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ORIGINAL PAPER

Network Analysis of Internet Addiction Symptoms Among a Clinical Sample of Japanese Adolescents with Autism Spectrum Disorder

Tomoya Hirota[1] · Eoin McElroy[2] · Ryuhei So[3,4]

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Abstract

In the present study, we employed network analysis that conceptualizes internet addiction (IA) as a complex network of mutually influencing symptoms in 108 adolescents with autism spectrum disorder (ASD) to examine the network architecture of IA symptoms and identify central/influential symptoms. Our analysis revealed that defensive and secretive behaviors and concealment of internet use were identified as central symptoms in this population, suggesting that mitigating these symptoms potentially prevent the development and/or maintenance of IA in adolescents with ASD. Providing adolescents and their caregivers with psychoeducation on the role of central symptoms above in IA can be a salient intervention. Doing so may facilitate nonconflicting conversations between them about adolescents' internet use and promote more healthy adolescents' internet use behavior.

Keywords Internet addiction · Behavioral addiction · Autism spectrum disorder · Network analysis · Centrality

Introduction

Internet addiction (IA) has been gaining recognition and popularity in research and clinical practice due to its impact on individuals' wellbeing and health, including mental health (Kuss and Lopez-Fernandez 2016; Spada 2014). Although terminologies defining IA remain somewhat inconsistent (problematic internet use, pathological internet use, for example: Kuss and Lopez-Fernandez 2016), this condition is generally conceptualized as behavior addiction, featuring six core components: salience, mood modification, tolerance, withdrawal, conflict, and relapse (Griffiths 2005). Prevalence estimates of IA in a general population are reported to be approximately 4% (Durkee et al. 2012; Kaess et al. 2014; Mak et al. 2014). Existing cross-sectional studies indicate that IA is associated with challenges in interpersonal relationships, decreased well-being, poor academic performance, and mental health problems, such as anxiety and depression (Yücens and Üzer 2018).

Recent studies have reported higher prevalence of IA in individuals with autism spectrum disorder (ASD) than that estimated in a general population (Kawabe et al. 2019; So et al. 2017). In addition, studies have indicated that individuals with ASD exhibit more severe IA symptoms compared to non-ASD individuals (MacMullin et al. 2016), suggesting more serious internet use problems in this clinical population. One study suggested that the relationship between IA and some aspects of the behavioral phenotype of ASD, such as restricted interests and repetitive behaviors, could account for higher prevalence and severe symptoms of IA among individuals with ASD (Engelhardt et al. 2017). While screen-based media may provide opportunities for social engagement for individuals with ASD, preoccupation with these media is reported to negatively affect their functioning (Mazurek and Engelhardt 2013). Thus, understanding the mechanism

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✉ Tomoya Hirota
tomoya.hirota@ucsf.edu

[1] Department of Psychiatry and Behavioral Sciences, Weill Institute for Neurosciences, University of California San Francisco, 401 Parnassus Ave, San Francisco, CA, USA

[2] Department of Neuroscience, Psychology and Behaviour, University of Leicester, Leicester, UK

[3] Department of Psychiatry, Okayama Psychiatric Medical Center, Okayama, Japan

[4] Health Promotion and Human Behavior, Graduate School of Medicine / School of Public Health, Kyoto University, Kyoto, Japan

of the development and maintenance of IA in this population is clinically important as it can lead to successful interventions.

However, existing theoretical models remain inconclusive. One of the challenges related to this is that existing models have conceptualized IA based on latent models, which suggests observable clinical signs and symptoms are caused by latent variables. Based on these models, researchers have aggregated individual IA scale items (signs and symptoms) and conceptualized IA as a static construct in previous studies (L. Chen et al. 2018; Pan et al. 2018; So et al. 2017; Tang et al. 2014). However, IA is composed of heterogeneous signs and symptoms which represent groups of observable indicators. Therefore, treating IA at the latent variable level may obscure meaningful associations between individual symptoms.

Recent methodological advancement let us use network models. Network modeling is an alternative approach to understand direct associations among individual signs and symptoms (Borsboom and Cramer 2013; Borsboom 2017). According to the network perspective, a mental disorder is not an underlying latent (unobservable) disease entity. Rather, it is an emergent phenomenon, arising as a complex network of mutually reinforcing symptoms (Borsboom 2017; Borsboom and Cramer 2013; Fried et al. 2017). By quantifying associations between observed symptoms, network models can identify the most 'central' symptoms (i.e. connected to the highest number of symptoms/nodes with the strongest connections). These symptoms/nodes may help identify the core mechanism underlying the onset and maintenance of disorders, and thus targeting them could result in more efficient treatment strategies. Network analysis has been implemented in studying several mental disorders, including depression, anxiety, psychosis, autism spectrum disorder, and substance use disorder (Beard et al. 2016; Hirota et al. 2020; Rhemtulla et al. 2016; van Rooijen et al. 2017).

Accordingly, we applied this perspective to IA to pursue the following aims in the present study: (1) examine the network structure of IA (i.e. associations among individual IA symptoms) in adolescents with ASD; (2) identify central/influential symptoms in the IA network in adolescents with ASD, and; (3) compare the IA network in the ASD group with a sample of a general population. Given the exploratory nature of the present study, we did not form specific hypotheses to the first two aims. In regard to the third aim (i.e. the comparison of the networks between the two groups), we hypothesized that the overall strength of connectedness in the IA network in ASD could be greater given earlier studies have revealed higher prevalence and symptom scores of IA in individuals with ASD than a general population (MacMullin et al. 2016; So et al. 2017).

