



Impaired decision-making under risk is associated with gaming-specific inhibition deficits among college students with Internet gaming disorder

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ARTICLE INFO

Article history:

Received 2 November 2014

Received in revised form

28 May 2015

Accepted 5 July 2015

Keywords:

Internet gaming disorder

Addiction

Decision-making

Inhibition

ABSTRACT

A growing body of evidence indicates that both inhibition and decision-making deficits play essential roles in the development and maintenance of Internet gaming disorder (IGD). Clarifying whether impaired decision-making among individuals with IGD is related to poor inhibition will advance our understanding of IGD and contribute to intervention development. However, the relationship between these two functions remains unclear. In this study, we sought to systemically examine inhibitory processes, decision-making and the relationship between the two among individuals with IGD. Thirty-four individuals with IGD and 32 matched healthy controls (HCs) were recruited. In comparison to HCs, IGD subjects demonstrated inhibition deficits during performance of the gaming-related Go/No-Go task and impaired decision-making under risk. In addition, errors on No-Go trials during the gaming-related Go/No-Go task were positively associated with decision-making impairments under risk but not under ambiguity among IGD subjects. These results suggest individuals with IGD are impaired in some aspects of inhibition and decision-making functions, and that decision-making deficits under risk are linked to poor inhibition specifically related to gaming cues, which has implications for the development of novel intervention.

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1. Introduction

Internet gaming disorder (IGD) is defined as compulsive and uncontrolled gaming online despite negative consequences (e.g., poor academic performance, impaired social interaction, insomnia) (King and Delfabbro, 2014; Ko et al., 2014b; Petry et al., 2014). Considered a behavioral addiction, IGD was recently

included in Section III of the DSM-5 as a 'Condition for Further Study' (American Psychiatric Association, 2013; Dong and Potenza, 2014).

In China, it is estimated that there are over 360 million Internet game players, and young adults, including college students, make up the majority of this population (China Internet Network Information Center, 2014). Given the high rates of Internet gaming among young adults, the relative easy access to the Internet found on college campuses and the amount of free time available for online gaming among students, college students are one of the most susceptible populations to IGD (Chou et al., 2005; Ko et al., 2010).

One of the central diagnostic features of IGD is continued Internet gaming despite the experience of negative consequences

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(e.g., impaired academic performance, poorer health, problems with interpersonal relationships) (Petry et al., 2014), reflecting maladaptive decision-making in real life. Moreover, researchers have found that individuals with IGD demonstrate decision-making deficits under risk (when explicit information about probabilities and future outcomes are available) using different paradigms (Dong et al., 2013; Lin et al., 2015; Pawlikowski and Brand, 2011; Yao et al., 2014, 2015). However, whether individuals with IGD also have impairments in decision-making under ambiguity (when probabilities can only be estimated based on outcomes) is still under debate (Ko et al., 2010; Sun et al., 2009; Xu, 2012). Decision-making under risk and ambiguity are two relatively distinctive constructs of decision-making, varying in degrees of uncertainty (Brand et al., 2007; Brevers et al., 2012; Robbins and Clark, 2015). However, there are no published studies directly comparing decision-making under risk and under ambiguity among individuals with IGD.

Decision-making, the processes by which individuals regulate their actions, thoughts, and emotions according to their goals and the environment, involves a number of complex cognitive functions (Brand et al., 2007; Noël et al., 2013; Paulus, 2007; Platt and Huettel, 2008). In particular, evidence suggests that inhibitory control processes play an essential role in guiding optimal decision-making (Noël et al., 2007, 2013; Paulus, 2007). Impairments in inhibitory control have been reported in among individuals with IGD (Dong et al., 2010, 2011; Littel et al., 2012; Liu et al., 2014; Luijten et al., 2015) and are thought to play a central role in IGD (Brand et al., 2014; Dong and Potenza, 2014). It has further been suggested that reductions in inhibitory control may be greater when individuals with IGD are confronted with gaming-related cues (Brand et al., 2014; Liu et al., 2014).

Impairments in both inhibitory control and decision-making processes have similarly been reported among individuals with substance addictions (Bechara, 2005; Goldstein and Volkow, 2011; Verdejo-Garcia et al., 2010). In addition, existing data suggest that impairments in inhibitory control processes may be related to impairments in decision-making among individuals with substance and behavioral addictions, including individuals with alcohol dependence (Noël et al., 2007), heavy drinking adolescents (Field et al., 2007), patients with opiate dependence (Brand et al., 2008), and pathological gamblers (Ochoa et al., 2013). However, the relationship between inhibitory control and decision-making among individuals with IGD remains poorly understood.

