The validation of Implicit Association Test measures for smartphone and Internet addiction in at-risk children and adolescents

DAEYOUNG ROH1, SOO-YOUNG BHANG2*, JUNG-SEOK CHOI3,4, YONG SIL KWEON5, SANG-KYU LEE1* and MARC N. POTENZA6,7

1Mind-neuromodulation Laboratory, Department of Psychiatry, Hallym University College of Medicine, Chuncheon, Republic of Korea
2Department of Psychiatry, Eulji University School of Medicine, Eulji University Eulji Hospital, Seoul, Republic of Korea
3Department of Psychiatry, SMG-SNU Boramae Medical Center, Seoul, Republic of Korea
4Department of Psychiatry and Behavioral Science, Seoul National University College of Medicine, Seoul, Republic of Korea
5Department of Psychiatry, Uijeongbu St. Mary’s Hospital, College of Medicine, Catholic University, Seoul, Republic of Korea
6Departments of Psychiatry and Neuroscience, Child Study Center, The National Center on Addiction and Substance Abuse (CASA Columbia), Yale University School of Medicine, New Haven, CT, USA
7Connecticut Mental Health Center, New Haven, CT, USA

(Received: July 3, 2017; revised manuscript received: November 22, 2017; accepted: January 7, 2018)

Background: Potential concerns are increasing that smartphone and Internet addictions may have deleterious effects on the mental health. Despite the recognition of the important role that implicit associations may have over explicit processes in addiction, such implicit associations have not been comprehensively investigated with respect to Internet addiction. Therefore, we modified the Implicit Association Test (IAT) for smartphone and Internet addictions and investigated its validity in children and adolescents. Methods: In this experimental study, 78 at-risk children and adolescents ranging in age from 7 to 17 years completed an IAT modified with pictures captured from the most popular Internet games among youth. Furthermore, measures of Internet and smartphone addictions, mental health and problem behaviors, impulsive tendencies, self-esteem, daily stress, and quality of life were assessed simultaneously. Results: Significant correlations were found between IAT D2SD scores and standardized scales for Internet ($r = 0.28$, $p < .05$) and smartphone ($r = 0.33$, $p < .01$) addictions. There were no significant correlations between IAT parameters and other scales measuring the constructs that are less relevant to the features of addiction, such as daily stress levels, impulsivity, and quality of life. Multiple regression analysis revealed that the IAT D2SD was independently and positively associated with smartphone addiction ($p = .03$) after controlling for other clinical correlates. Conclusions: This study demonstrated good convergent and discriminant validity of this IAT as a novel measurement relating to Internet and smartphone addictions. Further longitudinal and prospective studies are needed to evaluate its potential utility in clinical and community settings.

Keywords: implicit association, Internet addiction, smartphone addiction, adolescent

INTRODUCTION

During the past several decades, there have been substantial increases in the types and patterns of Internet use. While the Internet affords several benefits, poor control over Internet use may lead to academic problems, family discord, and depressed mood (Christakis, 2010; Kubey, Lavin, & Barrows, 2001; Park, Hong, Park, Ha, & Yoo, 2013). This phenomenon may be conceptualized as Internet addiction and classified as a behavioral addiction (Holden, 2001), although some groups have argued that the specific behavior conducted on the Internet (e.g., gaming) should be the focus of the disorder (Petry et al., 2014). Although Internet addiction has been reported in both Eastern and Western populations (Cao & Su, 2007; Durkee et al., 2016; Heo, Oh, Subramanian, Kim, & Kawachi, 2014), the prevalence of Internet addiction is particularly high in Eastern Asia including South Korea. The prevalence of Internet addiction is higher in teenagers than in other age groups and has steadily increased from 10.4% in 2011 to 12.5% in 2014 among Korean adolescents (Korean National Information Society Agency, 2015). This phenomenon may relate to South Korea having the highest rate of smartphone ownership worldwide (Lee et al., 2016), and smartphones afford convenient Internet access. Considering that the typical onset of behavioral addiction may occur in adolescence and follow a chronic course with remissions and

* Corresponding authors: Sang-Kyu Lee, MD, PhD; Department of Psychiatry, Hallym University College of Medicine, Chuncheon Sacred Heart Hospital, 77 Sakju-ro, Chuncheon 24253, Republic of Korea; Phone: +82 33 240 5174; Fax: +82 33 244 0317; E-mail: skmind@hallym.ac.kr; Soo-Young Bhang, MD, PhD; Department of Psychiatry, Eulji University School of Medicine, Eulji University Eulji Hospital, 68 Hangeulbiseok-ro, Nowon-gu, Seoul 01830, Republic of Korea; Phone: +82 2 970 8303; Fax: +82 2 970 8429; E-mail: bsy1@eulji.ac.kr

This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License, which permits unrestricted use, distribution, and reproduction in any medium for non-commercial purposes, provided the original author and source are credited, a link to the CC License is provided, and changes – if any – are indicated.

