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Adult Attention Deficit and Hyperactivity Disorder Symptoms and Internet Addiction in College Students: Prevalence and Differential Associations

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Abstract: This paper presents an investigation that aims to: 1) explore the relations between core symptoms of adult Attention Deficit and Hyperactivity Disorder (ADHD) and several typical Internet activities, and 2) compare the predictive power of two core symptoms of ADHD- inattention and hyperactivity/impulsivity- in predicting Internet addiction. Methods: A total of 2016 Chinese college students participated in this study. The ADHD symptoms were assessed using Conners self-rating scales and DSM-5 semi-structured interviews. Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (SCID-5) was used to exclude other psychiatric disorders. Chen's Internet addiction scale (CIAS) was used to evaluate Internet addiction. Information about Internet activities (e.g., online gaming) was collected through a self-constructed questionnaire. Results: The ratio of Internet addiction problems among individuals with ADHD symptoms is significantly higher than in ordinary individuals (48.9% vs. 14.3%). Further, each core ADHD symptom has unique relations with different types of Internet activities. Specifically, both core ADHD symptoms are negatively associated with information downloading and online learning, and positively associated with online gaming, while online shopping is only associated with hyperactivity/impulsivity. Furthermore, both core ADHD symptoms are significant predictors of Internet addiction, especially inattention. Conclusion: College students with ADHD symptoms are at a higher risk of having Internet addiction than peers without ADHD symptoms. For individuals with ADHD symptoms and excessive online gaming and/or online shopping behaviors, the probability of having Internet addiction is even higher. These findings have important implications for identifying risk factors of Internet addiction and preventing Internet addiction in Higher Education settings.

Keywords: ADHD, college students, Internet activities, Internet addiction.

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Introduction

The Internet has become an essential element in modern societies. The convenience of accessible Internet profoundly changes many aspects of human life, such as recreational, business, and academic activities. Internet addiction, defined as excessive Internet use characterized as compulsive, withdrawal, and tolerance to network, has been associated with many undesirable outcomes, such as impaired daily and work functioning, mental health, and social and physical problems (Maheri et al., 2017). Among college students, the prevalence of Internet addiction was 3.2% to 19%, based on two international studies (Kuss et al., 2013; Niemz et al., 2005). Higher susceptibility to Internet addiction among college students is associated with significant changes during this developmental stage and the uniqueness of the setting, in which young adults have greater autonomy and meanwhile low levels of supervision, with easy access using Wi-Fi network on campus (Niemz et al., 2005). Understanding the predictors of Internet addiction is crucial to reducing or preventing Internet addiction in college students.

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One known factor associated with Internet addiction is attention deficit hyperactivity disorder (ADHD), the most common psychiatric disorder (Kim et al., 2017). The defining core features of ADHD are inattentiveness and hyperactivity/impulsivity. The onset of ADHD occurs during childhood, and among children diagnosed with ADHD, more than 60-80% of them have the symptoms persisting into adulthood (Matthies & Philippsen, 2016). The comorbidity rate of ADHD and Internet addiction has been reported as 37% (Panagiotidi & Overton, 2018; Yen et al., 2009). It was also reported that individuals with Internet addiction had higher total ADHD symptoms scores (Yen et al., 2007). In addition, inattention and hyperactivity/impulsivity symptoms were related to the severity of Internet addiction (Evren et al., 2018). However, the relations between different ADHD symptoms and Internet addiction among college students with ADHD symptoms is unknown. This study aims to bridge this gap.

