



Article

Investigation of Correlated Internet and Smartphone Addiction in Adolescents: Copula Regression Analysis

Minji Lee ¹, Sun Ju Chung ², Youngjo Lee ³, Sera Park ⁴, Jun-Gun Kwon ⁴, Dai Jin Kim ⁵, Donghwan Lee ^{1,*}  and Jung-Seok Choi ^{2,6,*} 

¹ Department of Statistics, Ewha Womans University, Seoul 03760, Korea; hsjiho2104@gmail.com

² Department of Psychiatry, SMG-SNU Boramae Medical Center, Seoul 07061, Korea; sunjujung1991@gmail.com

³ Department of Statistics, Seoul National University, Seoul 08826, Korea; youngjo@snu.ac.kr

⁴ I Will Center, Seoul Metropolitan Boramae Youth Center, Seoul 07062, Korea; seramanim@boramyc.or.kr (S.P.); jun@boramyc.or.kr (J.-G.K.)

⁵ Department of Psychiatry, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul 06591, Korea; kdj922@catholic.ac.kr

⁶ Department of Psychiatry and Behavioral Science, Seoul National University College of Medicine, Seoul 03080, Korea

* Correspondence: donghwan.lee@ewha.ac.kr (D.L.); choijs73@gmail.com (J.-S.C.)

Received: 1 June 2020; Accepted: 6 August 2020; Published: 11 August 2020



Abstract: Internet and smartphone addiction have become important social issues. Various studies have demonstrated their association with clinical and psychological factors, including depression, anxiety, aggression, anger expression, and behavioral inhibition, and behavioral activation systems. However, these two addictions are also highly correlated with each other, so the consideration of the relationship between internet and smartphone addiction can enhance the analysis. In this study, we considered the copula regression model to regress the bivariate addictions on clinical and psychological factors. Real data analysis with 555 students (age range: 14–15 years; males, $N = 295$; females, $N = 265$) from South Korean public middle schools is illustrated. By fitting the copula regression model, we investigated the dependency between internet and smartphone addiction and determined the risk factors associated with the two addictions. Furthermore, by comparing the model fits of the copula model with linear regression and generalized linear models, the best copula model was proposed in terms of goodness of fit. Our findings revealed that internet and smartphone addiction are not separate problems, and that associations between them should be considered. Psychological factors, such as anxiety, the behavioral inhibition system, and aggression were also significantly associated with both addictions, while ADHD symptoms were related to internet addiction only. We emphasize the need to establish policies on the prevention, management, and education of addiction.

Keywords: internet addiction; smartphone addiction; copula regression

1. Introduction

The spread of the Internet and smartphones has the advantage of rapidly offering information and improving living conditions. Moreover, Korea has seen a steady rise in the Internet penetration rate since the launch of internet commercial services in 1994, along with the growth rate of smartphones among teenagers [1,2]. Because adolescents generally have less self-control and spend more time using smartphones compared to adults, the probability of potential addiction is observed as higher in adolescents than adults. [3]. Recent work has demonstrated that the excessive use of online gaming is linked to poorer social skills and an absence of real-life relationships [4], while the addictive use of

social media leads to problems strongly associated with symptoms of attention-deficit/hyperactivity disorder (ADHD) [5]. Furthermore, low levels of self-control and emotional control issues have been associated with adolescent internet addiction [6]. An over-reliance on smartphones can even result in psychological problems, such as anxiety and depression [7]. In addition to this, physical problems have also been linked to long-term smartphone usage, including muscle ache and headaches, which subsequently deteriorate sleep quality [8].

The main function of smartphones is the operation of internet-based applications. Smartphones are known as the “handheld internet” because they provide personalized services anywhere in real time, unlike generally fixed desktops [9]. Thus, the Internet and smartphones are used in sync, and although internet and smartphone addictions have unique characteristics, such as that males are at more risk of internet addiction, while females are more prone to smartphone addiction [9], they also share behavioral addiction features based on information technology (IT) [10]. It is well-known that several clinical characteristics, such as depression, anxiety, aggression, and impulsivity have a positive relationship with both addictions [11–14]. Using these shared or similar properties, smartphone addiction criteria were developed by referring to internet addiction criteria [15]. A study in Japan also determined that smartphone and internet addictions were significantly associated [16]. Previous studies have investigated the positive association between internet and smartphone addictions. For example, smartphone addiction risk groups were observed to use mobile messenger, social networking services, and the Internet for significantly longer periods of time compared to non-risk groups [17]. The smartphone addiction scale (SAS) was found to be a significant factor of internet addiction using stepwise multiple regression. Conversely, when SAS was used as a response variable, internet addiction was exhibited as a relevant factor [10].

However, up until now, the majority of studies have used multiple or binary logistic regression in order to analyze internet and smartphone addiction. Such analysis methods assume that internet and smartphone addiction are independently observed [10,17]. The copula regression model can be easily applied when the response variables have different distribution patterns and are correlated in multivariate data [18]. In this paper, we applied copula regression analysis for the prediction of internet and smartphone addiction simultaneously. More specifically, we used data collected from Korean adolescents on internet and smartphone addictions and compared our proposed model with regression and generalized linear models. In addition, we explained the consequences of the model selection criteria. Finally, we determined the optimum model and significant features associated with internet and smartphone addiction, such as depression, anxiety, aggression, anger expression, the behavioral inhibition system, and behavioral activation system. We chose these variables since these are known as the most representative psychological characteristics associated with internet and smartphone addiction, which lots of previous research have revealed.

2. Materials and Methods

2.1. Participants

This study was approved by the Institutional Review Board of Seoul St. Mary’s Hospital, Seoul, Republic of Korea (KC13ONSI0080, 8 April 2013), and all subjects provided written informed consent prior to participation. Data was collected from 714 (males, $N = 389$; females, $N = 325$) middle school students (age range: 14–15 years) in Seoul, South Korea. All participants received an explanation about the research and completed self-administered questionnaires. Participants were offered gift certificates as a reward for their participation. The survey included basic information, such as the age, sex, and drinking and smoking characteristics of participants, and medical records of psychiatric hospitals were checked. Out of the 714 observations, we eliminated 159 samples due to missing values for the Internet Addiction Test (IAT) and Smartphone Addiction Scale (SAS). The data for the final sample used for analysis included 295 males and 260 females, with total of 555 subjects.

