Network Structures of Internet Gaming Disorder and Gaming Disorder: Symptom Operationalization Causes Variation

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Abstract

Background: From 2022, the ICD-11 includes the first mental disorder based on digital technology, "gaming disorder", which was previously suggested as a condition for further study in the DSM-5 (2013). In this study, we provide the first large-scale network analysis of various symptom structures for these constructs to understand the complex interconnections between their proposed symptoms.

Methods: Culturally diverse samples of 2,846 digital game players (*M* = 25.3 years) and 746 esports players (*M* = 23.5 years) were recruited. Network approach was applied to explore a multiverse of gaming disorder symptom structures, effects of item operationalization, and possible external moderators.

Findings: Two symptoms (lack of control and continued use despite problems) present in both, the DSM-5 and ICD-11, were systematically central to most of the analyzed networks. Alternative operationalizations of single items systematically caused significant network differences. Networks were invariant across groups of play style, age, gender, gaming time, and most of the psychosocial characteristics.

Interpretation: Our results caution practitioners and researchers when studying and interpreting gaming disorder symptoms. The data indicate that even minor item-level changes can lead to significant network-level changes, thus highlighting the need for careful operationalization. Considering this high sensitivity of the network structure, future clinical validation studies should not be strictly limited to the wordings, criteria, and symptoms of current diagnostic manuals.

As billions of people now play digital games globally, gaming has come to serve as a highly important leisure activity for children, adolescents, and adults. At the same time, current meta-analysis estimates 2.4% of people to develop pathological gaming patterns (Kim et al., 2021). In line with these estimations, the first mental disorder based on digital technology, "gaming disorder" (GD), enters global clinical use in 2022. This diagnostic category refers to both offline and online digital game play under the addictive behaviors class in the World Health Organization's ICD-11 (WHO, 2018). So far, the American Psychiatric Association has not included digital play behaviors in the DSM-5 (APA, 2013), however, "internet gaming disorder" (IGD) is listed as a potential condition needing more research.

The current knowledge regarding IGD/GD symptoms[1] is limited. The nine symptoms proposed in the DSM-5 (see Table 1) were soon found weak in utility (e.g., Griffiths et al., 2016); and while the ICD-11 criteria tend to be considered more useful, new clinical evidence implies that the majority of treatment-seekers do not meet these criteria either (Starcevic et al., 2020).

1 The DSM-5 uses the term "symptom" and the ICD-11 "criterion" for their listed diagnostic requirements. We use the former due to its consistency with the network approach, however, we also note our skepticism toward the causal implication of symptoms being produced by a latent construct (IGD/GD).

Table 1

Description of IGD/GD symptoms and criteria

Internet gaming disorder (DSM-5)	Gaming disorder (ICD 11)
Persistent and recurrent use of the Internet to engage in games, often with other players, leading to clinically significant impairment or distress as indicated by five (or more) of the following in a 12-month period:	Persistent or recurrent gaming behavior ('digital gaming' or 'video-gaming'), which may be online (i.e., over the internet) or offline, manifested by:
Symptoms	Criteria
1. **Preoccupation** Preoccupation with internet games. (The individual thinks about previous gaming activity or anticipates playing the next game; internet gaming becomes the dominant activity in daily life.)	1. **Control** Impaired control over gaming (e.g., onset, frequency, intensity, duration, termination, context).
2. **Withdrawal** Withdrawal symptoms when internet gaming is taken away. (These symptoms are typically described as irritability, anxiety, or sadness, but there are no physical signs of pharmacological withdrawal.)	2. **Prioritization** Increasing priority given to gaming to the extent that gaming takes precedence over other life interests and daily activities.
3. **Tolerance** Tolerance—the need to spend increasing amounts of time engaged in internet games.	3a. **Continued use** Continuation or escalation of gaming despite the occurrence of negative consequences.
4. **Control** Unsuccessful attempts to control the participation in internet games.	3b. **Problems** The behavior pattern is of sufficient severity to result in significant impairment in personal, family, social, educational, occupational or other important areas of functioning.
5. **Loss of interests** Loss of interests in previous hobbies and entertainment as a result of, and with the exception of, internet games.	
6. **Continued use** Continued excessive use of internet games despite knowledge of psychosocial problems.	
7. **Deception** Has deceived family members, therapists, or others regarding the amount of internet gaming.	
8. **Escape** Use of Internet games to escape or relieve a negative mood (e.g., feelings of helplessness, guilt, anxiety).	
9. **Problems** Has jeopardized or lost a significant relationship, job, or education or career opportunity because of participation in internet games.	