According to American Center for Online Addiction, Internet addiction divides into several different types (e.g., Internet gaming addiction, social network addiction, information overload), which are relevant to different kinds of Internet activities such as video games, cyber social communication, information search (Teo, 2001). The etiological connection between ADHD and excessive Internet usage has been suggested in the literature. The underlying cause of the behavioral symptoms of ADHD is cognitive and executive functioning deficits, including but not limited to aversion to delay, a lack of inhibition of reaction, poor verbal working memory and visuospatial working memory (Campez et al., 2020; He et al., 2012; Miranda et al., 2015). Among these deficits, delay aversion particularly contributes to the susceptibility to Internet addiction among individuals with ADHD. According to the delay aversion theory (Sonuga-Barke et al., 1992), individuals with ADHD are insensitive to punishment and aversive to delayed reward, but are easily reinforced by immediate, positive responses (Dockstader et al., 2009), such as those provided by many leisure or commercial Internet activities (Li et al., 2016). For example, online games with quick feedback and immediate reward are particularly appealing to individuals with ADHD and are associated with a higher risk of Internet addiction in this population (Ji & Tao, 2014). However, it is still unclear how ADHD core symptoms (i.e., inattention and hyperactivity/impulsivity) are related to different Internet activities. Exploring the answers to this research question would enhance understanding of the connections between ADHD and the risks of developing Internet addiction.

As an initial effort to clarify the correlation patterns between these variables, the present study investigated the associations between each ADHD core symptom and several parameters of Internet usage (i.e., the age of Internet usage, time spent online per day); types of positive Internet activities (information downloading and online learning); and types of harmful Internet activities (online gaming, chatting and shopping). Further, we examined how Internet addiction is associated with each of the core symptoms of ADHD. The results might further the understanding of the risk factors for Internet addiction among college students and shed light on prevention or intervention efforts in Higher Education systems.

Methodology

Research Design

This study applied a cross-sectional, correlational design. Several self-report rating scales were administered to measure ADHD core symptoms and typical Internet activities and to compare the predictability of two core symptoms in Internet addiction. Semi-structured and structured clinical interviews were conducted to identify participants with ADHD more accurately.

Sample and Data Collection

A total of 2100 participants were recruited from different departments across two universities in southern China using the cluster sampling method. Students from the same department were concentrated in a large classroom to complete the survey. The consented students were informed of the purposes and requirements of the procedures by the research assistants before survey administration. Next, a two-step procedure was conducted.

Firstly, students filled out the paper forms of the Conners' Adult ADHD Rating Scales-Self-Report: Short Version (CAARS-S:S) along with other self-report surveys in the classroom. A total of 2016 participants (96% of the initial sample) correctly completed the measures administered. The age range was from 17 to 28 years ($M = 19.35$, $SD = 1.00$). The majority of student's home origin was village ($n = 1225$, 60.76%), followed by town ($n = 483$, 23.96%), and city ($n = 306$, 15.18%). Social-economic status was assessed based on students' family income, and parental education and occupation in China, and classified into four levels, including poor ($n = 469$, 23.26%), common ($n = 1421$, 70.49%), fine ($n = 113$, 5.61%), and rich ($n = 6$, 0.30%). A total of 774 participants (38.39%) were the only child in the family.

Secondly, all the participants who filled out the survey correctly ($n = 2016$) were invited to attend a semi-structured interview session. A trained and experienced clinician conducted DSM-5 structured clinical interviews (SCID) to assess the levels of two core symptoms of ADHD to identify further individuals with ADHD based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria. Through this interview, individuals with other disorders that might confound with the symptoms of ADHD, including severe emotional and behavioral problems, including affective disorders (major depression), psychotic disorders, anxiety disorders, disruptive behavioral disorders,

and substance abuse, were identified and excluded in the analysis. A total of 90 individuals were identified as meeting the diagnostic criteria for ADHD. The flow chart of the participant recruitment at each step is shown in Fig. 1.