2.2. Measures

2.2.1. Young's Internet Addiction Test (Y-IAT)

The Y-IAT, developed by Kimberly Young, is one of the most utilized diagnostic instruments for Internet addiction. It is based on a five-point scale (from "1 = very rarely" to "5 = very frequently"). The Y-IAT has 20 items, including questions such as, "How often do you find that you stay online longer than you intended?" and "How often do you neglect household chores to spend more time online?". It contains six subscales: cognitive conspicuousness (Y1), overuse (Y2), neglect of duty (Y3), expectation (Y4), lack of control (Y5), and neglect of social activities (Y6). A Cronbach's alpha coefficient for Y-IAT of 0.939 has previously been reported. Based on previous research, the total scores were calculated according to Young's procedure, with possible scores for all 20 items ranging from 20 to 100. A total score of 20–39 represents average internet usage with self-control. A score of 40–69 denotes excessive internet usage with experience of frequent problems, and 70–100 represents serious problems due to internet usage [19].

2.2.2. Smartphone Addiction Scale (SAS)

The SAS was used to assess the degree of problematic smartphone usage. The SAS includes 33 items, such as questions of "feeling calm or cozy while using a smartphone" and "missing planned work due to smartphone use" with a six-point response format, ranging from "1 = strongly disagree" to "6 = strongly agree". The SAS is composed of and calculated from six subscales: daily life disturbance (S1), positive anticipation (S2), withdrawal (S3), cyberspace-oriented relationship (S4), overuse (S5), and tolerance (S6). The SAS has previously demonstrated an internal consistency with a Cronbach's alpha coefficient of 0.967. The higher the total SAS score, the higher the degree of addictive behavior related to smartphones [20].

2.2.3. Psychosocial Measures

The Beck Depression Inventory (BDI) is a self-rated measure that consists of 21 questions. It is used to quantify the severity of a particular symptom experienced during the past week and includes cognitive, emotional, motivational, and physical features of depression. A total score of 0–13 is considered to denote minimal depression, 14–19 mild depression, 20–28 moderate depression, and 29–63 severe depression. The Korean version has previously been validated with a Cronbach's alpha coefficient of 0.85 [21,22].

The Beck Anxiety Inventory (BAI) is another self-rated measure used to rate the seriousness of anxiety and consists of questions on, for example, sensitivity and physical sense. In total, 21 questions and a four-point scale (0 = "not at all" to 3 = "it bothered me severely") are used. Scores for the 21 items are summed up to calculate a single anxiety score. Previous research has demonstrated internal consistency with a Cronbach's alpha coefficient of 0.93 [23].

The Behavioral Inhibition System (BIS) and Behavioral Activation System (BAS) scales were designed based on Gray's theory of biomechanical nature, whereby the pursuit of avoidance of a punishment system, and sensitivity and approach to a compensation system are evaluated. This scale consists of 20 questions rated on a four-point scale from "totally agree" to "totally disagree". In particular, the BIS scale contains seven items on anticipated punishment, and the BAS scale has 13 items [24].

The short form of the Conners-Wells' Adolescent Self-Report Scale (CASS) evaluates ADHD symptoms, concentrating on cognitive- and hyperactivity-related issues. It consists of 27 items that rate problems of ADHD symptoms based on a four-point scale, ranging from 0 (not true) to 3 (very often). This measure has demonstrated internal consistency with a Cronbach's alpha coefficient of 0.88 [25].

The Aggression Questionnaire (AQ) consists of 29 questions on a five-point Likert scale from 1 (uncharacteristic of me) to 5 (very characteristic of me) as a measure of aggressive behavior. The questions are divided into four domains: physical or verbal aggression, anger, and hostility. This measure has demonstrated internal consistency with a Cronbach's alpha coefficient of 0.889 [26].

The State–Trait Anger Expression Inventory (STAXIE) developed by Spielberger [27] was designed to measure how often the respondent experiences anger on the same scale. It consists of 20 questions, and each item is evaluated with a four-point scale [27].

2.2.4. Internet/Smartphone Usage Pattern Survey

We surveyed internet and smartphone usage patterns on weekdays and weekends. A recent review found that problematic internet use is most common in adolescents, as they are more vulnerable to internet addiction due to their limited ability to control their enthusiasm for internet activities [10]. Moreover, first using a smartphone at a younger age was found to be significantly associated with several smartphone addiction symptoms [28]. Following this, the initial use of the internet and smartphones was added to our survey. In addition, participants answered questions related to gaming patterns based on a study on internet-based games that determined game play as an important indicator of the potential risk of internet gaming addiction [28].

2.3. Statistical Analysis

In order to model Y-IAT and SAS simultaneously, we used the copula regression model. Copula models are useful for describing response variables that are not normally distributed and that have the dependence structure. In addition, different marginal distributions for response variables are allowed.

Let $F_{Y_1}(y_1) \dots F_{Y_d}(y_d)$ denote the marginal distribution of the multivariate responses Y_1, \dots, Y_d . From Sklar's Theorem [29], their joint distribution function can be created by referring to a unique copula function C , as

$$F_{Y_1, \dots, Y_d}(y_1, \dots, y_d) = C[F_{Y_1}(y_1), \dots, F_{Y_d}(y_d)]. \quad (1)$$

If the marginal distributions are continuous, then the copula function C is unique. In this paper, we set $d = 2$ because the outcome variables (Y-IAT and SAS) are two-dimensional. The Gaussian copula is a model generated from the multivariate normal distribution using the inverse normal transformation,

$$C(u_1, u_2; \rho) = \Phi_2(\Phi^{-1}(u_1), \Phi^{-1}(u_2); \rho),$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution and $\Phi_2(\cdot)$ is the bivariate normal cumulative distribution with 0 mean, unit variances, and correlation parameter ρ [30]. Similarly, the Student-t copula [31], with the degrees of freedom parameter $\nu > 2$, is derived with bivariate t distribution, $t_{\Sigma, \nu}(\cdot)$ with the density

$$f(y) = \frac{\Gamma(\frac{\nu+2}{2})}{\Gamma(\frac{\nu}{2}) \sqrt{(\pi\nu)^2 |\Sigma|}} \left(1 + \frac{y^T \Sigma^{-1} y}{\nu} \right)^{-\frac{\nu+2}{2}},$$

where $y = (y_1, y_2)^T$.