In particular, little is known about the relationships between the proposed symptoms. Our study responds to this need from the perspective of network analysis (see, e.g., Borsboom et al., 2021), which is well suited for exploring the structures of relationships between symptoms — those which have been included to and non-included to diagnostic manuals (Fried et al., 2016; Hansen et al., 2021). Previously, some symptoms have been labeled as "core" and other as "peripheral," however, the literature on IGD/GD is mixed regarding which should belong to each class (e.g., Ballou & van Rooij 2021; Snodgrass et al., 2018). The present study was designed to pursue clarity on this issue as well.

Present study

In this exploratory study, we studied the linkages between the different network structures of gaming disorder, based on DSM-5 and ICD-11 symptomatologies, and different operationalizations of symptoms varying in content validity. In the network approach, symptoms are assumed to act as independent causal agents, directly affecting each other. Under this approach, psychopathology is modeled as a complex system, emerging from self-sustaining recurrent interactions of causally linked symptoms. Network analysis then allows one to explore complex patterns of symptom relationships and identify which symptoms are central and which are peripheral to the given disorder (see Borsboom et al., 2021). We formulated research questions 1.1. and 1.2. before data collection, and they additionally led us to ask 1.3, 1.4, and 1.5 during the analyses:

RQ 1.1 *How are the IGD/GD symptoms structurally interconnected?*
RQ 1.2 *What are the central and peripheral symptoms in the IGD/GD networks?*
RQ 1.3 *How is the (non-overlapping) combination of IGD/GD symptoms structurally interconnected?*
RQ 1.4 *Which symptoms bridge the IGD and GD constructs?*
RQ 1.5 *How does the inclusion of causally relevant variables from outside of the diagnostic manuals—craving, neglect of own health, and gaming time—change the combined IGD/GD network?*

The preliminary state of GD research is also mirrored by the large number of screening scales, the items of which collectively measure hundreds of differently operationalized symptoms (King et al., 2020). In theory, after the DSM-5 (2013) and ICD-11 (2019) were published, new screening scales should have a shared semiology. However, content validity analysis shows that scales following the diagnostic manuals operationalize their symptoms in substantially different ways—thus measuring potentially different constructs (Karhulahti et al., 2021). Whether these different operationalizations result in different screening outcomes remains an open empirical question, and our network approach is a fitting method for seeking answers to it. We choose to investigate the operationalization of four DSM-5 symptoms that previous research (ibid.) found weak in content validity across scales. We formulated 2.1, 2.2, 2.3, and 2.4 before data collection, and they led us to ask 2.5 during analysis:

*How do different operationalizations of "withdrawal" (**RQ 2.1**), "*loss of interests*" (**RQ 2.2**), "tolerance" (**RQ 2.3**), and "*continued use*" (**RQ 2.4**) affect the DSM-5 network?*
***RQ 2.5** How is the combination of DSM-5 network with different operationalizations of "withdrawal", "*loss of interests*", "tolerance", and "*continued use*" together with causally relevant variables from outside of the diagnostic manuals—craving, neglect of own health, and gaming time—structurally interconnected?*

As Wittgenstein (1953) pointed out already in the 1950s, "games" represent such a rich conceptual category that one such item may have almost nothing to do with another. This issue of family resemblance is a serious challenge for IGD/GD measurement, as different groups of people play different games and thus entail different measurements. For instance, many digital games designed for children are different from those for adults, and women may have different play preferences compared to men (e.g., Hartmann & Klimmt, 2006). In addition, the recently emerged competitively oriented play, *esports*—hundreds of millions of players now globally—represents a unique type of gaming subculture (Karhulahti, 2020). The above issues of operationalization should be further examined within distinct player groups to better understand if and how symptoms are differently structurally interconnected in different player populations and across different gameplay characteristics. All research questions in the third group were formulated before data collection.