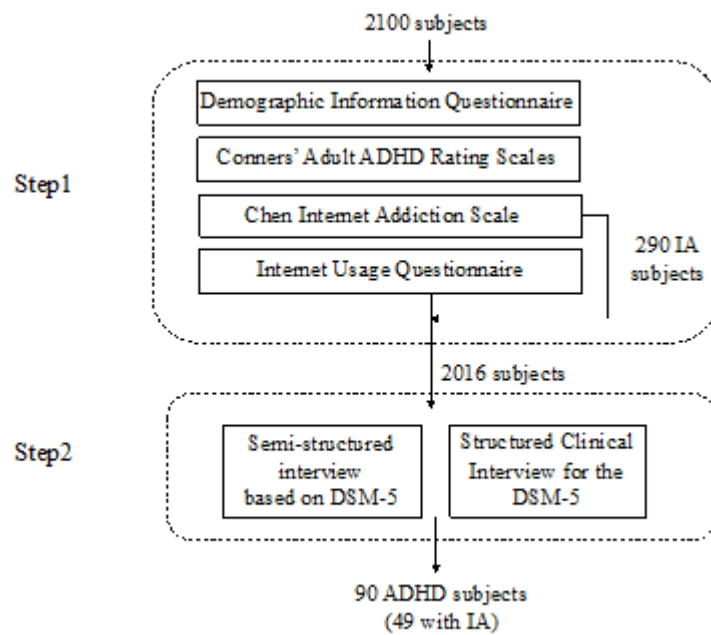


Figure 1. Participant Recruitment Procedure Chart

Instruments

Demographic Information Questionnaire. Demographic information questions include age, gender (male and female), family origin (village, town, and city), family economic status (poor, common, fine, and rich), family type (two-parent family, signal-parent family, and remarried family) and single child status (one-child family or not).

ADHD Symptom Measure. The instruments for identifying ADHD below have been validated in the Chinese context (Zhang et al., 2016).

Conners' Adult ADHD Rating Scales–Self Report: Short Version (CAARS-S:S; Conners et al., 1999). The CAARS-S:S is a 26-item questionnaire measured on a Likert scale from 0 (not at all/never) to 3 (very much/frequently), generating a total ADHD score (ADHD index). It includes four factor-derived subscales: inattention/ memory problems, hyperactivity/restlessness, impulsivity/emotional lability, and problems with self-concept. The internal consistency of the scale and subscales ranges from 0.74 to 0.95 (Christiansen et al., 2012), and 0.65 to 0.88 in the present study. Participants with a total raw score of 40 or more than 40 (T scores ≥ 65) would be classified as having a high risk for ADHD (Conners et al., 1999).

Structured Clinical Interview for the DSM-5 (SCID; First et al., 1997) and the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5; American Psychiatric Association, 2013). The SCID was used to assess ADHD symptoms, and the participants' responses were compared to the DSM-5 criteria for ADHD, which includes nine symptoms in the inattention domain and 13 symptoms in the hyperactivity/impulsivity domain. Individuals having six or more inattention or hyperactivity/impulsivity symptoms would meet the criteria for ADHD. The SCID was also used to clinically identify mood disorders, schizophrenia, material abuse, schizophrenia, anxiety disorder, and gambling disorder as standard exclusion criteria (Xu et al., 2011).

Internet Addiction Measure. The Chen Internet Addiction Scale (CIAS) was developed to measure Internet addiction in the Chinese population (Chen et al., 2003). It consists of 26 items on a 4-point Likert scale with total scores ranging from 26 to 104. A higher total score on the CIAS suggests more severe Internet addiction symptoms. The entire scale has five sub-scales: compulsive, withdrawal, tolerance, interpersonal, health problems, and time management problems. Its estimates of the internal reliability of the instrument and its subscales ranged from 0.79 to 0.93 in the original study (Chen et al., 2003) and ranged from 0.68 to 0.92 in this study. Researchers found that a total score of 63, as the cut-off point of CIAS, has the highest diagnostic accuracy (87.6%), accepted sensitivity (67.8%), and specificity (92.6%) (Ko et al., 2005). Therefore, participants with scores of 63 or higher were classified as having Internet addiction in the current study.

Internet Usage Measure. One self-constructed questionnaire was used to measure different dimensions of Internet usage, including the age onset of Internet usage, time spent online per day, and participation in five Internet activities (i.e., online gaming, online chatting, information downloading, online shopping, and online learning) in the last month. Types of

Internet activities were collected in a multiple-choice question format. According to the rules of the chi-square test in statistics, only Internet activities that contained over 5% of the participants from the sample were included in the main analysis.

