DOCTORAL (PHD) DISSERTATION

Patrik Koncz

Attention-deficit/hyperactivity disorder (ADHD) symptoms and gaming motivations underlying problematic video game use

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EÖTVÖS LORÁND UNIVERSITY FACULTY OF EDUCATION AND PSYCHOLOGY

Patrik Koncz

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Doctoral School of Psychology
Head of the doctoral school: Prof. Róbert Urbán
Clinical Psychology and Addiction Science
Program leader: Prof. Zsolt Demetrovics
Supervisors: Prof. Zsolt Demetrovics;
Dr. Orsolya Király

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List of publications directly used in the dissertation

Study 1: Király, O., Billieux, J., King, D. L., Urbán, R., Koncz, P., Polgár, E., & Demetrovics, Z. (2022). A comprehensive model to understand and assess the motivational background of video game use: The Gaming Motivation Inventory (GMI). *Journal of Behavioral Addictions*, 11(3), 796-819. https://doi.org/10.1556/2006.2022.00048

Study 2: Király, O., Koncz, P., Griffiths, M. D., & Demetrovics, Z. (2023). Gaming disorder: A summary of its characteristics and aetiology. *Comprehensive Psychiatry*, 122, 152376. https://doi.org/10.1016/j.comppsych.2023.152376

Study 3: Koncz, P., Demetrovics, Z., Takacs, Z. K., Griffiths, M. D., Nagy, T., & Király, O. (2023). The emerging evidence on the association between symptoms of ADHD and gaming disorder: A systematic review and meta-analysis. *Clinical Psychology Review*, 106, 102343. https://doi.org/10.1016/j.cpr.2023.102343

Study 4: Koncz, P., Demetrovics, Z., Urbán, R., Griffiths, M. D., & Király, O. (2024). Gender-specific motivational pathways in ADHD-related inattention and gaming disorder symptoms. *Addictive Behaviors*, 158, 108120. https://doi.org/10.1016/j.addbeh.2024.108120

1. General introduction

1.1. Definition and popularity of video games

"The term "video game" refers to any electronically enacted game played using an input controller (such as joysticks, keypads, or motion sensors) to interface with a display device or platform (typically showing video imagery)." (Craig, Geraldine, 2024, para. 1). Games are generally categorized into genres, frequently including the following: adventure games, shooter games, fighting games, sports games, puzzle games, role-playing games (RPGs), simulations and "sandbox" games. All genres could be divided into subgenres (e.g. shooters into FPS/TPS), while combination of each genre (e.g. action RPGs) and addition of other structural elements (e.g. large interactive shared online virtual spaces in the case of MMOs) is also a preferred direction for game development which further increases the complexity of the videogame landscape. Games can be played on various devices. At the beginning of the video game industry games were mainly playable on coin-operated arcade game machines placed in popular public places, which were later replaced by personal home and portable devices, such as personal computers (PCs), video game consoles, tablets and smart phones (Craig, Geraldine, 2024).

Videogame use seems to show a continuously growing trend in the past 10 years, which leads to the point where in 2024 approximately one third of the global population plays videogames, and the pattern of usage shows it is more popular in the Asian population and among young males (Fabio, 2024). Regarding the Hungarian population, a similar pattern of participation (greater proportion of young males) can be seen as globally. Based on the previous results of the European School Survey Project on Alcohol and Other Drugs (ESPAD) from 2019, among Hungarian adolescents 71.8% (86.3% of males and 55.7% of females) reported video game use during the past month (Király, Demetrovics, 2020). For comparison with Hungarian adults the National Survey on Addiction Problems in Hungary (NSAPH) are available and based on their estimations, only 10.7% (14.9% of males and 7.1% of females) participated in video game use during the past month (Király, Demetrovics, Paksi 2021).

1.2. The concept of problematic use

Several benefits of videogame use are widely recognized, ranging from being recreational and social activity, across promoting goals in education, physical activity

(Sailer, Homner 2020; Mazeas et al., 2022), cognitive development (Green, Bavelier, 2015), to even being tools for therapeutic interventions (Kollins et al., 2020). Despite these benefits, gaming is one of the popular activities, which have been associated with problematic use and related negative consequences. While initially only substance use was associated with symptoms of problematic use (often referred to as "addiction"), following the publication of the components model of addiction (Griffiths, 2005), several daily activities (sex, exercise, internet and videogames) were found to have an unhealthy pattern among a minor proportion of users. The components model describes addictions by the following components:

1. **Salience:** the activity becomes a priority in the life of an individual involving cognitive (e.g. thinking about it when not engaged in the behavior), affective (e.g. craving) and behavioral (e.g. seeking to create an opportunity to engage in the behavior) preoccupation.
2. **Mood modification:** the behavior functions to alter mood, either by providing excitement or by managing negative emotions.
3. **Tolerance:** greater engagement in the activity is necessary for the same psychological effect after repeated use.
4. **Withdrawal symptoms:** occurrence of unpleasant effects in the reduction or absence of the behavior (e.g. bad mood, irritability, discomfort).
5. **Conflict:** the excessiveness of the behavior leads to conflict internally (characterized by guilt) and/or externally (conflicts due to negligence of friends, relatives and work/education related responsibilities).
6. **Relapse:** the individual returns to earlier problematic patterns of behavior after a period of abstinence or controlled use.

Another, more recent model called the component model of addiction treatment (Kim, Hodgins, 2018) has described addictive behaviors by their changeable transdiagnostic features, which have the benefit of serving as the focus of interventions. The components of this model are the following:

1. (negative) **Urgency:** a tendency to act maladaptively, without consideration when intense emotions are experienced.

2. **Deficits in self-control:** lack of proper focus in the presence of disruptive stimuli (conditioned cues in case of addiction) and impaired behavioral inhibition which prevents goal-oriented behavior.
3. **Expectations and motives:** permissive and anticipatory beliefs paired up with motivations (enhancement, social and coping) which fuel behaviors with problematic use potential.
4. **Deficits in social support:** deficits recognized as interpersonal conflicts, lack of social and communication skills.
5. **Compulsivity:** repetitive engagement in a behavior driven by a feeling of "necessity" instead of enjoyment.

Additionally, this model recognizes the "lack of motivation", a characteristic of addicted individuals. Individuals with addiction tend to show no interest in changing habits despite their clear negative consequences, which can undermine treatment outcomes if remain unresolved.

Intense research regarding the problematic use of video games resulted in being recognized in two broadly applied diagnostic systems: the DSM-5 (American Psychiatric Association, 2013) and ICD-11 (World Health Organization, 2019). In the DSM-5, problematic use of videogames is present as Internet Gaming Disorder (IGD), characterized by a persistent and recurrent gaming behavior that leads to significant functional impairment during daily life and/or significant distress. Despite the presence of a clear diagnostic criteria IGD is not a formal disorder yet, it is only present in section III of DSM-5 under "Conditions for further study". The diagnostic criteria consist of nine symptoms from which at least five should be present over at least 12 months:

1. Preoccupation with gaming
2. Withdrawal symptoms
3. Tolerance
4. Unsuccessful attempts to reduce gaming
5. Loss of interest in previous hobbies
6. Continuation despite negative consequences
7. Deceiving others about gaming time
8. Gaming to escape or to remove negative mood

9. Jeopardization or loss of significant relationships, work or school related opportunities

The ICD-11 refers to problematic video game use as Gaming disorder (GD), which compared to the DSM-5 is a recognized diagnosis. The ICD-11 defines GD as a continuous or episodic and recurrent pattern of gaming behavior present over at least a 12-month period (which in case of serious symptoms can be lowered) which causes significant impairment in important areas of life (social, education, occupation). All three of the following symptoms must be present to make for diagnosis:

1. Impaired control over gaming
2. Precedence of gaming over other interests and activities
3. Continuation or escalation of gaming despite negative consequences

Based on a recent meta-analysis, the pooled global prevalence rate of GD is 1.96% (including studies with strict sampling methods), showing a 2.5 higher rate among males compared to females (Stevens et al., 2021). Based on the 2019 data collection of the ESPAD survey 1.5% of Hungarian adolescents (2.2% of males, 0.4% of females) are screened positive for GD (Király, Demetrovics, 2020), while the results of the NSAPH study screened 0.2% of Hungarian adults positive for GD (Király, Demetrovics, Paksi 2021). A qualitative synthesis of longitudinal research verified that GD negatively impacts mental health and school performance, leading to increasing symptoms depression, anxiety, psychological distress, loneliness and lower life satisfaction and GPA scores (Düll et al., 2024).

1.3. Models of gaming disorder

Main models aimed to describe the antecedents of GD have detailed a wide range of internal factors (Dong, Potenza, 2014; Wei et al., 2017; Brand et al., 2016; Brand et al., 2019). The central component of the cognitive-behavioral model of IGD (Dong, Potenza, 2014) is the non-specified motivation to play (or craving in case of addiction) is driven by either an intent to reduce stress or to seek reward, further weighted by decision making processes and can also be inhibited by executive control. In this model, GD develops due to recurrent gaming behavior, which enhances reward sensitivity and creates cognitive biases towards gaming, while also disturbs inhibitory capacity.

The tripartite neurocognitive model of IGD (Wei et al., 2017) describes the addiction process as a progressive shift to imbalance in the regulation of the "impulsive system" (involving the amygdala and the striatum) and the "reflective system" (controlled by the prefrontal cortex) which are both modulated by the "interoceptive system" (involving the insular cortex).

- The **"impulsive system"** is responsible for automatic, habitual behavior, which through recurrent play-related reward experiences increases reactivity to game related cues. This process helps gaming become a less conscious, more habitual activity supported by attentional biases towards gaming cues and impairments in time perception.
- The **"reflective system"** consists of two, interacting subsystems: the "cool subsystem" (responsible for the inhibition of strong impulses) and the "hot subsystem" (which determines emotion driven behavior). The hypoactivity of this system limits self-regulation capacity by reducing the ability of players to suppress gaming related urges and seek real-life goals.
- The role of the **"interoceptive system"** lies in its capacity to undermine the impulsive and reflective system. While the function of this system would be to signal the loss of internal balance by feelings of disgust and strong desire, in case of addiction the activation of this system is followed by the experience of craving, which seems to deactivate the other two systems manifesting in a lack of self-monitoring and response inhibition.

Partially inspired by the earlier two models, the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2016; Brand et al., 2019) was constructed to explain disorders related to internet use (in addition to gaming the model is also applied to online gambling, pornography consumption, shopping and communication). I-PACE is a process model, meaning that it describes the development of disordered use over time, while also attempts to define the roles of related factors in the process. Regarding the temporal aspects of development, the model differentiates between an early phase, when the behavior is gratifying by itself and has the capacity to build habitual use (thus driven by positive reinforcement), and a later phase, which is characterized by compensatory need (thus being mainly driven by negative reinforcement). The components of the model are assigned to three different roles:

1. **Risk factors** include several neurobiological and psychological features, such as social cognitions, personality, biopsychological constitution, comorbid psychopathology and motives.
2. **Mediators of risk factors** include subjective situation perception (e.g. salience, stress reactivity), affective and cognitive responses (e.g. craving, attentional bias) and executive functioning/inhibitory control.
3. **Moderators of risk factors** include coping style and internet related cognitive biases (e.g. expectancies).