*How do the IGD and GD networks differ between groups of play style (**RQ 3.1**), age (**RQ 3.2**), gender (**RQ 3.3**), gaming time **(RQ 3.4)** and psychosocial characteristics (**RQ 3.5**)?*

Methods

Participants

Data from an international, culturally diverse sample of digital game players was collected via the Prolific platform (for all details, see supplementary materials). Several screening procedures aimed at data quality were carried out (bot detection, failed attention checks, and careless responding patterns). As a result, 5.6% of the participants were excluded from analyses. The final sample size was *N* = 2,846. The sample comprised digital game players (80.5% male, 18.2% female, 1% non-binary) with a mean age of 25.3 years (*SD* = 7.4). The average reported time spent gaming equaled 3.97 hours per day (*SD* = 2.48) (61.11% of this time was dedicated to online gaming, on average). The participants spent another 3.06 hours per day (*SD* = 2.88) on additional activities related to digital games (watching gaming-related videos, etc.). For RQ 3.3, a similar sample of esports-specific players (*N* = 746; see supplementary materials) was recruited. Given the exploratory nature of this study, we first maximized sample size by budget and then verified the stability of the networks via post hoc analysis.

Measures

DSM-5-based IGD was measured using the English version of Internet Gaming Disorder Scale Short-Form (IGDS9-SF; Pontes & Griffiths, 2015). ICD-11 based GD was measured using the English version of the Gaming Disorder Test (Pontes et al., 2019). For RQ2, we selected alternative

symptom operationalizations with high content validity, based on a previous semantic analysis (Karhulahti, et al., 2021). Items measuring *withdrawal*, *loss of interests*, and *continued use* were selected from C-IGDS (Sigerson et al., 2017); *tolerance* from PIE-9 (Pearcy et al., 2016). For RQ 3.4, we also measured moderator variables that reflected psychosocial characteristics (support within family, motives for gaming, problematic gaming cognitions, self-control, neuroticism, harm avoidance, loneliness, and reward responsiveness). For RQs 1.5 and 2.5, we measured *craving*, *neglect of one's own health*, and *gaming time* which have been suggested and found to be relevant non-diagnostic variables (Castro-Calvo et al., 2021; van Rooij et al., 2017; APA, 2013). Descriptive statistics are presented in Table 2.

Table 2

Descriptive statistics

	regular players	esports players	possible range
	M (*SD*)	*M* (*SD*)	
gaming time	3.97 (2.48)	5.37 (3.00)	0 - 24
IGDS9-SF	2.03 (0.62)	2.33 (0.66)	1 - 5
GDT	2.08 (0.81)	2.32 (0.84)	1 - 4
craving	3.05 (0.93)	3.21 (0.99)	1 - 5
neglect of own health	2.36 (1.13)	2.62 (1.19)	1 - 5
family relationship	2.25 (0.50)	2.23 (0.51)	1 - 3
social motive for gaming	2.48 (0.83)	2.75 (0.78)	1 - 5
competition motive for gaming	2.86 (0.99)	3.33 (0.89)	1 - 5
escape motive for gaming	3.14 (1.05)	3.19 (1.03)	1 - 5
coping motive for gaming	3.03 (0.76)	3.04 (0.75)	1 - 5
gaming cognition	1.53 (0.42)	1.65 (0.46)	1 - 3
neuroticism	2.83 (0.75)	2.90 (0.70)	1 - 5
harm avoidance	3.41 (0.65)	3.28 (0.65)	1 - 5
loneliness	3.13 (0.77)	3.17 (0.76)	1 - 5
self-control	2.97 (0.64)	2.87 (0.61)	1 - 5
reward responsiveness	1.54 (0.43)	1.56 (0.46)	1 - 4

Additional information about participants, data collection, and measures can be found at https://osf.io/p8qch/.

Statistical analysis

Networks modeling the nine IGD as well as the four GD symptoms were estimated using the EBICglasso method. The centrality/connectivity measures as well as edge-weights were obtained, and the nodes were compared in their strength. Networks reflecting four different operationalizations of IGD symptoms were estimated and the network comparison test (van Borkulo et al., 2017) was used to assess differences in the parameters (centrality measures and edge/weights) between the IGD structure based on a standardized measure and alternative operationalizations. To examine the effects of each operationalization in more detail, the networks in which only one item was substituted at the time were estimated and compared. The network