Data Analysis Plan

All the subjects answered carefully, and there were no missing values or outliers. The data were suitable for subsequent statistical analysis. Analyses were performed using SPSS17.0 software. Based on the CIAS scores, subjects were divided into an Internet addiction group and a non-Internet addiction group. We first conducted a preliminary analysis to determine whether Internet addiction status (Internet addiction versus non-Internet addiction) is related to other variables or not. For categorical variables (gender, family origin, family economic state, family type, time spent on the Internet per day, types of Internet activity, ADHD or non-ADHD), Chi-square tests were used. For continuous variables (age of participants, years of using the Internet, the scores of CAARS-S:S and the inattention and hyperactivity/impulsivity subscales in DSM-5), independent t-tests were used.

Next, the relations between types of Internet activity and ADHD symptoms were analyzed. For each Internet activity, participants were divided into the "Yes" group (who did this Internet activity in the last month) and the "No" group (who did not do this Internet activity in the last month). The difference in ADHD symptom scores between these two groups for each type of Internet activity was assessed via an independent t-test.

Lastly, a hierarchical regression analysis was used to examine the variance of Internet addiction explained by Internet usage variables and ADHD symptoms. Research has shown significant correlations between these demographic variables and Internet addiction (Ding et al., 2017) and, thus, the demographics were controlled in the regression model.

Results

Prevalence of ADHD and Internet Addiction

In the full sample, the percentage of college students classified as having Internet addiction was 14.38% (n=290). Within the Internet addiction group, 15.17% of the participants were diagnosed with ADHD, much higher than the percentage in the non-Internet addiction group (2.67%). Moreover, the percentage of college students who met the diagnostic criteria for ADHD was 4.46% (n=90). Among this subsample with ADHD, the percentage of adults with Internet addiction was 48.89%, much higher than the percentage in the full sample (14.38%).

Mean Comparisons between Groups

In comparison to the non-Internet addiction group, students in the Internet addiction group had more years of Internet usage ($t=3.86$, $p<0.001$) and spent more time on the Internet per day ($\chi^2=111.07$, $p<0.001$). Regarding the demographics, we found that the family type (single-parent) was significantly related to the severity of Internet addiction ($\chi^2=6.55$, $p<0.05$) compared to other family types. In addition, students in the non-Internet Addiction group mostly came from double-parents families ($\chi^2=6.55$, $p<0.05$). No difference was found between males (15.14%) and females (13.96%) in the rate of Internet addiction ($\chi^2=0.55$, $p>0.05$).

The Internet addiction group had a higher rate of online gaming ($\chi^2=6.85$, $p<0.01$) and a lower rate of online learning ($\chi^2=26.06$, $p<0.001$) compared to the non-Internet addiction group. Online gaming (87.24%) was the most frequent activity reported by the Internet addiction group, followed by social communication (82.07%). Furthermore, the following results were all significantly higher in the Internet addiction group than the non-Internet addiction group, including scores of CAARS-S:S ($t=17.22$, $p<0.001$), numbers of inattention and hyperactivity/impulsivity symptoms in DSM-5 ($t=11.37$, $p<0.001$; $t=15.44$, $p<0.001$), and the ADHD diagnosis rate ($\chi^2=90.70$, $p<0.001$). See Table 1.

Table 1. Chi-Square analysis and t-test for associations between demographic characteristics, internet usage, ADHD symptoms, and Internet addiction

	IA group	Non-IA group	χ^2/τ
	N(%) or Mean \pm SD	N(%) or Mean \pm SD	
Demographic characteristics			
Gender			0.55
Male	111(15.14%)	622(84.86%)	
Female	179(13.96%)	1103(86.04%)	
Age	19.38 \pm 1.18	19.35 \pm 0.97	0.58
Family type			6.55*
two-parents family	256(88.28%)	1585(91.83%)	
single-parent family	25(8.62%)	85(4.92%)	
remarried family	9(3.12%)	54(3.13%)	

