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Response Inhibition and Internet Gaming Disorder: A Meta-analysis

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HIGHLIGHTS

- A significant association between impairments in inhibition and Internet Gaming Disorder was found.
- The neurocognitive task used to measure response inhibition did not moderate this relationship.
- Our findings are in alignment with literature on inhibition and addictive and impulsive behaviors.

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ABSTRACT

Previous research has demonstrated that Internet Gaming Disorder (IGD) has multiple negative effects in psychological functioning and health. This makes the identification of its underpinnings, such as response inhibition, essential for the development of relevant interventions that target these core features of the disorder resulting in more effective treatment. Several empirical studies have evaluated the relationship between response inhibition deficits and IGD using neurocognitive tasks, but provided mixed results. In this study, we conducted a meta-analysis of studies using three neurocognitive tasks, the Go/No Go, the Stroop, and the Stop-Signal tasks, to integrate existing research and estimate the magnitude of this relationship. We found a medium overall effect size ($d = 0.56$, 95% CI [0.32, 0.80]) indicating that compared with healthy individuals, individuals with IGD are more likely to exhibit impaired response inhibition. This finding is in alignment with literature on inhibition and addictive and impulsive behaviors, as well as with neuroimaging research. Theoretical implications regarding the conceptualization of IGD as a clinical disorder, shared commonalities with externalizing psychopathology, and clinical implications for treatment are discussed.

Contents

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1. Introduction

Internet (or video) gaming is one of the most popular activities among children and young adults, with approximately 68% of US youth reporting spending time gaming at least weekly (Gentile, 2009). Generally, gaming at reasonable levels is considered harmless and can even have positive effects (Wilms, Petersen, & Vangkilde, 2013). However, a large number of individuals in Western and Eastern countries engage in uncontrolled gaming behaviors (Gentile, 2009). Historically, these poorly controlled behaviors have been conceptualized in diverse and inconsistent ways, based on adaptations of the definitions and criteria of pathological gambling or substance use disorders, making the psychometric assessment of the construct highly variable across the different studies (Pontes, Király, Demetrovics, & Griffiths, 2014). In response to calls for consensus the *Diagnostic and Statistical Manual of Mental Disorders, 5th edition* (DSM-5), workgroup introduced the Internet Gaming Disorder (IGD) in the Section III of the manual as a disorder warranting additional study (American Psychiatric Association [APA], 2013; Petry & O'Brien, 2013). In the APA's conceptualization, IGD is characterized by persistent and recurrent use of the Internet playing games, and this preoccupation results in clinically significant impairment and distress (APA, 2013). Indeed, research has shown that IGD has multiple negative effects in psychological functioning and health, including decreased job performance and academic achievement, social relationship problems, increased stress and decreased well-being, depression and anxiety symptoms, and sleep problems (Kuss & Griffiths, 2012a, 2012b; Kuss, Griffiths, Karila, & Billieux, 2014; Lam, 2014; Sublette & Mullan, 2012).

Regardless of the conceptualization used, a central feature of IGD, which is hypothesized to be responsible for the lack of control over impulses related to gaming, is poor self-regulation a deficit that characterizes all types of addiction and impulse control disorders (Brewer & Potenza, 2008; APA, 2013; Dong & Potenza, 2014; Petry, Rehbein, Ko, & O'Brien, 2015). Related to the personality traits of impulsivity and disinhibition, self-regulation is thought to be underlied by inhibitory neurocognitive mechanisms (Fillmore, 2012; Young et al., 2009). More specifically, research has demonstrated that successful self-regulation requires the ability to inhibit impulses that are not compatible with one's goals (Hofmann, Schmeichel, & Baddeley, 2012). This ability to deliberately suppress a prepotent or automatic response in order to produce a less automatic, but goal-directed response, is represented by the term response inhibition (Miyake et al., 2000; Snyder, Miyake, & Hankin, 2015). Inhibition is an aspect of executive functions, which are "a set of general-purpose control mechanisms, often linked to the prefrontal cortex of the brain, that regulate the dynamics of human cognition and action" (Miyake & Friedman, 2012, p. 8). Additionally, inhibition is thought to enable cognitive and behavioral control over motivational drives, and facilitate resistance over reward-seeking behaviors (Dong & Potenza, 2014; Miyake & Friedman, 2012).

Different experimental tasks have been used as indicators of inhibition, including the Stroop (Stroop, 1935), Stop-Signal (Logan, Schachar, & Tannock, 1997), and Go/No-Go tasks (Fillmore, 2003). In these experimental tasks participants are presented with task-related and task-unrelated stimuli and are asked to withhold or override an automatic reaction in response to task-unrelated or interfering stimuli. Indices of inhibition are considered the number of errors the individual makes in response to task-unrelated stimuli as well as the reaction time to the experimental conditions. However, since reaction times are highly related to articulation and motor speed along with inhibition ability (Miyake & Friedman, 2012), commission errors may reflect a better indicator of response inhibition.

Deficits in response inhibition have been observed in individuals with substance use disorders (Smith, Mattick, Jamadar, & Iredale, 2014), gambling disorder (Billieux et al., 2012), and excessive use of the Internet (Dong, DeVito, Du, & Cui, 2012). Regarding IGD specifically, neuroimaging research has demonstrated a connection between neural activity in brain regions thought to be implicated in executive function, and IGD (Meng, Deng, Wang, Guo, & Li, 2015). However, studies examining the relationship between inhibitory control deficits in individuals with IGD compared to control individuals using neurocognitive tasks, such as the Go/No Go and Stroop task, have provided mixed results with some studies finding statistically significant effects (e.g. Xing et al., 2014) and others reporting non-significant associations (e.g. Yao et al., 2015). These non-significant findings could be attributed to potentially low statistical power, since the sample size in the majority of these studies was small. Additionally, the task impurity problem accompanying the neurocognitive tasks used to measure executive functions, in general, could be a reason for the mixed results. Specifically, these tasks require additional abilities, such as visual processing, articulation or motor abilities, in order to be completed, making impairments in other aspects of the task a potential explanation for the low scores (Miyake & Friedman, 2012; Miyake et al., 2000). Thus, the statistically significant effects may be systematically linked with the task used in the study.

To our knowledge, no previous study has been conducted so far attempting to integrate the results of the studies examining inhibition in the context of IGD using a meta-analysis. Identifying a relationship between inhibition and IGD is crucial in order to provide evidence for its credibility as a psychological disorder and recommendations for treatment strategies. Therefore, in the present study, we conducted a meta-analysis of studies using three neurocognitive tasks, the Go/No Go, Stroop, and stop-signal tasks, to estimate the magnitude of the relationship between inhibition and IGD. Additionally, in order to decrease the possibility that the task impurity problem affects our findings, we examined the potential moderation effect of the experimental task on the relationship between IGD and response inhibition.

2. Material and methods

2.1. Inclusion-exclusion criteria

The inclusion of a study in our meta-analysis was determined based on several inclusion and exclusion criteria. In order for a study to be included in the analysis, it had to examine both an IGD and a control group. Studies reporting mixed diagnostic groups, that is having participants with other comorbid psychological disorders, such as substance abuse, depression, and anxiety, were excluded. Additionally, studies were included if they used at least one neuropsychological task measuring inhibition and provided adequate information to calculate an effect size. Studies using neurocognitive tasks modified to use emotionally charged words (e.g., modified Stroop task) or game pictures (e.g., modified Go/No Go task) as distractors, were excluded. The reason for setting this criterion was to avoid confounding inhibition impairments with emotional processing deficits, which would exceed the scope of the current meta-analysis, and would threaten the validity of the