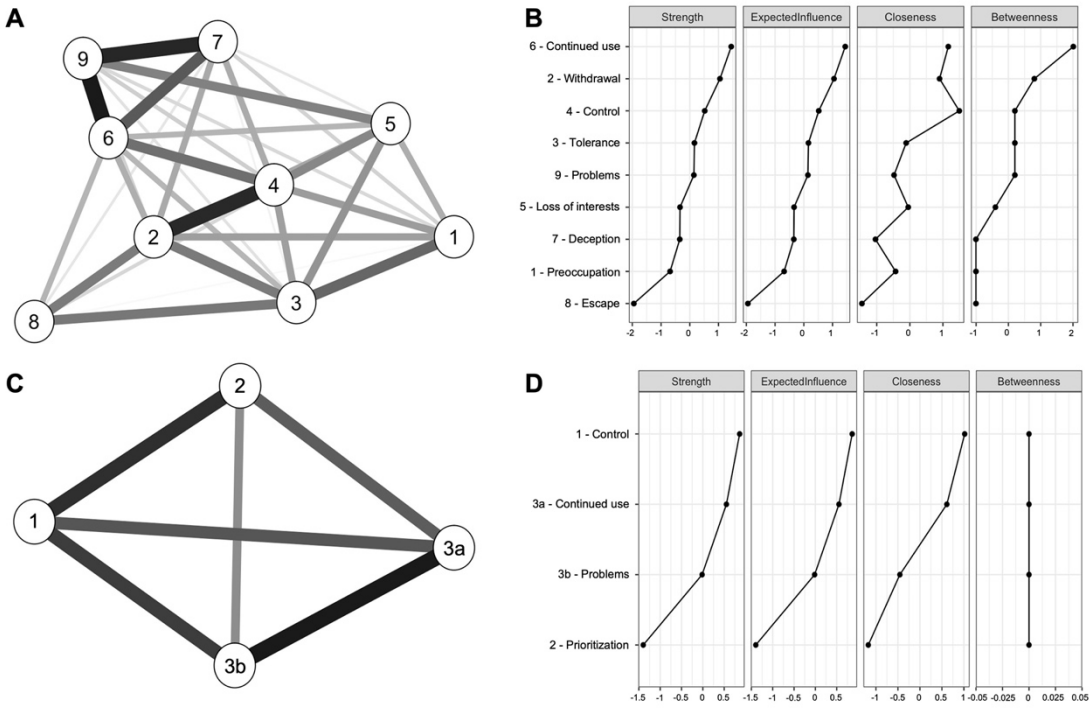
comparison test was also used to examine whether the network structures are invariant across different levels of moderating variables. The continuous moderators were dichotomized using the conditional inference trees method (Jones et al., 2020); the optimal threshold was determined by iteratively testing a particular network structure across all levels of the moderating variable up until the largest difference (when applicable) in the networks of the respective subgroups was found. The differences in network structure, global strength, and the proportion of significantly different edges and nodes were extracted. The analyses were performed in R, with *bootnet* (Epskamp et al., 2018), *NetworkComparisonTest* (van Borkulo et al., 2017), and *networktree* (Jones et al., 2020). For more technical details, see supplementary materials.

Results

RQ1. The visualizations of the network structures of IGD/GD and the corresponding centrality plots are displayed in Figure 1. The symptoms of *withdrawal*, *tolerance*, *control*, and *continued use* appear as central symptoms in the IGD network. For GD, *control* played the most central role.