Methods

Participants

Clinical Sample

This study is a secondary data analysis using an existing database. Data were obtained from adolescents who participated in a study previously conducted at Okayama Psychiatric Medical Center outpatient clinic from February to June 2016. This medical center provides various psychiatric services ranging from outpatient psychiatric care to acute inpatient psychiatric care in the regional urban area. The aim of the original study (So et al. 2017) was to estimate the prevalence of IA among adolescents with ASD alone, those with attention deficit hyperactivity disorder (ADHD) alone, and those with comorbid ASD and ADHD in psychiatric outpatient service.

Inclusion criteria were as follows: (1) students were 12–15 years old at the time of the study enrollment; (2) students had attended the child and adolescent psychiatric clinic regularly, defined as more than two scheduled visits within 6 months prior to the study enrollment; (3) students were previously diagnosed with ASD and/or ADHD by the board-certified child and adolescent psychiatrists based on DSM-5 criteria, and; (4) students and their caregivers provided informed assents and consents to the study participation, respectively. Students were excluded if they had previously received a diagnosis of moderate to severe intellectual disability, confirmed through the disability certificate (Supplementary Data 1), and the treating psychiatrists determined that they were unable to fully understand the study purpose and answer the questionnaire. Participants' IQ and verbal ability were not measured in the original study. Students included in the original study filled out a self-reported scale (Internet Addiction Test). For the present study, we used a subset of data from adolescents who received a diagnosis of ASD (N = 108). All 108 adolescents were receiving psychiatric services for their co-occurring psychiatric problems (ADHD, emotional and behavioral problems, for example) at the clinic.

The Comparison Group

Data were extracted from the general population for comparison with the ASD group, consisting of middle school students aged 12 – 15 years in Okayama prefecture, Japan, who had participated in a school survey in December 2015. This school survey was conducted in collaboration with the Board of Education in Okayama Prefecture and researchers at Okayama Psychiatric Medical Center. The

overarching goal of this survey was to assess the prevalence of problematic Internet use. The survey included the Internet Addiction Test (IAT) and individual questions inquiring if students had experienced cyberbullying and whether they had got into trouble online. Prior to the implementation of this survey, we mailed letters containing the information on this study to caregivers of each child. Children whose caregivers did not consent to the participation of their children in the survey were excluded from this study accordingly. Students were briefed about the purpose of the survey and completed the questionnaire in the classroom.

Measurement (self-administered Internet Addiction Test: IAT)

The IAT is a 20-item questionnaire, developed by adapting DSM-IV criteria for pathological gambling to the Internet use (Young 1998). These 20 items sum up to a total score ranging from 20 to 100 with a higher total score indicating severe IA status. The developer of the IAT suggests that individuals with a total IAT score of 70 – 100 have significant problems related to Internet use. The IAT questions reflect several elements related to Internet usage: for example, loss of control, withdrawal, preoccupation, social demeanor, sleep problems, and the decline in academic efficiency. The IAT has been validated for the use of non-Japanese adolescents only (Černja et al. 2019; Lai et al. 2013). The internal consistency of the Japanese IAT for the ASD clinical sample and the general population sample was as Cronbach's alpha of 0.93 and 0.92, respectively.

Analytic Plans

Network Estimation

In the network model, individual signs/symptoms are defined as nodes, and relationships between nodes are edges. In the present study, a regularized partial correlation network (i.e. Gaussian graphical model) was constructed using the matrix of polychoric correlations between the 20 symptoms. Polychoric correlations estimate the association between two ordinal variables that are theorized to be reflective of normally distributed latent variables. In this model, the lack of edge between two nodes means conditional independence relationships among the nodes. Edge thickness or weights can be understood as an estimation of partial correlations coefficients, representing the correlation between two nodes when controlling for all other nodes in the network. The network was estimated and visualized using the R-package 'qgraph' (Epskamp et al. 2012). In order to reduce the likelihood of type-I errors, 'qgraph' employs the EBICglasso procedure. In this procedure, all edges in the network and sets small edges are shrunk exactly to zero (the Lasso regularization). This process of regularization is coupled with best fit model selection, by minimizing an information criterion, in this case, Extended Bayesian Information Criterion (EBIC) (Chen and Chen 2008), leading to a sparse network with explanatory power.

Centrality

We calculated several indices of node centrality to quantify the importance of each of the 20 symptoms in the IA network (Opsahl et al. 2010): *closeness* (the inverse of the sum of distances from the node to all other nodes): *betweenness* (the number of times that a node lies on the shortest path between two other nodes): and *expected influence* (EI). EI is a measurement of centrality to quantify how strongly and directly a symptom node is associated with all other nodes in the network. EI sums the raw weights of edges, taking the sign of the edge into account (McNally 2016). These are typically presented as standardized Z-scores, with higher values reflecting greater overall importance of a symptom to the network.

Following these procedures, we explored the accuracy of the network edges and centrality indices and correlational stability of the network using bootstrapped difference tests (see the tutorial: Epskamp et al. 2017 for details of this procedure).

