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Reward/punishment sensitivities among internet addicts: Implications for their addictive behaviors

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ABSTRACT

Internet addiction disorder (IAD) has raised widespread public health concerns. In this study, we used a gambling task to simulate extreme win/lose situations to find the reward/punishment sensitivities after continuous wins and losses. FMRI data were collected from 16 IAD subjects (21.4 ± 3.1 years) and 15 healthy controls (HC, 22.1 ± 3.6 years). Group comparisons showed higher superior frontal gyrus activations after continuous wins for IAD subjects than for HC. The brain activities in IAD subjects were not disturbed by their losses. In addition, IAD participants showed decreased posterior cingulate activation compared to HC after continuous losses. These results indicated that IAD participants showed preference to win while neglecting their losses. Therefore they engaged less executive endeavor to control their frustration after continuous losses. Taken together, we concluded that IAD subjects showed enhanced sensitivity to win and decreased sensitivity to lose. This can help us understand why IAD subjects continue playing online even after noticing the severe negative consequences of their behaviors.

1. Introduction

Internet addiction disorder (IAD) is usually defined as the inability of an individual to control his/her use of the internet, eventually causing psychological, social, and/or work difficulties (Young, 1998). As the world's fastest growing 'addiction', IAD remains a controversy: whether this kind of addiction exists and whether it merits inclusion in DSM (Diagnostic and Statistical Manual of Mental Disorders)-V is something scientists are cautious about (Holden, 2001). Although significant prevalence estimates and associations with adverse consequences have been addressed (Dong et al., 2012a, 2013; Kim et al., 2010; Niemz et al., 2005; Young, 1998), the neurobiological underpinnings of IAD still remains to be understood (Block, 2006; Ko et al., 2009; Liu and Potenza, 2007).

IAD is often considered a behavioral addiction and may share similar neuropsychological (i.e., development of euphoria, craving, and tolerance) and personality characteristics with other addictions (Grant et al., 2010; Potenza et al., 2003). The reward system is thought to play a crucial role in the development and continuity of addictive behaviors (Robbins and Everitt, 1999; Volkow et al., 2002). Several lines of evidence converge toward the hypothesis that drug addicts have a deficient reward system and that drug intake is an attempt to compensate for this deficit (Robbins and Everitt, 1999). Comparably research on behavioral addictions, such as pathological gambling, showed reduced activation of the reward circuit in response to monetary reward (de Ruiter et al., 2009; Reuter et al., 2005), suggesting that pathological gambling could be characterized by a similar blunted response to rewarding stimuli as found in substance dependence (de Ruiter et al., 2009). However, in our previous fMRI studies IAD subjects showed enhanced reward sensitivity and decreased punishment sensitivity when compared to the healthy control group (Dong et al., 2011, 2012b). The decreased punishment sensitivity has been reported among other types of addictions, but the 'enhanced reward sensitivity' is specific to IAD specific and may be a key to IAD feature and was not reported among other types of addictions. This indicates that IAD has specific features that distinguish it from other addictions and further studies should be performed to unravel the neuronal underpinnings.

What makes IAD subjects continue playing online even when facing severe negative consequences of their behavior? One possible explanation is that their decreased sensitivity to punishment compared to healthy controls, just as reported in our previous studies (Dong et al., 2011, 2012b). One limitation of the guessing task we used in our previous studies was that the reward/punishment was too mild for IAD subjects because their losses in reality (lost jobs, breakdown of the family, or drop out of school) were much serious than win/lose 1.5 Dollars in

Abbreviations: IAD, internet addiction disorder; DSM, Diagnostic and Statistical Manual of Mental Disorders; PCC, posterior cingulate cortex; HC, healthy controls; IAT, internet addiction test; IGA, internet gaming addiction; WIN, experience after 3 consecutive winning trials; LOSS, experience after 3 consecutive losing trials; CONTROL, any pseudo-random order of 3 trials not including consecutive wins or losses; EPI, echo-planar images; GLM, general linear model; BOLD, blood oxygen level dependence; FWE, family-wise-error; SFG, superior frontal gyrus.

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the lab. The extreme situations will enlarge the reward/punishment experience and elicit much stronger emotion experience (Buhle and Wager, 2010; Gu et al., 2013) than mild situations. Thus, in this study, we designed a task to simulate the extreme reward/punishment experience situations to further investigate the neuronal mechanism of IAD subjects. The brain activity under this situation might help us understand why IAD subjects usually neglect their losses in daily-life situations.

One paradigm that taps into reward and punishment evaluation is the probabilistic guessing task (Reuter et al., 2005). In the task, subjects were asked to select one of the two cards with a button press. The results (win or lose) were displayed according to the color of the randomly selected card. The subjects were specifically informed that they were to receive the entire balance in cash at the end of the session. In our study, we created some extreme situations using pseudo randomization: continuous wins and continuous losses, to observe the brain activities during those situations.

Brain imaging studies on reward/punishment processes have reported that the ventral tegmental area, the ventral striatum, and part of the superior frontal gyurs that attempts to regulate and control behaviors by pleasurable effects (Starcke and Brand, 2012). We first hypothesize that IAD subjects show decreased brain activities during the punishment process because they usually neglect their losses in daily lives. In addition, the continuous losses will elicit strong negative emotion experience (Buhle and Wager, 2010; Gu et al., 2013), which require participants to control their emotional experience. Therefore, we expected to observe brain regions that contributed to emotion regulation or impulse control processes in our study, e.g. the anterior cingulate cortex (Gasquoine, 2013; Spunt et al., 2012), posterior cingulate cortex (PCC) (Hampson et al., 2006; Leech et al., 2011), ventral–lateral prefrontal cortex and dorsolateral prefrontal cortex (Hampson et al., 2006; Hoshi, 2006; Johnstone et al., 2007; Ochsner et al., 2004). We hypothesized that comparing to a healthy control group, IAD subjects showed lower brain activation in these brain areas when they lost: they might experience less negative emotion because of their 'decreased punishment sensitivity' (Dong et al., 2011, 2012b).