Table 1. Continued

	IA group	Non-IA group	χ^2/τ
	N(%) or Mean \pm SD	N(%) or Mean \pm SD	
Internet usage			
Years of using Internet	5.85 \pm 2.75	5.23 \pm 2.51	3.86***
Time spent on the Internet per day			
Below 1 hour	0(0.00%)	65(3.77%)	111.07***
1-3 hours	46(15.86%)	595(34.47%)	
3-5 hours	102(35.17%)	623(36.10%)	
5-8 hours	86(29.66%)	308(17.84%)	
Over 8 hours	50(17.24%)	92(5.33%)	
Internet activities			
Information download	177(61.03%)	1144(66.28%)	3.Mar
Online learning	76(26.21%)	726(42.06%)	26.06***
Online gaming	253(87.24%)	1391(80.59%)	6.85**
Online shopping	112(38.62%)	613(35.52%)	0.97
Social communication	238(82.07%)	1408(81.58%)	0.01
ADHD symptoms			
Scores of CAARS-S: S	33.99 \pm 8.94	24.49 \pm 8.65	17.22***
ADHD symptoms in DSM-V			
Inattention	3.40 \pm 8.94	2.67 \pm 2.19	11.37***
Hyperactivity/Impulsivity	4.48 \pm 2.55	3.05 \pm 1.98	15.44***

Note: CAARS-S: S = Conners' Adult ADHD Rating Scale Self-Report Short Version. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Relations between ADHD Symptoms and Different Types of Internet Activities

Table 2 shows the associations between different Internet activities, each core ADHD symptom and the total ADHD symptom based on the CAARS-S:S. The results revealed that inattention symptoms were negatively associated with information download ($t = -3.93$, $p < 0.001$, $d = 0.19$), online learning ($t = -6.12$, $p < 0.001$, $d = 0.29$), and positively associated with online gaming ($t = 1.95$, $p < 0.05$, $d = 0.03$). Interestingly, inattention symptoms were not significantly related to online shopping and social communication. The hyperactivity/impulsivity symptoms were negatively related to both information downloading ($t = -1.99$, $p < 0.05$, $d = 0.09$) and online learning ($t = -2.97$, $p < 0.01$, $d = 0.14$), and positively associated with online gaming ($t = 3.03$, $p < 0.01$, $d = 0.09$) and online shopping ($t = 2.00$, $p < 0.05$, $d = 0.09$), but not significantly related to social communication. The total CAARS-S:S ADHD symptom score was negatively related to information downloading ($t = -2.71$, $p < 0.01$, $d = 0.13$) and online learning ($t = -5.48$, $p < 0.01$, $d = 0.26$), but not significantly related to online gaming, online shopping and social communication.

Table 2. t-test for associations between ADHD symptoms and Internet activities (N=2016)

ADHD scores	ID		OL		OG		OS		SC	
	Yes (1321)	No (695)	Yes (802)	No (1214)	Yes (728)	No (1288)	Yes (1650)	No (366)	Yes (1649)	No (367)
Inattention	3.19 \pm 2.06	3.58 \pm 2.10	2.98 \pm 2.01	3.56 \pm 2.10	3.29 \pm 2.03	3.35 \pm 2.11	3.30 \pm 2.06	3.46 \pm 2.20	3.37 \pm 2.08	3.14 \pm 2.11
t value	-3.93***		-6.12***		1.95*		-0.63		-1.40	
Cohen's d	0.19		0.29		0.03		--		--	
Hyperactivity/Impulsivity	2.86 \pm 2.32	3.08 \pm 2.36	2.74 \pm 2.28	3.06 \pm 2.37	3.07 \pm 2.35	2.86 \pm 2.32	2.97 \pm 2.32	2.77 \pm 2.42	3.01 \pm 2.32	2.60 \pm 2.36
t value	-1.99*		-2.97**		3.03**		2.00*		1.52	
Cohen's d	0.09		0.14		0.09		0.09		--	
CAARS-S: S	25.45 \pm 9.25	26.63 \pm 9.37	24.47 \pm 8.77	26.77 \pm 9.54	25.64 \pm 8.71	25.98 \pm 9.63	25.87 \pm 9.08	25.78 \pm 10.29	25.89 \pm 9.26	25.69 \pm 9.55
t value	-2.71**		-5.48**		0.38		-0.77		0.18	
Cohen's d	0.13		0.26		--		--		--	

ID: Information download; OL: Online learning; OG: Online gaming; OS: Online shopping; SC: Social communication

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Cohen's ds are shown for significant results only.