Network Comparison Between the ASD Group and the General Population Group

Networks from different groups can be compared in the following three aspects: (1) overall structural invariance; (2) edge strength invariance; and (3) global connectivity invariance(van Borkulo 2016). The first aspect concerns the structure of the network as a whole and tests whether the structure is identical across groups or not. The second aspect pertains to the difference in the strength of a specific edge of interest. The third aspect is related to the overall level of connectivity (i.e. whether symptoms are connected to the same degree across groups or not). Networks for the ASD group and the general population group were re-estimated for both of these groups and compared using the 'NetworkComparisonTest (NCT)' package (van Borkulo 2016) which tests for three above-mentioned aspects using non-parametric permutation tests (1000 random permutations were used in this study).

Results

Table 1 shows characteristics of adolescents with ASD (N = 108) and those in a general population (N = 3080). In the clinical sample, 25 of 108 adolescents with ASD had

Table 1 Characteristics of study participants

	ASD	General population
N	108	3080
% of male	63.9%	49.6%
Age		
Range (years old)	12—15	12–15
7th grade	31 (28.7%)	1044 (33.9%)
8th grade	35 (32.4%)	1003 (32.6%)
9th grade	42 (38.9%)	1033 (33.5%)
IAT total score		
Mean (SD)	45.8 (18.5)	35.8 (13.7)
20 – 39 (n, %)	44 (40.7%)	2032 (66.0%)
40 – 69	50 (46.3%)	892 (29.0%)
70 or above	14 (13.0%)	69 (2.2%)
Missing data	0 (0%)	87 (2.8%)

IA Internet Addiction, *IAT* internet addiction test, *SD* standard deviation

co-occurring ADHD. The male/female ratio was higher in the ASD group. In addition, the percentage of adolescents whose total IAT score belonged to "significant problems related to internet use" (score of 70 – 100) was higher in the ASD group. We did not conduct descriptive analyses to compare the characteristics of these two groups due to uneven sample sizes.

Network Structure and Centrality

Figure 1 depicts the network structure of relations among IA symptoms in adolescents with ASD (left graph in Fig. 1). The estimated network yielded 190 edges (20*(20–1)/2), among which 93 edges had non-zero weights (mean weight 0.05). The weight of the edge connecting IAT items 6 ("*School grades suffer due to the internet use*") and 7 (*"Academic efficiency declines due to the internet use"*) was the strongest (0.47). Other strong associations include those between *"Conceal the amount of time spent online"*