For applying the copula function in the regression context, each marginal distribution $F_{Y_1}(y_1) = F_1(y_{i1}; X_{i1}, \beta_1)$ and $F_{Y_2}(y_2) = F_2(y_{i2}; X_{i2}, \beta_2)$ can be modeled with the explanatory variables X_{i1} and X_{i2} and the regression coefficients β_1 and β_2 . Therefore, in order to estimate unknown parameters, we can maximize the likelihood constructed by the joint distribution

$$F_{Y_1, Y_2}(y_{i1}, y_{i2}; X_{i1}, X_{i2}, \beta_1, \beta_2, \theta) = C[F_1(y_{i1}; X_{i1}, \beta_1), F_2(y_{i2}; X_{i2}, \beta_2); \theta],$$

where the parameter θ captures the degrees of association between two marginals. In summary, following [18], fitted outcome variables can be derived based on the copula regression model with the following steps: (a) Determine the model for the joint distribution of the outcome variables and covariates; (b) estimate the distribution and parameters of the model (marginal and copula); and (c) estimate the conditional mean of the outcome variables given the covariates. We compared our proposed model with a linear regression model [32] and a generalized linear model (GLM) [33] for the

outcome variables of Y-IAT and SAS, and covariates of psychosocial measures and Internet/smartphone usage patterns.

3. Results

First, we investigated the characteristics of the outcome variables (Y-IAT and SAS) and psychological measures. Table 1 shows the mean, standard deviations of the measures, and their correlations. Figure 1 demonstrates that Y-IAT and SAS are non-negative and skewed to the right. Figure 2 shows that there is a strong and positive correlation between IAT and SAS. In particular, the Pearson correlation between the two variables is $\rho_{y_1, y_2} = 0.49$ (p -value < 0.001). Moreover, a strong association is still observed following the log-transformation of IAT and SAS. Thus, in order to jointly model IAT and SAS, the dependence structure between IAT and SAS must be considered.

Table 1. Descriptive statistics of addiction and psychosocial measures.

Variable	Mean	SD	Correlations							
			Y_IAT	SAS	BDI	BAI	BIS	CASS	AQ	STAXI_E
Y_IAT	33.88	13.05	1	0.49	0.23	0.44	0.32	0.42	0.4	0.23
SAS	80.25	27.94		1	0.39	0.48	0.39	0.39	0.49	0.26
BDI	7.46	7.82			1	0.65	0.31	0.52	0.5	0.33
BAI	6.46	8.56				1	0.3	0.55	0.52	0.3
BIS	63.55	8.34					1	0.44	0.33	0.14
CASS	17.91	12.59						1	0.6	0.44
AQ	63.42	20.06							1	0.53
STAXI_E	53.28	11.39								1

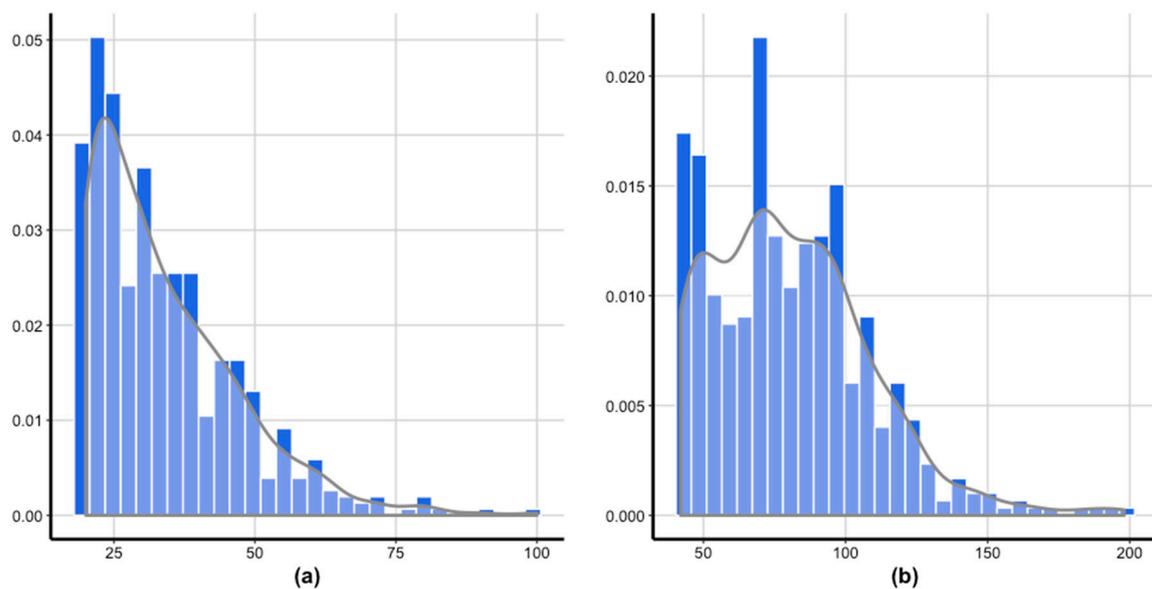


Figure 1. Histogram and density plot of the response variables: (a) Y-IAT; (b) SAS.

