, M.N. Potenza, Gaming disorder among female adolescents: A hidden problem? J Adolescent Health. 66 (2020) 650-652.
24. A.H. Bargeron, J.M. Hormes, Psychosocial correlates of internet gaming disorder: Psychopathology, life satisfaction, and impulsivity, Comput Hum Behav. 68 (2017) 388-394.
25. Y.J. Kim, J.A. Lim, J.Y. Lee, S. Oh, S.N. Kim, D.J. Kim, J.E. Ha, J.S. Kwon, J.S. Choi, Impulsivity and compulsivity in Internet gaming disorder: A comparison with obsessive-compulsive disorder and alcohol use disorder, J Behav Addict. 6 (2017) 545-553.
26. Ş.İ. Şalvarlı, M.D. Griffiths, The association between internet gaming disorder and impulsivity: A systematic review of literature, Int J Ment Health Addict. Advance online publication. (2019). https://doi.org/10.1007/s11469-019-00126-w.
27. H. Jeong, H.K. Lee, Y.S. Kwon, H.W. Yim, S.Y. Lee, Gaming disorder and bidirectional relationships with aggression and impulsivity, Curr Opin Behav Sci. 31 (2020) 69-75.
28. S.Y. Lee, H.K. Lee, S.Y. Bang, H. Jeong, H.W. Yim, Y.S. Kweon, Aggression and harm-avoidant trait impede recovery from internet gaming disorder, Front Psychiatry. 9 (2018) 263.
29. H. Li, Y. Zou, J. Wang, X. Yang, Role of Stressful Life Events, Avoidant Coping Styles, and Neuroticism in Online Game Addiction among College Students: A Moderated

Mediation Model, Front Psychol. 7 (2016) 1794.

30. M. Mehroof, M.D. Griffiths, Online gaming addiction: the role of sensation seeking, self-control, neuroticism, aggression, state anxiety, and trait anxiety, Cyberpsych Beh Soc N. 13 (2010) 313-316.
31. E. Argyriou, C.B. Davison, T.T.C. Lee, Response inhibition and internet gaming disorder: A meta-analysis, Addict Behav. 71 (2017) 54–60.
32. M. Brand, E. Wegmann, R. Stark, A. Müller, K. Wölfling, T.W. Robbins, M.N. Potenza, The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors, Neurosci Biobehav R. 104 (2019) 1-10.
33. G.H. Dong, M. Wang, Z. Wang, H. Zheng, X. Du, M.N. Potenza, Addiction severity modulates the precuneus involvement in internet gaming disorder: Functionality, morphology and effective connectivity, Prog Neuro-Psychoph. 98 (2020) 109829. doi.org/10.1016/j.pnpbp.2019.109829.
34. A. Weinstein, A. Livny, A. Weizman, New developments in brain research of internet and gaming disorder, Neurosci Biobehav R. 75 (2017) 314-330.
35. L. Liu, Y.W. Yao, C.S.R. Li, J.T. Zhang, C.C. Xia, J. Lan, X.Y. Fang, The comorbidity between internet gaming disorder and depression: Interrelationship and neural mechanisms, Front Psychiatry. 9 (2018) 154.
36. E.G. Ostinelli, C. Zangani, B. Giordano, D. Maestri, O. Gambini, A. D'Agostino, M. Purgato, Depressive symptoms and depression in individuals with Internet Gaming

Disorder: A systematic review and meta-analysis, J Affect Disorders. 284 (2021) 136-142.