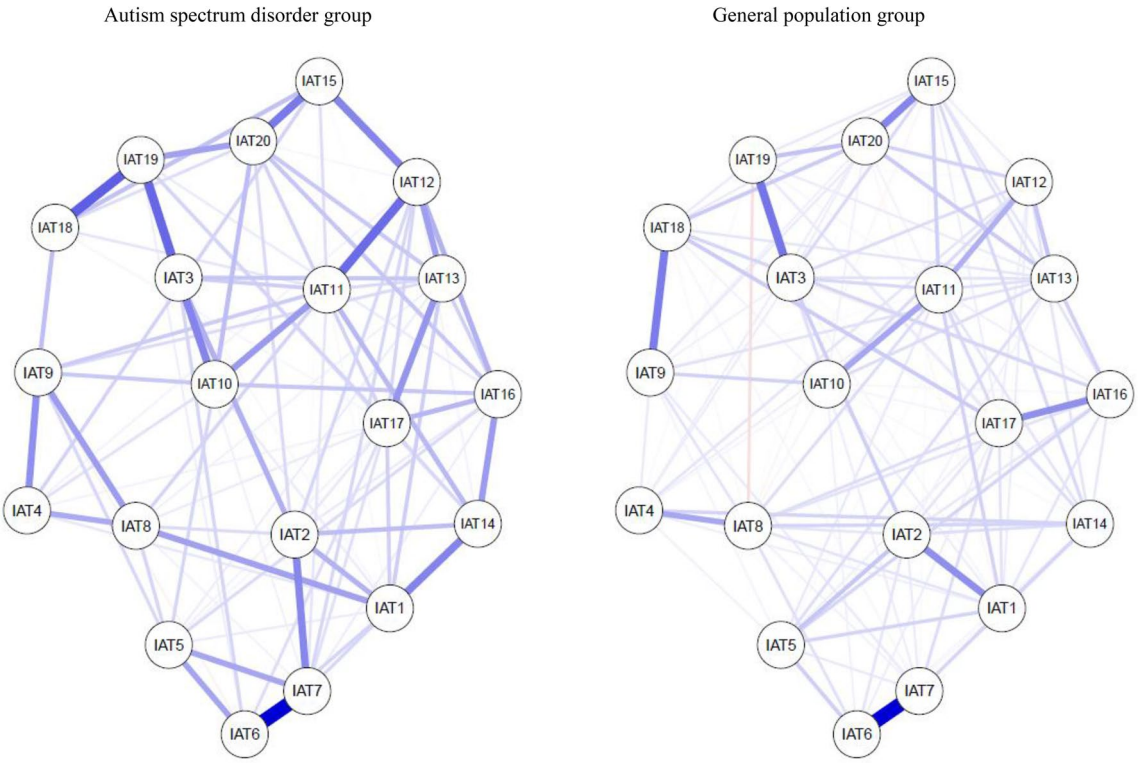

Fig. 1 Network structures among internet addiction symptoms. In the figure, blue and red lines pertain to positive associations and negative associations, respectively. The thickness of each line refers to the strength of each connection between nodes (circles). IAT1: Stay online longer than you intend, IAT2: Neglect chores to spend more time online, IAT3: Prefer the excitement online to the time with others, IAT4: Form new relationships with online users, IAT5: Others complain about your time spent online, IAT6: School grades suffer due to internet use, IAT7: Academic efficiency declines due to internet use, IAT8: Check email/SNS before doing things you need to do, IAT9: Become defensive/secretive about the internet use, IAT10: Soothe disturbing thoughts using the Internet, IAT11: Anticipation for future online activities, IAT12: Life boring and empty without the Internet, IAT13: Snap or act annoyed if bothered while being online, IAT14: Sleep loss due to late-night logins, IAT15: Preoccupation with the Internet, IAT16: Request an extension for longer time spent online, IAT17: Failure to cut down the time spent online, IAT18: Conceal the amount of time spent online, IAT19: Spend more time online over going out with others, IAT20: Depressed/moody/nervous only while being offline

and *"Spend more time online over going out with others "* (0.29), between *"Prefer the excitement online to the time with others"* and *"Spend more time online over going out with others"* (0.28), and between "*Anticipation for future online activities*" and "*Life boring and empty without the Internet*" (0.27)". All edge weights of this network are listed in Supplementary Data 2.

Figure 2 represents plots depicting centrality indices of 20 symptoms to the IAT network in the ASD group. The item *"Academic efficiency declines due to internet use"* was highest in EI, meaning this symptom had the strongest positive associations with other symptoms, although its other centrality indices were not pronounced. The items *"Life boring and empty without the Internet*" and *"anticipation for future online activities"* had the highest closeness and relatively high EI meaning this cognitive symptom was influential in connecting other symptoms that were otherwise unrelated in the network. The item *"Prefer the excitement online to the time with others"* was high in the betweenness and closeness centrality indices.

For the comparison of the networks between two different groups, we also estimated the network structure of relations among IA symptoms in the general population (Fig. 1, right graph), yielding a total of 128 non-zero edges with a mean weight at 0.05. The strongest edge weight was 0.61 between IAT items 6 and 7. Centrality indices were also computed and plotted (Fig. 2). In this population, the items "*Anticipation for future online activities*" was high in all three central indices. Other items "*Failure to cut down the time spent online*" and *"Academic efficiency declines due to internet use"* also had high EI.

Examination of the network accuracy in the ASD group revealed wide bootstrapped confidence intervals (CIs) for most edges, suggesting low accuracy of the edge strengths in the network (Supplementary Data 3). The stability of node centrality was also unsatisfactory in the ASD group with the correlation stability coefficient being below 0.5 (Epskamp et al. 2018) (expected influence: 0.046, closeness: 0.046, betweenness: 0) (Supplementary Data 4). On the other hand, edge-strength in the general population was considered accurate as bootstrap CIs of the strong edges did not overlap zero. Expected influence and closeness were considered stable in the general population group (expected influence: 0.75, closeness: 0.52, betweenness: 0.21).

Network Comparison

The network comparison revealed no statistically significant differences for the overall network structure ($p = 0.57$) for the two networks, suggesting that the structures were similar between the ASD group and the general population group. Post-hoc comparisons of each edge weight between the two

