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.

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.

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Behavioral addiction
Inhibition
Executive functions

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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
conclusions made. Papers written in languages other than English were also excluded from the meta-analysis.

2.2. Search strategies

Using Web of Science, PsychInfo, and Google Scholar, the primary author searched for studies on IGD, with keywords: Internet Gaming Disorder, including Internet or video game or computer or online, and addiction or excessive use combined with executive function and inhibition terms. The date of last search was on May 2016. An initial screen was performed to eliminate studies that clearly did not meet the predetermined inclusion criteria based on the article titles. After the first screen, a review of the abstracts of the remaining articles was conducted and the full text of these articles that were likely to meet the inclusion criteria was obtained. The identified articles were examined and their references were screened to pinpoint any missed articles from the initial search. From the resulting article list, one study was excluded because it did not provide sufficient information to calculate an effect size. Two studies were excluded, because they used modified neuropsychological tasks (Stroop, Go/No Go) measuring processes outside the scope of this meta-analysis. The search process (see Fig. 1) led to the identification of twelve studies (k = 12) meeting the inclusion and exclusion criteria, which were subsequently included in the main analysis (Chen et al., 2015; Choi et al., 2014; Ding et al., 2014; Ko et al., 2014; Littel et al., 2012; Liu et al., 2014; Luijten, Meerkerk, Franken, van de Wetering, & Schoenmakers, 2015; Wang et al., 2015; Xing et al., 2014; Yao et al., 2015; Yuan et al., 2016).

2.3. Statistical analyses

As a measure for response inhibition we used the number of errors conducted by the participants in the experimental condition. We decided to use the number of errors as an indicator of response inhibition and not reaction times for the following reasons. First, the reaction time was not reported to a significant number of studies meeting the inclusion criteria. Therefore, conducting a meta-analysis to a small number of studies could lead to considerably reduced statistical power limiting our ability to detect smaller effect sizes. Second, there is a possibility that reaction time reflects to a great extend slow processing speed instead of deficits in response inhibition (Miyake & Friedman, 2012; Snyder, 2013). In contrast, the accuracy in responses, not having speed as a requirement, may be a better representation of an individual’s ability to suppress an automatic, but task-unrelated response, for a deliberate and task-related response, which defines response inhibition.

An effect size was calculated for every study using the standardized mean difference of the IGD and control group, corrected for its positive bias, i.e., Hedges’g (Hedges & Olkin, 1985). One study was excluded (Cai et al., 2016) after the calculation of the effect size, because it was considered an outlier (d > 3). We conducted the meta-analysis in the R statistical software using the metafor package (Viechtbauer, 2010). This package includes functions for fitting the meta-analytic fixed-, random-, and mixed-effects models allowing for the inclusion of moderator variables. We first fitted a random-effects meta-analysis to estimate the average effect size for all the studies combined. Then, we fitted a mixed-effects model which enables the introduction of moderators in the

Fig. 1. Flow chart for selection of studies used in the meta-analysis.
meta-analysis that could influence the size of the estimated effect. The neurocognitive measure used in the included studies could account for at least part of the heterogeneity in the true effects and thus, it was introduced as a moderator in the analysis. Restricted maximum-likelihood estimation was used to estimate the amount of heterogeneity (i.e., $\tau^2$). Research has shown that the restricted maximum-likelihood estimator is approximately unbiased and quite efficient (Viechtbauer, 2005). The hypothesis of heterogeneity in effect sizes was tested with the Cochran’s Q-test (Hedges & Olkin, 1985). However, due to the poor performance of this test at detecting significant heterogeneity in small sample sizes (Higgins & Thompson, 2002), the $I^2$ was also calculated. The $I^2$ statistic is the percentage of the total variability due to heterogeneity. A funnel plot was created which can be used as a graphical device to diagnose certain forms of publication bias. To test funnel plot asymmetry, the regression test suggested by Egger, Smith, Schneider, and Minder (1997) was performed.

3. Results

3.1. Study characteristics

Table 1 shows the authors, sample size, target population, age and gender of the participants, inhibition and IGD measures for each study. The total number of participants from the 11 studies combined was 447. From these participants, 226 were in the IGD group and 221 were in the healthy control group. The majority of the studies (82%) used student samples, whereas two studies recruited participants from hospitals or mental health centers. The average age of the IGD participants was 20.1 years and the average age of the healthy controls was 20.5, with only one study using participants younger than 18 years (Ding et al., 2014). The vast majority of the participants were males (86%). The calculated effect size of the association between inhibition and IGD for each study is also presented in Table 1.