Even though the model aims to describe common factors of different internet related disorders, it also recognizes the unique determinants of these issues, highlighting that higher materialism pushes individuals to shopping addiction, higher sexual drive rather leads to porn addiction and stronger novelty seeking, aggressivity and narcissism is more likely to underlie GD.

The strength of these models is the inclusion of a wide range of factors and in the case of the I-PACE model, even the roles of these factors are defined. But even these models are not completely comprehensive, as they lack external factors (e.g. culture, family, peers) and video game-related factors (e.g. genres, platforms, game mechanics) that were shown to be responsible for the development and maintenance of GD. Despite these limitations, they provide great framework for both daily clinical practice and further psychological research.

1.4. ADHD, a risk factor of addiction

ADHD is a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity typically (but not exclusively) present before the age of 12 for at least a 6-month period which interferes with functioning or development. Individuals affected by ADHD are characterized by either or both inattentive symptoms (including failure or difficulty in organization, giving close and sustained attention to details and following instructions, distractibility, forgetfulness and avoidance of tasks requiring sustained mental effort) and hyperactivity/impulsivity (including fidgeting, difficulties in waiting, inability to remain still or restlessness, excessive speech, social intrusion, interruption of others and answering questions before completion) (American Psychiatric Association, 2013).

Based on the systematic synthesis of previous meta-analyses, the global prevalence of ADHD among children and adolescents is estimated at 8% (95% CI: 6-10%), showing a double rate among boys (10.0%, 95% CI: 8-11%) compared to girls (5%; 95% CI: 4-7%) (Ayano et al., 2023). A more recent meta-analysis including large scale representative sample studies confirmed the validity of rates estimated in survey studies, finding similar rates of ADHD in survey studies 5.0% (95% CI: 2.9; 8.6) and one-stage 4.2% (95% CI: 2.9; 6.0) and two-stage clinical studies 4.8% (95% CI: 4.0; 5.8) (Popit et al., 2024). While the effect of age was not clearly described, the lower rate reported in this study compared to the previous meta-synthesis indicating that ADHD is more prevalent among children and adolescents due to the decline of symptoms with ageing (Popit et al., 2024). Compared to GD, ADHD seems to show a similar sociodemographic distribution, showing the largest prevalence rates among young males.

The role of ADHD is defined as a comorbid psychopathological risk factor for disorders related to internet use in the I-PACE model (Brand et al., 2016; Brand et al., 2019), and considering the whole range of addictive behaviors, ADHD is a common vulnerability factor for different types of addiction, including alcohol, cigarette and substance use and gambling (French et al., 2024). It is worth to mention that addiction risk is only one issue among ADHD affected individuals, as several other areas are evidently affected: greater severity of suicidal and self-harming behavior, mood and personality disorders, eating and psychotic disorders, sleep difficulties, poorer educational and occupational outcomes and worse relationship quality (French et al., 2024). Despite the great number of studies showing that ADHD and GD symptoms generally show a positive association (Dullur et al., 2021), a meta-synthesis of these results and qualitative summary of studies focusing on the potential mediators of this association was not yet made. To Considering the potential interrelationship of the functional and mental health issues of ADHD affected individuals provide a direction to understand this association, while a meta-synthesis could provide a more accurate estimate of the strength of this association.

1.5. Motivational theories in addiction research

The drives underlying substance use and dependence is a considerable focus of interest in clinical psychology and addiction research. Several theories have emerged to explain

the problematic consumption of different substances such as alcohol, tobacco or marihuana, leading to the identification of several similar factors. Initially alcohol consumption motives were identified (Cox, Klinger 1988; Cooper, 1994), differentiating four theoretically independent factors lying on the spectrum of positive/negative (reinforcement) and internal/external (source of outcome):

1. **Social** (positive/external): drinking to facilitate social interactions.
2. **Enhancement** (positive/internal): drinking to elevate mood, promote euphoric states.
3. **Coping** (negative/internal): drinking to alleviate or remove negative emotions.
4. **Conformity** (negative/external): drinking to fit into a social environment or to avoid rejection.

These motives were further generalized to marihuana and tobacco use. For marihuana use, the same factors were applicable with the addition of one marihuana specific factor called "expansion", which is aimed to describe marihuana use as a tool to modify the state of consciousness, achieve spiritual insight and boost creativity (Simons, Correia, Carey, & Borsari, 1998). In case of tobacco use, the original motives were integrated into a theoretical multilevel model, including general addiction and unique tobacco specific factors (Piper et al., 2004), following the structure below:

- **Primary dependence motivations**: automaticity, craving, loss of control and tolerance.
- **Secondary dependence motivations**: affiliative attachment, behavioral choice/ melioration, cognitive enhancement, cue exposure, negative reinforcement, positive reinforcement, social/environmental goals, taste/sensory processes, weight control.

The utility of motivational factors was proven in the context of daily use by ecological momentary assessment studies which can explain within-person variance of several aspects of substance use (Votaw, Witkiewitz, 2021). Enhancement motive predicted higher odds of drinking initiation, greater alcohol consumptions quantity, more alcohol-related negative consequences and higher severity of acute alcohol use disorder. In some studies, social and coping motives had shown some utility in predicting alcohol consumption quantity, but these findings were more mixed. Enhancement, social and

coping motives explained the quantity of cannabis consumption and all motives (except expansion) were predictive of cannabis-related negative consequences.

1.6. Application of motivational theories in GD research

The most basic model which could be used to explain motivations behind GD is reinforcement theory, which has been widely applied to explain substance addictions (Wise, Koob, 2014). Based on this theory, the initiation of use in the early stages of addiction is mainly characterized by pleasure/reward seeking behavior (positive reinforcement), which due to repeated exposure to substances lead to several changes (such as the development of tolerance and withdrawal), thus the driver of use becomes progressively replaced by a motive to alleviate negative emotions (negative reinforcement). This theory can be generalized to GD (even though it lacks the intake of drugs), as video games use several different means of rewards (Koepp et al., 1988), ranging from points (which are simple indicators player success), through virtual items with in-game benefits, to even goods with "real life" monetary worth (Drummond et al., 2020), while also being effective tools to regulate negative emotions (such as anxiety) (Lou et al., 2025). The importance of both positive and negative reinforcement was highlighted in the I-PACE model (see early gratification and later compensation phase) (Brand et al., 2016; Brand et al., 2019), which received further support from research on the addictive nature of video game structural features, showing that the use of general reward types (e.g. experience points) and chance-based purchases or loot boxes were repeatedly found to be related to symptoms of problematic use (Saini, Hodgins, 2023).

The self-determination theory (SDT; Ryan, Deci, 2000) describes human motivation on a spectrum, ranging between amotivation (when a person lacks motivation to act), extrinsic motivation (being motivated by more-or-less external means, such as reward and punishment) to internal motivation (when a person finds inherent interest in an activity that is satisfying in itself). Although the external component of this model is already described by reinforcement theory, this theory highlights the existence of internal motivation and provides foundations by describing the following three basic human needs:

1. **Competence**, a need to own, improve and use personal skills to accomplish achievements.

2. **Autonomy**, a need to be in control by having freedom of choice regarding important decisions in personal life.
3. **Relatedness**, a need to be connected to others and a need to belong.

By proper game development, all these needs can be easily satisfied (Ryan, Rigby & Przybylski 2006). As video games are interactive media with a capacity to provide access to almost unlimited options to influence the events in their worlds, the need for autonomy can be easily satisfied. Games are also historically built upon challenges to beat (e.g. finish a level, beat a boss) which require skills to improve (e.g. learning controls, memorizing environments and non-player character behavior), the need for competence is also inevitably satisfied. And lastly, the inclusion of cooperative and competitive options to play that became accessible with the spread of the internet and which are further frequently supported by several built-in systems (e.g. clans, guilds, ranked modes), users need to relate also does not remain unfulfilled. Research shows that basic human need satisfaction during gaming and frustration (an active obstruction) of needs during daily life are both useful predictors of problematic video game use (Mills et al., 2018; Vuorinen et al., 2022).

The last framework frequently applied to explain the experience and driving force of videogame use is flow theory (Csikszentmihalyi, Nakamura, 2014). Based on flow theory, if the right circumstances are present, including clear goals, quick and unambiguous feedback, meaningful and predictable outcomes, equal opportunities, control over the behavior and proper adjustment of challenge to personal skills, flow state emerges. Humans seek to experience a flow state during their everyday lives (e.g. during sports and artistic activities), characterized by intense concentration and immersion, the fusion of behavior and consciousness, alterations in time perception and the enjoyment of the activity. Videogames can be thoroughly programmed to automatically provide all the necessary foundations to trigger flow state. Empirical research found a positive link between flow experiences and GD severity, highlighting that loss of time perception component of flow during gaming seems to be a central, differentiating component (Footitt et al., 2024; Burleigh et al., 2025).

While the benefit of these theories is these are built to describe general drivers of human motivation and thus, they were successfully applied to several different activities (besides video game use), the limitation of these models stems for the same source,

namely the lack of specificity. A distinct wave of research has emerged when instead of applying pre-existent theories to video game player behavior, models were created mostly based on player responses. The most influential starting point of this direction was the two-level model called "motivations for play in online games" (MPOGQ; Yee, 2006), which is built upon answers of massively multiplayer online role-playing game (MMORPG) players. In this model, three main motivational factors were identified, which consisted of an additional 10 subcomponents:

- **Achievement:** this factor described the ambition of players to seek high performance and be skillful, including subcomponents of *advancement* (a motivation for progression), *mechanics* (a motivation to understand and optimize the game) and *competition* (a motivation to be superior to other players).
- **Social:** this factor includes the drive of players to utilize the options provided by the video game environment to connect with others, involving *socializing* (a motivation to chat, make friends and help others), *relationship* (a drive to not just meet others, but form long-term bonds) and *teamwork* (a motivation to co-operate with others).
- **Immersion:** the final factor describes the motivation of players to experience the world of the game and all aspects of it, consisting of the subcomponents of *discovery* (motivation to explore the game world), *role-playing* (motivation to impersonate virtual characters), *customization* (motivation to create and modify virtual avatars and environment) and *escapism* (the use of game environment to avoid negative emotions and real-life problems).