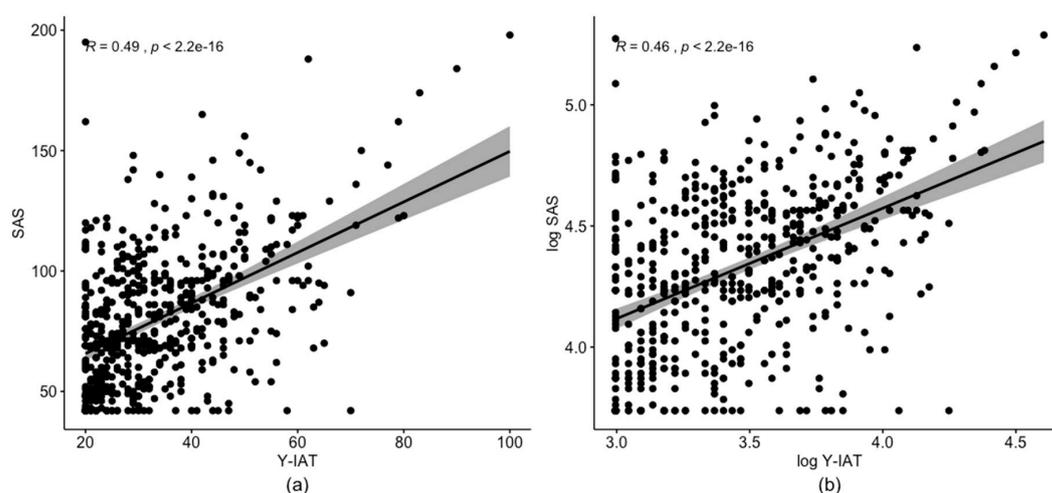


Figure 2. Scatter plot and correlation (a) between Y-IAT and SAS; (b) between log-transformed Y-IAT and log-transformed SAS.

Figures 1 and 2 suggest that right-skewed distributions, such as the gamma, log-normal, and Weibull distribution are potential candidates for marginal distributions. Tables 2 and 3 report the estimated parameters of the fitted distributions of Y-IAT and SAS, respectively, using R-package *fitdistrplus* [34]. The standard error, Akaike information criterion (AIC), and Bayesian information criterion (BIC) for the log-normal (AIC of IAT = 4023.95, AIC of SAS = 4917.60) and gamma (AIC of IAT = 4063.73, AIC of SAS = 4922.90) distributions were smaller than that of the Weibull distribution (AIC of IAT = 4168.62, AIC of SAS = 4978.22). Therefore, herein, we assume the distributions of IAT and SAS to be log-normal and gamma, respectively.

Table 2. Parameter estimates of probability distributions of Y-IAT.

Parameters		Estimate	SE	AIC	BIC
Gamma	shape	8.073	0.488	4063.73	4072.26
	rate	0.237	0.015		
Log-normal	mean	3.464	0.015	4023.95	4032.48
	standard deviation	0.346	0.011		
Weibull	shape	2.700	0.083	4168.22	4177.15
	scale	38.262	0.658		

Abbreviations: SE, Standard error; AIC, Akaike information criterion; BIC, Bayesian information criterion; Y-IAT, Young’s Internet Addiction Test.

Prior to conducting the copula regression model, we first determined an appropriate copula distribution without explanatory variables using the R (version 3.5.1) package *VineCopula*. This package is able to select a suitable copula family for given dependence data, and the relevant parameter estimates are calculated by maximum likelihood estimation. Moreover, the optimal distribution is selected based on the AIC and BIC [35]. Based on this, we determined the optimal copula distribution to be a t-distribution with three degrees of freedom. Goodness-of-fit tests for the selected copula function were performed using *gofCopula* [36].

For each model, the AIC was calculated for variable selection by backward elimination [37]. As the linear regression and generalized linear models assume the IAT and SAS to be independent, the total AIC for each variable is calculated as the sum of the AIC values in two models. Table 4 reports the AIC of the copula regression model with varying marginal and copula values. In terms of AIC, the copula regressions performed better than the linear regression and generalized linear models. For the copula

models, the optimum scenario was for the IAT with a log-normal distribution, SAS with a gamma distribution, and the copula with a t-distribution.

Table 3. Parameter estimates of probability distributions of SAS.

Parameters		Estimate	SE	AIC	BIC
Gamma	shape	8.073	0.488	4063.732	4072.262
	rate	0.237	0.015		
Log-normal	mean	3.464	0.015	4023.95	4032.481
	sd	0.346	0.011		
Weibull	shape	2.70	0.083	4168.623	4177.154
	scale	38.262	0.658		

Abbreviations: SE, Standard error; AIC, Akaike information criterion; BIC, Bayesian information criterion, SAS, Smartphone Addiction Scale.

Table 4. Model comparison results.

Linear Regression			GLM			Copula			
IAT	SAS	AIC	IAT	SAS	AIC	IAT	SAS	Copula	AIC
Norm.	Norm.	8605.3	Log.	Log.	8587.1	Log.	Gam.	Norm.	8363.1
Log.	Log.	8421.8	Gam.	Gam.	8453.2	Log.	Log.	t	8362.2
Norm.	Log.	8572.6	Log.	Gam.	8567.4	Log.	Gam.	t	8348.5
Log.	Norm.	8454.5	Gam.	Log.	8472.9	Gam.	Log.	t	8373.4

Abbreviations: Norm., Normal distribution; Log., Log normal distribution; Gam., Gamma distribution; GLM, generalized linear model.

Table 5 and Figure 3 present the fitted results of the best model, the t-copula regression model. The response variables IAT and SAS were dependent on each other. For the IAT, the gender coefficient was a negative value (reference variable = male). However, the SAS female regression coefficient exhibited a high, significantly positive value ($p < 0.05$). Among the psychological factors, BAI, BIS, and AQ were significantly associated with both addictions, while CASS affected to IAT only. As well as the psychological measures, internet and smartphone usage patterns from the survey were also significant.

Table 5. Parameter estimates of the t-copula regression model.