Figure 1

Visualization of IGD and GD networks and their centrality/connectivity indices

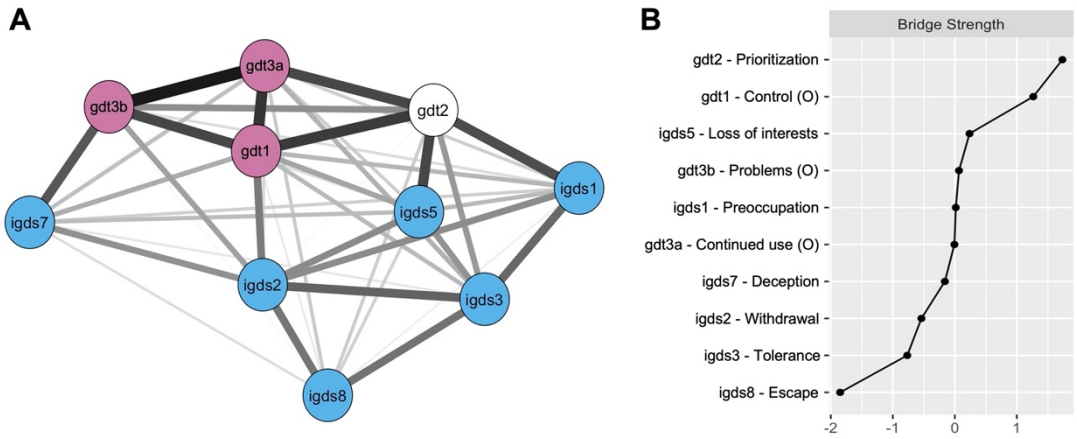


Note: A = visualization of the IGD network; B = centrality/connectivity indices for the IGD network; C = visualization of the GD network; D = centrality/connectivity indices for the GD network

For a visualization of the combined network see Figure 2. *Prioritization* symptom was the bridge indicator with the highest strength. In both networks, with operationalizations based on a standardized measure and alternative operationalizations including causally relevant variables from outside of the diagnostic manuals, *craving* was among the strong nodes, *neglect of own health* was among the weak nodes, and *gaming time* was the weakest of all nodes.

Figure 2

Visualization of a combined IGD/GD network and bridge symptoms strength

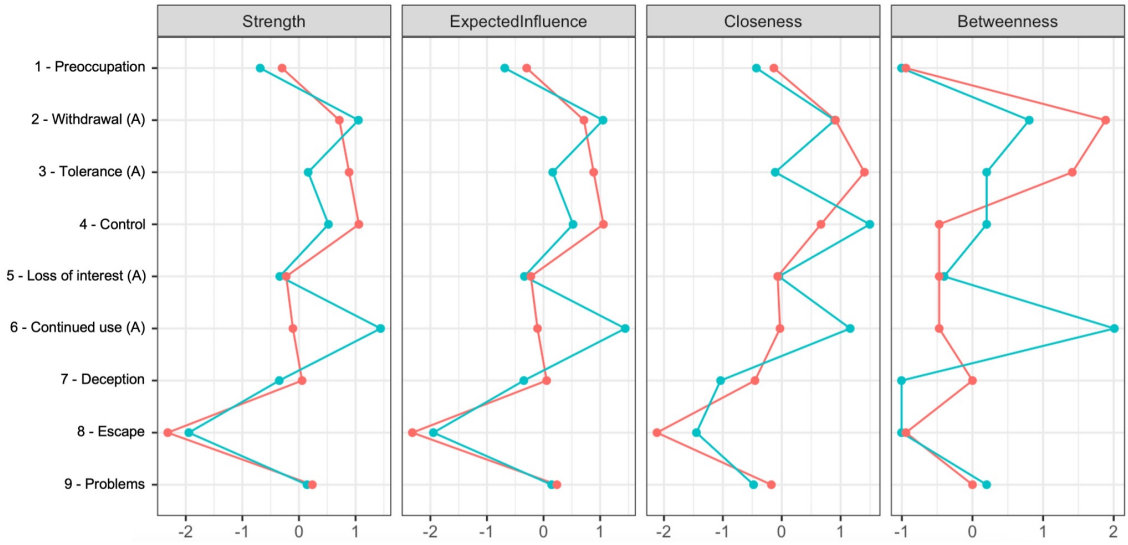


Note: A = visualization of the combined network (GD symptoms are in magenta, non-overlapping IGD symptoms are in blue; the strongest bridge symptom is in white); B = bridge symptoms strength

RQ2. The network structure of IGD (by IGDS9-SF) and that with four higher-content-validity operationalizations were non-invariant, but the global strength was invariant across the two structures. Out of the nine symptoms, a significant and substantial difference was observed for *continued use* (see Figure 3).

Figure 3

Centrality/connectivity indices networks of IGD involving IGDS9-SF items and four alternative higher-content-validity operationalizations



Note: Blue color represents parameters for the original IGDS9-SF items. Red color represents parameters for higher-content-validity operationalizations. For the red color, the alternative items are marked by (A). *P*-values for difference in strength in the pairs of items: 1 = .087, 2 = .041, 3 = .061, 4 = .352, 5 = .639, 6 = < .001, 7 = .270, 8 = .674, 9 = .978.