The motives for online gaming questionnaire (MOGQ) (Demetrovics et al., 2011) provided another similar model for gaming motivation research. Compared to MPOGQ the MOGQ dimensions were established from the answers of a players from a wide range of video game genres, not only MMORPGs. In the MOGQ model, similar, but not identical dimensions can be found, including the following seven:

1. **Escape**: play to escape from real world problems and unpleasant emotions.
2. **Coping**: playing to cope with stress, aggression and to increase positive mood.
3. **Fantasy**: playing to discover fictional worlds, trying other identities and roles that would not be possible in the real world.

4. **Skill development**: play to develop coordination, concentration and other skills.
5. **Recreation**: play for fun, relaxation and entertainment.
6. **Competition**: play to compete and win against others.
7. **Social**: play to meet and interact with others, make friends or become a part of a community.

While these video game specific models were less suitable to show why any person could be interested in video games, they were useful in explaining what activities video games enable which players are happily engaged in. An important outcome of these models is the inspiration of research regarding the usage of video game mechanics to enhance motivation in other fields of life (Mazeas et al., 2022; Sailder, Homner, 2020). A recent meta-analysis had shown that all motivations of MOGQ and MPOGQ (except socializing and teamwork components) and even motivations originating from the SDT (except motivation to satisfy the need of competence) have positive association with GD symptom severity showing the strongest association with escape and introjected regulation (playing in order to avoid internal pressure from external origin such as shame or guilt) (Bäcklund et al., 2022). Even though such systematic synthesis of empirical results can clarify the role of these motivations, a comprehensive motivational model for further research is still lacking that includes all available dimensions of gaming motivation while also takes into account their interdependence. Furthermore, the use of motivational theories has already shown great value in explaining the role of mental health issues in relation to GD, especially through the mediating role of escapism (Király et al., 2015; Ballabio et al., 2017), thus further research could take an attempt to utilize motivations in the explanation of a wider range of risk factors.

2. Research aims

I. Execute a qualitative synthesis of the previous gaming motivation theories and construct a comprehensive measurement tool that can broadly explore the drivers of video game use while taking their overlap into consideration (Study 1).

II. Write a narrative review of available empirical research on the etiological factors of GD to support and/or refute previous models. Additionally, provide a summary of areas not covered in earlier models: the role of external (e.g. culture, peers, family etc.) and game-related (e.g. game genres, structural characteristics etc.) factors (Study 2).

III. Provide a quantitative synthesis of studies focusing on the ADHD-GD association and supplement earlier research with qualitative summary of the potential mediators explaining the underlying process of this association (Study 3).

IV. Test the potential mediator role of video game motivations in the association between ADHD, GD and average time spent playing (Study 4).

3. A comprehensive model to understand and assess the motivational background of video game use: the Gaming Motivation Inventory (GMI) (Study 1)[1]

The popularity of video gaming is continuously growing in all regions of the world (Statista, 2021) and its appeal extends to many different demographic groups (Entertainment Software Association, 2021). Because society spends a considerable amount of time and money on video games, it is important to understand this activity, including its benefits and risks. Video games help people relax, connect, and be entertained (Jones et al., 2014). Furthermore, they have great potential in several areas, such as education (Janarthanan, 2012), improving cognitive functioning (Wang et al., 2016), and other skills (e.g., hand-eye coordination; Gupta et al., 2021). However, gaming can be implicated in cases of toxic online behavior and cyberbullying (Kordyaka et al., 2020; Kwak et al., 2015; Paul, 2018), and, for some vulnerable individuals, it can become uncontrolled and associated with addiction-like symptoms and functional impairment (Castro-Calvo et al., 2021; Király et al., 2018; Rumpf et al., 2018).

Motivation is the psychological force that activates and maintains goal-directed thought and behavior (Wasserman & Wasserman, 2020); the study of gaming motives therefore has utility in understanding the popularity of video games. The attraction of video games rests in their ability to pull people in and keep them engaged for long periods because such games are highly rewarding. They are designed to motivate players in numerous ways to both strengthen engagement and appeal to a large customer base. Although early video games such as Pong and Tetris mostly appealed to a player's need for competence, video games today usually aim to satisfy a wide range of psychological needs (Przybylski et al., 2010).

Studying gaming motives is crucial in exploring the line between healthy and problematic engagement. For example, research on alcohol use and alcohol use disorder has consistently found that drinking motivation is of high importance in determining decisions about whether to drink or not (Cooper, 1994; Kuntsche et al., 2007), and

[1] The published version of this study is the following: „Király, O., Billieux, J., King, D. L., Urbán, R., Koncz, P., Polgár, E., & Demetrovics, Z. (2022). A comprehensive model to understand and assess the motivational background of video game use: The Gaming Motivation Inventory (GMI). *Journal of Behavioral Addictions*, 11(3), 796-819. https://doi.org/10.1556/2006.2022.00048"

motivation explains up to 50% of the variance in adolescent alcohol use (Kuntsche, 2007). Building on these findings, research exploring the role of motives in various problematic and non-problematic use has emerged (e.g., video gaming, gambling, cannabis and new psychoactive substance use, various online activities such as TV series watching and compulsive sexual behavior; e.g., Benschop et al., 2020; Flayelle et al., 2019; Koós et al., 2021; Simons et al., 1998; Stewart & Zack, 2008).

Problematic or addictive engagement in video games was recognized as an official diagnosis in the *International Classification of Diseases and Related Health Problems*, 11th ed., in 2019 under the name gaming disorder (GD; Billieux et al., 2021; Reed et al., 2022). It refers to a condition manifested by a persistent or recurrent gaming behavior – over a period of at least 12 months – characterized by an impaired control over gaming, increasing priority given to gaming over other activities to the extent that gaming takes precedence over other interests and daily activities and continuation of gaming despite the occurrence of negative consequences. The behavior pattern is of sufficient severity to result in significant impairment in personal, family, social, educational, occupational or other important areas of functioning. (World Health Organization, 2019; code 6C51)

Studies have shown that some motives (e.g., escapism: playing video games to avoid everyday problems and difficulties) are associated with GD (Billieux et al., 2015; Kwon et al., 2011) and also constitute mediators between psychiatric symptoms and GD (Ballabio et al., 2017; Király et al., 2015). One explanation is that players who struggle with psychopathological symptoms such as depression or anxiety are prone to escaping in games to avoid their problems and relieve negative affect, thus promoting overinvolvement and the development and maintenance of GD (Di Blasi et al., 2019; Kardefelt-Winther, 2014a). Consequently, studying gaming motives is crucial, from both theoretical and applied perspectives (e.g., prevention, intervention), for understanding healthy and passionate gaming, as well as problematic engagement.

Research in video gaming motives has a relatively long history. The earliest and most cited empirical model and measurement scale was created among massively multiplayer online role-playing game (MMORPG) players in the early 2000s. Yee (2006) built his model based on Bartle's early work on player types in multi-user dungeons, that is, text-based virtual environments (Bartle, 1996), and created a motivational model with 10 different motives that clustered into three overarching motivational components: (a) Achievement: advancement, mechanics, and competition;

(b) Social: socializing, relationship, and teamwork; and (c) Immersion: discovery, role playing, customization, and escapism. Although Yee's model is comprehensive and frequently used in research, it was developed primarily for MMORPG players and many of its items apply to MMORPGs (e.g., "How important is it to you that your character's armor/outfit matches in color and style?"). Yee's market research company, Quantic Foundry (https://quanticfoundry.com/), proposed a model comprising 12 distinct motives belonging to six higher-order motivation clusters (Action: destruction and excitement; Social: competition and community; Mastery: challenge and strategy; Achievement: completion and power; Immersion: fantasy and story; Creativity: design and discovery; Yee, 2015b). This model is robust, tested on more than 500,000 gamers worldwide. However, it is not openly accessible to the scientific community due to copyright protection. Another issue is that the model removed the escapism motivation, which has clinical relevance due to its moderate-to-strong association with GD (Bányai et al., 2019; Melodia et al., 2020). Game designers may be more interested in motives that are related to game characteristics that can be modified (e.g., fantasy motive: features that provide authenticity to the game world, such as non-player characters), whereas the escapism motive is more about the player than the game.

Another established motivational scale developed from a large sample of online game players of several different genres is the Motives for Online Gaming Questionnaire (MOGQ; Demetrovics et al., 2011), comprising seven gaming motives: recreation, social, competition, skill development, escape, fantasy, and coping. After a series of exploratory factor analyses (EFAs) and confirmatory factor analyses (CFAs), a distinction was made between escape and coping motives, the latter referring to playing games to reduce stress and aggression or to improve mood. The most recent scale is the Videogaming Motives Questionnaire (López-Fernández et al., 2020), which was developed by building on the previous instruments. It comprises eight motives: recreation, social interaction, coping, violent reward, fantasy, cognitive development, customization, and competition.

Although these instruments were developed by generating large item pools and using a factor analytical approach to arrive at a final model, other instruments were developed mainly from a theoretical perspective. For instance, the Player Experience of Need Satisfaction scale (Ryan et al., 2006) and the Gaming Motivation Scale (Lafrenière et al., 2012) were both based on self-determination theory, which posits that people have three basic psychological needs: competence, autonomy, and relatedness to

others. Satisfaction of these needs contributes to well-being and is associated with autonomous motivation, whereas frustration of these needs contributes to ill-being and is related to lower quality and highly controlled forms of motivation (Ryan et al., 2019). The Player Experience of Need Satisfaction scale assesses perceived in-game autonomy, competence, and relatedness, and the Gaming Motivation Scale assesses intrinsic (i.e., when someone engages in an activity solely because he or she enjoys it and gets personal satisfaction from it) and extrinsic motivation (i.e., when someone does something in order to gain an external reward), as well as amotivation (i.e., the relative lack of motivation) related to video gaming.

Existing motivational scales have several limitations. First, although they cover a number of different motives (see Table 1 in López-Fernández et al., 2020), none of them cover all motives and some of the comprehensive scales lack the escapism motivation, which has the highest clinical relevance because of its moderate-to-strong association with GD. Second, many of the instruments are genre specific and therefore are not generic instruments that can be used independently of the game genre. Because game genres are constantly evolving, instruments need to be as generic as possible to avoid becoming rapidly outdated with the emergence of new game genres. Third, as a result of fast technological advancement, video games evolve rapidly and some of the scales or items become outdated because new terms and game mechanics are used.

To address the limitations of existing measurement instruments of gaming motives, we aimed in this study to create a new motivation inventory that is comprehensive (i.e., covering all motives identified in the literature) and genre neutral; that is, it can be applied to any video game genres. To achieve these objectives, we conducted a systematic literature review to identify all of the gaming motivation scales developed up to late 2019. We then selected the most popular scales, along with the motivational factors from less used scales that seemed relevant to consider, and developed a comprehensive item pool that covered all motives in the scales. We aimed to cover each gaming motive with three to five items and test the psychometric properties of the factors created. Furthermore, we assumed that numerous different motives would emerge from the systematic literature search and measurement instruments identified; therefore, we aimed to test the higher-order structure of these motives and the construct validity of the structure obtained.