37. Z. Teng, H.M. Pontes, Q. Nie, M.D. Griffiths, C. Guo, Depression and anxiety symptoms associated with internet gaming disorder before and during the COVID-19 pandemic: A longitudinal study, J Behav Addict. Advance online publication (2021). doi.org/10.1556/2006.2021.00016
38. H.R. Wang, H. Cho, D.J. Kim, Prevalence and correlates of comorbid depression in a nonclinical online sample with DSM-5 internet gaming disorder, J Affect Disorders. 226 (2018) 1-5.
39. J.D. Elhai, J.C. Levine, R.D. Dvorak, B.J. Hall, Non-social features of smartphone use are most related to depression, anxiety and problematic smartphone use, Comput Hum Behav. 69 (2017) 75-82.
40. D. Rozgonjuk, J.C. Levine, B.J. Hall, J.D. Elhai, The association between problematic smartphone use, depression and anxiety symptom severity, and objectively measured smartphone use over one week, Comput Hum Behav. 87 (2018) 10-17.
41. J. Yang, X. Fu, X. Liao, Y. Li, Association of problematic smartphone use with poor sleep quality, depression, and anxiety: A systematic review and meta-analysis, Psychiat Res. 284 (2020) 112686.
42. L. Quigley, I. Yakovenko, D.C. Hodgins, K.S. Dobson, N. El-Guebaly, D.M. Casey, D.P. Schopflocher, Comorbid problem gambling and major depression in a community sample, J Gambl Stud. 31 (2015)1135-1152.
43. M.G. Schluter, H.S. Kim, J.C. Poole, D.C. Hodgins, D.S. McGrath, K.S. Dobson, H.

Taveres, Gambling-related cognitive distortions mediate the relationship between depression and disordered gambling severity, Addict Behav. 90 (2019) 318-323.

44. V. González-Bueso, J.J. Santamaría, D. Fernández, L. Merino, E. Montero, J. Ribas, Association between internet gaming disorder or pathological video-game use and comorbid psychopathology: A comprehensive review, Int J Env Res Pub Health. 15 (2018) 668.
45. N. Männikkö, H. Ruotsalainen, J. Miettunen, H.M. Pontes, M. Kääriäinen, Problematic gaming behaviour and health-related outcomes: A systematic review and meta-analysis, J Health Psychol. 25 (2020) 67-81.
46. S. Achab, M. Nicolier, F. Mauny, J. Monnin, B. Trojak, P. Vandel, E. Haffen, Massively multiplayer online role-playing games: comparing characteristics of addict vs non-addict online recruited gamers in a French adult population, BMC Psychiatry. 11 (2011) 1-12.
47. J. Mikuška, A.T. Vazsonyi, Developmental Links Between Gaming and Depressive Symptoms, J Res Adolescence. 28 (2018) 680-697.
48. A.J. Van Rooij, C.J. Ferguson, M. Colder Carras, D. Kardefelt-Winther, J. Shi, E. Aarseth, A.K. Przybylski, A weak scientific basis for gaming disorder: Let us err on the side of caution, J Behav Addict. 7 (2018) 1-9.
49. H. Jeong, H.W. Yim, S.Y. Lee, H.K. Lee, M.N. Potenza, S.J. Jo, H.J. Son, Reciprocal relationship between depression and Internet gaming disorder in children: A 12-month follow-up of the iCURE study using cross-lagged path analysis, J Behav Addict. 8 (2019) 725-732.

50. E. Fujiwara, Looking at the eyes interferes with facial emotion recognition in alexithymia, J Abnorm Psychol. 127 (2018) 571.
51. J. Poquérusse, L. Pastore, S. Dellantonio, G. Esposito, Alexithymia and autism spectrum disorder: a complex relationship, Front Psychol. 9 (2018) 1196.
52. M. Di Tella, L. Castelli, Alexithymia in chronic pain disorders, Curr Rheumatol Rep. 18 (2016) 41.
53. E. Kinnaird, C. Stewart, K. Tchanturia, Investigating alexithymia in autism: A systematic review and meta-analysis, Eur psychiatry. 55 (2019) 80–89.
54. G. Martino, A. Caputo, P. Schwarz, F. Bellone, W. Fries, M.C. Quattropani, C.M.Vicario, Alexithymia and Inflammatory Bowel Disease: A Systematic Review, Front Psychol. 11 (2020) 1763.
55. G. Martino, A. Caputo, C.M. Vicario, A. Catalano, P. Schwarz, M.C. Quattropani, The relationship between alexithymia and type 2 diabetes: A systematic review, Front Psychol. 11 (2020) 2026.
56. L. Hemming, G. Haddock, J. Shaw, D. Pratt, Alexithymia and its associations with depression, suicidality, and aggression: An overview of the literature, Front Psychiatry, 10 (2019) 203.
57. K.E. Cruise, R. Becerra, Alexithymia and problematic alcohol use: A critical update, Addict Behav. 77 (2018) 232-246.
58. A. Mahapatra, P. Sharma, Association of Internet addiction and alexithymia - A scoping review, Addict Behav. 81 (2018) 175-182.
59. D. Marchetti, M.C. Verrocchio, P. Porcelli, Gambling problems and alexithymia: A

systematic review, Brain Sci. 9 (2019) 191.