RQ3. Both IGD and GD networks were invariant across play styles (general digital game players vs. esports players; *p*s > .57) even when re-tested only with those who self-identified as

esports players. Neither age, gender, nor gaming time (*p*s > .23) were significant moderators of IGD/GD networks. Testing for network invariance across levels of all 11 psychosocial variables revealed that the IGD network was invariant in terms of both structure and global strength across all of them, while the GD network structure was significantly moderated by social and escape motives (*p*s < .05) for gaming and its global strength was non-invariant for self-control and neuroticism (*p*s < .02).

Supplementary analyses and sensitivity analyses

Elaborated outcomes, additional research questions, and replication of the analyses on a sample of esports players can be found at https://osf.io/p8qch/. Sensitivity analyses are incorporated into the R code that can be found at https://osf.io/pe9zd/.

Discussion

Our main findings shed light on the structural importance of specific symptoms, their operationalizations in particular, and the absence of network differences between different groups of players.

RQ 1.1 Symptoms in the networks

In all DSM-5 based IGD networks, *escape* was systematically the weakest and least influential symptom. Conceptually, this is consistent with the previous findings where gaming for mood management also occurs in non-problematic play (Lemmens et al., 2015; Rehbein et al., 2015). Although recent literature (Stenseng et al., 2021) has suggested different operationalizations to reflect different kinds of escape and only those involving "self-suppression" to be IGD-relevant, in our data *escape* was weak and non-influential despite self-suppressive operationalization—thus yielding counterevidence for the above. Notably, the ICD-11 does not list any mood management as a criterion for GD.

Second, we found *control* to be the strongest and most influential symptom in both IGD and GD networks. On the other hand, the second ICD-11 symptom, *prioritization*, was found to be a weak and the least influential symptom within the network. This corroborates the view of 29 international experts who rated the symptom as the least relevant of all four ICD-11 symptoms (Castro-Calvo et al., 2021). This supports the idea (Kuss et al., 2017) that prioritizing gaming in daily life is rather common for healthy people who play digital games. Of note, while *prioritization* may serve as a (non-sufficient necessary) symptom, as listed in ICD-11, considering that many DSM-5 based instruments include it as one of the nine symptoms in polythetic measurement, scholars should remain skeptical toward such models. The two symptoms that have not been included in diagnostic manuals, *neglect of one's own health* and *time spent gaming*, played only a minor role in all respective networks, which supports their lack of relevance for the current diagnostic constructs. *Craving* together with *tolerance* and *withdrawal*, on the other hand, were among the strongest nodes in both networks.

RQ 1.2 Core vs peripheral symptoms

When using a DSM-5-based scale for IGD, *continued use*, *withdrawal*, and *control* were found the most important based on centrality measures. In contrast, *escape* and *preoccupation* were the least important. When using an ICD-11 based scale for GD, *prioritization* was the least important. Notably, *control* and *continued use* were central for both constructs. Our results are in line with some previous findings but in conflict with others. In the only previous network analysis on IGD, Yuan et al. (2022) found *control* and *continued use* to be strong and influential symptoms in the network; however, their strongest and most influential symptom *preoccupation* was mediocre in our data. This could be due to variation in operationalizing *preoccupation*, as discussed below. Likewise, one of our three strong and influential IGD symptoms, *withdrawal*, has been considered lacking utility for diagnostic purposes by experts (e.g., Castro-Calvo et al., 2021) and was accordingly excluded from the most recent criteria list in the ICD-11. On the other hand, recent studies (e.g., Ballou & Zendle, 2021) have indicated *withdrawal* to be among the potential signifiers of gaming-related health problems. Based on our findings in the context of previous literature, there is a high probability that *control* and *continued use* (despite related health problems) are indicators of disordered gaming habits at core. However, the role of other symptoms remains difficult to assess—to a large degree due to the numerous different ways in which they have been interpreted and operationalized (see below). Nonetheless, we found *prioritization* as the weakest in the GD network, but as the strongest in the combined IGD/GD network. This implied a bridge function, which we tested and confirmed. We interpret this as evidence for *prioritization* to be a potential peripheral symptom, albeit it remains to be seen how it should be applied in clinical practice (e.g., it may not be useful with individuals in treatment).