3.1 Overview of Study Stages

The study comprised four separate analytical stages. In Stage 1, we conducted a systematic literature review of studies in which psychometric instruments were applied to assess video gaming motives empirically. From these instruments, a comprehensive and genre-neutral item pool was generated, in which items were clustered in motivational factors derived from the previous literature on gaming motives. Data were collected from a large-scale sample of highle engaged video game players to examine (a) the psychometric properties and higher-order structure of the motivational factors (Stage 2); (b) associations of the higher-order motivational dimensions with demographic, gaming-related, personality, and psychological variables (Stage 3); and (c) associations of the motives with depression symptoms, GD symptoms, and gaming time (Stage 4). The aim in Stages 2 and 3 was to test the construct validity of the identified motives.

3.2. Method and Results

3.2.1. Stage 1: Systematic Literature Review and Item Pool Creation

To develop a comprehensive and genre-neutral pool of items assessing gaming motives, we first ran a systematic literature review to identify studies in which gaming motives were measured empirically. We conducted a computer database search of PubMed, ScienceDirect, Web of Science, and Scopus on November 21, 2019, using the following search terms and logic: (videogame OR videogames OR video game OR video games OR videogaming OR video gaming OR computer game OR computer games OR computer gaming OR internet game OR internet games OR internet gaming OR digital game OR digital games OR digital gaming OR online game OR online games OR online gaming OR excessive gaming OR compulsive gaming OR gaming addiction OR gaming disorder OR problematic gaming OR pathological gaming) AND (motive OR motives OR motivation OR motivations OR motivational). All searches were limited to full-text papers (i.e., journal articles, book chapters, and review papers) published in English. These database search parameters yielded a total of 3,965 hits: PubMed (396 results), ScienceDirect (300 results), Scopus (1,745 results), Web of Science (1,524 results). After duplicates were deleted, 2,463 hits remained. Abstracts and full texts, where necessary, were examined and studies were selected on the basis of using a psychometric instrument to assess video gaming motives empirically. The reference lists of the papers included were also examined. In total, 163 papers were retained (see Supplemental Figure S1 in the online supplemental materials for a

flowchart of the search procedure including exclusion criteria; the table comprising the selected papers can be requested from the corresponding author).

Next, the most frequently used motivational instruments were identified, along with motivational factors from less used scales that were assessed by the present authors as not identical, yet relevant to consider (e.g., the items had some incremental validity; Supplemental Table S1 in the online supplemental materials). A list of 100 items covering 27 motives was generated from these instruments and factors. Considering that these items were meant to serve as the initial item pool for the development of the Gaming Motivation Inventory (GMI), we aimed to be as comprehensive and inclusive as possible, covering motives used consistently in previous studies, as well as those proposed to address recent developments in gaming (e.g., financial motives related to earning money in video games, such as in e-sports, blockchain developments). Furthermore, we aimed to generate items that were genre-neutral, which involved modifying some items to remove specific references to certain games or features. The items followed two different formats: (a) “Why do you play video games? I play video games…” and (b) “What kind of gameplay do you prefer? I like video games that…”. Both item formats were answered on a 7-point Likert scale from 1 (*does not correspond at all*) to 7 (*it corresponds exactly*). The 100 items and the generation process are presented in detail in Supplemental Table S2 in the online supplemental materials.

3.2.2. Stages 2-4: Empirical Analyses Using Data from a Gamer Sample

3.2.2.1. Participants and Procedure

An online survey was designed and administered in Qualtrics (https://www.qualtrics.com) to collect data from highly engaged video gamers (i.e., a term referring to gaming as a consistent, usually daily, routine involving regular long sessions or frequent short sessions, and which typically amount to a substantial weekly commitment that approximates part-time or full-time employment). The most popular Hungarian gaming magazine, *GameStar*, targeting the Hungarian-speaking gamer community (living in Hungary and surrounding countries such as Romania, Serbia, Slovakia, and Ukraine), promoted our survey among online readers and Facebook followers. Three advertisements containing the link to the questionnaire were posted on the magazine’s website and Facebook page in March and April 2020 (a period when stay-at-home restrictions due to the COVID-19 pandemic were in force in the target countries). Paid Facebook ads were also used to reach the target audience during this period. Incentives were offered in the form of shopping vouchers (20 vouchers of 30

euros each, five vouchers of 60 euros each, and two vouchers of 300 euros each). All articles contained the link to the questionnaire, as well as a description of the aims of the survey, the cooperation between our research group and the gaming magazine, and the opportunity to win some of the prizes. We also emphasized that the results of the survey would be reported on the website of the magazine, which was done in the first half of 2021.[2]

Before starting the questionnaire, participants were informed about the aim of the study and the time necessary for completion and they were assured about anonymity and confidentiality. They provided informed consent by ticking a box if they agreed to continue and participate in the study (children 14–17 years old had to tick another box for parental permission). Email addresses were obtained from those willing to participate in the draw and used only to contact the winners.

On the basis of our previous data collection experiences with the same gaming magazine, we aimed for a sample of a minimum of 5,000 participants in approximately 4 weeks to avoid any possible timing effect and because, after the first 4 weeks, the rate of completion had considerably decreased in previous data collections. In total, 20,300 gamers started the survey. Initial data cleaning resulted in the removal of cases with severe inconsistencies, identical answers to items of longer scales, and an unreliably fast completion time (n = 105 in total). Because of the length of the questionnaire, we noticed a gradual attrition, in which 49.8% of the sample (n = 10,104) fully completed the survey and 59.7% (n = 12,065) had a maximum of two missing values. We decided to remove cases of participants who withdrew before answering the motivational item list. Therefore, a sample of 14,740 cases was used for the analyses. The listwise deletion method in SPSS version 25 (IBM Corp., 2017) and the full information maximum likelihood method in Mplus 8 (Muthén & Muthén, 1998–2017) were used to treat missing values.

3.2.2.2. Measures

Sociodemographic information (age, gender, marital status, education, current study and work status) and questions regarding gaming habits were collected. The following gaming-related variables were assessed: weekly gaming time, gaming platform, and game genres. *Average weekly gaming time* was assessed with two

[2] Three popular-science articles in Hungarian appeared that described part of the findings of the present research project: https://www.gamestar.hu/extralife/mi-motivalja-a-magyar-gamert-287693.html; https://www.gamestar.hu/extralife/sokat-mesel-el-a-szemelyisegedrol-ahogy-jatszol-289916.html; https://www.gamestar.hu/extralife/hogyan-vehetjuk-eszre-a-jatekfuggoseg-jeleit-293161.html.

separate questions asking the exact hours (to one decimal) for an average weekday and weekend day. Values could be given between 0 and 12; if respondents played more than 12 hours a day, they were instructed to record 12. The two variables were combined during the analysis ([hours on an average weekday × 5] + [hours on an average weekend day × 2]). *Gaming platform* use in the previous year was assessed by asking respondents to divide 100% use among four response options: (a) PC/laptop, (b) gaming console, (c) smartphone, and (d) mobile devices other than smartphones (e.g., phone, tablet, handheld console). *Game genres* were measured in a similar way for the previous year by dividing 100% use among the following response options: (a) shooters, first-person shooter, third-person shooter (e.g., Call of Duty, Counter-Strike, Overwatch), (b) battle royale (e.g., Fortnite, PUBG), (c) multiplayer online battle arena (MOBA; e.g., League of Legends, Dota 2), (d) auto chess/auto battler games (e.g., Hearthstone Battlegrounds, Teamfight Tactics, Dota Underlords), (e) open-world action-adventure (e.g., GTA series, Red Dead Redemption, Watch Dogs), (f) role-playing games (e.g., Witcher, Skyrim), (g) online role playing games (RPGs), MMORPGs (e.g., World of Warcraft, Guild Wars 2, The Elder Scrolls Online), (h) strategy games, real-time strategy, turn-based strategy (e.g., StarCraft, Hearthstone, Civilization, XCOM), (i) card games (e.g., Hearthstone, Magic: The Gathering Arena, The Elder Scrolls: Legends), (j) sport games (e.g., FIFA, Need for Speed, Madden NFL), (k) simulations (e.g., vehicle: Euro Truck Simulator, animal: Goat Simulator, life: The Sims), other (e.g., puzzle, platformer, casual games, Facebook games).

Gaming motives were assessed by administering the motivational item pool comprising 100 items (see Supplemental Table S2 in the online supplemental materials) to the sample. To avoid systematic missing values on the later part of the item pool because of fatigue that may have appeared due to the lengths of the inventory, we randomized the items of the two blocks for each participant individually[3]. More specifically, we randomized items 1 to 78 of the first format "Why do you play video games? I play video games…" and then items 79-100 of the second format "What kind of gameplay do you prefer? I like video games that…" separately.

Sociability was assessed with five items proposed by Asendorpf and Wilpers (1998). The scale measures the preference for being with people (e.g., "I find people more stimulating than everything else"). Responses were answered on a 5-point scale

[3] Qualtrics software provides the option to randomize the items of a scale for each respondent individually returning the items in the original order when data is downloaded.

from 1 (*strongly disagree*) to 5 (*strongly agree*), with one reversed item. Summarized scores ranged from 5 to 25, higher scores indicating stronger sociability. Cronbach's alpha was .82 in the present sample.

Competitiveness was assessed with three items from the nine-item Enjoyment of Competition subscale of the Revised Competitiveness Index (Harris & Houston, 2010; Houston et al., 2002). The items were as follows: (i) "I like competition," (ii) "I am a competitive individual," and (iii) "I find competitive situations unpleasant" (reversed item). Items were selected by taking into consideration their content and factor loadings in the original study. We decided to use only three items because of the high semantic similarity of the original nine items. Responses were given on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Summarized scores ranged from 3 to 15, higher scores indicating a more competitive nature. Cronbach's alpha in the present sample was .84.

Sensation seeking is the tendency to enjoy and pursue activities that are stimulating or exciting and the willingness to try new and unconventional experiences. It was assessed with the four-item subscale of the short version of the UPPS-P Impulsive Behavior Scale (Billieux et al., 2012; Zsila et al., 2020). Responses were obtained on a 4-point scale (1 = strongly agree, 2 = agree somewhat, 3 = disagree somewhat, 4 = strongly disagree). All items were reversed during the analyses; therefore, the summed total scores ranged from 4 to 16, higher scores being indicative of stronger sensation seeking tendencies. Cronbach's alpha was .80 in the present sample.

Self-esteem was measured with the five positive items of the Rosenberg Self-Esteem Scale (Rosenberg, 1965). These items were selected to reduce the length of the questionnaire and because they cluster in a methodological factor that has a high correlation with the entire scale. Responses were provided on a 4-point scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Summarized scores ranged from 5 to 20, higher scores indicating higher self-esteem. Internal consistency on the present sample was .87.