60. K.P. Morie, S.W. Yip, C. Nich, K. Hunkele, K.M. Carroll, M.N. Potenza, Alexithymia and addiction: A review and preliminary data suggesting neurobiological links to reward/loss processing, Curr Addict Rep. 3 (2016) 239–248.
61. M. Lyvers, R. Hinton, S. Gotsis, M. Roddy, M.S. Edwards, F.A. Thorberg, Traits linked to executive and reward systems functioning in clients undergoing residential treatment for substance dependence, Pers Indiv Differ. 70 (2014) 194-199.
62. C. Bonnaire, D. Baptista, Internet gaming disorder in male and female young adults: The role of alexithymia, depression, anxiety and gaming type, Psychiat Res. 272 (2019) 521-530.
63. C. Evren, B. Evren, E. Dalbudak, M. Topçu, N. Kutlu, J.D. Elhai, Relationship between internet gaming disorder symptoms with attention deficit hyperactivity disorder and alexithymia symptoms among university students, Addicta: Turkish J Addict. 7 (2020) 1-9.
64. N. LePera, Relationships between boredom proneness, mindfulness, anxiety, depression, and substance use, The New School Psychology Bulletin. 8 (2011) 15-25.
65. S.E. Iso-Ahola, E. Weissinger, Perceptions of boredom in leisure: Conceptualization, reliability and validity of the leisure boredom scale, J Leisure Res. 22 (1990) 1-17.
66. A. Stringaris, Editorial: Boredom and developmental psychopathology, J Child Psychol Psychiatry. 57 (2016) 1335–1336.
67. E. Wegmann, S. Ostendorf, M. Brand, Is it beneficial to use Internet-communication for escaping from boredom? Boredom proneness interacts with cue-induced craving

and avoidance expectancies in explaining symptoms of Internet-communication disorder, PloS One. 13 (2018) e0195742.

68. R.P. Smith, Boredom: A review, Hum Factors. 23 (1981) 329-340.
69. M. Todman, Boredom and psychotic disorders: Cognitive and motivational issues, Psychiatry. 66 (2003) 146–167.
70. V.A. Pironti, M.C. Lai, U. Müller, E.T. Bullmore, B.J. Sahakian, Personality traits in adults with attention-deficit hyperactivity disorder and their unaffected first-degree relatives, BJPsych Open. 2 (2016) 280-285.
71. M. Spaeth, K. Weichold, R.K. Silbereisen, The development of leisure boredom in early adolescence: Predictors and longitudinal associations with delinquency and depression, Dev Psychol. 51 (2015) 1380.
72. Z. Wang, X. Yang, X. Zhang, Relationships among boredom proneness, sensation seeking and smartphone addiction among Chinese college students: Mediating roles of pastime, flow experience and self-regulation, Technol Soc. 62(2020) 101319.
73. China Internet Network Information Center, A survey on adolescents' Internet use in China, (2020). Retrieved February 16, 2021 from: http://www.cnnic.net.cn/hlwfzyj/hlwxzbg/qsnbg/202005/P020200513370410784435.pdf
74. S.H. Huang, Y.J. Chen, Q.A. Zhou, Y.R. Wang, Boredom proneness and Internet gaming disorder in university freshmen: The role of the meaning in life, China J Health Psychol. 28 (2020) 580-585.
75. W.C. Wang, Exploring the Relationship Among Free-Time Management, Leisure

Boredom, and Internet Addiction in Undergraduates in Taiwan, Psychol Rep. 122 (2019) 1651-1665.