ISSN 2062-5871 © 2018 The Author(s)
exacerbations, Internet addiction is becoming a major concern in adolescents.

Behavioral addictions bear a resemblance to substance addiction in terms of natural history, phenomenology, and neurobiology (Banz, Yip, Yau, & Potenza, 2016; Hammond, Mayes, & Potenza, 2014; McGue & Iacono, 2005). Behavioral addictions are characterized by maladaptive, repetitive behaviors, and they share considerable phenomenological parallels with substance addictions (Banz et al., 2016; Potenza, 2001). A growing body of evidence supports that problematic Internet use should be conceptualized as a behavioral addiction (Chamberlain et al., 2016; Spada, 2014). For example, Internet gaming disorder, as identified in Section III of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), is the next most likely candidate after gambling disorder to become a formally recognized behavioral addiction, in line with the proposed inclusion of gambling and gaming disorders in ICD-11 (World Health Organization, 2017) as “Disorders Due to Addictive Behaviors.” Thus, poorly controlled Internet use may share mechanisms of underlying impaired control over gambling or substance use.

Dual-process models of addiction (Wiers & Stacy, 2006) suggest that two different systems may control addictive behaviors: (a) an automatic (or implicit) system component comprised memory associations that are prompted relatively spontaneously by motivational and situational circumstances; and (b) a controlled (or explicit) system comprised cognitions amenable to introspection and deliberate decision-making processes. With respect to addictive behaviors, the controlled system may be overidden by the automatic system. In the context of Internet addiction, such models could explain why individuals continue overusing Internet despite the awareness that it may cause or exacerbate negative consequences. The model suggests that implicit cognitions may also contribute to poor control over Internet use and thus should be evaluated.

It has been proposed that automatic processes contribute importantly to the development and maintenance of addictions (Robinson & Berridge, 2003; Wiers, Rinck, Kordts, Houben, & Strack, 2010). Data suggest that processes of implicit cognitions, and especially implicit associations, may reliably predict substance use (Rooke, Hine, & Thorsteinsson, 2008). Hence, it is important to understand the automatic processes that contribute to addictive behaviors. The Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) interrogates implicit cognitions and has been used to investigate substance addictions (Rooke et al., 2008). Regarding behavioral addictions, implicit associations assessed by IAT have been connected with problematic gambling (Brevers et al., 2013; Yi & Kanetkar, 2011) and cybersex addiction (Snagowski, Wegmann, Pekal, Laier, & Brand, 2015). Despite studies implicating automatic processes in addiction, questions regarding the validity of different types of IATs have been raised (De Houwer, Heider, Spruyt, Roets, & Hughes, 2015; Tibboel, De Houwer, Dirix, & Spruyt, 2017). Although one IAT study showed some relations with Internet gaming addiction (Yen et al., 2011), the validity of the IAT was limited due to the lack of associations with addiction-related variables.

This study describes the development and validation of the IAT – measures for smartphone and Internet addiction (IAT-SI) for use in teenagers. The IAT-SI was developed to measure the implicit associations between positive emotions and Internet-game-related pictures. We examined the IAT-SI’s convergent and discriminant validity. Furthermore, we examined whether the positive implicit associations persisted after controlling for other addiction-related variables. Based on prior studies in the fields of substance and behavioral addictions, we hypothesized that scores on the IAT-SI would show convergent validity with Internet and smartphone addiction measures and divergent validity with psychiatric assessments (e.g., of attention-deficit/hyperactivity disorder (ADHD)) and other measures less closely linked to Internet use (e.g., self-esteem and quality of life). We also hypothesized that youth at high-risk for smartphone addiction as compared with those at low risk would show greater IAT-SI scores and would differ on multiple Internet-related, psychiatric, and other measures including self-esteem and quality of life. Finally, we hypothesized that IAT-SI scores would be related to measures of Internet or smartphone addiction after controlling for other measures.

MATERIALS AND METHODS

Participants

We screened children with Internet addiction and/or smartphone overuse who visited the Clinic I-CURE Center (Uijeonbu St. Mary’s Hospital/Nowon Eulji Hospital/SMG-SNU Boramae Medical center) located in a metropolitan area of South Korea. The Clinic I-CURE Center is a hospital-based research center, which obtains data on Internet and/or smartphone overuse in children aged 7–18 years. All children were screened using self-report forms of Korean scale for Internet addiction and two different smartphone addiction-related scales and Internet Addiction Proneness Scale for children and adolescents checked by their caregivers. Participants should score higher than cut-off value at least one of these screening tools (cut-off scores are shown in Supplementary Table 1, link: www.akademiai.com/doi/suppl/10.1556/2006.7.2018.02). We screened 85 children from August 2015 to 2016 and 81 who met screening criteria enrolled in this project (80% boys). Among them, IAT data of 78 students ranging in age from 7 to 17 were available for this study.