Self-esteem when playing video games was assessed with a modified version of the five positive items of the Rosenberg Self-Esteem Scale (Rosenberg, 1965). Items were complemented with the statement "When I play games, …" and respondents were asked to think about their gaming activity when answering the questions. Internal consistency on the present sample was also .87.

Positive and negative affect trait version was measured with the 20-item Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). PANAS comprises 20 words describing mood (e.g., interested, distressed, upset, strong) and has two factors, positive and negative affect (10 items each), which are highly uncorrelated with each other. Items were rated on a 5-point scale (1 = very slightly or not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely) and respondents were asked about mood/characteristics in general (trait type). Scores on both subscales ranged from 10 to 50, with higher scores indicating higher positive or negative affect. Both scales had high internal consistencies in the present sample, $\alpha_{\text{PANAS positive}} = .87$, $\alpha_{\text{PANAS negative}} = .86$.

Perceived stress was measured for the previous 3 months with the short four-item version of the Perceived Stress Scale (Cohen, 1986; Cohen & Williamson, 1988), which assesses how uncontrollable and overloaded respondents find their lives to be and the degree to which situations in their life is appraised as stressful. Responses were obtained on a 5-point scale (1 = never, 2 = almost never, 3 = sometimes, 4 = often, 5 = very often). Summarized scores ranged from 5 to 20, with higher scores indicating higher perceived stress. Cronbach's alpha was .77 in the present sample.

GD symptoms were assessed with the Ten-Item Internet Gaming Disorder Test (IGDT-10; Király et al., 2019; Király et al., 2017a). The IGDT-10 assesses internet gaming disorder (IGD) criteria in the previous 12 months, as proposed in the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association, 2013). Items referred to video gaming in general, not only internet gaming. Responses were recorded on a 3-point scale (never, sometimes, often) and dichotomized (never and sometimes were coded as "no," often was coded as "yes") during the analysis to match the categorical nature of the *DSM-5*. The last IGD criterion ("Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of participation in Internet games") was operationalized with two items to avoid having double-barreled questions. These two items were merged during the analysis in such a way that an "often" response given to any of the two items meant a "yes" for the merged criterion. Furthermore, in this study, we decided to exclude Item 8 of the IGDT-10 that assesses "escapism or mood relief" to avoid overlap with the Immersion/Escapism higher-order motive when assessing the association of the two variables (see Giardina et al., 2021a, for a similar approach). Thus, total scores on the IGDT-10 ranged from 0 to 8, higher scores indicating more IGD symptoms. Composite reliability for the instrument comprising the eight dichotomized items was .88.

Depression symptoms were measured with the six-item version of the Center of Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977), used in the European School Survey Project on Alcohol and Other Drugs (ESPAD; Hibell et al., 2009). When answering the questions, respondents were asked to think of the previous 3 months. CES-D is not designed to diagnose clinical depression, but it is a valid screening instrument to assess depressive mood and emotional suffering. The validity of the six-item version was reported in the *2007 ESPAD Report* (Hibell et al., 2009). Items were answered on a 4-point scale (*rarely or never* to *most of the time*). Scores ranged from 4 to 24, with higher scores indicating higher depressive mood level or more depression symptoms. Cronbach's alpha was .81 in the present sample.

3.2.2.3. Transparency and Openness

We report how we determined our sample size, data exclusions, all manipulations, and all measures in the study, and we follow the Journal Article Reporting Standards (Kazak, 2018). All data and analysis code are available at the open science framework: https://osf.io/tfhjx/. All research materials are described in detail in the manuscript. Analyses were performed with SPSS version 25 (IBM Corp., 2017) and Mplus 8 (Muthén & Muthén, 1998–2017). This study's design and its analysis were not preregistered.

Ethics

The study was approved by the Institutional Review Board of ELTE Eötvös Loránd University and was performed in line with the Helsinki Declaration.

3.2.2.4. Descriptive Statistics

The majority of the respondents in the sample were male (89.3%), with a mean age of 24.1 years (*SD* = 7.0) and a range between 14 and 75 years. Approximately half were single (48.3%), the other half being in a relationship and living either separately (22.8%) or together (28.3%). Some of the respondents were studying at the time of data collection (47.0%), and 50.6% had a full-time job. Overall, the sample comprised highly engaged video gamers, who played 27.6 hours per week on average (*SD* = 14.9). Respondents divided 100% of their time between four gaming platforms that they had used in the previous year: PCs/laptops were the most used at 47.7% on average, consoles followed at 36.2%, and then smartphones at 14.7%. Gaming genres were assessed similarly. The most popular genre in the present sample was shooters (25.1%), followed by open-world action-adventure games (17.0%), RPGs (12.0%), battle royale games (10.1%), and sport games (9.4%) (Table 1).

Table 1

Demographics and Gaming-Related Information of the Sample

Demographics	Total sample (N = 14,635-14,740)[a]
Gender, male	13,157 (89.3%)
Age, years; mean (*SD*)	24.1 (7.0)
Education (number of years completed), mean (*SD*)	13.0 (2.7)
Marital status	
Single	7,105 (48.3%)
In a relationship but living separately	3,357 (22.8%)
Married/living in a partnership	4,166 (28.3%)
Divorced	75 (0.5%)
Widowed	7 (<0.1%)
Currently a student	6,927 (47.0%)
Working status	
Does not work	5,378 (36.5%)
Has a full-time job	7,449 (50.6%)
Has a part-time job	782 (5.3%)
Works on ad hoc basis	1,125 (7.6%)
Gaming time	
On an average weekday (hours)	3.3 (2.1)
On an average weekend day (hours)	5.6 (2.7)
On an average week (hours)	27.6 (14.9)
Gaming platform (respondents divided 100% use among platforms in the previous year); mean % (*SD*)	
PC/laptop	47.7 (38.1)
Console (e.g., Xbox, PS, Wii)	36.2 (36.5)
Smartphone	14.7 (18.4)
Other mobile device (e.g., tablet)	1.4 (6.5)
Gaming genre (respondents divided 100% use among genres in the previous year); mean % (*SD*)	
Shooters, FPS, TPS (e.g., Call of Duty, Counter-Strike, Overwatch)	25.1 (24.5)
Battle royale (e.g., Fortnite, PUBG)	10.1 (18.0)
MOBA (e.g., League of Legends, Dota 2)	6.8 (16.7)
Auto chess/auto battler games (e.g., Hearthstone Battlegrounds, Teamfight Tactics, Dota Underlords)	2.3 (7.4)
Open-world action-adventure (e.g., GTA series, Red Dead Redemption, Watch	17.0 (19.6)

Dogs)	
Role-playing games, RPGs (e.g., Witcher, Skyrim)	12.0 (18.6)
Online role-playing games, MMORPGs (e.g., World of Warcraft, Guild Wars 2, The Elder Scrolls Online)	5.4 (14.5)
Strategy games, RTS, TBS (e.g., Starcraft, Hearthstone, Civilization, XCOM)	3.7 (9.9)
Card games (e.g., Hearthstone, Magic: The Gathering Arena, The Elder Scrolls: Legends)	1.4 (5.6)
Sport games (e.g., FIFA, Need for Speed, Madden NFL)	9.4 (17.6)
Simulations (e.g., vehicle: Euro Truck Simulator, animal: Goat Simulator, life: Sims)	3.8 (10.9)
Other (e.g., puzzle, platformer, casual games, Facebook games)	3.1 (10.1)

Note. PC = personal computer; FPS = first-person shooter; TPS = third-person shooter; MOBA = multiplayer online battle arena; RPG = role-playing game; MMORPGs = massively multiplayer online role-playing games; RTS = real-time strategy; TBS = turn-based strategy.

[a] Sample size for the analyses varied due to missing values.

Data collection took place in March and April 2020 when restrictions were applied in Hungary because of the first wave of the COVID-19 pandemic. To examine the effects of the lockdown situation, we administered additional questions (see Supplemental Table S3 in the online supplemental materials). According to the results, 66.4% of the sample played more in this period than before the pandemic (28.2% played much more, and 38.2% played a bit more), whereas gaming habits (gaming types played, part of the week/day when playing, motives for gaming, and gaming partners) were unchanged for 42.0% of the sample and changed only a little for 28.0%.

3.2.3. Stage 2: Higher-order Structure of the Motivational Factors

To test the psychometric properties and higher-order structure of the theoretically proposed motivational factors, we collected data from a large sample of highly engaged video game players.

3.2.3.1. Statistical Analysis

First, psychometric properties of the 27 theoretically proposed motivational factors were examined by using CFA and checking Cronbach's alphas as internal consistency measures separately for each factor in the total sample. A Pearson-correlation was run to test the strength of the associations between the theoretically proposed factors. On the basis of these analyses, items with low factor loadings or overlapping content were removed and all items belonging to one motivational factor were parceled into one composite score for each motive. Second, the total sample was

divided into three non-overlapping random subsamples. Sample 1 ($N = 4{,}905$) was used to perform an initial EFA of the theoretically proposed motivational factors (items were averaged). Sample 2 ($N = 4{,}894$) was used to conduct a separate EFA to cross-validate the factor structure found in the first analysis. Samples 1 and 2 were used to define the factor structure tested separately, with an exploratory structural equation modeling (ESEM) analysis on Sample 3 ($N = 4{,}941$). The two EFAs were conducted with a principal axis factoring estimation method and oblique rotation, Promax (Kappa = 4), because factors were expected to be correlated. The number of factors was determined from the eigenvalues (larger than 1.0) and theoretical interpretability of the factors.

To cross-validate the higher-order factor structure obtained from the two EFA analyses, we conducted an ESEM analysis. In contrast to CFA, where items are defined to load only on their respective factor, whereas cross-loadings are constrained to zero, in ESEM analysis, items are defined to load on their main factors, whereas cross-loadings are "targeted," but not forced, to be as close to zero as possible with the oblique target rotation procedure (Browne, 2001). We chose to retain all motives for the ESEM analyses despite the existence of weak factor loadings and considerable cross-loadings in order to maximize the comprehensiveness of the item pool and motives they covered. The robust maximum likelihood estimator (MLR) was used because it provides standard errors and tests of model fit that are robust to the non-normality of the data. When interpreting the magnitude of the factor loadings, the following thresholds were applied: excellent above 0.71, very good between 0.63 and 0.70, good between 0.55 and 0.62, fair between 0.44 and 0.33, and poor below 0.32 (Comrey & Lee, 2013).