IAT	Estimate	SE	p-Value	SAS	Estimate	SE	p-Value
Intercept	69.1356	72.4595	0.34	Intercept	114	71.86	0.11267
GENDER	−0.0929	0.027	0.0006	GENDER	0.0484	0.0239	0.0428
BDI	−0.0044	0.0021	0.0363	BDI	−0.0019	0.0021	0.3732
BAI	0.0089	0.0019	0.0000	BAI	0.0079	0.0019	0.0000
BIS	0.0052	0.0016	0.0009	BIS	0.0082	0.0015	0.0000
CASS	0.0029	0.0013	0.0307	CASS	−0.0007	0.0013	0.6154
AQ	0.0037	0.0008	0.0000	AQ	0.0049	0.0008	0.0000
WDGH	0.0375	0.0111	0.0008	WDSH	0.0057	0.0086	0.5077
WEGH	0.0264	0.0073	0.0003	WESH	0.0251	0.0069	0.0003
WDIH	0.0376	0.0098	0.0001	YEAR	−0.051	0.0352	0.1478
YEAR	−0.0332	0.0362	0.3595	ALC	0.0341	0.0716	0.6343
ALC	−0.1677	0.0762	0.0277	SMK	0.0497	0.1008	0.622
SMK	0.0969	0.1039	0.3508				
AIC				8348.471			
Corr.				0.364 (0.288, 0.429)			

Abbreviations: SE, standard error; Corr., Correlation; AIC, Akaike information criterion; WDGH, Weekday daily gaming hours; WEGH, Weekend daily gaming hours; WDIH, Weekday daily Internet usage hours; WDSH, Weekday daily Smartphone usage hours; WESH, Weekend daily Smartphone usage hours; YEAR, Birth year, ALC, Alcohol Drinking, SMK, Smoking.

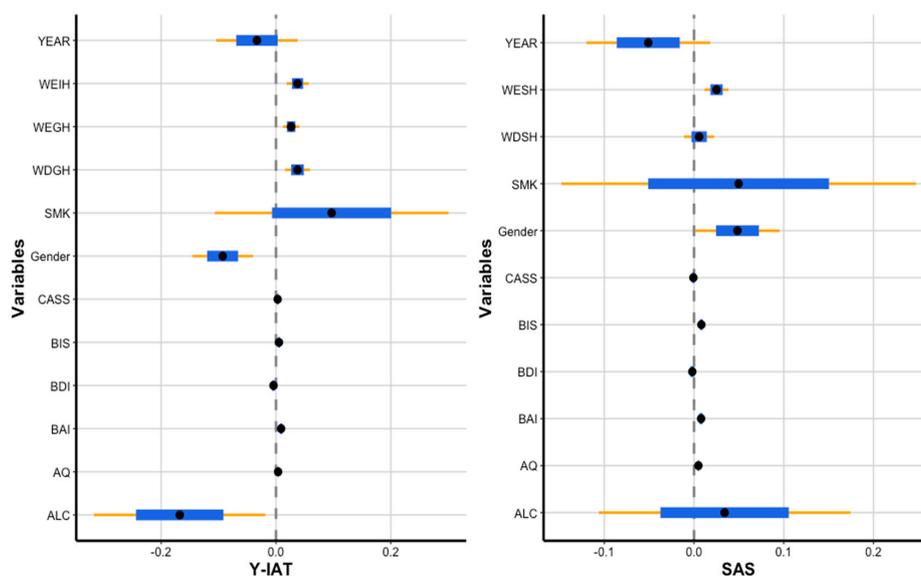


Figure 3. The plots of regression coefficients when fitting the t-copula, (a) Internet Addiction Test (Y-IAT) part and (b) Smartphone Addiction Scale (SAS) part.

4. Discussion

We explored regression models for internet and smartphone addiction, with the relevant predictors. In order to account for the dependence between the two addictions, we used the copula regression method and demonstrated that this model was better than conventional methods in terms of AIC. Most studies generally predict addiction using multiple linear or logistic regressions, without considering the association between variables [10,17]. In addition, the marginal correlation between internet and smartphone addiction has been tested in previous studies [16]. Similar to previous results, we found that, in the final model for internet addiction, the gaming hour variables during weekdays and weekend were significant. Moreover, psychological variables, such as anxiety, behavioral inhibition, and aggression are potential risk factors of both addictions. Several studies have reported anxiety and aggression as significant risk factors of the smartphone [7,38] and internet [11,39] addictions. BIS sensitivity is also a known key influence on internet addiction [40–42], and individuals with a smartphone addiction have demonstrated higher BIS values compared to non-addicted users [43]. Thus, our findings act as additional evidence that these factors, which may increase vulnerability to internet and smartphone addictions, independently increase the risk of both addictions. Our results indicate that adaptive coping strategies must be developed, specifically including the mood regulation of individuals with high levels of anxiety, aggression, and BIS reactivity, in order to prevent internet and smartphone addiction.

Additionally, the present study identified the fact that internet addiction encompasses broader factors related to both addictions, in that there are more independent factors which predict internet addiction rather than smartphone addiction apart from common predictors of both addictions. It was revealed that symptoms of depression and ADHD were significantly associated with internet addiction, although the powers of significance were low, whereas no significant relationship was observed for smartphone addiction in this study. Similar to previous research [44,45], we found that ADHD symptoms positively predicted internet addiction. This finding demonstrates the necessity to assess and treat comorbidities associated with internet addiction. Furthermore, in a recent study using structural equation modeling [46], affective components, such as depression and anxiety, were significantly associated with both internet addiction and smartphone addiction, whereas aggression, the expression of anger, and ADHD symptoms affected only internet addiction. Adolescents are more easily addicted to the Internet, or playing internet games to gain rewards instantly and express their negative feelings through externalizing problems, while adolescents with depression or anxiety might use the Internet

or smartphone to avoid or reduce their negative mood [46]. Therefore, internet addiction might be related with more psychological and clinical factors rather than smartphone addiction. However, in the present study, depression was negatively associated with internet addiction, inconsistent with previous results [47–49]. Because the correlation between anxiety and depression was positively high in this study, and the symptom of anxiety is very significantly related to addictions with a positive sign, there may have been a confounding effect due to the multicollinearity. It is necessary to confirm relationships between depression and internet addiction in the further study with a larger sample.

