

Gaming Increases Craving to Gaming-Related Stimuli in Individuals With Internet Gaming Disorder

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ABSTRACT

BACKGROUND: Internet gaming disorder (IGD) has been proposed as a behavioral addiction warranting additional investigation. Craving is considered a core component of addictions. However, few studies to date have investigated craving in IGD. In the current study, we investigated how gaming was associated with changes in response to gaming-related stimuli in subjects with IGD and those with recreational game use (RGU).

METHODS: Behavioral and functional magnetic resonance imaging data were collected from 27 individuals with IGD and 43 individuals with RGU. Subjects' craving responses to gaming-related stimuli were measured before and after 30 minutes of gaming.

RESULTS: The comparison between post- and pre-gaming measures showed that for IGD, gaming was associated with increased craving and increased brain activation of the lateral and prefrontal cortex, the striatum, and the precuneus when exposed to gaming-related stimuli. In individuals with RGU, no enhanced brain activity was observed.

CONCLUSIONS: These results suggest that gaming behavior enhances craving responses in subjects with IGD but not in subjects with RGU, provide insight into potential mechanisms underlying IGD, and suggest behavioral and neurobiological targets for IGD-related interventions.

Keywords: Craving, fMRI, Internet gaming disorder, Prefrontal cortex, Recreational gaming use, Striatum

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Craving is an important feature of addictions and has recently been included as inclusionary criteria for substance use disorders (1). Craving reflects a motivational state that promotes seeking drugs in drug addiction (2,3). Craving also appears to be relevant to behavioral addictions like gambling disorder (4) and is thus a target for behavioral therapies like cognitive behavioral therapy (5) and pharmacotherapies like naltrexone (6). Craving may impair subjects' cognitive processes and promote self-regulation failures (2,7). For example, craving may shift attentional and monitoring processes toward drug-related cues (2,8) and interfere with abilities to notice these changes (9). In addition, craving may also be associated with evaluation of drug-related information; it may influence decision-making processes, shifting choices toward the pursuit of immediate satisfaction rather than long-term rewards (10–12).

In 2013, the DSM-5 committee considering substance use and addictive disorders generated criteria for Internet gaming disorder (IGD), and this condition is included in the section of the DSM-5 containing disorders warranting additional study (1,13). IGD has been associated with negative health measures and Internet café-related deaths, prompting a need for further investigation to develop treatments for this disorder (14). Brain reactivity to gaming-related cues may provide important

insight into IGD. Enhanced craving and impaired control over urges for gaming (15,16) have been associated with disruptions in brain pathways in IGD, as occur in drug and alcohol addictions (7). Subjects with IGD demonstrate greater cognitive biases toward gaming-related stimuli (16,17). For example, subjects with IGD, as compared with those without IGD, show greater cue-induced activations in the striatum when exposed to gaming-related pictures, and they show cognitive and shifting biases toward them (15,18).

Existing findings suggest that craving may operate similarly across IGD and drug addictions. In drug addictions, drug cues (e.g., photos of drugs or paraphernalia or videotapes or audiotapes of experiences associated with drug use) may induce craving, and exposure to such cues and the subsequent craving may lead to more drug use (19–21). However, studies to date have not directly investigated how gaming may influence craving responses to gaming-related stimuli in individuals with and without IGD.

In drug addictions, drugs may influence brain reward circuits, including corticostriatolimbic circuitry underlying motivated behaviors (22), and this circuitry has been implicated in drug craving responses (20). People with substance use disorders may engage in addictive behaviors to compensate for hypofunctioning reward signals in the mesolimbic

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dopamine pathway (23,24), or vice versa, with drug deprivation enhancing craving and drug taking relieving craving. The extent to which similar mechanisms may operate in IGD has yet to be examined directly.

In craving studies, familiarity with cues is an important consideration. In some studies of alcohol craving (25,26) or cocaine/stimulant craving (20,27), a social drinking/recreationally using group has been used to contrast with groups with substance addictions to provide a meaningful comparison. Such groups have had experience with substances without having developed problems. Thus, when examining gaming-related craving in the current study, we used a comparison group with recreational game use (RGU). Gaming is enjoyable for many people, and many individuals, particularly young male individuals, report gaming (28); however, only a small group of individuals who play online games develop IGD, with the majority demonstrating the ability to control gaming behaviors without developing problems (29–31). The inclusion of an RGU comparison group can overcome some limitations of a nongaming group by having similar familiarities with gaming-related cues and gaming exposure.