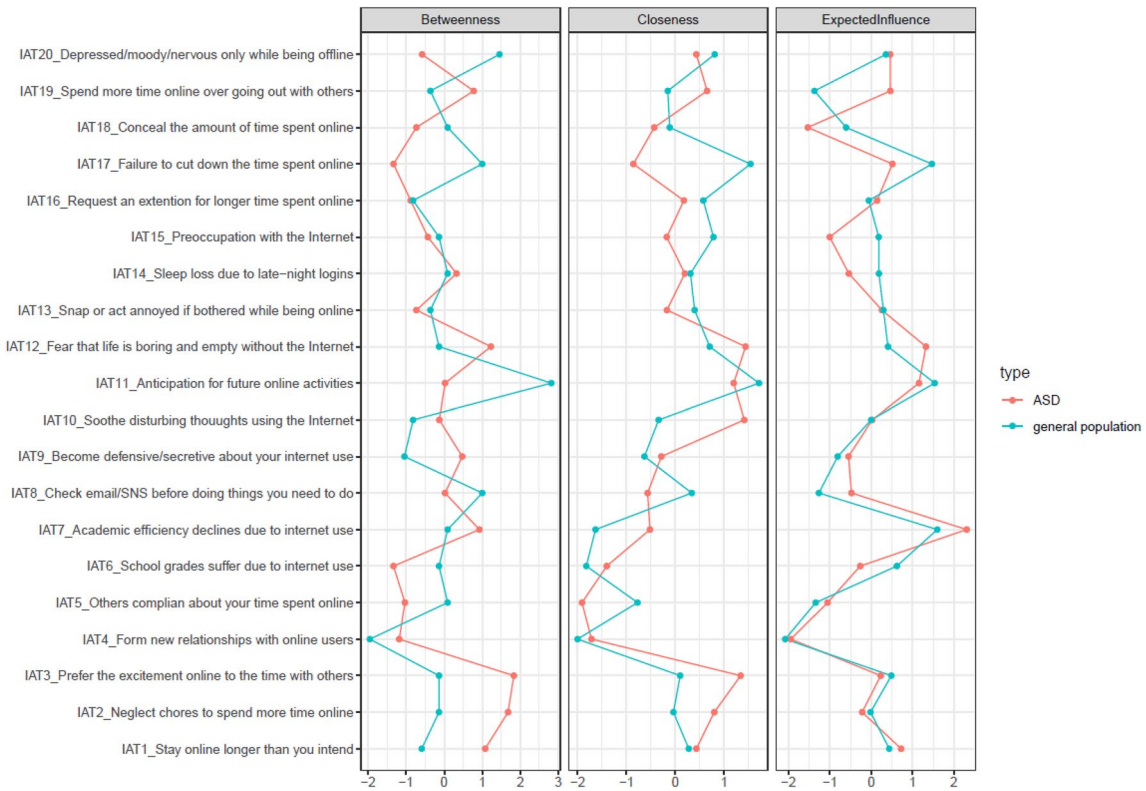

Fig. 2 Network centrality

networks through the NCT showed 11 specific edge weights that reached statistical significance (Supplementary Data 5). However, the comparison test indicated that the global edge strengths did not differ between the two groups ($p = 0.40$).

Discussion

In the present study, we elucidated the network structure of internet addiction symptoms among adolescents with ASD and identified central symptoms in the IA symptom network. Furthermore, we compared the IA symptom network between the ASD group and the general population group. This is the first study that employed network analysis, a novel statistical approach, to understand psychopathology of IA symptoms among adolescents with ASD. The benefit to zoom in on symptom-symptom associations in the ASD population has been reported in recent studies that examined the network structures of psychiatric and psychological comorbidities related to ASD, including anxiety (Montazeri et al. 2018), depression (Montazeri et al. 2019), obsessive–compulsive disorder (Ruzzano et al. 2015), and irritability and aggression (Hirota et al. 2020).

The IA symptom network revealed strong edges that seem clinically important for understanding the mechanism of IA. For example, the edge connecting "*Conceal the amount of time spent online*" and "*Spend more time online over going out with others*" may indicate a bidirectional symptom-symptom relationship between self-concealment of one's problem and decreased healthy social engagements. Adolescents who conceal their internet use problems may lose opportunities to engage with peers. On the other hand, it is also possible that adolescents who do not prefer building social relationships may conceal their internet use to avoid unnecessary conflicts with parents as parents may limit adolescents' internet use in such cases. Another important strong edge identified in the ASD group was the one connecting "*Anticipation for future online activities*" and "*Life boring and empty without the Internet*", which represent preoccupation/anticipation and negative affect, respectively. In studies examining the neurobiology of addiction, addiction is conceptualized as a three-stage recurring cycle, consisting of binging, withdrawal/negative affect, and preoccupation/anticipation (Goldstein and Volkow 2002). Therefore, our finding is suggestive of a possible causal link, which needs to be investigated using longitudinal data.

In the present study, we identified *"Academic efficiency declines due to the internet use"* as one of the central symptoms in the IA symptom network both in the ASD group and the general population group. The relationship between IA and academic performance has been reported in previous studies (Chen and Peng 2008; Samaha and Hawi 2016), which might account for our findings in the present study. Although the decline in academic efficiency is likely a consequence of IA given the wording of this IAT item, it is also possible that individuals who have academic challenges could have higher risks of increasing their Internet use to avoid facing academic demands and to soothe stress related to academic work. Furthermore, as seen in Fig. 1, this item in the ASD group had strong associations with the items *"Neglect household chores to spend more time online"* and *"Others in your life complain to you about the amount of time you spend online,"* indicating that the challenges with time management and performance can become pervasive both at school and at home.

Similarly, two items "*Life is boring and empty without the Internet*" and "*Anticipation for future online activities*" were central to the IA network in both groups based on our findings. However, the item "*Life is boring and empty without the Internet*" had a stronger association with the item regarding preoccupation with the Internet (IAT15 in Fig. 1) in the ASD group in comparison to the general population group. The greater degree of preoccupation with the Internet in the ASD group can be attributed to repetitive and restricted interests and behaviors (RRIB), which are ASD core symptoms. One study revealed a positive association between preoccupation with online (Internet) activities and RRIB in college students (Shane-Simpson et al. 2016), supporting the hypothesis mentioned above. Additionally, as observed in Fig. 1, these preoccupation symptoms serve as important hubs connecting different domains of symptoms, such as negative emotions, sleep problems, and challenges with time management. Thus, addressing the central item "*Life is boring and empty without the Internet*" could prevent the onset, progression, and maintenance of the IA symptom network in this clinical population. To this aim, cognitive behavioral therapy (CBT) can be beneficial as the item pertaining to the fear that life can be boring and empty without online activities is considered a core belief in individuals with difficulty controlling their use of Internet (Young 2007). Previous studies have reported the efficacy of CBT on IA, decreasing internet use, and improving time management skills and emotional stability (Du et al. 2010; Fioravanti et al. 2012). However, no studies have examined its efficacy among the ASD population.