Our findings regarding gender are in line with previous studies which indicate the different patterns of internet and smartphone usage by gender [50,51]. Lee et al. (2018) [50] explored internet and smartphone usage patterns among adolescents, and revealed that female students exhibited problematic usage trends in smartphones, but lower levels of severity for internet usage compared to male students [50]. These findings suggest that gender is a significant predictor of internet and smartphone addictions, and particularly indicate females as more susceptible to smartphone addiction than internet addiction. Such gender-specific results may be explained by previous research. Studies have revealed that females tend to use mobile phones and the Internet for social communication, while males use the Internet for leisure activities and interests, such as gaming and entertainments [52,53]. Thus, gender differences must be considered for addiction interventions, with particular focus on gender-specific characteristics for internet and smartphone addictions.

The results of our study also demonstrated that the time spent using the Internet on weekdays, and gaming hours during both weekdays and the weekend were significant predictors of internet addiction. Similarly, the time spent using smartphones on the weekend positively predicted smartphone addiction. That is, the more time spent on each media type, the higher the severity of the addiction. Consequently, these results suggest that the quantitative index of each media type reflects the level of addiction. In particular, the fact that online gaming generally accounts for a great portion of internet usage [12,54] offers an explanation of the results, and implies that online gaming usage must be dealt with within internet addiction treatments. Our study is limited by our data. For example, our dataset was gathered from an adolescent age group. Thus, difficulties can arise in generalizing our results because adults' internet and smartphone addiction may have different patterns due to other social problems, such as gambling. Hence, we propose further studies that can extend the scope of the survey, with greater gender and age ranges in order to allow for generalizations of internet and smartphone usage patterns. Furthermore, these real examples have missing values of addiction scores. In this paper, we simply used completed-case analysis because we found no meaningful difference between the distributions of psychological variables of samples with or without addiction values. If the non-response patterns are not ignorable, more care is necessary.

5. Conclusions

In this paper, we considered a regression model where the marginal distributions of each response variable are different and are correlated with each other. We selected and predicted the best model considering the correlation between internet and smartphone addiction. Consequently, we found that the copula regression provides a better fit compared to the linear regression and generalized linear models. Our findings reveal that internet and smartphone addiction are not separate problems; the association between IAT and SAS should be considered. Furthermore, we found the potential risk factors associated with the two addictions, so we emphasized the need to establish policies on the prevention, management, and education of addiction. Though current interventions of both addictions usually take place independently, this suggests there is a necessity for interventions on both addictions in future, even if there is only one risk of either, keeping in mind the possibility of it developing into another one.

Author Contributions: J.-S.C. and D.L. were responsible for the study concept and design. M.L. and S.J.C. drafted the manuscript and performed interpretation of data. M.L., Y.L., D.L. conducted the statistical analysis. S.P., J.-G.K., D.J.K. also took part in drafting and reviewed the scientific the concept. All authors had fully access to all data in the study and take responsibility for the accuracy of the data analysis. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by a grant from the National Research Foundation of Korea (Grant No. 2014M3C7A1062894; 2014M3C7A1062896; 2018R1D1A1B07050910; 2019R1A2C1002408). This work was also supported by a multidisciplinary research grant-in-aid from the Seoul Metropolitan Government - Seoul National University (SMG-SNU) Boramae Medical Center (02-2019-4).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ministry of Science and ICT. 2018 Internet Usage Survey Summary Report. Available online: https://www.kisa.or.kr/public/library/etc_View.jsp?regno=0011990 (accessed on 1 November 2019).
2. Kim, Y.H. Analysis of Cellular Phone Retention and Usage Behavior of Children and Adolescent. Available online: <https://www.kisdi.re.kr/kisdi/fp/kr/publication/selectResearch.do?cmd=fpSelectResearch&sMenuType=2&controlNoSer=43&controlNo=14421&langdiv=1> (accessed on 31 October 2018).
3. Hwang, Y.; Park, N. Is Smartphone Addiction Comparable between Adolescents and Adults? Examination of the Degree of Smartphone Use, Type of Smartphone Activities, and Addiction Levels among Adolescents and Adults. *Int. Telecommun. Policy Rev.* **2017**, *24*, 59–75.
4. Griffiths, M.D. Online Games, Addiction and Overuse of. In *The International Encyclopedia of Digital Communication and Society*; Available online: <https://onlinelibrary.wiley.com/doi/full/10.1002/9781118767771.wbiedcs044> (accessed on 1 June 2020).
5. Andreassen, C.S.; Billieux, J.; Griffiths, M.D.; Kuss, D.J.; Demetrovics, Z.; Mazzoni, E.; Pallesen, S. The relationship between addictive use of social media and video games and symptoms of psychiatric disorders: A large-scale cross-sectional study. *Psychol. Addict. Behav.* **2016**, *30*, 252–262. [[CrossRef](#)] [[PubMed](#)]
6. Koo, H.J.; Kwon, J.H. Risk and Protective Factors of Internet Addiction: A Meta-Analysis of Empirical Studies in Korea. *Yonsei Med. J.* **2014**, *55*, 1691–1711. [[CrossRef](#)] [[PubMed](#)]
7. Boumosleh, J.M.; Jaalouk, D. Depression, anxiety, and smartphone addiction in university students—A cross sectional study. *PLoS ONE* **2018**, *12*, e0182239. [[CrossRef](#)]
8. Thomee, S.; Harenstam, A.; Hagberg, M. Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults—a prospective cohort study. *BMC Public Health* **2011**, *11*, 66. [[CrossRef](#)]
9. Kim, J. The Evolution of Mobile Internet Service. *OSIA Stand. Technol. Rev.* **2010**, *38*, 4–12.
10. Choi, S.W.; Kim, D.J.; Choi, J.S.; Ahn, H.; Choi, E.J.; Song, W.Y.; Kim, S.; Youn, H. Comparison of risk and protective factors associated with smartphone addiction and Internet addiction. *J. Behav. Addict.* **2015**, *4*, 308–314. [[CrossRef](#)]
11. Lim, J.-A.; Gwak, A.R.; Park, S.M.; Kwon, J.-G.; Lee, J.-Y.; Jung, H.Y.; Sohn, B.K.; Kim, J.-W.; Kim, D.J.; Choi, J.-S. Are Adolescents with Internet Addiction Prone to Aggressive Behavior? The Mediating Effect of Clinical Comorbidities on the Predictability of Aggression in Adolescents with Internet Addiction. *Cyberpsychol. Behav. Soc. Netw.* **2015**, *18*, 260–267. [[CrossRef](#)]
12. Whang, S.; Lee, S.; Chang, G. Internet Over-Users' Psychological Profiles: A Behavior Sampling Analysis on Internet Addiction. *CyberPsychol. Behav.* **2003**, *6*, 143–150. [[CrossRef](#)]
13. Ko, C.; Yen, J.-Y.; Yen, C.-F.; Chen, C.-S.; Chen, C.-C. The association between Internet addiction and psychiatric disorder: A review of the literature. *Eur. Psychiatry* **2012**, *27*, 1–8. [[CrossRef](#)]
14. Demirci, K.; Akgonul, M.; Akpınar, A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *J. Behav. Addict.* **2015**, *4*, 85–92. [[CrossRef](#)] [[PubMed](#)]
15. Kwon, M.; Lee, J.Y.; Won, W.Y.; Park, J.W.; Min, J.A.; Hahn, C.; Gu, X.; Kim, D.J. Development and validation of a smartphone addiction scale (SAS). *PLoS ONE* **2013**, *8*, e56936. [[CrossRef](#)]
16. Tateno, M.; Kim, D.J.; Teo, A.R.; Skokauskas, N.; Guerrero, A.; Kato, T.A. Smartphone Addiction in Japanese College Students: Usefulness of the Japanese Version of the Smartphone Addiction Scale as a Screening Tool for a New Form of Internet Addiction. *Psychiatry Investig.* **2019**, *16*, 115–120. [[CrossRef](#)]