76. W.J. Chou, Y.P. Chang, C.F. Yen, Boredom proneness and its correlation with Internet addiction and Internet activities in adolescents with attention-deficit/hyperactivity disorder, Kaohsiung J Med Sci. 34 (2018) 467-474.
77. G. Dong, L. Wang, X. Du, M.N. Potenza, Gaming increases craving to gaming-related stimuli in individuals with internet gaming disorder, Biol Psychiat-Cogn Neuroscience N. 2 (2017) 404-412.
78. D.L. King, S.R. Chamberlain, N. Carragher, J. Billieux, D. Stein, K. Mueller, P.H. Delfabbro, Screening and assessment tools for gaming disorder: A comprehensive systematic review, Clin Psychol Rev. 77 (2020) 101831.
79. J.M. Ernst, J.T. Cacioppo, Lonely hearts: Psychological perspectives on loneliness, Appl Prev Psychol. 8 (1999) 1-22.
80. J.T. Cacioppo, L.C. Hawkley, L.E. Crawford, J.M. Ernst, M.H. Burleson, R.B. Kowalewski,G.G. Berntson, Loneliness and health: Potential mechanisms, Psychosom Med. 64 (2002) 407-417.
81. F.M. Alpass, S. Neville, Loneliness, health and depression in older males, Aging Ment Health. 7 (2003) 212-216.
82. P. Qualter, S.L. Brown, P. Munn, K.J. Rotenberg, Childhood loneliness as a predictor of adolescent depressive symptoms: An 8-year longitudinal study, Eur Child Adoles Psy. 19 (2010) 493-501.
83. M. Jaradat, M. Jibreel, H. Skaik, Individuals' perceptions of technology and its

relationship with ambition, unemployment, loneliness and insomnia in the Gulf, Technol Soc. 60(2020) 101199.

84. S.L. Canham, P.M. Mauro, C.N. Kaufmann, A. Sixsmith, Association of alcohol use and loneliness frequency among middle-aged and older adult drinkers, J Aging Health. 28 (2016) 267-284.

85. Y. Özdemir, Y. Kuzucu, Ş. Ak, Depression, loneliness and Internet addiction: How important is low self-control? Comput Hum Behav. 34 (2014) 284-290.

86. A. McQuade, P. Gill, The role of loneliness and self-control in predicting problem gambling behaviour, Gambl Res. 24 (2012) 18-30.

87. D. Chappell, V. Eatough, M.N. Davies, M. Griffiths, EverQuest—It's just a computer game right? An interpretative phenomenological analysis of online gaming addiction, Int J Ment Health Addict. 4 (2006) 205-216.

88. J.S. Lemmens, P.M. Valkenburg, J. Peter, Psychosocial causes and consequences of pathological gaming, Comput Hum Behav. 27 (2011) 144-152.

89. H.S. Qureshi, M.J. Khan, U. Masroor, Increased aggression and loneliness as potential effects of pathological video-gaming among adolescents, Pakistan J Soc Clin Psychol. 11 (2013).

90. J. Kim, R. LaRose, W. Peng, Loneliness as the cause and the effect of problematic Internet use: The relationship between Internet use and psychological well-being, CyberPsychol Behav. 12 (2009) 451-455.

91. P. Wang, J. Wang, Y. Yan, Y. Si, X. Zhan, Y. Tian, Relationship between loneliness and depression among Chinese junior high school students: The serial mediating roles of

internet gaming disorder, social network use, and generalized pathological internet use, Front Psychol. 11 (2020) 529655.

92. D.J. Mills, J.J. Allen, Self-determination theory, internet gaming disorder, and the mediating role of self-control, Comput Hum Behav. 105(2020) 106209.
93. W.B. Gao, Z.Y. Chen, A Study on Psychopathology and Psychotherapy of Internet Addiction, Adv Psychol Sci. 14 (2006) 596-603.
94. J. Billieux, Problematic use of the mobile phone: A literature review and a pathways model, Curr Psychiat Rev. 8 (2012) 299-307.
95. S.P. Borgatti, A. Mehra, D.J. Brass, G. Labianca, Network analysis in the social sciences, Science. 323(5916)(2009) 892-895.
96. R.J. McNally, Network analysis of psychopathology: Controversies and challenges, Annu Rev Clin Psycho. Advance online publication (2020). https://doi.org/10.1146/annurev-clinpsy-081219-092850
97. A.M. Isvoranu, C.D. van Borkulo, L.L. Boyette, J.T. Wigman, C.H. Vinkers, D. Borsboom, Group Investigators, A network approach to psychosis: pathways between childhood trauma and psychotic symptoms, Schizophrenia Bull. 43 (2016) 187-196.
98. D.K. Marcus, J. Preszler, V. Zeigler-Hill, A network of dark personality traits: What lies at the heart of darkness? J Res Pers. 73 (2018) 56-62.
99. A.L.M. Andrade, A. Scatena, G.D.G. Martins, B. de Oliveira Pinheiro, A.B. da Silva, C.C. Enes, D.J. Kim, Validation of smartphone addiction scale–Short version (SAS-SV) in Brazilian adolescents, Addict Behav. 110 (2020) 106540.
100. R. Mullen, E.S. Jones, Network analysis of competitive state anxiety, Front