MEASURES

IAT

In this, the IAT (Greenwald et al., 1998) was modified with Internet-game-related pictures to generate the IAT-SI. The reason why Internet-game-related pictures were used is that Internet gaming is a primary form of Internet use (aside from academic purposes) among Korean adolescents (Heo et al., 2014). The IAT-SI was administered in computerized form using Inquisit 4.0 Millisecond Software (2014). During the IAT-SI, participants were instructed to categorize picture
Table 1. Demographic and psychological characteristics of the participants (n = 78)

| Variables                        | Mean (N) | SD (%) |
|----------------------------------|----------|--------|
| Sex                              | 61       | 78.2   |
| Male                             | 17       | 21.8   |
| Age (years)                      | 12.75 ± 2.50 | 17.8 |
| IAT-SI D2SD                      | 0.03 ± 0.66 | |
| K total (Internet addiction)     | 75.03 ± 17.18 | |
| K_D (disturbance of adaptive functions) | 17.88 ± 5.01 | |
| K_W (withdrawal)                 | 11.23 ± 3.69 | |
| K_T (tolerance)                  | 11.62 ± 3.37 | |
| SAS-SV total (smartphone addiction) | 30.85 ± 11.56 | |
| CASS-S                           | 23.14 ± 9.97 | |
| DHQ                              | 67.95 ± 18.17 | |
| K-ARS                            | 15.83 ± 10.51 | |
| RSES                             | 27.52 ± 5.79 | |
| BIS                              | 55.98 ± 9.20 | |
| AQ                               | 63.66 ± 16.42 | |
| PQL                              | 1,809.38 ± 387.67 | |

Note. Values are the mean ± standard deviation or n (%). K-scale: Korean Scale for Internet Addiction for adolescents; SAS-SV: Smartphone Addiction Scale – short form version; CASS-S: Conners–Wells’ Adolescent Self-Report Scale – short form; DHQ: Daily Hassles Questionnaire; K-ARS: Korean ADHD Rating Scale; RSES: Rosenberg Self-Esteem Scale; BIS-II: Barratt Impulsiveness Scale-II; PQL: Pediatric Quality of Life Inventory/ Generic Core Scale; AQ: Aggression Questionnaire.

The D2SD score was used as primary outcome measurement for the IAT since this algorithm was recommended by Greenwald, Nosek, and Banaji (2003). The D2SD outperformed other scoring algorithms in a representative study by Glashouwer (Glashouwer, Smulders, de Jong, Roefs, & Wiers, 2013). The D scores ranged from −2.00 to 2.00, with zero indicating no difference in average response latency between conditions. Higher D2SD scores indicated stronger positive implicit associations with game-related pictures and positive values. The internal consistency of IAT-SI (calculated as in Greenwald et al., 2003) was α = 0.75.

Figure 1. Sequence of blocks in the IAT-SI. Half of the participants received the blocks in the opposite order (incompatible and compatible) separated by a short break.
are scored based on a 4-point Likert scale (ranging from 1: “not at all” to 4: “it really is”) (Korean National Information Society Agency, 2011). The Internet Addiction Proneness Scale for Children and Adolescents has 15 items, and it was administered to parents for corroborating the self-report K-scale. The proneness scale is scored based on a 4-point Likert scale (ranging from 1: “not at all” to 4: “it really is”) and is used to define high-risk, potential-risk, and general user groups (Korean National Information Society Agency, 2011). The reliability test of the scale yielded a Cronbach’s α of .880. In our analysis, the SAPS was excluded, because scores on the SAPS and SAS-SV overlapped in domains being assessed.

Other clinical measurements

To measure common psychiatric problems that may co-occur with Internet and smartphone addiction, we used scales measuring ADHD, impulsiveness, aggression, and stress. First, we used the Conners–Wells’ Adolescent Self-Report Scale – short form (CASS-S), which is a self-report assessment tool for adolescents with ADHD in Korea (Bahn, Shin, Cho, & Hong, 2001). Cronbach’s α for internal consistency was .88. We also used the parent version of the Korean ADHD Rating Scale-IV (K-ARS) (DuPaul et al., 1998) to evaluate ADHD symptoms; the K-ARS comprised 18 items reflecting the DSM-IV diagnostic criteria. The reliability (Cronbach’s α values with .82–.89) and validity of the Korean version has been well-established (So, Noh, Kim, Ko, & Koh, 2002). The Barratt Impulsiveness Scale-II (BIS-II; Barratt & White, 1969) was used to assess impulsiveness and consists of 23 questions (Lee, 1992). Cronbach’s α values were .81. The Aggression Questionnaire (AQ) consists of four subscales and has a total of 27 items. Two of the 29 items developed by Buss and Perry (1992) were excluded from the Korean version (Kwon & Seo, 2002). Cronbach’s α for internal consistency was .86. The Daily Hassles Questionnaire (DHQ) consists of six sub-factors: parent, family environment, friends, school, teacher, and school-related stress (Han & Yoo, 1995).