Predictors of Internet Addiction

Results from the hierarchical linear regression analysis that tested a variety of predictors of Internet addiction are displayed in Table 3. Demographic characteristics included age, gender, family origin, family economic status, family type, and one-child family status. First, the results indicated that gender and single-parent family were significantly related to the severity of Internet addiction ($\Delta F=2.37$, $p<0.05$, $\Delta R^2=.01$). Second, when Internet usage was added ($\Delta F=13.29$, $p<0.001$, $\Delta R^2=.12$), years of using Internet, time spent on the Internet per day, online gaming, online social communication, and online shopping all positively predicted Internet addiction, while online learning was the only negative predictor for Internet addiction. Finally, when total ADHD symptoms (CAARS-S:S scores) were included in the model, total ADHD symptom scores significantly predicted Internet addiction ($\Delta F=40.39$, $p<0.001$, $\Delta R^2=.31$).

The model with added scores of inattention and hyperactivity/impulsivity symptoms based on the DSM-V criteria instead of scores of CAARS-S:S, was also tested. In this model, both symptoms predicted the severity of Internet addiction ($\Delta F=31.83$, $p<0.001$, $\Delta R^2=.27$), and the effect size for inattentive symptoms was larger.

Table 3. Hierarchical Linear regression model when CIAS score was taken as a dependent variable ($n=2016$)

	Model 1			Model 2			Model 3			Model 4		
	β	t	p	β	t	p	β	t	p	β	t	p
Demographic characteristics												
Gender	-.00	-2.98	.003	-.04	-1.82	.07	-.09	-4.41	.001	-.05	-2.37	.018
Family type												
Two-parents	.01	.13	.90	.01	.17	.87	.03	.83	.41	.02	.67	.52
Single-parent	.07	1.96	.05	.06	1.71	.09	.05	1.81	.07	.05	1.68	.09
Internet usage												
Years of using Internet				.06	2.56	.01	.08	3.45	.001	.058	2.56	.01
Time spent on the Internet per day												
1-3 hours				.04	1.02	.31	.04	.87	.38	.03	.80	.42
3-5 hours				.22	4.76	.001	.19	4.76	.001	.19	4.45	.001
5-8 hours				.26	6.45	.001	.20	5.46	.001	.19	5.07	.001
Over 8 hours				.23	7.60	.001	.19	6.82	.001	.18	6.38	.001
Positive Internet activities												
Information download				-.02	-1.02	.31	-.015	-.76	.45	-.01	-.30	.76
Online learning				-.14	-6.09	.001	-.09	-4.13	.001	-.10	-4.43	.001
Negative Internet activities												
Online shopping				.05	2.07	.04	.03	1.52	.13	.03	1.40	.16
Social communication				.05	2.19	.03	.04	2.17	.03	.05	2.24	.03
Online gaming				.08	3.47	.001	.06	3.35	.001	.05	2.72	.01
ADHD symptoms												
Scores of CAARS							.45	23.54	.001	.33	14.36	.00
ADHD symptoms on the DSM-V												
Inattention										.28	12.32	.001
Hyperactivity/Impulsivity										.17	7.58	.001

CAARS-S: S = Conners' Adult ADHD Rating Scale Self-Report Short Version

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Discussion

College students have been reported as a population with a higher risk for developing Internet addiction (Kuss et al., 2013; Niemi et al., 2005). Also, individuals with an ADHD diagnosis were more likely to have Internet addiction (Kim et al., 2017; Yen et al., 2009). The present study further explored the associations between the core ADHD symptoms and Internet usage related to Internet addiction, as well as the predictability of ADHD symptoms given Internet addiction as the outcome. The major findings showed that both core symptoms of ADHD were negatively related to information downloading and online learning and positively associated with online gaming. Additionally, hyperactivity/impulsivity symptoms were associated with online shopping. Both ADHD symptoms predicted Internet addiction, with inattention as a stronger predictor. Findings are discussed in more detail below.

Comorbidity between ADHD and Internet Addiction.