Psychol. 11 (2021) 3726.

101. L. Masferrer, A.D. Mancini, B. Caparrós, Understanding the relationship between complicated grief symptoms and patterns of personality disorders in a substance users' sample: A network analysis approach, Front Psychol. 11 (2020) 566785.

102. A.Y. See, T.A. Klimstra, A.O. Cramer, J.J. Denissen, The network structure of personality pathology in adolescence with the 100-Item Personality Inventory for DSM-5 Short-Form (PID-5-SF), Front Psychol. 11 (2020) 823.

103. H.M. Pontes, B. Schivinski, C. Sindermann, M. Li, B. Becker, M. Zhou, C. Montag, Measurement and conceptualization of Gaming Disorder according to the World Health Organization framework: The development of the Gaming Disorder Test, Int J Ment Health Addict. Advance online publication (2019). https://doi.org/10.1007/s11469-019-00088-z

104. American Psychiatric Association, Diagnostic and statistical manual of mental disorders DSM-IV-TR. 4th ed. Text Revision. Washington DC: American Psychiatric Association.(2000).

105. B. Löwe, J. Unützer, C.M. Callahan, A.J. Perkins, K. Kroenke, Monitoring depression treatment outcomes with the Patient Health Questionnaire-9, Med Care. (2004) 1194-1201.

106. B.P. Lai, A.K. Tang, D.T. Lee, A.S. Yip, T.K. Chung, Detecting postnatal depression in Chinese men: A comparison of three instruments, Psychiat Res. 180 (2010) 80-85.

107. R.M. Bagby, J.D. Parker, G.J. Taylor, The twenty-item Toronto Alexithymia Scale—I. Item selection and cross-validation of the factor structure, J Psychosom Res. 38 (1994)

23-32.1.

108. J.Y. Yi, S.Q. Yao, X.Z. Zhu, The Chinese version of the TAS-20: Reliability and validity, Chinese Ment Health J. 17 (2003) 763-767.

109. L.S. Radloff, The CES-D scale: A self-report depression scale for research in the general population, Appl Psych Meas. 1 (1977) 385-401.

110. L. Bergkvist, J.R. Rossiter, The predictive validity of multiple-item versus single-item measures of the same constructs, J Marketing Res. 44 (2007) 175-184.

111. D.G. Gardner, L.L. Cummings, R.B. Dunham, J.L. Pierce, Single-item versus multiple-item measurement scales: An empirical comparison, Educ Psychol Meas. 58 (1998) 898-915.

112. S.M. Shaw, L.L. Caldwell, D.A. Kleiber, Boredom, stress and social control in the daily activities of adolescents, J Leisure Res. 28 (1996) 274-292.

113. C.D. van Borkulo, Network Comparison Test: Statistical comparison of two networks based on three invariance measures, (2016). Retrieved February 16, 2021 from: https://cran.r-project.org/web/packages/NetworkComparisonTest/index.html.

114. J. Friedman, T. Hastie, R. Tibshirani, Sparse inverse invariance estimation with the graphical lasso, Biostatistics. 9 (2008) 432-441.

115. J. Chen, Z. Chen, Extended Bayesian information criteria for model selection with large model spaces, Biometrika. 95 (2008) 759-771.

116. S. Epskamp, A.O. Cramer, L.J. Waldorp, V.D. Schmittmann, D. Borsboom, qgraph: Network visualizations of relationships in psychometric data, J Stat Softw. 48 (2012) 1-18.

117. S. Epskamp, D. Borsboom, E.I. Fried, Estimating psychological networks and their accuracy: A tutorial paper, Behav Res Methods. 50 (2018) 195-212.