Craving is an important factor that may trigger and maintain addiction. A meta-analysis of 41 addiction studies indicated that people suffering from substance addiction show higher subjective and physiological reactions when encountering substance-related cues (19). Similar findings have been observed in behavioral addictions such as pathological gambling (20), IGD (17), and compulsive shopping (32). In addition, the physiological and neural reactions in individuals with addictions appear to be associated with relapse (33). A recent meta-analysis showed overlapping neuronal substrates of reactivity to drug, gambling, food, and sexual cues in individuals with corresponding conditions (34).

With respect to brain regions underlying cue-induced substance-related craving, several meta-analyses suggest that the ventral striatum, dorsal and medial prefrontal cortex (MPFC), and anterior cingulate cortex were more active during the presentation of substance-related cues as compared with non-substance-related cues (7,35–37). However, additional brain regions (e.g., lateral PFC [LPFC]) have also been observed with respect to drug cue-induced activations, particularly in men (20). Individuals with IGD also show greater activation of the PFC to gaming-related words (17) and of the dorsal and ventral striatum to gaming-related pictures (18). The MPFC has been previously implicated in craving processes. Meta-analyses have indicated that deprived smokers show higher cue activation in the MPFC than nondeprived smokers (7,38). Another meta-analysis of drug users found that the left PFC, especially the dorsolateral PFC, was activated to drug cues in drug users, suggesting that craving might be associated with the expectancy of drug-taking (36). The MPFC is a final projection site of the reward system and is directly activated by drugs or other substances (39,40). The MPFC may thus contribute to drug-seeking behaviors in response to drug cues. In addition, the frontal cortex, especially the dorsolateral PFC, is important in executive functions, for example, in inhibitory control (20,41,42). More robust brain responses in these areas to relevant cues may suggest an attempt to inhibit urges in response to cues, although this possibility is speculative. Together, studies suggest that

craving is positively associated with brain activations in the MPFC and LPFC in individuals with addictions.

In this study, we investigated in individuals with IGD and those with RGU and without IGD how gaming related to changes in craving (subjective and brain responses) following exposure to gaming-related stimuli. Previous studies of substance addictions have shown that deprivation may enhance craving and that substance use may decrease craving (2,43). Based on these findings, we hypothesized that gaming would decrease subjective craving responses to gaming-related stimuli in subjects with IGD. We also hypothesized that gaming in IGD would be related to decreased brain responses in cue reactivity-related brain regions such as the MPFC, anterior cingulate cortex, and striatum. We also hypothesized that these findings would not be observed in individuals with RGU, with group \times gaming period (pre/post) interactions observed.

METHODS AND MATERIALS

Participant Selection

The experiment conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki). The Human Investigations Committee of Zhejiang Normal University approved this research. All subjects were university students from Shanghai and were recruited through advertisements. Data were collected from 27 subjects with IGD and 43 subjects with RGU. There were no significant between-group differences in age (Table 1). All participants were right-handed, had normal or corrected-to-normal vision, provided written informed consent, and completed a structured psychiatric interview (Mini-International Neuropsychiatric Interview) (44) that was performed by an experienced psychiatrist and lasted approximately 15 minutes after the subjects had completed written portions of the Mini-International Neuropsychiatric Interview. All participants were free of Axis I psychiatric disorders assessed via the Mini-International Neuropsychiatric Interview. We further assessed depression with the Beck Depression Inventory (45), and only participants scoring less than 5 were included (Table 1). Thus, participants with IGD or RGU did not fulfill criteria for a non-IGD mental disorder, which was an inclusion criterion for the study. All participants were instructed not to use any substances of abuse, including tobacco and caffeinated drinks, on the day of scanning. No participants reported previous use of illicit drugs.

IGD was determined based on scores of 50 or more on Young's online Internet addiction test (www.netaddiction.com) (46) and also based on meeting the proposed nine-item DSM-5 IGD diagnosis (meeting at least five of nine inclusionary criteria) (47) (Table 1). The Internet addiction test is a valid and reliable instrument that can be used in classifying Internet addiction (48,49). To control for types for gaming, we recruited only subjects (IGD and RGU) who regularly played *League of Legends* (Riot Games, Santa Monica, CA) and had played the game for at least 1 year.

Definition and Selection of the RGU Group

Because the definition of RGU is an important component of our study, we reviewed the extant literature and interviewed 14

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