2. Methods

2.1. Participant

The experiment conforms to The Code of Ethics of the World Medical Association (Declaration of Helsinki) and has been approved by the Human Investigations Committee of Zhejiang Normal University. Two groups (16 IAD subjects, 15 healthy controls (HC)) of fully informed and consent participants were tested. Participants were all right-handed male adults with no age differences between the two groups (IAD mean = 21.4, SD = 3.1 years; HC mean = 22.1, SD = 3.6 years; $t(29) = 0.83$, $p > 0.05$).

Internet addiction disorder was determined based on Young's online internet addiction test (IAT) (Young, 2009). Young's IAT consists of 20 items associated with online internet use including psychological dependence, compulsive use, withdrawal, related problems in school or work, sleep, family or time management. The IAT was proved to be a valid and reliable instrument that can be used in classifying IAD (Widyanto and McMurran, 2004; Widyanto et al., 2011). For each item, a graded response is selected from 1 = "Rarely" to 5 = "Always", or "Does not Apply".

Participants scored 80 or higher were recruited as IAD group. HCs all scored lower than 30 on Young's IAT (mean = 16.3, SD = 4.3). We used a much more stringent criterion for the IAD group than the proposed 50 in Young's criteria. Scoring more than 80 in IAT means 'Your Internet usage is causing significant problems in your life'. Internet addiction consists of at least three subtypes: internet gaming addiction (IGA), sexual preoccupations, and email/text messaging (Block, 2006). In China, the most important subtype of IAD is IGA (Dong et al., 2011, 2012b, 2013, in press). Thus, in the present study, we only paid attention the IGA subjects. We added some specific limitations on Young's established measures of internet addiction, such as 'you spend most of your time playing online games (>80%)'.

All participants underwent structured psychiatric interviews (M.I.N.I.) (Lecrubier et al., 1997) performed by an experienced psychiatrist with an administration time of approximately 15 min. The MINI was designed to meet the need for a short but accurate and structured psychiatric interview for multicenter clinical trials and epidemiology studies. All participants were free of Axis I psychiatric disorders listed in M.I.N.I. Depression was further assessed with the Beck Depression Inventory (Beck et al., 1961) and no participants scoring 5 or higher were included. Both IAD and HC groups did not fulfill DSM-IV criteria for abuse or dependence of substances, including alcohol, although both groups reported having consumed alcohol in their lifetime. All participants were medication free and were instructed not to use any substances, including coffee, on the day of scanning. No participants reported previous experience with illicit drugs (e.g., cocaine, marijuana).

2.2. Task and procedure

A reality-simulated guessing task was designed to create a win or loss context (Dong et al., 2011). This task used fast event-related design with pseudo randomization. Fig. 1 shows the event sequence of each trial. A white cross was presented at the center of a black screen for 500 ms at the beginning of each trial. Then the two face-down cards were shown side by side for 1500 ms during which participants were asked to choose either the right or the left one with a button press as fast as possible. Participants would win 10 Chinese Yuan (≈$1.5) if the selected card was red or lose the same amount if it was black. The selected card would be flipped over after 1500 ms and simultaneously the word "win" or "lose" with the cumulated balance would appear. This feedback frame would be presented for a further 2000 ms. The win or loss trials were presented randomly throughout the task. A black screen was presented for 500–1000 ms as inter-trial interval (Dong et al., 2011). The whole task consisted of 245 trials grouped into two blocks; one of them consisted of 120 trials while the other consisted of 125 trials with a one-minute break between blocks. The task lasted 1260 s (21 min) in total. E-prime software (Psychology Software Tools, Inc.) was used to present the task and acquire behavioral data.

After finishing the gambling task in the scanner, participants were asked to answer a 6-item questionnaire about their experiences in different balance situations out of scanner (Supplemental materials 1).

Each participant was provided 50 Yuan as the initial balance before the task, and was explicitly informed that he or she would receive the entire balance in cash at the end of the task. Although the participants were told to perform a totally randomized task, we used the pseudo-random design and created three types. The task contained three trial types: (1) Reward/punishment after 3 consecutive winning trials (WIN); (2) Reward/punishment after 3 consecutive losing trials (LOSS); (3) a control condition with any pseudo-random order of 3 trials not including consecutive wins or losses (CONTROL) Fig. 2.

2.2.1. Behavioral task

Before the tasks in the scanner, a classic word-color Stroop task was performed to test the executive function of all subjects. Three target color words (e.g. red, green, yellow) were presented randomly in congruent (e.g., the word "RED" in red ink) or incongruent (e.g., the word "RED" in green ink) trials. The task was comprised of 2 sessions of 120 trials each. Each stimulus was presented for 2000 ms, and participants were asked to press a button to indicate the ink color of the word as soon as possible using three buttons (i.e., green = thumb, red = index finger, yellow = middle finger). A black screen was presented for a random interval of 600–1400 ms (average 1000 ms) between trials.