To evaluate the goodness of fit of measurement models (e.g., ESEM), we relied on a combination of several different goodness-of-fit indices (Brown, 2015): the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). The following rough guidelines for adequate and excellent thresholds for these fit indices (Hu & Bentler, 1999; Marsh, 2007; Marsh et al., 2005; Marsh et al., 2004) were applied: values greater than 0.90 and 0.95 were considered adequate and excellent, respectively, in the case of CFI and TLI, and values smaller than 0.08 and 0.06 indicated acceptable and excellent model fit, respectively, for the RMSEA and SRMR. We also report the robust chi-square (χ^2) test of exact fit; however, this fit index tends to be oversensitive to sample size and minor model misspecifications (Byrne, 2010).

Missing data in Mplus were treated with the full information maximum likelihood method (Muthén & Muthén, 1998-2017).

3.2.3.2. Results

First, CFAs were performed separately on each of the 27 theoretically proposed motivational factors to examine their psychometric properties. Fit indices, modification indices, factor loadings, and internal consistency measures were examined and are shown in Supplemental Table S4 in the online supplemental materials. Each of the 27 factors comprised three to five items. When only three items covered a factor, the degree of freedom was 0 and model fit was not informative. However, factor loadings were > 0.6 for all items in all these cases (see Supplemental Table S4). For factors with four or five items, fit indices did not meet the proposed thresholds in a few cases. In these cases, items with relatively low factor loadings were removed. Where modification indices indicated high error covariance between items, one or two items per factor were removed. The process for each factor is detailed in Supplemental Table S4. After "cleaning" the factors, we conducted a correlation analysis to determine the associations between the 27 motives. All correlations were < 0.7 except for Exploration and Mechanics motives (r = .744). These factors were merged, and four items were retained in the final merged factor, fitting the data well. Psychometric details related to the newly merged factor can also be seen in Supplemental Table S4. Finally, 88 items remained, parceled in 26 motives (see Appendix A and B for the GMI). Descriptive statistics for the motives can be seen in Supplemental Table S5 in the online supplemental materials. The strength of the associations between the 26 final motives varied between r = .003 (p = .741) and r = .695 (p < .001) and can be seen in Supplemental Table S6 in the online supplemental materials.

Second, we conducted two EFAs on two non-overlapping random subsamples (i.e., Samples 1 and 2) to investigate how the 26 motivational factors cluster into higher-order motivational dimensions. Six factors had eigenvalues above 1, and structures with five, six, and seven factors were examined. The factor structure with six factors was retained because of theoretical considerations. Table 2 shows factor loadings and percentages of total variance explained for both samples.

Table 2

Exploratory Factor Analysis of the 26 Motivational Factors on Two Non-Overlapping Random Subsamples (n_1 = 4,587; n_2 = 4,562)

	Mastery		Immersion/ Escapism		Competition		Stimulation		Social		Habit/Boredom	
	Sample1	Sample 2	Sample1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Advancement	.757	.788			.126	.127						
Amotivation	.178	.153									.728	.717
Autonomy	.494	.538	.502	.437								
Boredom			.170	.173	.136		.173	.177			.403	.410
Competence	.178	.181	.297	.286	.584	.606						
Competition	.134		-.241	-.185	.696	.697	.208	.230				
Completion	.835	.828	-.155	-.161	.199	.160			-.153	-.123		
Coping	-.172	-.154	.700	.681			.138	.150				
Escape	-.194	-.182	.867	.867								.108
Exploration + Mechanics	.919	.936						-.121			.104	
Fantasy	.197	.198	.766	.765	-.156	-.185						
Financial					.361	.405					.104	
Game skills	.608	.641	-.118	-.155	.508	.476					-.101	
Identity	.133	.190	.616	.597	.229	.242	-.152	-.175			-.104	-.126
Introjected regulation	-.101		.518	.539	.381	.360			-.115	-.111	.167	.121
Recreation		.131	.351	.283	-.181	-.237	.149	.210			-.220	-.219

Skill development	.312	.387	.163		.281	.260			.131	.127	-.163	-.119
Social			.160	.175	.262	.280	-.148	-.135	.638	.599		
Status				.104	.745	.756						
Arousal-action					.230	.217	.639	.675				
Cooperation			-.133	-.103					.895	.910		
Customization	.307	.382	.138		-.145	-.142	.298	.308				.127
Destruction			.153	.127	.161	.163	.556	.558			.126	.110
Graphics							.559	.538				
Story	.392	.412	.251	.218	-.457	-.404	.172	.151				
Strategy	.423	.371	-.117	-.129	-.107				.322	.356		
% of total variance explained	33.23	33.30	9.13	9.19	8.32	7.99	5.44	5.57	4.27	4.21	3.96	3.99

Note. Factor loadings below .10 are not included.

In line with the eigenvalue information, the first three factors were more robust with more motives loading strongly on them, whereas the last three factors had only two to three motives loading on them. The merged motivation of exploration and mechanics, completion, advancement, and game skills loaded strongly on the first higher-order factor, whereas autonomy, strategy, story, customization, and skill development loaded weakly, and some (autonomy, story) had cross-loadings with other higher-order factors. On this basis, the first factor was named *Mastery*. The second factor was labeled *Immersion/Escapism* because escape, fantasy, coping, identity, and introjected regulation loaded strongly on it. In addition, autonomy, recreation, competence, and story had weak loadings. The third factor had status, competition, competence, and game skills loading on it strongly and several other motives loading weakly, including financial, introjected regulation, skill development, social, action-arousal, and identity, of which only financial did not have cross-loadings on other factors. The third higher-order factor was labeled *Competition*. The fourth higher-order motivational dimension was called *Stimulation* because it had arousal-action, destruction, and graphics loading on it, whereas competition, customization, and recreation had weak loadings and cross-loadings with other higher-order factors. The fifth higher-order factor had cooperation and social loading strongly on it and strategy loading weakly. Therefore, it was labelled *Social*. The last higher-order factor was called *Habit/Boredom* because it had only two motives loading on it: amotivation and boredom.

To cross-validate this higher-order factor structure, we conducted an ESEM analysis on the third random subsample (Sample 3). The model had an adequate fit to the data, $\chi^2(184) = 3264.4$, $p < .001$; CFI = 0.944; TLI = 0.901; RMSEA = 0.059, 90% confidence interval 0.057-0.060; SRMR = 0.021. Autonomy, game skills, introjected regulation, skill development, and strategy motives had considerable cross-loadings. Furthermore, recreation, skill development, customization, story, and strategy had low factor loadings. Correlations between the six higher-order factors ranged from -0.013 to 0.480 (Table 3), the strongest association being between Competition and Social.

Table 3

Exploratory Structural Equation Modeling of the 26 Motivational Factors from the Results of the Exploratory Factor Analysis (n_3 = 4,872)

	Mastery	Immersion/ Escapism	Competition	Stimulation	Social	Habit/Boredom
	Factor loadings					
Advancement	**.730**	.018	.196	.059	-.080	-.011
Amotivation	.057	-.032	.012	-.049	.033	**.677**
Autonomy	**.533**	**.458**	-.040	.021	.000	.030
Boredom	-.024	.093	.066	.167	-.013	**.464**
Competence	.145	**.332**	**.606**	.021	.005	-.014
Competition	.101	-.183	**.660**	.243	.053	.043
Completion	**.778**	-.087	.193	.018	-.102	.037
Coping	-.070	**.631**	.115	.158	.046	-.051
Escape	-.113	**.783**	.050	.020	-.011	.099
Exploration + Mechanics	**.878**	.030	-.014	-.147	.085	.071
Fantasy	.217	**.735**	-.109	.073	-.053	.035
Financial	.024	.028	.293	-.111	.140	.127
Game skills	**.622**	-.093	**.503**	.019	.019	-.058
Identity	.159	**.620**	.273	-.133	.061	-.111
Introjected regulation	-.075	**.499**	**.335**	.002	-.033	.173
Recreation	.159	.271	-.129	.191	.035	-.237
Skill development	**.384**	.136	**.306**	-.008	.132	-.144
Social	.018	.163	.178	-.102	**.694**	-.010

Status	.005	.125	**.692**	.035	.144	.054
Arousal-action	.079	-.009	.222	**.644**	.111	-.052
Cooperation	.009	-.124	-.020	.102	**.875**	.005
Customization	**.324**	.127	-.143	.286	.106	.075
Destruction	-.007	.156	.086	**.534**	.025	.165
Graphics	.090	.015	.004	**.503**	-.042	-.165
Story	.344	.237	**-.341**	.180	.010	-.038
Strategy	**.390**	-.104	-.113	.093	**.359**	.042

	Correlation between the factors				
	Mastery	Immersion/ Escapism	Competition	Stimulation	Social
Immersion/Escapism	.447***				
Competition	.329***	.269***			
Stimulation	.436***	.350***	.124***		
Social	.337***	.191***	.480***	.276***	
Habit/Boredom	-.223***	.111***	.172***	-.013	.047*

Note. Salient factor loadings (>0.30) are boldfaced.

*$p < .05$. ***$p < .001$.

3.2.4. Stage 3: Associations of the Higher-order Motivational Dimensions With Demographic, Gaming-Related, Personality and Psychological Variables

In Stage 3, we aimed to investigate the associations of the higher-order motivational dimensions with gaming genre, demographic, gaming-related, personality, and psychological variables to test the construct validity of the model.

3.2.4.1. Statistical Analysis

Gaming motives were introduced in the analysis as latent variables (the six higher-order motives as defined in the ESEM analysis). A correlation analysis between the six higher-order motives and the game genres was conducted, complemented with a graphical illustration of the associations between these variables. Factor scores of the six higher-order motives obtained from the ESEM analysis (having a mean of 0 and standard deviation of 1) were rescaled with minimum-maximum normalization ranging from 0 to 100.

We performed a multiple indicators multiple causes (MIMIC) analysis with the MLR estimation method in Mplus 8 to validate the six-factor motivational structure and test the association with personality traits (sociability, competitiveness, sensation seeking) and psychological variables (self-esteem, positive and negative affect, perceived stress) on the total sample. Gender and age were introduced in the model as control variables. The MIMIC technique, a specification of SEM, was chosen because it can estimate the effect of indicators on latent variables (the six higher-order motives as defined in the ESEM analysis) at the same time when direct effects of grouping variables or other continuous variables on the latent variables are also included, and it increases the precision of estimations because of the elimination of measurement errors. In addition, the zero-order correlation matrix of the variables included in the MIMIC model was established.