While the item "*Prefer the excitement online to time with others*" did not become pronounced in any centrality indices in either of the two groups, the betweenness and closeness of this item were high only in the ASD group. This finding accounts for the important role of this item connecting items that otherwise do not have strong associations. Of note, this item is strongly associated with the item "*Block out disturbing thoughts about your life with soothing thoughts from the Internet*" (IAT10) and "*Spend more time online over going out with others*" (IAT19), both of which are not directly associated as shown in Fig. 1. Therefore, the item "*Prefer*

the excitement online to the time with others" can function as an essential item that expands the IA network in the ASD group by connecting different IA symptom domains. The Internet may provide individuals with ASD who have experienced offline social challenges (e.g., difficulty with social interactions) with opportunities to compensate for these challenges (Finkenauer et al. 2012). Our findings support this notion. Given the strong association between the item "*Prefer the excitement online to the time with others*" and the item "*Block out disturbing thoughts about your life with soothing thoughts of the Internet*" as observed in Fig. 1, individuals with ASD may engage in online activities to relieve their heightened stress in daily life. Therefore, providing this population and their families with psychoeducation on what can be standard and aberrant Internet use behaviors, as well as the importance of maintaining offline social activities, could be both therapeutic and preventative for IA. Additionally, social skills training in this population would be beneficial as the improvement of social skills could ease stress in social situations and promote more engagement in offline social activities.

The comparison of the two networks revealed no significant differences in the overall network structure between the two groups. This finding did not support our hypothesis that the overall network connectivity could be stronger in the ASD group. Studies with larger sample sizes of adolescents with ASD are required in future research to further examine whether the networks between these two groups remain identical or become different.

Despite the novelty of our study and valuable study findings above, our findings need to be interpreted with caution due to the following limitations. First, we found low accuracy of edge weights and centrality indices and correlational stability of the IA network in the ASD group. This is the major limitation of the present study as these findings make it difficult for us to interpret the rank ordering of edge weights or centrality indices with confidence. The poor accuracy and stability were likely due to small sample sizes of adolescents with ASD, and thus the network structure of IA symptoms and its accuracy need to be examined by larger-sample studies in future research. Related to the first limitation, the small sample size in the ASD group prohibited us from dividing the ASD group into subgroups (boys vs. girls, for example) for further analyses. As previous studies reported sex differences in internet use patterns (Weiser 2000), internet addiction symptoms (Dufour et al. 2016), and other addictive behaviors (Fattore et al. 2014), it would be meaningful to investigate how the network structure of IA symptoms vary by sex in the future studies. Additionally, as adolescents with ASD in the present study were patients attending the psychiatric clinic, their characteristics and co-occurring psychopathology profiles would be likely different from those in other ASD populations (a community sample of adolescents with ASD, for example). Given the high prevalence of co-occurring psychiatric problems in ASD (Simonoff et al. 2008) and the association of IA with these psychiatric problems (Ko et al. 2012), our findings can provide important clinical implications in assessing and addressing IA problems in similar ASD populations. However, the generalizability of our findings to other ASD populations may be limited. Furthermore, we did not quantify ASD symptoms in the present study, and thus we were unable to examine the role of ASD symptoms in the IA symptom network. However, doing so is beyond the scope of the present study, and therefore future research can elucidate the influence of individual ASD symptoms on the IA symptom network. Lastly, we did not obtain information regarding whether participants had access to the Internet and how much (e.g. hours per day) they were allowed to access the Internet, preventing us from examining the associations of these factors with IAT scores.

This study indicates the intricate network system of IA symptoms mutually influencing each other in adolescents with ASD. Central symptoms, such as preoccupations with online activities and avoidance of offline social activities can be the targets for therapeutic interventions (CBT, psychoeducation, social skills group, for example). These interventions can be beneficial not only for adolescents with IA problems but also for their caregivers. Future research requires larger sample sizes of adolescents with ASD to produce sufficient power to determine the differences in the IA network structure between this clinical group and the general population group. Lastly, future research should include risk factors for IA, including symptoms of attention-deficit hyperactivity disorder and depression, in analyses to elucidate how individual symptoms of these risk factors interact with IA symptoms, resulting in the promotion of tailored interventions for IA.

Compliance with Ethical Standards

Ethical Approval This study was approved by the institutional review board at Okayama psychiatric medical center before study enrollment commenced. The authors obtained written informed assent forms from the adolescent participants and written informed consent forms from the participants' parents.

References

Beard, C., Millner, A. J., Forgeard, M. J. C., Fried, E. I., Hsu, K. J., Treadway, M. T., et al. (2016). Network analysis of depression and anxiety symptom relationships in a psychiatric sample. *Psychological Medicine, 46*(16), 3359–3369. https://doi.org/10.1017/S0033291716002300.

Borsboom, D. (2017). A network theory of mental disorders. *World psychiatry: official journal of the World Psychiatric Association (WPA), 16*(1), 5–13. https://doi.org/10.1002/wps.20375.

Borsboom, D., & Cramer, A. O. J. (2013). Network Analysis: An Integrative Approach to the Structure of Psychopathology. *Annual Review of Clinical Psychology, 9*(1), 91–121. https://doi.org/10.1146/annurev-clinpsy-050212-185608.

Černja, I., Vejmelka, L., & Rajter, M. (2019). Internet addiction test: Croatian preliminary study. *BMC Psychiatry, 19*(1), 388. https://doi.org/10.1186/s12888-019-2366-2.

Chen, J., & Chen, Z. (2008). Extended Bayesian information criteria for model selection with large model spaces. *Biometrika, 95*(3), 759–771. https://doi.org/10.1093/biomet/asn034.