To measure positive psychology, we used self-esteem and quality-of-life scales. The Rosenberg Self-Esteem Scale (RSES) consists of items assessing positive self-esteem and negative self-esteem. The reliability and validity of the Korean version has been established (Lee, Nam, Lee, Lee, & Lee, 2009). Cronbach’s α was .86, .88, and .80 for elementary-, middle-, and high-school students, respectively. The Pediatric Quality of Life Inventory (PedsQL 4.0)/Generic Core Scale developed by Varni, Seid, and Kurtin (2001) and validated by Choi (2004) is divided into child and parental reports.

Statistical analysis

Continuous variables were analyzed parametrically using the $t$-tests. Categorical data were analyzed using the $\chi^2$ tests. Pearson’s correlation analyses between the IAT $D_{\text{SD}}$ scores and other clinical scales were performed to test the convergent and discriminant validity of the implicit association measurements. Step-wise multiple regression analysis was used to adjust for relevant covariates and to explore the psychometric properties associated with the IAT for smartphone and Internet addictions. All statistical analyses were conducted using SPSS version 16.0 (SPSS, Chicago, IL). A $p < .05$ was considered to indicate statistical significance.

Ethics

The study procedures were carried out in accordance with the guidelines of Declaration of Helsinki. The study was approved by the institutional review board (IRB) for human subjects of Uijeonbu St. Mary’s Hospital (IRB no. UC150NMI0072) and Eulji University Eulji Hospital (IRB no. EMCS2015-05-020-001) and Seoul Metropolitan Government Seoul National University Boramae Medical Center (IRB no. 16-2016-4). All participants and their parents consented to attend the study after being informed about purpose and procedures of the study.

RESULTS

The demographic and psychological variables for 78 participants are shown in Table 1. More male participants (78%) were enrolled than the female participants. According to the total scores on the SAS-SV, 55% of participants were considered as high-risk for smartphone addiction.
**Convergent validity**

Significant correlations were found between scores on the IAT-SI and standardized scales for Internet or smartphone addiction. There were significant relationships between the IAT D_{2SD} score and the K-scale total score ($r = 0.28, p < 0.05$) and “Disturbance of Adaptive Functions” subscale score of the K-scale ($r = 0.25, p < 0.05$) (Table 2). In addition, IAT $D_{2SD}$ scores were most strongly correlated with scores on the SAS-SV ($r = 0.33, p < 0.01$).

**Discriminant validity**

There were no significant correlations between scores on the IAT-SI and other psychological scales, such as the CASS-S, DHQ, ARS, RSES, BIS, AQ, and PQL, measuring constructs hypothesized to be less relevant to Internet use and smartphone addiction. In conjunction with the findings in Table 2, the correlations in Table 3 demonstrate the specificity of the IAT-SI with respect to Internet and smartphone addiction measures and not for ADHD or other less-related measures.

According to the scores of the SAS-SV total and subscales, the participants were classified into high-risk and low-risk groups for smartphone addiction. IAT $D_{2SD}$ scores significantly differentiated between high-risk ($0.214 \pm 0.541$) and low-risk groups ($0.137 \pm 0.648$) for smartphone addiction ($t = 2.340, p < 0.023$) (Figure 3). The high-risk and low-risk groups significantly differed on many but not all psychological measures (Table 4).

To explore the psychometric properties of the IAT-SI, a first univariate regression independently analyzed all the factors, and only factors (SAS-SV total, DHQ, and PQL) with a significance level $<0.15$ were included in a second step-wise multiple regression with $D_{2SD}$ score as the dependent variable. This two-step multiple regression analysis revealed that only SAS-SV total was significantly associated with $D_{2SD}$ score ($R = 0.31$, adjusted $R^2 = 0.08$, $\beta = 0.31$, $t = 0.22$, $p = 0.03$).

**DISCUSSION**

The results partially support our a priori hypotheses and provide preliminary evidence for the validity of the IAT-SI in children and adolescents at risk of smartphone and Internet addiction. In support of its convergent validity, correlations between the IAT-SI and explicit measurements of smartphone ($r = 0.33$) or Internet addiction ($r = 0.28$) were comparable in magnitude to implicit–explicit measurement correlations from the broader literature on behavioral addictions ($r = 0.21–0.29$) (Snagowski et al., 2015). Correlations between scores on the IAT-SI and the disturbance subscore of Internet addiction ($r = 0.25$) provided additional support for the instrument’s convergent validity. Preliminary evidence for its discriminant validity was provided by statistically non-significant, low correlations between scores on the IAT-SI, and explicit measurements of theoretically less-related constructs (e.g., self-esteem, impulsivity, and quality of life).

