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Dysfunctional inhibitory control and impulsivity in Internet addiction

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ABSTRACT

The purpose of this study was to explore a psychological profile of Internet addiction (IA) considering impulsivity as a key personality trait and as a key component of neuropsychological functioning. Twenty three subjects with IA (Young's Internet Addiction Test scores=70 or more) and 24 sex-, age-, and intelligence-matched healthy controls were enrolled. Participants filled out a questionnaire about trait impulsivity, the Trait Characteristic Inventory, depression, and anxiety. Next, we administered traditional neuropsychological tests including the Stroop et al. and computerized neuropsychological tests using the Cambridge Neuropsychological Test Automated Battery. The IA group exhibited more trait impulsivity than the healthy control group. They also scored higher for novelty seeking and harm avoidance. The IA group performed more poorly than the healthy control group in a computerized stop signal test, a test for inhibitory function and impulsivity; no group differences appeared for other neuropsychological tests. The IA group also scored higher for depression and anxiety, and lower for self-directedness and cooperativeness. In conclusion, individuals with IA exhibited impulsivity as a core personality trait and in their neuropsychological functioning.

1. Introduction

Internet addiction (IA) is defined as the inability to control Internet use; it increases vulnerability to impairments in psychological and social functioning, including depression/anxiety, and difficulties with school, work, and interpersonal relationships (Young, 1996; Young, 1998b; Young and Rogers, 1998). IA can be considered a behavioral addiction like those involving pathological gambling, sexual activity, or spending (Holden, 2001). These disorders share clinical features such as repetitive behavior despite negative results, lack of control over urges, cravings prior to engagement in the behavior, etc. (Grant et al., 2006).

IA is not only a behavioral addiction; it is also an impulse control disorder (Sadock et al., 2007). One study found that participants in their IA group were more impulsive than their control group, as measured by both self-reports and the Go–Stop impulsivity paradigm (Cao et al., 2007). A recent study suggested that trait impulsivity is a marker of vulnerability to IA as well as to pathological gambling (Lee et al., 2012). Impulsivity is a key personality trait that can predict an individual's loss of control and addictive behaviors (Blaszczynski et al., 1997). Individuals with addictions to drugs, or gambling score highly on self-reported questionnaires regarding trait impulsivity, including the Barratt Impulsiveness Scale (BIS) (Barratt, 1965, 1975), the NEO Personality Inventory (NEOPI) (Costa and McCrae, 1985), and the Temperament and Character Inventory (TCI) (Cloninger, 1994). Our previous research demonstrated that impulsivity plays an important role in addictive behavior and that fun-seeking (Gray, 1991) predicts IA (Park et al., 2013).

Impulsivity is often related to the response-inhibition or inhibition-control of executive functioning due to a frontal lobe malfunction; many patients suffering from addiction exhibit impaired executive functioning and impulse control (Crews and Boettiger, 2009). Most studies on behavioral addictions have focused on pathological gambling and have reported that pathological gamblers exhibit impaired executive functioning represented by diminished performance during inhibition, time-estimation, cognitive-flexibility, planning, and decision-making tasks (Brand et al., 2007). Researchers have also widely reported that neuropsychological functions, including those related to attention, memory, and executive control, are frequently impaired as a consequence of substance abuse (Baldacchino et al., 2012).

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With respect to IA, Stroop task results indicate that heavy Internet users exhibit impaired the executive control functioning with regard to interference-control (Wright et al., 2003); this finding was confirmed by electro-physiological brain potential and functional brain imaging (Dong et al., 2011, 2012).However, one study reported that subjects with IA were not likely to exhibit executive dysfunction on a decision-making task (Ko et al., 2010). This discrepancy suggests that a battery of neuropsychological test make help clarify IA and global executive functioning related to impulsivity.

This study aimed to develop a psychological profile of individuals with IA considering impulsivity as a key personality trait and as a key component of neuropsychological functioning as assessed by traditional and computerized tests. We tested the following hypotheses: (1) individuals with IA would exhibit more impulsivity than normal controls on both self-administered questionnaires and neuropsychological tests; (1-1) individuals with IA would score higher for personality traits related to impulsivity, such as novelty seeking; and (1-2) individuals with IA would exhibit less efficient executive functioning than normal controls. We also investigated factors related to psychological well-being, such as depression, anxiety, and personality characteristics, and analyzed correlations among the variables.

2. Methods

2.1. Participants

A total of 23 participants with IA (M=12, F=11) and 24 age-, sex-, and IQ-matched healthy controls (M=13, F=11) were enrolled in this study. They were recruited using an online advertising and referral system operated by the Health Service Center of a university located in Seoul, Korea. The mean age of participants was 22.76 years (S.D.=2.91), and the mean number of years of education was 14.82 (S.D.=1.67). Based on Young's criteria (Young, 1998a), participants who scored 70 or more on the Internet Addiction Test (IAT) and spent four or more hours per day using the Internet were placed into the IA group, and those who scored less than 40 on the IAT and spent less than 2 h per day using the Internet were placed in the normal control (NC) group (Hardie and Tee, 2007; Young, 1996). Additionally, the Structured Clinical Interview for DSM-IV (SCID) was used to identify past and current psychiatric illnesses. Normal controls had no history of any psychiatric disorder (First et al., 1996). All subjects were drug-naïve.

2.2. Assessment instruments

2.2.1. Self-reported questionnaires

2.2.1.1. Young's Internet Addiction Test (IAT). Items were rated on a five-point scale where 1 indicates 'very rarely' and 5 indicates 'very frequently' (Cronbach's *alpha* coefficient=0.84). Total scores were calculated according to Young's method (Young, 1998a), with possible scores for all 20 items ranging from 20 to 100. Those who scored 20–39 were classified as 'average online users', those who scored 40–69 were classified as 'experiencing frequent problems', and those who scored 70–100 were classified as suffering from 'significant problems' because of Internet use. We used a version of the IAT that has been validated for Korea (Kim et al., 2003).