Chen, L., Zhou, H., Gu, Y., Wang, S., Wang, J., Tian, L., et al. (2018). The Neural Correlates of Implicit Cognitive Bias Toward Internet-Related Cues in Internet Addiction: An ERP Study. *Frontiers in Psychiatry*. https://doi.org/10.3389/fpsyt.2018.00421.

Chen, Y.-F., & Peng, S. S. (2008). University students' internet use and its relationships with academic performance, interpersonal relationships, psychosocial adjustment, and self-evaluation. *CyberPsychology and Behavior, 11*(4), 467–469. https://doi.org/10.1089/cpb.2007.0128.

Du, Y., Jiang, W., & Vance, A. (2010). Longer term effect of randomized, controlled group cognitive behavioural therapy for internet addiction in adolescent students in Shanghai. *Australian & New Zealand Journal of Psychiatry, 44*(2), 129–134. https://doi.org/10.3109/00048670903282725.

Dufour, M., Brunelle, N., Tremblay, J., Leclerc, D., Cousineau, M. M., Khazaal, Y., et al. (2016). Gender Difference in Internet Use and Internet Problems among Quebec High School Students. *Canadian Journal of Psychiatry Revue Canadienne de Psychiatrie, 61*(10), 663–668. https://doi.org/10.1177/0706743716640755.

Durkee, T., Kaess, M., Carli, V., Parzer, P., Wasserman, C., Floderus, B., et al. (2012). Prevalence of pathological internet use among adolescents in Europe: demographic and social factors. *Addiction (Abingdon, England), 107*(12), 2210–2222. https://doi.org/10.1111/j.1360-0443.2012.03946.x.

Engelhardt, C. R., Mazurek, M. O., & Hilgard, J. (2017). Pathological game use in adults with and without Autism Spectrum Disorder. *PeerJ, 5*, e3393. https://doi.org/10.7717/peerj.3393.

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

Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). Network Visualizations of Relationships in Psychometric Data. *Journal of Statistical Software, 48*(1), 1–18. https://doi.org/10.18637/jss.v048.i04.

Epskamp, S., Kruis, J., & Marsman, M. (2017). Estimating psychopathological networks Be careful what you wish for. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0179891.

Fattore, L., Melis, M., Fadda, P., & Fratta, W. (2014). Sex differences in addictive disorders. *Frontiers in Neuroendocrinology, 35*(3), 272–284. https://doi.org/10.1016/j.yfrne.2014.04.003.

Finkenauer, C., Pollmann, M. M. H., Begeer, S., & Kerkhof, P. (2012). Brief Report: Examining the Link Between Autistic Traits and Compulsive Internet Use in a Non-Clinical Sample. *Journal of Autism and Developmental Disorders, 42*(10), 2252–2256. https://doi.org/10.1007/s10803-012-1465-4.

Fioravanti, G., Dèttore, D., & Casale, S. (2012). Adolescent internet addiction: testing the association between self-esteem, the perception of internet attributes, and preference for online social interactions. *Cyberpsychology, Behavior, and Social Networking, 15*(6), 318–323. https://doi.org/10.1089/cyber.2011.0358.

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. *Social Psychiatry and Psychiatric Epidemiology, 52*(1), 1–10. https://doi.org/10.1007/s00127-016-1319-z.

Goldstein, R. Z., & Volkow, N. D. (2002). Drug addiction and its underlying neurobiological basis: neuroimaging evidence for the involvement of the frontal cortex. *The American Journal of Psychiatry, 159*(10), 1642–1652. https://doi.org/10.1176/appi.ajp.159.10.1642.

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

Hirota, T., Deserno, M., & McElroy, E. (2020). The Network Structure of Irritability and Aggression in Individuals with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-019-04354-w.

Kaess, M., Durkee, T., Brunner, R., Carli, V., Parzer, P., Wasserman, C., et al. (2014). Pathological Internet use among European adolescents: psychopathology and self-destructive behaviours. *European Child & Adolescent Psychiatry, 23*(11), 1093–1102. https://doi.org/10.1007/s00787-014-0562-7.

Kawabe, K., Horiuchi, F., Miyama, T., Jogamoto, T., Aibara, K., Ishii, E., et al. (2019). Internet addiction and attention-deficit / hyperactivity disorder symptoms in adolescents with autism spectrum disorder. *Research in Developmental Disabilities, 89*, 22–28. https://doi.org/10.1016/j.ridd.2019.03.002.

Ko, C.-H., Yen, J.-Y., Yen, C.-F., Chen, C.-S., & Chen, C.-C. (2012). The association between Internet addiction and psychiatric disorder: A review of the literature. *European Psychiatry, 27*(1), 1–8. https://doi.org/10.1016/j.eurpsy.2010.04.011.

Kuss, D. J., & Lopez-Fernandez, O. (2016). Internet addiction and problematic Internet use: A systematic review of clinical research. *World Journal of Psychiatry, 6*(1), 143–176. https://doi.org/10.5498/wjp.v6.i1.143.

Lai, C.-M., Mak, K.-K., Watanabe, H., Ang, R. P., Pang, J. S., & Ho, R. C. M. (2013). Psychometric properties of the internet addiction test in Chinese adolescents. *Journal of Pediatric Psychology, 38*(7), 794–807. https://doi.org/10.1093/jpepsy/jst022.

MacMullin, J. A., Lunsky, Y., & Weiss, J. A. (2016). Plugged in Electronics use in youth and young adults with autism spectrum disorder. *Autism The International Journal of Research and Practice, 20*(1), 45–54. https://doi.org/10.1177/1362361314566047.