| Measure    | IAT D_{2SD} | K_total | K_D  | K_W  | K_T  | SAS-SV  |
|------------|-------------|---------|------|------|------|---------|
| IAT-SI D_{2SD} | 1           |         |      |      |      |         |
| K_total     | 0.28*       | 1       |      |      |      |         |
| K_D         | 0.25*       | 0.81**  | 1    |      |      |         |
| K_W         | 0.23        | 0.84**  | 0.64**| 1    |      |         |
| K_T         | 0.12        | 0.77**  | 0.67**| 0.60**| 1    |
| SAS-SV      | 0.33**      | 0.56**  | 0.48**| 0.59**| 0.45**| 1       |

**Table 2. Correlations between $D_{2SD}$ scores on the IAT-SI and hypothesized convergent measures**

*Note.* K-scale: Korean Scale for Internet addiction for adolescents; D: subscale for disturbance of adaptive functions; W: subscale for withdrawal; T: subscale for tolerance; SAS-SV: Smartphone Addiction Scale – short form version.

| Measure    | IAT D_{2SD} | CASS-S | DHQ   | ARS   | RSES  | BIS   | AQ   | PQL   |
|------------|-------------|--------|-------|-------|-------|-------|------|-------|
| IAT-SI D_{2SD} | 1           |        |       |       |       |       |      |       |
| CASS-S      | 0.12        | 1      |       |       |       |       |      |       |
| DHQ         | 0.25        | 0.61** | 1     |       |       |       |      |       |
| K-ARS       | −0.14       | 0.25   | 0.06  | 1     |       |       |      |       |
| RSES        | −0.20       | −0.61**| −0.54**| −0.20 | 1     |       |      |       |
| BIS-II      | 0.10        | 0.57** | 0.23  | 0.07  | −0.55**| 1    |      |       |
| AQ          | 0.20        | 0.59** | 0.61**| 0.12  | −0.47**| 0.30*| 1    |       |
| PQL         | −0.28       | −0.66**| −0.56**| −0.11 | 0.66**| −0.56**| −0.50**| 1    |

**Table 3. Correlations between $D_{2SD}$ scores on the IAT-SI and hypothesized divergent measures**

*Note.* CASS-S: Conners–Wells’ Adolescent Self-Report Scale – short form; DHQ: Daily Hassles Questionnaire; K-ARS: Korean ADHD Rating Scale; RSES: Rosenberg Self-Esteem Scale; BIS-II: Barratt Impulsiveness Scale-II; AQ: Aggression Questionnaire; PQL: Pediatric Quality of Life Inventory/Generic Core Scale.

*p < 0.05. **p < 0.01.
that were used in the IAT-SI in this study may be

Note

of a similar magnitude (Rooke et al., 2008). Picture images
diction-related measurements was observed, and these were
positive relationship between implicit associations and ad-

Implications of the
higher IAT-SI scores remained associated with measures of
phone addiction scores had higher scores on the IAT-SI and
hypothesized, individuals with higher versus lower smart-
relating to smartphone and Internet addiction. Also as
findings from studies of substance-use disorders in which a
ects good construct validity of this task as a measurement
ings are described below.

Our preliminary results were comparable with previous
findings in studies of substance-use disorders in which a
positive relationship between implicit associations and ad-
cussion was observed, and these were
of a similar magnitude (Rooke et al., 2008). Picture images
that were used in the IAT-SI in this study may be
particularly appropriate, because unlike substance-use dis-
orders, addictive use of the Internet or smartphones pre-
dominantly involves visual stimuli. Our findings provide
evidence that problematic use of the Internet or smartphones
shares common implicit characteristics with substance-use
disorders.

In dual process models of addiction (De Houwer, 2006; Wiers & Stacy, 2006), addictive behaviors are viewed as the
joint outcomes of two semi-independent processes: relatively rapid appetitive or impulsive processes, which include automatic appraisals of stimuli in terms of their emotional and motivational significance, and relatively slower reflective processes, which include controlled pro-
cesses related to conscious deliberations, emotional regula-
tion, and expected outcomes. In this regard, an addictive
behavior, once established, may be perpetuated by strong
appetitive processes, which may exert their influences out-
side conscious awareness and receive relatively little guid-
ance from reflective processes. Thus, this study demonstrat-
ed that the IAT-SI might be helpful to capture implicit pro-
cesses uniquely, relatively beyond respondents’ inten-
tional control, which may be relevant to the understanding
of smartphone and Internet addictions.

Incentive salience may develop relatively rapidly in
early adolescence (Brenhouse & Andersen, 2008), and
adolescents are particularly vulnerable to developing
addictions (Chambers, Taylor, & Potenza, 2003). Similar-
lly, the observation that the prevalence of Internet addic-
tion has increased more rapidly in teenagers than in other
age groups (Korean National Information Society Agency,
2015) suggests that teenagers might be more greatly
affected by Internet and smartphone overuse. Along with
our findings, reports that implicit positive associations
 prospectively predicted binge drinking in adolescents

Furthermore, multiple regression analysis of independent
associations with IAT-SI and smartphone addiction scores
reflects good construct validity of this task as a measurement
relating to smartphone and Internet addiction. Also as
hypothesized, individuals with higher versus lower smart-
phone addiction scores had higher scores on the IAT-SI and
showed differences on many but not all measures. Finally,
higher IAT-SI scores remained associated with measures of
smartphone addiction after controlling for other variables.
Implications of the findings are described below.