3.2. Mean-level differences in inhibition

The results of the random-effects meta-analysis are shown in the forest plot (Fig. 2) that we created to provide a graphical overview of the findings. We found a statistically significant medium overall effect size ($d = 0.56$, 95% CI [0.32, 0.80], $z = 4.6268$, $p < 0.001$). This means that individuals with IGD made significantly more errors in the experimental condition of the neurocognitive tasks than controls. That is, participants with IGD had a greater difficulty withholding their response to task unrelated stimuli. The test for heterogeneity that we performed was not statistically significant [$Q(df = 10) = 14.6957$, $p = 0.1436$], providing no evidence that there are real differences underlying the results of the studies. However, due to the low statistical power of this test with small sample sizes we also calculated the $F$. $F$ is a measure of the total variation across studies explained by heterogeneity instead of chance ($F = 100 \times (Q - df) / Q$). In our analysis, $F$ was 33% indicating low heterogeneity that does not cause concern (Higgins & Thompson, 2002).

Table 1 Description of the studies included in the meta-analysis.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample</th>
<th>Age</th>
<th>Gender</th>
<th>Geographic location</th>
<th>IGD measure</th>
<th>Inhibition measure</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen et al., 2015</td>
<td>15 IGD, 15 HC</td>
<td>24.67 ± 3.12</td>
<td>All males</td>
<td>Taiwan</td>
<td>DCIA</td>
<td>Go/No-Go</td>
<td>0.40</td>
</tr>
<tr>
<td>Choi et al., 2014</td>
<td>15 IGD, 15 HC</td>
<td>24.47 ± 2.83</td>
<td>All males</td>
<td>South Korea</td>
<td>DSM-5, IAT</td>
<td>Stop-signal</td>
<td>0.83</td>
</tr>
<tr>
<td>Ding et al., 2014</td>
<td>17 IGD, 17 HC</td>
<td>16.41 ± 3.20</td>
<td>All males</td>
<td>China</td>
<td>YDQ</td>
<td>Go/No-Go</td>
<td>0.24</td>
</tr>
<tr>
<td>Ko et al., 2014</td>
<td>26 IGD, 23 HC</td>
<td>15.82 ± 2.32</td>
<td>All males</td>
<td>Taiwan</td>
<td>DCIA</td>
<td>Go/No-Go</td>
<td>0.40</td>
</tr>
<tr>
<td>Littel et al., 2012</td>
<td>25 IGD, 27 HC</td>
<td>20.52 ± 2.95</td>
<td>All males</td>
<td>Netherlands</td>
<td>VAT</td>
<td>Go/NoGo</td>
<td>0.77</td>
</tr>
<tr>
<td>Liu et al., 2014</td>
<td>11 IGD, 11 HC</td>
<td>23.45 ± 3.34</td>
<td>All males</td>
<td>Taiwan</td>
<td>DCIA-C</td>
<td>Go/NoGo</td>
<td>0.30</td>
</tr>
<tr>
<td>Luijten et al., 2015</td>
<td>18 IGD, 16 HC</td>
<td>20.83 ± 3.05</td>
<td>All males</td>
<td>Netherlands</td>
<td>VAT</td>
<td>Go/NoGo, Stroop</td>
<td>0.65</td>
</tr>
<tr>
<td>Wang et al., 2015</td>
<td>28 IGD, 28 HC</td>
<td>18.8 ± 1.33</td>
<td>All males</td>
<td>China</td>
<td>YDQ, IAT</td>
<td>Stroop</td>
<td>0.43</td>
</tr>
<tr>
<td>Xing et al., 2014</td>
<td>17 IGD, 17 HC</td>
<td>19.1 ± 0.7</td>
<td>All males</td>
<td>China</td>
<td>IAT</td>
<td>Stroop</td>
<td>1.21</td>
</tr>
<tr>
<td>Yao et al., 2015</td>
<td>34 IGD, 32 HC</td>
<td>22.29 ± 2.07</td>
<td>All males</td>
<td>China</td>
<td>CIAS</td>
<td>Stroop</td>
<td>0.02</td>
</tr>
<tr>
<td>Yuan et al., 2016</td>
<td>20 IGD, 20 HC</td>
<td>19.3 ± 2.1</td>
<td>All males</td>
<td>China</td>
<td>YDQ</td>
<td>Stroop</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Note. IGD = Internet Gaming Disorder; HC = healthy control group; DCIA = Diagnostic Criteria for Internet Addiction; IAT = Internet Addiction Test; YDQ = Internet Dependence Questionnaire; VAT = Video game addiction test; CIAS = Chen Internet Addiction Scale.