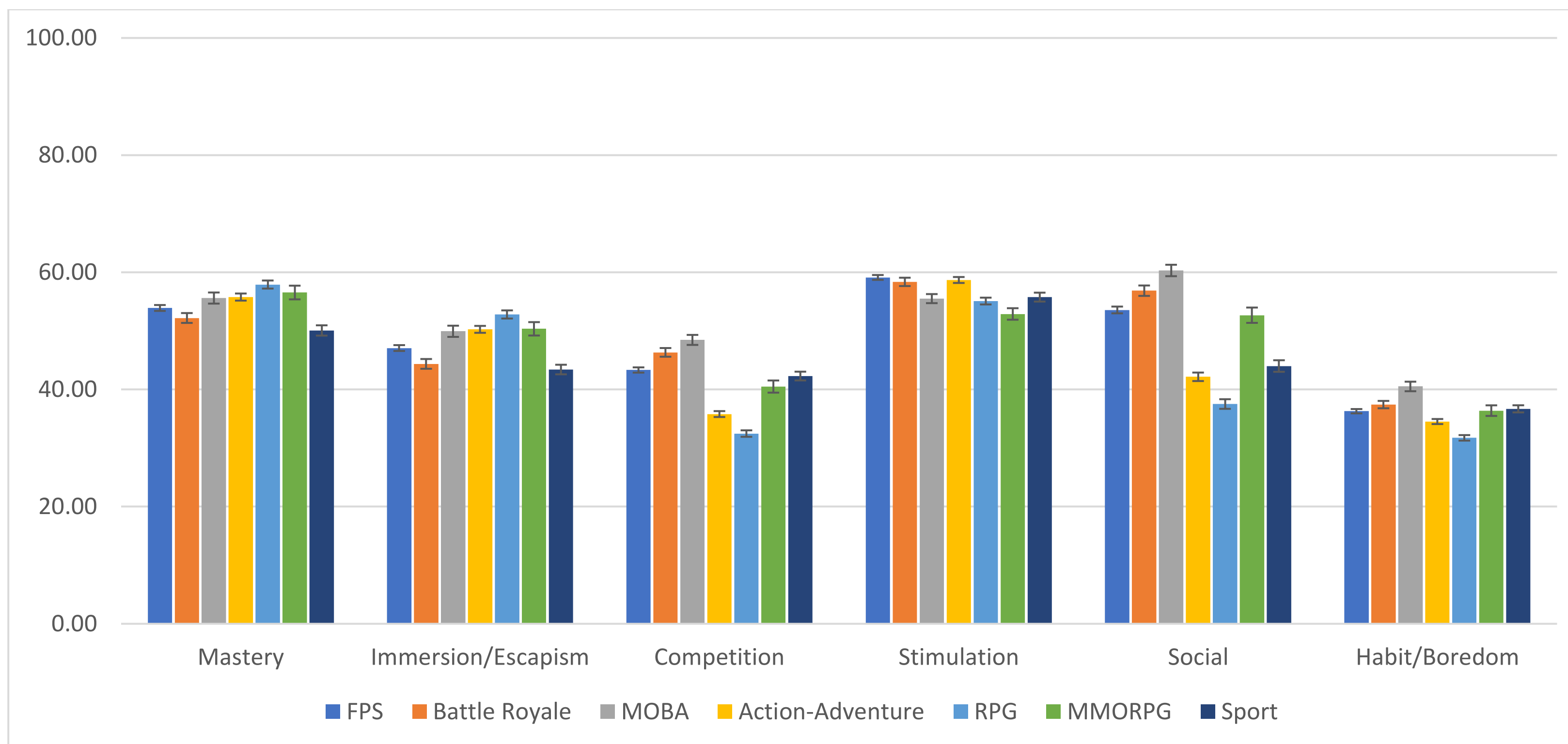
3.2.4.2. Results

Gaming Motives and Game Genres. To test the associations between gaming motives and game genres, we first computed a correlation matrix (Supplemental Table S7 in the online supplemental materials). Correlations were very weak in general, ranging from -.251 to .201, the former being between the Competition higher-order motive and the RPG genre. The highest positive correlation coefficient found was .201 between the Social higher-order motive and the MOBA genre. Second, we created a graphical illustration of the motives and the seven most popular genres in our sample (Figure 1). Gaming genre

variables were dichotomized (respondents who indicated a percentage equal to or higher than 30% in a particular genre were considered players with a preference for that genre and were included in the analysis).

Figure 1

Gaming Motivation Scores Compared Across the Seven Most Popular Gaming Genres in the Study Sample



Note. 95% confidence intervals are presented on the bar charts. FPS = first-person shooter; MOBA = multiplayer online battle arena; RPG = role-playing game; MMORPG = massively multiplayer online role-playing game. FPS group (n=5,307); Battle Royale group (n=1,835); MOBA group (n=1,434); Action-adventure group (n=3,463); RPG group (n=2,456); MMORPG group (n=978); Sport group (n=1,739). The summarized sample size of the seven groups exceeds the total sample size because groups partially overlap.

According to the results, several significant differences in all six motives were found between the players of the seven gaming genres, but the magnitude of these differences was generally small. The largest differences were found in the Social and Competition higher-order motive scores between the players with a preference for the MOBA and RPG genres (16-point difference in the Competition higher-order motive scores and 23-point difference in the Social higher-order motive scores on a 100-point scale). Furthermore, players with a preference for the MOBA genre had the highest scores in the Social, Competition, and Habit/Boredom higher-order motives; players with a preference for the RPG genre had the highest scores in the Mastery and Immersion/Escapism higher-order motives; and players with a preference for action-adventure, first-person shooter, and battle royale genres had the highest scores in the Stimulation higher-order motive.

MIMIC Model. A MIMIC analysis was done to test the associations between the six higher-order motivational factors and numerous predictors. According to the results, associations between relevant personality and psychological variables and the six higher-order motives were as expected (see Table 4 for the standardized regression coefficients of the MIMIC model and Supplemental Table S8 in the online supplemental materials for the correlation coefficients of the variables included in the model). For instance, the Mastery higher-order motive was moderately associated with positive affect and weakly with sensation seeking. The Immersion/Escapism higher-order motive was positively and moderately associated with negative affect and weakly with perceived stress, and it was negatively associated with competitiveness with weak effect size. The Competition higher-order motive was most strongly associated with competitiveness, and it was also weakly associated with negative affect and negatively associated with age with weak effect size. The Stimulation higher-order motive was also weakly associated with competitiveness, sensation seeking, and negative affect. The Social higher-order motive was moderately associated with sociability and negatively associated with age with medium effect size, and the Habit/Boredom higher-order motive was moderately associated with negative affect and negatively associated with positive affect and age, having medium effect sizes in both cases.

Table 4

*How Relevant Psychological Variables Predict the Six Main Motivations: Path Coefficients of Multiple Indicator Multiple Cause Model (*N*=14,740)*

	Gaming motive					
Predictor	Mastery	Immersion/ Escapism	Competition	Stimulation	Social	Habit/ Boredom
Self-esteem	-.096***	-.063***	-.023*	.052***	-.087***	-.036
Positive affect	.344***	.123***	.033**	.092***	.097***	-.220***
Negative affect	.024	.242***	.154***	.128***	.010	.250***
Sociability	-.087***	-.103***	-.016	-.020	.261***	.067**
Competitiveness	.012	-.148***	.604***	.187***	.133***	-.120*
Perceived stress	.077***	.188***	.044***	.053**	.030*	.148***
Sensation seeking	.123***	.080***	-.008	.174***	.083***	.050**
Age	-.067***	-.080***	-.155***	-.045	-.250***	-.266***
Gender	.056***	.062***	-.034***	-.060*	-.041***	-.103***

Note. Effect sizes are provided as standardized betas. Gender: males were coded as 0, females as 1. *$p < .05$. **$p < .01$. ***$p < .001$.

In addition, the relation of COVID-19 distress with the six higher-order motivational factors was analyzed (see Supplemental Figure S2 in the online supplemental materials). Results showed that the relatively small group whose mood has improved due to the pandemic situation reported significantly higher scores across all motives than those whose mood has not changed or worsened. Besides, the group whose mood worsened scored higher on Immersion/Escapism and Habit/Boredom motives and lower on Social motive than the group whose mood has not changed.

3.2.5. Stage 4: Associations of the Higher-order Motivational Dimensions With Depression Symptoms, Gaming Disorder Symptoms, and Gaming Time

Finally, in Stage 4, as the last step of the validation process, we examined how the six higher-order motives mediated between depression symptoms and GD symptoms and gaming time. We aimed to compare the mediation model with similar models reported previously[4] (e.g., Ballabio et al., 2017; Bányai et al., 2019; Király et al., 2015).

3.2.5.1. Statistical Analysis

To test the direct and the indirect effects (via the higher-order gaming motives) of depression symptoms on GD symptoms and gaming time, we performed structural regression analyses within structural equation modelling (SEM) with the MLR estimation method. We assumed that depression symptoms have both a direct and indirect effect (via the mediating effect of the six higher-order gaming motives) on GD symptoms and gaming time. Depression symptoms were measured with the short version of the CES-D and introduced in the model as a continuous observed variable. GD symptoms were assessed by the summarized score of the dichotomized IGDT-10 items, except for Item 8 (i.e., escaping or relieving a negative mood; see Measures section), and implemented in the model as a continuous observed variable. Gaming time was calculated from time spent on games during weekdays and weekend days and was also entered in the model as a continuous observed variable. Higher-order gaming motives were introduced in the model as

[4] Mediation models reported previously used general psychiatric distress (an index composed of multiple psychiatric symptoms including depression and anxiety symptoms) as a predictor. In this study, we decided to only assess depression symptoms as one of the most common psychiatric symptoms, and because of its high correlations with other psychiatric symptoms such as anxiety symptoms (Jacobson & Newman, 2017).

continuous latent variables as defined in the ESEM analysis. In addition, Pearson's correlation coefficients of the variables included in the mediation model were calculated.

3.2.5.2. Results

According to the results of the mediation model (see Figure 2 for the model, Table 5 for the mediation pathways, Supplemental Table S9 in the online supplemental materials for the predictive effects in the model, and Supplemental Table S10 in the online supplemental materials for the correlation coefficients between the variables included in the model), depression symptoms had a significant direct effect on GD symptoms ($\beta = .180$, $p < .001$), as well as on four of six higher-order gaming motives, the strongest effects being on Habit/Boredom ($\beta = .415$, $p < .001$) and Immersion/Escapism ($\beta = .389$, $p < .001$). Regarding the associations between motives and GD symptoms, Immersion/Escapism, Habit/Boredom, and Competition motives had considerable effect sizes ($\beta = .228$, $\beta = .216$, and $\beta = .199$, respectively).