2.2.1.2. Barratt Impulsiveness Scale-11 (BIS-11). A translated version of the Korean Barratt Impulsiveness Scale-11 (BIS-11) (Barratt, 1975; Lee, 1992) was used to assess impulsivity (Cronbach's *alpha* coefficient=0.83). This instrument includes three subscales: cognitive impulsiveness (e.g., "I get easily bored when solving thought problems"), motor impulsiveness (e.g., "I do things without thinking"), and non-planning impulsiveness (e.g., "I am more interested in the present than in the future").

2.2.1.3. Temperament and Character Inventory (TCI). The Korean version of the TCI (Cloninger, 1994; Sung et al., 2002) contains 226 items designed to measure dimensions of personality traits using a forced binary-choice questionnaire. It includes four temperament and three character dimensions. Temperament manifests early in life and involves pre-conceptual or unconscious learning. Character refers to conceptual or insight-based learning of self-concepts, matures in adulthood, and is not linked to particular biological processes.

The four temperament dimensions in the instrument are: (1) novelty-seeking (NS), which reflects behavioral activation and is defined as the tendency to respond actively to novel stimuli, leading to pursuing rewards and escaping punishment; (2) harm-avoidance (HA), which reflects behavioral inhibition and corresponds to the tendency to engage in an inhibitory response to aversive stimuli, leading to avoidance of punishment and non-reward; (3) reward dependence (RD), which reflects the maintenance of behavior and is defined as the tendency to positively respond to signals of reward to maintain or resist behavioral extinction; and (4) persistence (PE), which was originally included in the RD dimension and was later treated as a separate dimension. PE is not presently linked to a specific neurotransmitter, and we did not include it as a variable in this study.

The three character dimensions in the instrument are (1) self-directedness (SDT), which refers to the ability of an individual to control, regulate, and adapt his/her behavior to fit the situation based on his/her own goals and values; (2) cooperativeness (CO), which was developed to account for individual differences in the identification with and acceptance of other people; (3) self-transcendence (ST), which is a characteristic associated with spirituality, and generally refers to identification with everything conceived as an essential and consequential part of a unified whole (Cloninger et al., 1993; Cloninger, 1994).

2.2.1.4. Beck Depression Inventory (BDI) and Beck Anxiety Inventory (BAI). The Korean version of the BDI (Beck and Steer, 1987; Lee and Song, 1991) is a 21-item self-reported questionnaire in which each item consists of four statements reflecting different levels of the severity of a particular symptom experienced during the past week. Scores for all 21 items are summed to yield a single depression score. The internal consistency of the BDI is 0.89.

The Korean version of the BAI (Beck and Steer, 1993; Yook and Kim, 1997) consists of 21 symptoms rated on a four-point scale and measures the severity of certain symptoms experienced during the past week. Scores for the 21 items are summed to yield a single anxiety score. The internal consistency of the BAI is 0.88.

2.2.2. The short form of Korean-Wechsler Adult Intelligence Scale (K-WAIS SF)

The K-WAIS SF (Thompson, 1987; Yeom et al., 1992; Wechsler, 1997) was used to assess verbal and nonverbal intellectual functioning. The short form includes four subtests: vocabulary, arithmetic, block design, and picture arrangement.

2.2.3. Traditional neuropsychological test battery

The traditional neuropsychological test battery includes the following: the Letter–Number Sequencing subtest from K-WAIS (Yeom et al., 1992) and the Korean Color-Word Stroop Test (K-CWST) (Stroop, 1935; Kang and Na, 2003), which assess sustained and selective attention, cognitive inhibition, and working memory; the Trails Making Test (TMT) (Reitan, 1992; Seo et al., 2006), which assesses motor planning and cognitive shifting; and the Verbal Fluency (VF) test (Kim, 2001), which assesses cognitive fluency.

2.2.4. Cambridge Neuropsychological Test Automated Battery (CANTAB)

The CANTAB (Robbins et al., 1994) tests were among the most important in this study. This series of computerized tasks was run on an Acorn BBC Master 128 microcomputer with a high resolution Microvitec (Bradford, U.K.) 12-in. VDU and a Microvitec Touchtec 501 touch-sensitive screen. Participants sat at a comfortable height approximately 0.5 m from the monitor. They were instructed to respond to stimuli by touching the screen or response pad.

The CANTAB tests used in this study included: the Intra-Extra Dimensional Set Shift (IED) test, a test of rule acquisition and reversal used to assess visual discrimination, attentional set-formation maintenance, and the ability to shift and flexibly allocate attention; the Stockings of Cambridge (SOC) test, used to assess spatial planning; the Spatial Span (SSP) test, a visuo-spatial analog of the Digit Span test used to assess working memory capacity; and the Stop-Signal Test (SST), a classic stop-signal response-inhibition test used to assess the ability to inhibit a prepotent response (see ⟨http://www.camcog.com for details⟩).

2.3. Procedure

This study was approved by the Institutional Review Board of SMG-SNU Boramae Medical Center. All participants completed consent forms after receiving information about the study; they then completed the questionnaires. The K-WAIS III SF and traditional neuropsychological tests were then administered. Finally, participants completed the CANTAB battery. The entire procedure took approximately 90 min.

3. Results

3.1. Demographic and clinical characteristics of IA and NC groups

All statistical analysis in this study was conducted by SPSS 18.0 version and two-tailed tests.

Table 1 presents descriptive statistics regarding the demographic and clinical characteristics of the IA and NC groups.