17. Cha, S.S.; Seo, B.K. Smartphone use and smartphone addiction in middle school students in Korea: Prevalence, social networking service, and game use. *Health Psychol. Open* **2018**, *5*, 2055102918755046. [[CrossRef](#)] [[PubMed](#)]
18. Parsa, R.A.; Klugman, S.A. Copula Regression. *Variance* **2011**, *5*, 45–54.
19. Faraci, P.; Craparo, G.; Messina, R.; Severino, S. Internet Addiction Test (IAT): Which is the Best Factorial Solution? *J. Med. Internet Res.* **2013**, *15*, e225. [[CrossRef](#)] [[PubMed](#)]
20. Kwon, M.; Kim, D.J.; Cho, H.; Yang, S. The smartphone addiction scale: Development and validation of a short version for adolescents. *PLoS ONE* **2013**, *8*, e83558. [[CrossRef](#)] [[PubMed](#)]
21. Beck, A.T.; Steer, R.A.; Brown, G.K. Beck Depression Inventory-Second Edition. Available online: <https://www.nctsn.org/measures/beck-depression-inventory-second-edition> (accessed on 1 June 2020).
22. Chung, Y.C.; Rhee, M.K.; Lee, Y.H.; Park, S.H.; Sohn, C.H.; Hong, S.K.; Lee, B.K.; Chang, P.L.; Yoon, A.R. A standardization study of Beck depression inventory I—Korean version (K-BDI): Reliability and factor analysis. *Korean J. Psychopathol* **1995**, *4*, 77–95.
23. Beck, A.T.; Epstein, N.; Brown, G.; Steer, R.A. An inventory for measuring clinical anxiety: Psychometric properties. *J. Consult. Clin. Psychol.* **1988**, *56*, 893. [[CrossRef](#)]
24. Carver, C.S.; White, T.L. Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *J. Personal. Soc. Psychol.* **1994**, *67*, 319. [[CrossRef](#)]
25. Conners, C.K.; Wells, K.C.; Parker, J.D.A.; Sitarenios, G.; Diamond, J.M.; Powell, J.W. A new self-report scale for assessment of adolescent psychopathology: Factor structure, reliability, validity, and diagnostic sensitivity. *J. Abnorm. Child. Psychol.* **1997**, *25*, 487–497. [[CrossRef](#)] [[PubMed](#)]
26. Buss, A.H.; Perry, M. The aggression questionnaire. *J. Personal. Soc. Psychol.* **1992**, *63*, 452. [[CrossRef](#)]
27. Chon, K.K.; Hahn, D.W.; Lee, C.H.; Spielberger, C. Korean adaptation of the state-trait anger expression inventory: Anger and blood pressure. *Korean J. Health Psychol.* **1997**, *2*, 60–78.
28. Jaalouk, D.; Boumosleh, J. Is Smartphone Addiction Associated with a Younger Age at First Use in University Students? *Glob. J. Health Sci.* **2018**, *10*, 134. [[CrossRef](#)]
29. Sklar, A. Fonctions de répartition à n dimensions et leurs marges. *Publ. Inst. Statist. Univ.* **1959**, *8*, 229–231.
30. Song, P.X.-K. Multivariate Dispersion Models Generated From Gaussian Copula. *Scand. J. Stat.* **2000**, *27*, 305–320. [[CrossRef](#)]
31. Demarta, S.; McNeil, A.J. The t Copula and Related Copulas. *Int. Stat. Rev.* **2007**, *73*, 111–129. [[CrossRef](#)]
32. Montgomery, D.C.; Peck, E.A.; Vining, G.G. *Introduction to Linear Regression Analysis*, 5th ed.; Wiley: Hoboken, NJ, USA, 2012.
33. Faraway, J.J. *Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models*, 2nd ed.; Chapman & Hall/CRC: New York, NY, USA, 2016.
34. Delignette-Muller, M.-L.; Dutang, C. fitdistrplus: An R Package for Fitting Distributions. *J. Stat. Softw.* **2015**, *64*, 15459. [[CrossRef](#)]
35. Schepsmeier, U.; Stoeber, J.; Brechmann, E.C.; Graeler, B.; Nagler, T.; Erhardt, T. VineCopula: Statistical Inference of Vine Copulas. Available online: <https://CRAN.R-project.org/package=VineCopula> (accessed on 26 November 2019).
36. Okhrin, O.; Trimborn, S.; Waltz, M. GofCopula: Goodness-of-Fit Tests for Copulae. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3560825 (accessed on 14 June 2020).
37. Bozdogan, H. Model selection and Akaike's Information Criterion (AIC): The general theory and its analytical extensions. *Psychometrika* **1987**, *52*, 345–370. [[CrossRef](#)]
38. Lee, J.; Sung, M.-J.; Song, S.-H.; Lee, Y.-M.; Lee, J.-J.; Cho, S.-M.; Park, M.-K.; Shin, Y.M. Psychological Factors Associated With Smartphone Addiction in South Korean Adolescents. *J. Early Adolesc.* **2016**, *38*, 288–302. [[CrossRef](#)]
39. Razieh, J.; Ali, G.; Zaman, A.; Narjesskhatoon, S. The relationship between Internet addiction and anxiety in the universities students. *Interdiscip. J. Contemp. Res. Bus.* **2012**, *4*, 942–949.
40. Park, S.M.; Park, Y.A.; Lee, H.W.; Jung, H.-Y.; Lee, J.-Y.; Choi, J.-S. The effects of behavioral inhibition/approach system as predictors of Internet addiction in adolescents. *Pers. Individ. Differ.* **2013**, *54*, 7–11. [[CrossRef](#)]
41. Li, W.; Zhang, W.; Xiao, L.; Nie, J. The association of Internet addiction symptoms with impulsiveness, loneliness, novelty seeking and behavioral inhibition system among adults with attention-deficit/hyperactivity disorder (ADHD). *Psychiatry Res. Neuroimaging* **2016**, *243*, 357–364. [[CrossRef](#)] [[PubMed](#)]