Fig. 2. Forest plot showing the results of the meta-analysis.
3.3. Neurocognitive measure as moderator for the mean-level differences

Since task impurity may cause task-specific impairments, the neurocognitive task may be a significant contributor of heterogeneity in the meta-analysis. To control for the effect of the neurocognitive measure on the average effect size, we included the neurocognitive task as a moderator in the meta-analysis. However, we excluded the stop-signal task, because only one study used this task to measure inhibition. This analysis provided no evidence for moderation ($p = 0.876$) and the difference in the effect sizes between Stroop and Go/No Go tasks was only 0.14 (Stroop effect size: 0.64; Go/No Go effect size: 0.50).

3.4. Publication bias

In order to evaluate the possibility of publication bias which could account for the finding that IGD is associated with impairments in inhibition, we used both a visual and a statistical test approach. Fig. 3 shows the funnel plot created as a graphical device to examine the presence of publication bias. Based on this plot, there was no evidence of asymmetry that would suggest the presence of publication bias. In order to test the presence of such an asymmetry more explicitly we performed the regression test suggested by Egger et al. (1997). The test was not statistically significant ($z = 1.489$, $p = 0.136$), providing no evidence for publication bias.

4. Discussion

4.1. Discussion of the results

So far, research attempting to link response inhibition and IGD has produced inconsistent results. Plausible explanations for these results are the potential low statistical power resulting from the small sample sizes involved and the task impurity problem accompanying the neurocognitive measures of inhibition (Miyake et al., 2000). Therefore, the aim of the current meta-analysis was to estimate the overall effect size of the relationship of response inhibition with IGD, and to provide a more powerful overall statistical test compared to each individual study, taking into account the potential differential effect of the neurocognitive task. Overall, our findings revealed that individuals with IGD had significantly impaired performance in the measures of inhibition compared with healthy control participants. Specifically, our analysis demonstrated a medium effect size ($d = 0.56$), with IGD individuals conducting significantly more errors in the experimental condition of the neurocognitive tasks. Contrary to our hypothesis, there was no evidence that the neurocognitive task used to measure response inhibition in the different studies moderates the relationship between inhibition and IGD. Finally, although there was a concern there would be heterogeneity across studies that might be partially explained by the use of different criteria for the inclusion of participants in the IGD group, our analysis showed a relatively low degree of heterogeneity not providing evidence of inconsistency across studies that would cause a concern (Higgins & Thompson, 2002).

Although no previous meta-analysis exists on this topic with which our results can be compared, our findings are consistent with the broad literature linking the poor self-regulation with deficits in inhibitory control and addictive and impulsive behaviors (Fillmore, 2012; Hofmann et al., 2012; Young et al., 2009). The central feature of IGD incorporated in all its conceptualizations is poor control over impulses related to gambling (APA, 2013; Dong & Potenza, 2014; Petry et al., 2015). Research has shown that inhibition, as the ability to override incompatible with long-term goals responses, such as impulses and habits, is the quintessence of successful self-regulation (Hofmann et al., 2012). This is because inhibition enables goal-directed behavior by avoiding internal or external distractors. Inability or impairments in the cognitive processes that keep away such distractors can foster impulsive behaviors. More specifically, difficulties in suppressing or delaying impulses for the sake of goal directed behavior is thought to be a central characteristic of a number of addictive or impulse-control disorders, including substance use (Smith, Mattick, Jamadar, & Iredale, 2014) and gambling disorder (Billeux et al., 2012).

Additionally, research has provided evidence that the poor self-regulation which characterizes individuals with IGD is strongly associated with high levels of impulsivity which is considered a vulnerability for this disorder (Yen et al., 2017). Impulsivity and the closely related trait, disinhibition, are diagnostic features of all externalizing disorders and are thought to be underlined by inhibitory neurocognitive functions. In fact, Young et al. (2009) demonstrated a considerable genetic correlation ($r = -0.63$) between response inhibition and behavioral disinhibition. Since impulsivity-like traits are found to characterize IGD, and, according to literature, are linked to inhibition impairments, it comes to no surprise that IGD is characterized by inhibition deficits.

Further support for our results is provided by neuroimaging studies linking IGD with the activation of brain regions implicated in the executive function and inhibition, more specifically. Meng et al. (2015), in their meta-analysis of neuroimaging studies on the prefrontal dysfunction of IGD, found in individuals with IGD abnormalities in the activation of several areas of the prefrontal cortex, which is thought to be the base of executive function. More specifically, their findings revealed an increased activation of the anterior cingulate cortex, a part of the brain’s limbic system, which is considered key for executive functioning. Additionally, in IGD compared to healthy control individuals, they found increased activation of the dorsolateral prefrontal cortex, a region which lies in the middle frontal gyrus of humans (Meng et al., 2015). Therefore, our findings based on evidence from behavioral tasks align well with findings emerging from neuroimaging data, strengthening the evidence in favor of identifying impaired inhibition as a strong correlate of IGD.