118. C.D. Van Borkulo, L. Boschloo, J. Kossakowski, P. Tio, R.A. Schoevers, D. Borsboom, L.J. Waldorp, Comparing network structures on three aspects: A permutation test. Unpublished manuscript. (2017). doi:10.13140/RG.2.2.29455.38569

119. R.A. Desai, S. Krishnan-Sarin, D. Cavallo, M.N. Potenza, Video-gaming among high school students: health correlates, gender differences, and problematic gaming, Pediatrics. 126 (2010) e1414–e1424.

120. G. Dong, L. Wang, X. Du, M.N.Potenza, Gender-related differences in neural responses to gaming cues before and after gaming: implications for gender-specific vulnerabilities to Internet gaming disorder, Soc Cogn Affect Neur. 13 (2018) 1203–1214.

121. N. Zeng, M. Wang, H. Zheng, J. Zhang, H. Dong, M.N. Potenza, G.H. Dong, Gender-related differences in frontal-parietal modular segregation and altered effective connectivity in internet gaming disorder, J Behav Addict. Advance online publication (2021). doi.org/10.1556/2006.2021.00015

122. D. Moore, N.R. Schultz, Loneliness at adolescence: Correlates, attributions, and coping, J Youth Adolescence. 12 (1983) 95-100.

123. J. Skues, B. Williams, J. Oldmeadow, L. Wise, The effects of boredom, loneliness, and distress tolerance on problem internet use among university students, Int J Ment Health Addict. 14 (2016) 167-180.

124. S.X. Zhou, L. Leung, Gratification, loneliness, leisure boredom, and self-esteem as

predictors of SNS-game addiction and usage pattern among Chinese college students, In: Internet and technology addiction: Breakthroughs in research and practice. (2019). (pp. 613-629). IGI Global.

125. Z. Tras, Internet addiction and loneliness as predictors of internet gaming disorder in adolescents, Educ Res Rev. 14 (2019) 465-473.

126. H. Dong, M. Wang, H. Zheng, J. Zhang, G.H. Dong, The functional connectivity between the prefrontal cortex and supplementary motor area moderates the relationship between internet gaming disorder and loneliness, Prog Neuro-Psychoph. 108 (2021) 110154.

127. J.T. Cacioppo, M.E. Hughes, L.J. Waite, L.C. Hawkley, R.A. Thisted, Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses, Psychol Aging. 21 (2006) 140.

128. P. Qualter, S.J. Quinton, H. Wagner, S. Brown, Loneliness, interpersonal distrust, and alexithymia in university students, J Appl Soc Psychol. 39 (2009) 1461-1479.

129. R.W. Moeller, M. Seehuus, Loneliness as a mediator for college students' social skills and experiences of depression and anxiety, J Adolescence. 73 (2019) 1-13.

130. T. Richardson, P. Elliott, R. Roberts, Relationship between loneliness and mental health in students, J Public Ment Health. 16 (2017) 48-54.

131. R.F. Levant, Toward the reconstruction of masculinity, J Fam Psychol. 5 (1992) 379.

132. K.M. Carpenter, M.E. Addis, Alexithymia, gender, and responses to depressive symptoms, Sex Roles. 43 (2000) 629-644.

133. D.L. King, S.R. Chamberlain, N. Carragher, J. Billieux, D. Stein, D., K. Mueller, K., ... & P.H. Delfabbro, Screening and assessment tools for gaming disorder: A comprehensive systematic review. Clin Psychol Rev. 77 (2020) 101831.

Table 1. Descriptive characteristics of the sample (n = 1,635)

Variables		N (100%)/Mean±SD
Age		20.2±1.6
Gender		
	Male	913 (55.8%)
	Female	722 (44.2%)
Grade		
	Freshmen	542(33.1%)
	Sophomore	481 (29.4%)
	Junior	120(7.3%)
	Senior	492(30.1%)
Residential status		
	Urban	748 (45.7%)
	Rural	887 (54.3%)
Left-behind children		
	Yes	609 (37.2%)
	No	1026 (62.8%)
Family structure		
	parents	1469 (89.8%)
	Single parent or stepparents	131 (8%)
	Other	35 (2.1%)
Game time (years)		
	≤3	548(33.5%)
	3～10	854(52.2%)
	>10	233(14.3%)
Weekly time spent		

gaming (days)		
	≤3	981(60%)
	4～7	654(40%)
Everyday time spent gaming (hours)		
	≤3	1400(85.6%)
	3～10	206(12.6%)
	>10	29(1.8%)
gaming time spent on weekend		
	≤3	1056(64.6%)
	3～10	527(32.2%)
	>10	52(3.2%)