RQ2. Operationalization

One of the foremost challenges in the field is that both DSM-5 and ICD-11 based IGD/GD screening instruments operationalize the official diagnostic criteria in many different ways (Karhulahti et al., 2021). This means that results produced by one instrument can differ significantly from those of another instrument—even when both claim to measure the same symptoms. Our findings are the first to provide strong evidence regarding this question: changes in only four item operationalizations already alter the dynamics of the entire network. Updating IGD items *continued use*, *withdrawal*, *tolerance*, and *loss of interests* into items with arguably higher content validity (of identically defined symptoms) resulted in network changes in the first three cases. *Continued use* (despite negative consequences), which was the strongest symptom in *IGDS9-SF* (“Have you continued your gaming activity despite knowing it was causing problems between you and other people?”), became weaker after re-operationalization (“Do you continue to use digital games excessively despite knowledge of psychosocial problems?”, adapted CIGDS). Similarly, *withdrawal* symptoms (“Do you feel more irritability, anxiety or even sadness when you try to either reduce or stop your gaming activity?”, *IGDS9-SF*) lost strength and network influence when updated (“Do you feel irritable, anxious, or sad when gaming is taken away?”, adapted CIGDS). On the other hand, *tolerance*, which was originally a weak symptom (“Do you feel the need to spend an increasing amount of time engaged in gaming in order to achieve satisfaction or

pleasure?", IGDS9-SF), became stronger after revision ("Do you find an increasing need to spend increasing amounts of time engaged in digital games?", adapted PIE-9).

Although our data and methods do not allow making inferences about which operationalizations are "better" or "correct" (or if any of them are), the findings are so far perhaps the most disconcerting evidence suggesting researchers to exercise caution when comparing survey results produced by different IGD/GD items and instruments. As we see, even small item-level changes can lead to significant network-level changes. Previous content validity studies have suggested that rating scales may only be interchangeable indicators if their item content overlaps (Fried, 2017) - our present findings provide direct empirical support for this. The next steps in the field should be to start assessing the validity of actively applied screening instruments and their items with clinically, culturally, and otherwise diverse populations, which can eventually lead to an understanding of how to make useful real-world inferences of various statistical cutoffs and outcomes. Moreover, as the re-operationalized items were not designed to operate in a network with the rest of the analyzed items, future studies should pursue comparative analyses between multiple complete IGD and GD instrument networks.

RQ3. Group differences

We were unable to detect any meaningful group differences based on play style, age, gender, gaming time, and psychosocial characteristics in both networks. The networks and centrality measures were very similar in all groups, suggesting an absence of different mechanisms between symptoms across the subgroups. Especially interesting is the absence of significant differences between esports and other digital game players. We interpret this as evidence for esports games/gaming to operate in a relatively similar manner with other digital games and play, i.e., regardless of esports involvement, people who play intensively (~4 hour/day) do not differ in their gaming experiences as per the DSM-5 and ICD-11 symptomatologies. It is possible that competitive and collaborative elements—which define esports gaming—are such common design components across digital game genres that statistical differences between players of genres are insignificant. Because all of our participants were highly engaged in terms of daily play hours, future research should investigate whether null results can also be obtained between highly active players and those who play only occasionally (e.g., a few hours per week).

Although our analyses were carried out with the symptoms suggested by the current diagnostic authorities, we cannot know if our measured variables are clinically relevant or if some clinically relevant (yet unknown) variables should have been included. With an improved future clinical understanding, exclusions and inclusions of variables can further improve network analyses. Also, the relatively high gaming time in both of our samples means that less frequent players might produce different network structures. Taken together, our findings voice an acute need for collaborative efforts to pursue more coherent operationalization, symptomatology, and careful application of the present diagnostic manuals in both clinical practice and research.

Data sharing

Sharing the data was approved along with the permission to conduct the study by the Ethics committee of the Faculty of Arts, University of Presov, following the ethical principles stated in the Declaration of Helsinki. The data, R code, and ratings are openly available at https://osf.io/a8fhx/.

Supplementary materials

Additional information about participants, data collection, and measures can be found at https://osf.io/p8qch/.

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Authors' contributions

MA: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original Draft, Writing - Review & Editing. **MM**: Conceptualization, Methodology, Investigation, Resources, Writing - Original Draft, Writing - Review & Editing. **VMK**: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing. **IR**: Conceptualization, Methodology, Formal analysis, Writing - Review & Editing. First authorship shared by MA, MM, and VMK.

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