4.2. Theoretical implications

IGD is a psychological condition recently incorporated in the DSM-5 as a disorder requiring additional research before finding its place in the main diagnostic manual (APA, 2013). One of the reasons for its inclusion only in Section III of the diagnostic manual is the sparsity of research making a cogent case for its merit as a clinical disorder. The results of this meta-analysis identified impaired response inhibition, a transdiagnostic characteristic of a wide range of clinical disorders
(Snyder et al., 2015), as a feature of IGD. Impaired inhibition has been found to underlie the self-regulation deficits and impulsivity that characterize externalizing disorders, and addictive behaviors more specifically (Smith, Mattick, Jamadar, & Iredale, 2014; Snyder et al., 2015). Thus, providing evidence for its presence in IGD enhances the argument for its legitimacy as a clinical disorder, sharing commonalities, and possibly genetic variations, with externalizing psychopathology. As Dong and Potenza (2014) proposed in their conceptual review article, a potential path through which inhibition might lead to the phenotype of IGD is through the inadequate suppression of cravings for the rewarding behavior of gaming leading to uncontrollable use of the Internet.

4.3. Clinical implications

The clinical implications of our findings are equally important. Specifically, this meta-analysis provides evidence for the need of intervention efforts to target the inhibition deficits of individuals with IGD seeking treatment for their condition. Since inhibition is inextricably linked to poor self-regulation and impulsive behavior (Hofmann et al., 2012), interventions focusing on the difficulties of individuals with IGD in inhibiting their impulses may be essential for the improvement of the IGD symptomatology. More specifically, strengthening the cognitive capacities to inhibit the short-term reward gained from gaming behavior (which has deleterious consequences for the long-term goals) may significantly improve the psychosocial functioning of individuals with IGD. For example, a therapeutic approach that has been found quite effective in the enhancement of inhibitory control over impulsive behaviors and that could help individuals with IGD is Cognitive Behavior Therapy (CBT; Dong & Potenza, 2014; Kiluk, Nich, Babuscio, & Carroll, 2010). Future research on the effectiveness of CBT and similar approaches in treating IGD should be conducted.

5. Limitations

One limitation of our study is that the screening procedure for the identification of studies was performed by only one individual, the primary author of the article. Although an effort was made to derive an unbiased final pool of eligible studies using clear and very specific inclusion and exclusion criteria, the possibility of selection bias remains. Another limitation of this study is that due to the relatively new scientific interest in the study of IGD, the number of studies based on which we performed our meta-analysis was limited. This has several implications. First, we cannot conclude that the relationships that we found non-significant are actually non-existent. Although, by definition, the finding of a statistically significant relationship means that we do not have a statistical power (which is defined as the probability of a non-statistically significant result when there is a true relationship in the population) issue for our main hypothesis of the association between inhibition and IGD, the meaning of the non-significant moderating effect of the experimental task is not clear. This non-significant effect could potentially be attributed to low power. However, the small size of the effect along with the very high p-value (0.87) may give some evidence for the non-existence of a moderating effect. In any event, further research is required to provide more compelling evidence for the existence or lack of existence of such an effect.

Second, because of the limitation of the small sample of studies, we were not able to include more moderating variables in our analysis to examine the potentially differential effect of age, gender, or socio-cultural background in the relationship between IGD and inhibition. An interesting path for future research would be the examination of the effect of different demographic variables in the inhibition deficits of individuals with IGD. Furthermore, because IGD is more prevalent among males, most of the studies we identified used only male participants to study inhibition in IGD (Meng et al., 2015). Therefore, our results may not be validly generalizable to the female population as well. More research is needed using both male and female samples to identify similarities or differences between the two genders and establish more general conclusions for IGD.

6. Conclusions

In conclusion, using a quantitative approach to integrate existing research, our study demonstrated a significant association between impairments in inhibition and IGD. This finding is in alignment with literature on inhibition and addictive and impulsive behaviors, as well as with neuroimaging evidence showing impairments in brain areas related to executive function. However, whether impairments in inhibition precede or follow IGD remains to be established. Thus, future research is needed to provide a deeper understanding on how inhibition deficits arise and whether there is a causal link between these deficits and IGD. Answering these questions is critical for developing prevention and treatment strategies for individuals with IGD.

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Contributors

Ms. Argyriou was the primary writer of the manuscript, conducted the screening procedure and statistical analysis. Dr. Davison and Dr. Lee provided input on the project as well as assisted with the writing. All authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare they have no conflicts of interest.

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