By using the CAARS-S:S, a self-report measurement of compulsive, withdrawal, tolerance, interpersonal and health problems, and time management problems, we found that 14.38% of college students in the sample met the criteria of

having Internet addiction, which is similar to the findings reported in previous studies in China (Liang et al., 2006; Zhang & Li, 2011). Further, the rate of ADHD diagnosis based on the DSM-5 was higher in the Internet addiction group (15.17%) than in the non-Internet addiction group (2.67%). Other studies suggested that individuals with ADHD seem to be more susceptible to developing Internet addiction than other behavioral and emotional disorders (Chou et al., 2015; Dalbudak et al., 2015; Ko et al., 2008; Yen et al., 2009;). Though the current study did not examine other behavioral or emotional disorders, the comorbidity rate found supports the conclusion that individuals with ADHD have a higher likelihood of being addicted to the Internet.

Some researchers have stated that having an abnormal reinforcement mechanism is a fundamental cause of the high susceptibility to various substances and behaviors in individuals with ADHD (Leung, 2008; Plichta et al., 2009). Abnormal reinforcement refers to hypersensitivity and excessive pursuit of reinforcement, neglect of punishment and low tolerance of delay of gratification. Our findings further supported that probability of comorbidity between ADHD and Internet addiction is larger than chance. Thus, this study supports the need to investigate further shared mental mechanisms of ADHD and Internet addiction (Mak et al., 2018).

Relations between Internet Usages and Internet Addiction.

Years of Internet usage and time spent on the Internet per day were positively related to Internet addiction, suggesting that people with continuous and frequent Internet usage are more likely to develop addiction symptoms (Servidio, 2014; Stavropoulos et al., 2017). For Internet activities, online gaming was positively related to Internet addiction, whereas online learning negatively relates to it. The finding is consistent with those reported in former studies (Choi & Kim, 2004; Hull et al., 2013; Kuss & Griffiths, 2011; Wan & Chiou, 2006).

Online gaming, a popular and highly accessible Internet activity for college students, raises the risk of Internet addiction (Choi & Kim, 2004) not only due to its eye-catching stimulus, quick feedback, and rewards from interacting with the game system but also its social interaction with others, which may meet students' social development needs. In contrast, online learning has been regarded as a self-directed and self-regulated learning behavior. Individuals who have high levels of self-directedness are inclined to have a good sense of control over their behaviors and more effective problem-solving strategies. In contrast, low self-directedness was a significant predictor of excessive Internet use (Montag et al., 2010). With weaker self-regulation in learning, persons diagnosed with ADHD have more difficulty controlling behaviors in online activities or shifting from online activities that provide more frequent, immediate external rewards (e.g., gaming) to online learning. On the flip side, these results suggested that if intervention efforts increase college students' online learning behavior, especially among those having ADHD, it likely reduces other online activities (if these behaviors are incompatible, e.g., online shopping in class) and subsequently reduces the risk for Internet addiction. Future applied studies are needed in this area.

ADHD and Different Types of Internet Activities.

The current study also found some interesting patterns of the associations between each ADHD core symptom and different types of Internet activities. Not surprisingly, both core ADHD symptoms were negatively associated with information downloading and online learning and positively associated with online gaming. These results attest to previous findings that showed that ADHD is a risk factor for underachievement and even failing grades, as individuals with ADHD often lose interest in activities related to study more quickly than their peers and are easily distracted by other activities such as online games (Ek et al., 2011). Interestingly, hyperactivity/impulsivity symptoms were positively related to online shopping, but not inattention. Online shopping, which has evolved into an integral part of everyday life, provides instant convenience and diversified services to buyers, often triggering impulsive purchasing or excessive consumption. Research has suggested that impulsively or excessively, online shopping behavior is problematic and associated with negative consequences (Rose & Dhandayudham, 2014). Disinhibition is one executive function deficit characterized by ADHD, which often leads to disturbance in motivation and self-regulation of emotion (Kwak et al., 2015). Thus, internal disinhibition and external impulsive behaviors likely contribute to a higher frequency of online shopping.

ADHD Symptoms Predict Internet Addiction.