Mak, K.-K., Lai, C.-M., Watanabe, H., Kim, D.-I., Bahar, N., Ramos, M., et al. (2014). Epidemiology of internet behaviors and addiction among adolescents in six Asian countries. *Cyberpsychology, Behavior and Social Networking, 17*(11), 720–728. https://doi.org/10.1089/cyber.2014.0139.

Mazurek, M. O., & Engelhardt, C. R. (2013). Video game use in boys with autism spectrum disorder, ADHD, or typical development. *Pediatrics, 132*(2), 260–266. https://doi.org/10.1542/peds.2012-3956.

McNally, R. J. (2016). Can network analysis transform psychopathology? *Behaviour Research and Therapy, 86*, 95–104. https://doi.org/10.1016/j.brat.2016.06.006.

Montazeri, F., de Bildt, A., Dekker, V., & Anderson, G. M. (2018). Network Analysis of Anxiety in the Autism Realm. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-018-3474-4.

Montazeri, F., de Bildt, A., Dekker, V., & Anderson, G. M. (2019). Network Analysis of Behaviors in the Depression and Autism Realms: Inter-Relationships and Clinical Implications. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-019-03914-4.

Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks, 32*(3), 245–251. https://doi.org/10.1016/j.socnet.2010.03.006.

Pan, N., Yang, Y., Du, X., Qi, X., Du, G., Zhang, Y., et al. (2018). Brain Structures Associated with Internet Addiction Tendency in Adolescent Online Game Players. *Frontiers in Psychiatry*. https://doi.org/10.3389/fpsyt.2018.00067.

Rhemtulla, M., Fried, E. I., Aggen, S. H., Tuerlinckx, F., Kendler, K. S., & Borsboom, D. (2016). Network analysis of substance abuse and dependence symptoms. *Drug and Alcohol Dependence, 161*, 230–237. https://doi.org/10.1016/j.drugalcdep.2016.02.005.

Ruzzano, L., Borsboom, D., & Geurts, H. M. (2015). Repetitive behaviors in autism and obsessive-compulsive disorder: new perspectives from a network analysis. *Journal of Autism and Developmental Disorders, 45*(1), 192–202. https://doi.org/10.1007/s10803-014-2204-9.

Samaha, M., & Hawi, N. S. (2016). Relationships among smartphone addiction, stress, academic performance, and satisfaction with life. *Computers in Human Behavior, 57*, 321–325. https://doi.org/10.1016/j.chb.2015.12.045.

Shane-Simpson, C., Brooks, P. J., Obeid, R., Denton, E., & Gillespie-Lynch, K. (2016). Associations between compulsive internet use and the autism spectrum. *Research in Autism Spectrum Disorders, 23*, 152–165. https://doi.org/10.1016/j.rasd.2015.12.005.

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry, 47*(8), 921–929. https://doi.org/10.1097/CHI.0b013e318179964f.

So, R., Makino, K., Fujiwara, M., Hirota, T., Ohcho, K., Ikeda, S., et al. (2017). The Prevalence of Internet Addiction Among a Japanese Adolescent Psychiatric Clinic Sample With Autism Spectrum Disorder and/or Attention-Deficit Hyperactivity Disorder: A Cross-Sectional Study. *Journal of Autism and Developmental Disorders, 47*(7), 2217–2224. https://doi.org/10.1007/s10803-017-3148-7.

Spada, M. M. (2014). An overview of problematic internet use. *Addictive Behaviors, 39*(1), 3–6. https://doi.org/10.1016/j.addbeh.2013.09.007.

Tang, J., Yu, Y., Du, Y., Ma, Y., Zhang, D., & Wang, J. (2014). Prevalence of internet addiction and its association with stressful life events and psychological symptoms among adolescent internet users. *Addictive Behaviors, 39*(3), 744–747. https://doi.org/10.1016/j.addbeh.2013.12.010.

van Borkulo, C. D. (2016). *Package 'NetworkComparisonTest': Statistical Comparison of Two Networks Based on Three Invariance Measures*. CRAN.

van Rooijen, G., Isvoranu, A.-M., Meijer, C. J., van Borkulo, C. D., Ruhé, H. G., de Haan, L., et al. (2017). A symptom network structure of the psychosis spectrum. *Schizophrenia Research, 189*, 75–83. https://doi.org/10.1016/j.schres.2017.02.018.

Weiser, E. B. (2000). Gender differences in internet use patterns and internet application preferences: a two-sample comparison. *CyberPsychology and Behavior, 3*(2), 167–178. https://doi.org/10.1089/109493100316012.

Young, K. S. (1998). Internet addiction: the emergence of a new clinical disorder. *CyberPsychology & Behavior, 1*(3), 237–244. https://doi.org/10.1089/cpb.1998.1.237.

Young, K. S. (2007). Cognitive behavior therapy with internet addicts: treatment outcomes and implications. *CyberPsychology & Behavior, 10*(5), 671–679. https://doi.org/10.1089/cpb.2007.9971.

Yücens, B., & Üzer, A. (2018). The relationship between internet addiction, social anxiety, impulsivity, self-esteem, and depression in a sample of Turkish undergraduate medical students. *Psychiatry Research, 267*, 313–318. https://doi.org/10.1016/j.psychres.2018.06.033.