Table 4. Comparison of demographic and clinical characteristics of the participants according to risk for smartphone addiction measured by SAS-SV

| Variables                              | High risk (n = 33) | Low risk (n = 40) | Statistica | p value |
|----------------------------------------|-------------------|-------------------|------------|---------|
| Sex                                     |                   |                   |            |         |
| Male                                    | 28 (84.8)         | 28 (70.0)         | c = 2.232  | .135    |
| Female                                  | 5 (15.2)          | 12 (30.0)         |            |         |
| Age (years)                             | 12.93 ± 2.53      | 12.67 ± 2.35      | t = 0.448  | .655    |
| IAT D2SD                                | 0.21 ± 0.54       | −0.14 ± 0.65      | t = 2.340  | <.023   |
| K total (Internet addiction)            | 81.20 ± 17.53     | 67.55 ± 13.59     | t = 3.414  | <.001   |
| K_D (disturbance of adaptive functions) | 19.58 ± 5.43      | 15.82 ± 3.55      | t = 4.229  | <.001   |
| K_W (withdrawal)                        | 12.73 ± 3.67      | 9.42 ± 2.84       | t = 4.229  | <.001   |
| K_T (tolerance)                         | 12.53 ± 3.48      | 10.52 ± 2.92      | t = 2.640  | .010    |
| SAS-SV total (smartphone addiction)     | 39.55 ± 5.88      | 20.30 ± 6.99      | t = 12.773 | <.001   |
| CASS-S                                  | 25.76 ± 10.85     | 20.33 ± 8.23      | t = 0.199  | .401    |
| DHQ                                     | 72.62 ± 16.94     | 62.93 ± 18.41     | t = 0.392  | .465    |
| K-ARS                                   | 14.72 ± 10.18     | 16.43 ± 10.75     | t = 0.833  | .541    |
| RSES                                    | 24.97 ± 38        | 30.26 ± 5.00      | t = 0.552  | <.001   |
| BIS-II                                  | 59.55 ± 8.04      | 52.15 ± 8.94      | t = 0.689  | .002    |
| AQ                                      | 68.43 ± 18.04     | 58.52 ± 12.91     | t = 0.024  | .022    |
| PQL                                     | 1,556.03 ± 408.54 | 1,475.57 ± 427.83 | t = 0.750  | .487    |

Note. Values are mean ± standard deviation or n (%). K-scale: Korean Scale for Internet Addiction for adolescents; SAS-SV: Smartphone Addiction Scale – short form version; CASS-S: Connors’ Wells’ Adolescent Self-Report Scale – short form; DHQ: Daily Hassles Questionnaire; K-ARS: Korean ADHD Rating Scale; RSES: Rosenberg Self-Esteem Scale; BIS-II: Barratt Impulsiveness Scale-II; AQ: Aggression Questionnaire; PQL: Pediatric Quality of Life Inventory/Generic Core Scale.

*a: t-test; c: χ².
Implicit association measurements have been incorporated (Cox, Fadardi, Intriligator, & Klinger, 2014). Consistently, process may be useful for understanding addictions implicit measurements. Potential tools to capture implicit associations have been proposed to be a particularly relevant social media use or cybersex. However, Internet gaming, in particular, has been proposed to be a particularly relevant threat to children and adolescents (Festl, Scharkowski, & Quandt, 2013; Kuss & Griffiths, 2012), and criteria for Internet-gaming disorder have been included in Section III of the DSM-5 (APA, 2013) as a condition warranting more clinical research. In addition, Internet addiction is more strongly related to Internet-game-related attitudes than social interaction preferences (Lee, Ko, & Chou, 2015). Therefore, we considered that in Korean children and adolescents, Internet game pictures could play a big part in giving a cue to the Internet addiction or proxy for Internet addiction. Nonetheless, future IAT studies focusing on different types of Internet addiction are required. Second, the sample size of this study was limited but comparable with other IAT studies in addiction research (Snagowski et al., 2015; Yen et al., 2011). Third, as this study was cross-sectional, causal relationships between implicit association and Internet addiction cannot be inferred. Longitudinal studies should reveal how both explicit variables and implicit associations develop when Internet addiction is initiated. Finally, several psychological tools for divergent measures, such as DHQ, BIS-II, and AQ, were not fully validated for use with young children.