The results indicate that ADHD symptoms were predictive of Internet addiction in college students, and inattention symptoms had a stronger association with Internet addiction than hyperactivity/impulsivity symptoms. Hypersensitivity to reinforcement and aversion to delay explain the etiological connection between ADHD and Internet addiction. Internet activities (e.g., gaming) provide fast-changing and abundant stimuli, quick responses, and often instant rewards, which effectively reduce boredom or aversion to delayed reward and can be very attractive to individuals with ADHD. It also provides a virtual world where individuals can avoid efforts in inhibition but enjoy positive emotions (e.g., pleasant, satisfied, and confident), which are hard to achieve in real life, especially for individuals with ADHD. Thus, it is very likely ADHD symptoms, when not well managed, set the individuals up for excessive use of Internet activities; without external guidance or supervision, such behaviors gradually develop into addiction.

Additionally, we found a stronger association between inattention and Internet addiction. This result, first, supported a previous study that reported a positive correlation between inattention and Internet addiction (Panagiotidi et al., 2018). Second, a higher proportion of the inattentive (ADHD-I) subtype than the hyperactivity/impulsivity (ADHD-HI) subtype in an adult population should be taken into consideration when discussing the finding (Chen et al., 2010). When taking a developmental lens, hyperactivity and impulse symptoms tend to weaken as children and adolescents mature, but attention deficit is more likely to persist into adulthood (Biederman et al., 1996). It is possible that among college students (mostly young adults), inattention symptoms are more prevalent than hyperactivity/impulsivity and have a more pervasive impact on online behaviors, including Internet addiction behaviors. This proposition, however, needs testing in future research.

Conclusion

The present study explored the associations between the core ADHD symptoms and Internet usage related to Internet addiction, as well as the predictability of ADHD symptoms given Internet addiction as the outcome. Compared to peers without ADHD symptoms, college students with ADHD symptoms are more likely to play online games and have less online information downloading and online study behaviors. In contrast, more severe hyperactivity/impulsivity symptoms are associated with more frequent online shopping activity. Moreover, college students with ADHD symptoms are at higher risk of having Internet addiction, inattention symptoms are more predictive of Internet addiction than hyperactivity/impulsivity symptoms.

Recommendations

Built upon the results of this study, which supported the association between ADHD and Internet addiction among young adults in the college setting, researchers should further explore the connection between ADHD and Internet addiction in younger populations, especially adolescents. Also, beyond observational research, the brain material basis that likely connects ADHD and Internet addiction should be examined by neuroimaging techniques, which may provide more solid evidence to support the development of treatment or preventive measures.

In addition, from the perspective of professionals in higher education, psychological service and public health sectors should be aware of the higher risk of having problematic use of the Internet, including excessive Internet use and Internet addiction among college students with ADHD symptoms, including those with inattention symptoms, who historically tend to be overlooked due to less observable behavioral problems. A strong support system in higher education and even secondary education to prepare students for more regulated Internet usage in college is needed, especially for those with ADHD. Disability Offices in colleges may consider providing regular screening, evaluation, and monitoring of Internet use to help students with a diagnosis of ADHD prevent Internet addiction. Also, promoting healthy online learning behavior may be one strategy to reduce inappropriate Internet activity and reduce the risk of developing Internet addiction.

Limitations

Several limitations of this study should be noted. Firstly, though the sample is large, it might not be highly representative of the national population. Secondly, though it was appropriate to use a screening tool to assess the ADHD symptoms and Internet addiction in the non-clinical sample, the symptoms were all self-rated and might be subject to self-report bias. Thirdly, the causal relation between ADHD symptoms and Internet addiction cannot be addressed since this study is cross-sectional and non-experimental. Future studies should employ more rigorous experimental designs and more advanced cognitive or neuroscientific technology to draw higher levels of inferences. We were also unable to reveal the mechanism that connects ADHD symptoms and Internet addiction. We recommend researchers further examine the shared causes of ADHD and Internet addiction, and the connection between ADHD symptoms and particular types of Internet addiction.

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Authorship Contribution Statement

Zhang: Conceptualization, design, writing, drafting manuscript. Jiang: Drafting manuscript, editing/reviewing, supervision. Yang: Data acquisition, data analysis, drafting manuscript. Zhu: Statistical analysis, critical revision of manuscript.

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