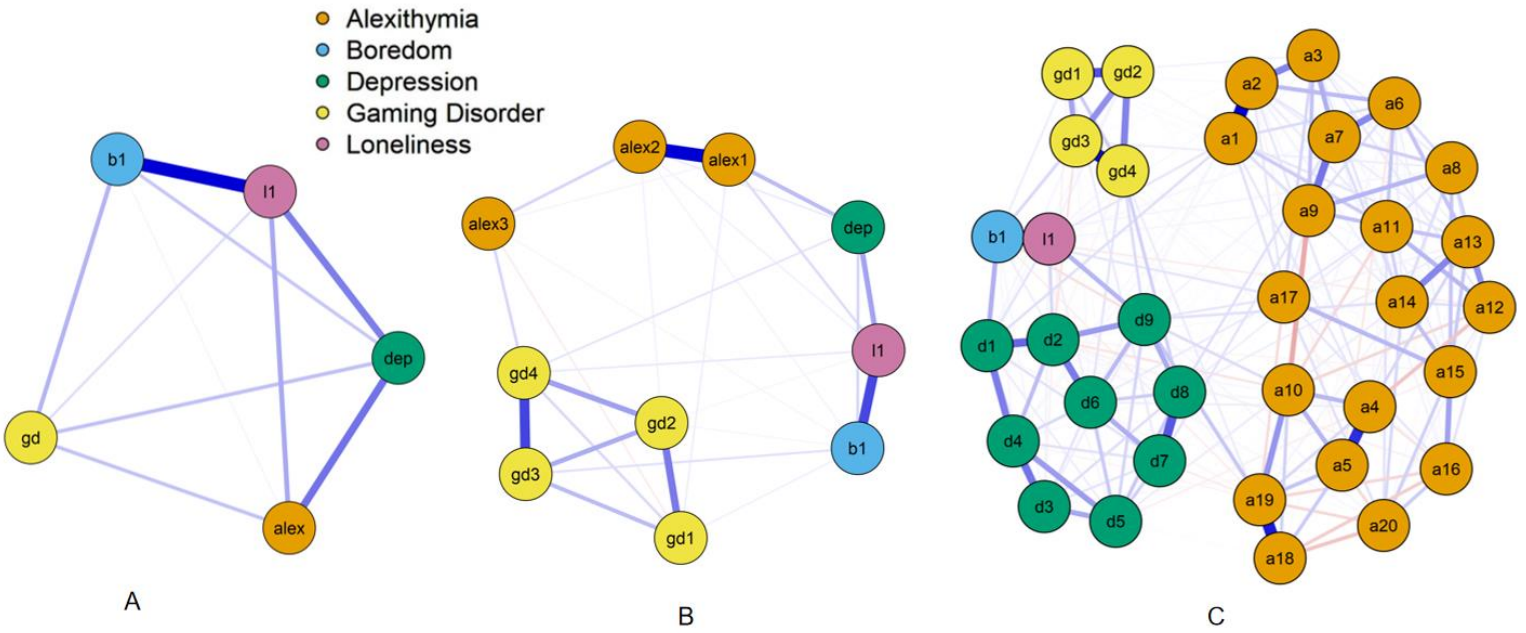

Figure 1. EBICglasso model based on network analysis according to the relationships between GD, depression, alexithymia, boredom and loneliness among 1635 participants in domain-level network (A), in facet-level network (B) and in item-level network (C). Note: gd, gd1～gd4 = Gaming disorder, dep, d1～d9 = Depression, alex, alex1～alex3, a1～a20 = Alexithymia, b1 = Boredom, l1= Loneliness.

Figure 2. Standardized estimates of node strength centrality in the domain-level network between males and female groups. Note: gd = Gaming disorder, dep = Depression, alex = Alexithymia, b1 = Boredom, l1= Loneliness.