CONCLUSIONS

Much research has historically focused on explicit processes of addiction, with several more recent studies investigating implicit measurements. Potential tools to capture implicit process may be useful for understanding addictions (Cox, Fadardi, Intriligator, & Klinger, 2014). Consistently, implicit association measurements have been incorporated into interventions targeting alcohol-use disorders (Boffo, Pronk, Wiers, & Mannarini, 2015; Houben et al., 2012). The good construct validity of the IAT-SI in this study suggests that implicit processes may similarly be targeted in Internet and smartphone addictions. The IAT-SI is short, and thus should be feasible to implement in multiple settings, and has promising psychometric properties. The generalizability of our findings to other samples, such as a community sample and for other age ranges, remains to be demonstrated. Further studies are required to examine the predictive potential and clinical utility of the IAT-SI, particularly with respect to developing treatments that consider non-reflective aspects of behavior.

Funding sources: This work was supported by a grant from the Korea Healthcare Technology R&D Project, Ministry for Health and Welfare, Republic of Korea (HM14C2603). Dr. MNP’s involvement was supported by the National Center for Responsible Gaming and the National Center on Addiction and Substance Abuse. The funding agencies had input into the content of the manuscript, and the views presented are those of the authors and may not reflect those of the funding agencies.

Authors’ contribution: S-KL and S-YB designed the study and DR wrote the protocol. S-KL, J-SC, YSK, and MNP managed the literature searches and analyses (including the statistical analysis). DR and S-KL wrote the first draft of the manuscript. S-KL and S-YB managed and contributed equally the entire study process. All authors contributed to and have approved the final manuscript.

Conflict of interest: The authors declare no conflicts of interest with respect to the content of the manuscript. MNP has consulted for and advised Ironwood, Lundbeck, INSYS, Shire, RiverMend Health and Jazz Pharmaceuticals; has received research support from Mohegan Sun Casino, the National Center for Responsible Gaming, and Pfizer; has participated in surveys, mailings, or telephone consultations related to drug addiction, impulse control disorders, or other health topics; has consulted for legal entities on issues related to impulse control and addictive disorders; provides clinical care in the Connecticut Department of Mental Health and Addiction Services Problem Gambling Services Program; has participated in surveys, mailings, or telephone consultations related to drug addiction, impulse control disorders, or other health topics; has consulted for legal entities on issues related to impulse control and addictive disorders; provides clinical care in the Connecticut Department of Mental Health and Addiction Services Problem Gambling Services Program; has performed grant reviews for the National Institutes of Health and other agencies; has edited journals or journal sections; has given academic lectures in grand rounds, CME events, and other clinical or scientific venues; and has generated books or book chapters for publishers of mental health texts.

REFERENCES

American Psychiatric Association [APA]. (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). Washington, DC: American Psychiatric Association.

Bahn, G. H., Shin, M. S., Cho, S. C., & Hong, K. E. (2001). A preliminary study for the development of the assessment...
scale for ADHD in adolescents: Reliability and validity for CASS(S). *Korean Journal of Child & Adolescent Psychiatry*, 12, 218–224.

Banz, B. C., Yip, S. W., Yau, Y. H., & Potenza, M. N. (2016). Behavioral addictions in addiction medicine: From mechanisms to practical considerations. *Progress in Brain Research*, 223, 311–328. doi:10.1016/bs.prb.2015.08.003

Barratt, E. S., & White, R. (1969). Impulsiveness and anxiety related to medical students’ performance and attitudes. *Journal of Medical Education*, 44(7), 604–607.

Boffo, M., Pronk, T., Wiers, R. W., & Mannarini, S. (2015). Combining cognitive bias modification training with motivational support in alcohol dependent outpatient: Study protocol for a randomised controlled trial. *Trials*, 16(1), 63. doi:10.1186/s13063-015-0576-6

Brenhouse, H. C., & Andersen, S. L. (2008). Delayed extinction and stronger reinstatement of cocaine conditioned place preference in adolescent rats, compared to adults. *Behavioral Neuroscience*, 122(2), 460–465. doi:10.1037/0735-7044.122.2.460

Brevers, D., Cleeremans, A., Hermant, C., Tibboel, H., Kornreich, C., Verbanck, P., & Noel, X. (2013). Implicit gambling attitudes in problem gamblers: Positive but not negative implicit associations. *Journal of Behavior Therapy and Experimental Psychiatry*, 44(1), 94–97. doi:10.1016/j.jbtep.2012.07.008

Buss, A. H., & Perry, M. (1992). The Aggression Questionnaire.

Cao, F., & Su, L. (2007). Internet addiction among Chinese adolescents: Prevalence and psychological features. *Child: Care, Health and Development*, 33(3), 275–281. doi:10.1111/j.1365-2214.2006.00715.x

Chamberlain, S. R., Llochier, C., Stein, D. J., Goudriaan, A. E., van Holst, R. J., Zohar, J., & Grant, J. E. (2016). Behavioural addiction – A rising tide? *European neuropsychopharmacology*, 26(5), 841–855. doi:10.1016/j.euroneuro.2015.08.013

Chambers, R. A., Taylor, J. R., & Potenza, M. N. (2003). Developmental neurocircuity of motivation in adolescence: A critical period of addiction vulnerability. *American Journal of Psychiatry*, 160(6), 1041–1052. doi:10.1176/appi.ajp.160.6.1041

Choi, E. S. (2004). Psychometric test of the PedsQLTM 4.0 Generic Core Scale in Korean adolescents. Seoul, South Korea: The Graduate School Yonsei University.