42. Ko, C.-H.; Yen, J.-Y.; Liu, S.-C.; Huang, C.-F.; Yen, C.-F. The Associations between Aggressive Behaviors and Internet Addiction and Online Activities in Adolescents. *J. Adolesc. Heal.* **2009**, *44*, 598–605. [[CrossRef](#)]
43. Kim, Y.; Jeong, J.-E.; Cho, H.; Jung, D.-J.; Kwak, M.; Rho, M.J.; Yu, H.; Kim, D.-J.; Choi, I.Y. Personality Factors Predicting Smartphone Addiction Predisposition: Behavioral Inhibition and Activation Systems, Impulsivity, and Self-Control. *PLoS ONE* **2016**, *11*, e0159788. [[CrossRef](#)]
44. Yen, J.-Y.; Ko, C.-H.; Yen, C.-F.; Wu, H.-Y.; Yang, M.-J. The Comorbid Psychiatric Symptoms of Internet Addiction: Attention Deficit and Hyperactivity Disorder (ADHD), Depression, Social Phobia, and Hostility. *J. Adolesc. Health* **2007**, *41*, 93–98. [[CrossRef](#)]
45. Yen, J.-Y.; Yen, C.-F.; Chen, C.-S.; Tang, T.-C.; Ko, C.-H. The Association between Adult ADHD Symptoms and Internet Addiction among College Students: The Gender Difference. *CyberPsychol. Behav.* **2009**, *12*, 187–191. [[CrossRef](#)]
46. Jeong, B.; Lee, J.Y.; Kim, B.M.; Park, E.; Kwon, J.-G.; Kim, D.-J.; Lee, Y.; Choi, J.-S.; Lee, D. Associations of personality and clinical characteristics with excessive Internet and smartphone use in adolescents: A structural equation modeling approach. *Addict. Behav.* **2020**, *110*, 106485. [[CrossRef](#)]
47. Ha, J.H.; Kim, S.Y.; Bae, S.C.; Bae, S.; Kim, H.; Sim, M.; Lyoo, I.K.; Cho, S.C. Depression and Internet Addiction in Adolescents. *Psychopathology* **2007**, *40*, 424–430. [[CrossRef](#)]
48. Ceyhan, A.A.; Ceyhan, E. Loneliness, Depression, and Computer Self-Efficacy as Predictors of Problematic Internet Use. *CyberPsychol. Behav.* **2008**, *11*, 699–701. [[CrossRef](#)]
49. Young, K.S.; Rogers, R.C. The Relationship between Depression and Internet Addiction. *CyberPsychol. Behav.* **1998**, *1*, 25–28. [[CrossRef](#)]
50. Lee, S.-Y.; Lee, D.; Nam, C.R.; Kim, D.Y.; Park, S.; Kwon, J.-G.; Kweon, Y.-S.; Lee, Y.; Kim, D.J.; Choi, J.-S. Distinct patterns of Internet and smartphone-related problems among adolescents by gender: Latent class analysis. *J. Behav. Addict.* **2018**, *7*, 454–465. [[CrossRef](#)] [[PubMed](#)]
51. Choi, S.-W.; Mok, J.Y.; Kim, D.-J.; Choi, J.-S.; Lee, J.-W.; Ahn, H.-J.; Choi, E.-J.; Song, W.-Y. Latent class analysis on internet and smartphone addiction in college students. *Neuropsychiatr. Dis. Treat.* **2014**, *10*, 817–828. [[CrossRef](#)] [[PubMed](#)]
52. Bianchi, A.; Phillips, J. Psychological Predictors of Problem Mobile Phone Use. *CyberPsychol. Behav.* **2005**, *8*, 39–51. [[CrossRef](#)] [[PubMed](#)]
53. Joiner, R.; Gavin, J.; Brosnan, M.; Cromby, J.; Gregory, H.; Guiller, J.; Maras, P.; Moon, A. Gender, Internet Experience, Internet Identification, and Internet Anxiety: A Ten-Year Followup. *Cyberpsychol. Behav. Soc. Netw.* **2012**, *15*, 370–372. [[CrossRef](#)]
54. Xin, M.; Xing, J.; Pengfei, W.; Houru, L.; Mengcheng, W.; Zeng, H. Online activities, prevalence of Internet addiction and risk factors related to family and school among adolescents in China. *Addict. Behav. Rep.* **2017**, *7*, 14–18. [[CrossRef](#)]