The aim of the current study was to comprehensively examine inhibitory control and decision-making processes and their relationships among college students with IGD. Previous studies have typically utilized a single response inhibition task (e.g. the Stroop task) and a single decision-making task (e.g. the Iowa Gambling Task; IGT), limiting findings to selected aspects of these two functions and therefore arguably limiting the generalizability of findings (Bechara et al., 2002; Monterosso et al., 2001). We therefore employed two different tasks measuring each of these domains: the Stroop color-word interference task (Kertzman et al., 2011; Stroop, 1935) and a gaming-related Go/No-Go task to measure inhibitory control processes, as well as the Cups task (Weller et al., 2007), and the IGT (Bechara et al., 1994) to measure aspects of decision-making under conditions of risk and ambiguity, respectively.

Based on previous findings, we hypothesized that: (1) relative to healthy controls (HCs), participants with IGD would demonstrate impairments in inhibitory control processes as assessed using both the gaming-related Go/No-Go task and the Stroop color-word task (Kertzman et al., 2011; Stroop, 1935), and these impairments would be greater during performance of the gaming-related Go/No-Go task relative to the neutral Stroop task (Brand et al., 2014; Liu et al., 2014); (2) relative to HCs, participants with

IGD would demonstrate impairments in decision-making as assessed using the IGT (Bechara et al., 1994) and the Cups task (Weller et al., 2007), which measures decision-making under ambiguity and under risk respectively; and (3) among IGD participants, there would be a significant positive association between decision-making (e.g., number of disadvantageous choices) and inhibitory control-related (e.g., errors during Go/No-Go task performance) impairments

2. Methods

2.1. Participants

Participants were thirty-four young adults with IGD and 32 matched healthy controls (HCs). Given the increased vulnerability to IGD reported among college students (Chou et al., 2005; Ko et al., 2010), all participants were recruited from local universities in Beijing by means of online advertisements, posters, and word of mouth. Additionally, given the higher prevalence of IGD among men versus women (Dalbudak et al., 2013; Ko et al., 2009; Tang et al., 2014), only male participants were included in this study. This study was approved by the Beijing Normal University Ethics Board. All participants provided written informed consent confirming their willingness to participate and were compensated for their time.

Participants were selected according to their weekly Internet gaming time and scores on the Chen Internet addiction scale (CIAS; Chen et al., 2003). The CIAS consists of 26-item evaluating five dimensions of Internet addiction: compulsive use, withdrawal, tolerance, problems in interpersonal relationships, and time management, on a 4-point Likert scale. The reliability and validity of the CIAS among college students has been demonstrated previously (Chen et al., 2003; Ko et al., 2009). Current status of depression and anxiety levels were assessed using the Beck Depression Inventory (Beck et al., 1961) and the Beck Anxiety Inventory (Beck et al., 1988).

Inclusion criteria for IGD subjects were (1) a score of 67 or higher on the CIAS (Ko et al., 2009); (2) engagement in Internet gaming (all IGD subjects in this study played Defense of the Ancients, a multiplayer online battle arena for the Warcraft III and one of the most popular multiplayer Internet games) for over 14 h per week for a minimum of one year; and (3) reporting of Internet gaming as their primary online activity (Yao et al., 2014, 2015). Inclusion criteria for HC subjects were: (1) a score of 50 or lower on the CIAS; and (2) less than 2 h per week spent on Internet games (non-gamers also included). Additional exclusion criteria for all participants included: (1) any self-reported history of any psychiatric or (2) neurological illness including substance use or other addictive disorder (with the exception of IGD for IGD subjects) and (3) current use of any psychotropic medication.

2.2. Inhibitory control measures: the gaming-related Go/No-Go task and Stroop task

2.2.1. The gaming-related Go/No-Go task

In order to examine inhibition related to gaming cues, we designed a gaming-related Go/No-Go task containing 15 gaming-related pictures and 5 neutral pictures. Pictures were all selected from a database developed in a pilot study. The gaming-related pictures were clear screenshots from videos of Defense of the Ancients (a multiplayer online battle game for the Warcraft III played by all of the IGD participants in this study). These gaming-related stimuli were found to induce significant craving for gaming among individuals with IGD in the pilot study (craving mean score $\pm$ standard deviation: 7.61 ± 1.36 for IGD subjects and

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