Christianis, D. A. (2010). Internet addiction: A 21st century epidemic? *BMC Medicine*, 8(1), 61. doi:10.1186/1741-7015-8-61

Cox, W. M., Fadardi, J. S., Intriligator, J. M., & Klinger, E. (2014). Attentional bias modification for addictive behaviors: Clinical implications. *CNS Spectrums*, 19(3), 215–224. doi:10.1017/S109252914000091

Cutler, R. B., & Fishbain, D. A. (2005). Are alcoholism treatments effective? The Project MATCH data. *BMC Public Health*, 5(1), 75. doi:10.1186/1471-2458-5-75

De Houwer, J. (2004). What are implicit measures and why are we using them?. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 11–28). Thousand Oaks, CA: Sage.

De Houwer, J., Heider, N., Spruyt, A., Roets, A., & Hughes, S. (2015). The relational responding task: Toward a new implicit measure of beliefs. *Frontiers in Psychology*, 6, 319. doi:10.3389/fpsyg.2015.00319

DuPaul, G. J., Anastopoulos, A. D., Power, T. J., Reid, R., Ikeda, M. J., & McGueyet, K. E. (1998). Parent ratings of attention-deficit/hyperactivity disorder symptoms: Factor structure and normative data. *Journal of Psychopathology and Behavioral Assessment*, 20(1), 83–102. doi:10.1023/A:1023087410712

Durkee, T., Carli, V., Floderus, B., Wasserman, C., Sarchiapone, M., Apter, A., Balazs, J. A., Bobes, J., Brunner, R., Corcoran, P., Cosman, D., Haring, C., Hoven, C. W., Kaess, M., Kahn, J. P., Nemes, B., Postuvan, V., Saiz, P. A., Vernik, P., & Wasserman, D. (2016). Pathological Internet use and risk-behaviors among European adolescents. *International Journal of Environmental Research and Public Health*, 13(3), 294. doi:10.3390/ijerph13030294

Festl, R., Scharkow, M., & Quandt, T. (2013). Problematic computer game use among adolescents, younger and older adults. *Addiction*, 108(3), 592–599. doi:10.1111/add.12016

Glashouwer, K. A., Smulders, F. T., de Jong, P. J., Roels, A., & Wiers, R. W. (2013). Measuring automatic associations: Validation of algorithms for the Implicit Association Test (IAT) in a laboratory setting. *Journal of Behavior Therapy and Experimental Psychiatry*, 44(1), 105–113. doi:10.1016/j.jbtep.2012.07.015

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology*, 74(6), 1464–1480. doi:10.1037/0022-3514.74.6.1464

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the Implicit Association Test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology*, 83(2), 197–216. doi:10.1037/0022-3514.85.2.197

Hammond, C. J., Mayes, L. C., & Potenza, M. N. (2014). Neurobiolology of adolescent substance use and addictive behaviors: Treatment implications. *Adolescent medicine: State of the art reviews*, 25(1), 15–32. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/25022184

Han, M. H., & Yoo, A. J. (1995). Development of Daily Hassles Scale for children in Korea. *Journal of the Korean Home Economics Association*, 33(4), 49–64.

Heo, J., Oh, J., Subramanian, S. V., Kim, Y., & Kawachi, I. (2014). Addictive Internet use among Korean adolescents: A national survey. *PLoS One*, 9(2), e87819. doi:e87819.10.1371/journal.pone.0087819

Holden, C. (2001). ‘Behavioral’ addictions: Do they exist? *Science*, 294(5544), 980–982. doi:10.1126/science.294.5544.980

Houben, K., Havermans, R. C., Nederkoorn, C., & Jansen, A. (2012). Beer a no-go: Learning to stop responding to alcohol cues reduces alcohol intake via reduced affective associations rather than increased response inhibition. *Addiction*, 107(7), 1280–1287. doi:10.1111/j.1360-0443.2012.03827.x

Inquisit 4.0.6.0. I. (2014). Inquisit 4.0.6.0. Seattle, WA: Millisecond Software.

Korean National Information Society Agency. (2011). Development of Korean Smartphone Addiction Proneness Scale for youth and adults. Seoul, Korea: Korean National Information Society Agency Report.

Korean National Information Society Agency. (2013). A validation study of K-scale as a diagnostic tool. Seoul, Korea: Korean National Information Society Agency Report.

Korean National Information Society Agency. (2015). A survey on Internet addiction 2014. Seoul, Korea: Korean National Information Society Agency Report.