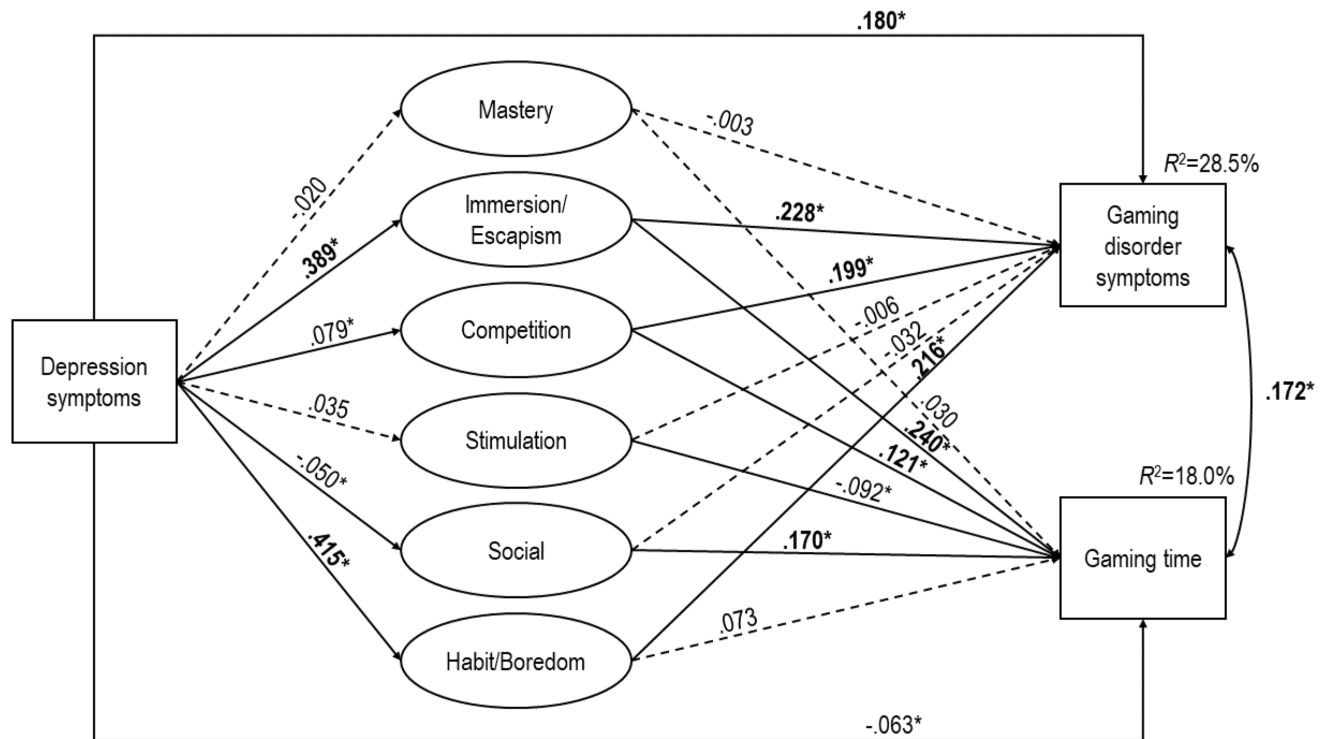
In relation to the indirect effect between depression symptoms and GD symptoms, three paths were statistically significant at the $p < .001$ level: (a) depression symptoms → Immersion/Escapism → GD symptoms ($\beta = .089$, $p < .001$); (b) depression symptoms → Habit/Boredom → GD symptoms ($\beta = .089$, $p < .001$); and (c) depression symptoms → Competition → GD symptoms ($\beta = .016$, $p < .001$). However, the latter pathway had a negligible effect size. The mediation pathways added up to a total standardized indirect effect size of .195 ($p < .001$). The proportion of the mediated effect in the total effect was 52%. Therefore, higher levels of depression symptoms were associated with higher Immersion/Escapism, Habit/Boredom, and Competition motives that were associated with higher GD symptoms. The full model explained 28.5% of the total variance of GD symptoms.

Furthermore, depression symptoms had a negative direct effect on gaming time, with a very small effect size ($\beta = -.063$, $p < .001$). Regarding the association between motives and gaming time, Immersion/Escapism, Social, and Competition had considerable effect sizes ($\beta = .240$, $\beta = .170$, and $\beta = .121$, respectively). Comparing the correlation and path coefficient between Stimulation and gaming time ($r = .133$, $p < .001$ vs. $\beta = -.092$, $p < .001$), we suspect a negative suppressor effect (Ludlow & Klein, 2014); therefore, we have not interpreted that association.

In relation to the indirect effect between depression symptoms and gaming time, only the pathway through Immersion/Escapism was close to 0.1 (β = .093, $p < .001$). The path through Habit/Boredom had an effect size of β = .030, $p = .021$, whereas the one through Competition was β = .010, $p < .001$ and the one through Social motive was β = -.009, $p < .001$. The mediation pathways added up to a total standardized indirect effect size of .121 ($p < .001$). Consequently, higher levels of depression symptoms were associated with a stronger Immersion/Escapism motive that was associated with higher GD symptoms. The full model explained 18.0% of the total variance of gaming time. Finally, the association between gaming time and GD symptoms was 0.172 ($p < .001$) in the model.

Figure 2

*Mediation Model Between Depression Symptoms and Gaming Disorder Symptom Severity and Gaming Time (*N*=14,740)*



Note. Values on single-headed arrows are standardized regression coefficients (β). The value on the double-headed arrow represents a correlation coefficient. Due to the large sample size, only $^*p < 0.001$ was considered as a significant effect. Solid lines represent significant standardized regression coefficients. Dashed lines represent non-significant standardized regression coefficients. Bold letters represent considerable standardized regression coefficients (β > 0.1). Gaming disorder symptoms were calculated by

summarizing the dichotomized Ten-Item Internet Gaming Disorder Test items, except for Item 8 (i.e., escaping or relieving a negative mood). We removed Item 8 because its content conceptually overlapped with the higher-order motive Immersion/Escapism, which could have biased the results. The model was controlled for age and gender. However, to ease the interpretation of the figure, correlation coefficients between the latent variables and the covariate effects of gender and age are not shown (see Supplemental Table S10 in the online supplemental materials).

Table 5

*Mediation Pathways Between Depression Symptoms and Gaming Disorder (GD) Symptoms and Gaming Time (*N *= 14,747)*

	GD symptom severity	Gaming time
Total effect	.375***	.058***
Total direct effect	.180***	-.063***
Total indirect effect	.195***	.121***
via Mastery	.000	-.001
via Immersion/Escapism	.089***	.093***
via Competition	.016***	.010***
via Stimulation	.000	-.003*
via Social	.002	-.009***
via Habit/Boredom	.089***	.030*

Note. Effect sizes are provided as standardized betas. GD symptoms were calculated by summarizing the dichotomized Ten-Item Internet Gaming Disorder Test items, except for Item 8 (i.e., escaping or relieving a negative mood). We removed Item 8 because its content conceptually overlapped with the higher-order motive Immersion/Escapism, which could have biased the results. *$p < .05$. ***$p < .001$.

3.3. Discussion

In this study, we aimed to create a comprehensive and genre-neutral (applicable to all types of video games) gaming motivation inventory (the GMI) and test its psychometric properties and associations with personality and psychological constructs. After developing a large item pool identified by a systematic literature review, we retained 26 motives that clustered into six higher-order motivational dimensions. The findings support the validity and good psychometric properties of the basic factors, as well as the higher-order structure.

The six higher-order motives retained in the GMI appear to be sufficiently comprehensive to cover those in most previous video gaming motivational models. For

example, the higher-order motives in our model cover the three overarching motivational components (Achievement, Social, and Immersion) from Yee's research (2006) to a high degree. The Achievement component is covered by two of the six higher-order motives retained in the GMI: Mastery and Competition. In our model, these motives were clearly separated; the first refers to advancing in games, exploring, mastering game mechanics, and completing tasks and challenges, whereas the second refers to competition and winning, as well as social comparison and recognition within the gaming community. Yee's higher-order Social component is covered by the higher-order motive of the same name in the GMI. Finally, Yee's Immersion higher-order component is mostly covered by the Immersion/Escapism higher-order factor in the GMI, and some of the subcomponents of Immersion (discovery and customization) can be found in the GMI's Mastery higher-order motive. Although the motives escape, fantasy, and coping appear as distinct motives in the MOGQ (Demetrovics et al., 2011; Wu et al., 2016), they belong to one higher-order motive in the GMI: Immersion/Escapism. The reason for this is most probably the considerable correlation between these motives in both studies, caused by their potentially overlapping content. Furthermore, in a study on Turkish students and video game players, Evren and colleagues (2020) conducted an EFA on the MOGQ items, which resulted in a six-factor structure, in which coping and escape items loaded on the same factor.

Another interesting point when comparing these motivational models is that competition and community cluster together in Quantic Foundry's model in the overarching dimension called Social, and Yee argues that gamers who enjoy social interaction tend to enjoy other types of social interaction too, including competing with fellow players (Yee, 2017). In line with this, the Competition and Social higher-order motives have the highest correlation (r = .48) in the GMI.

To test the construct validity of the six higher-order motivational dimensions in our model, we first checked their associations with gaming genres, relevant personality and psychological variables, age, and gender. The associations between the six higher-order motives and game genres were generally weak. The reason for this may be that video games today are designed in a way to motivate gamers in several different and complementary ways; consequently, there are few differential links between distinct game genres and specific motives. MMORPGs, for instance, are known for the large variety of

different gameplay choices that they offer. They can be highly competitive through the so-called player versus player challenges and highly cooperative through the so-called player versus environment challenges, but they also offer quests for players who like to play alone and focus more on exploration, customization, or role playing an imaginary character (Yee, 2006b). Furthermore, shooter games, battle royale games, and the MOBA genre have both strong competition and social elements through team-based matches. To succeed as a team member, one must be competitive, strategic, and cooperative at the same time.

The associations between the higher-order gaming motives and relevant personality and psychological variables (i.e., self-esteem, positive and negative affect, perceived stress, sensation seeking, sociability, competitiveness) were in line with expectations and previous findings supporting the validity of the motivational structure. The Competition higher-order motive was strongly associated with competitiveness and the higher-order motive Social was moderately associated with sociability. Stimulation was weakly associated with competitiveness, sensation seeking, and negative affect. Stimulation is about playing for the excitement and enjoying action and destruction, and it is associated with game genres that are highly competitive and full of fast-paced action such as first-person shooters. The Mastery higher-order motive had the highest association with positive affect. This indicates that playing to complete challenges, master skills, and explore different options is associated with a positive affective state, which is in line with findings from previous studies that have applied the self-determination theory to video games and report that perceived in-game competence and autonomy are associated with game enjoyment and increased well-being (Ryan et al., 2006).

Immersion/Escapism was moderately associated with negative affect and weakly with perceived stress and positive affect. This aligns well with previous studies that consistently report a moderate association between psychiatric symptoms and escapism, fantasy, and coping motives (i.e., playing games to reduce stress; Ballabio et al., 2017; Bányai et al., 2019; Király et al., 2015). This association suggests that players with different psychological problems such as depression or anxiety symptoms are more likely to immerse themselves in video games to avoid facing everyday difficulties, try to reduce stress, or get into a better mood. However, the "only" moderate effect size of these associations, as well as the weak association between this motive and positive affect,

indicate that Immersion/Escapism is not always or inherently a maladaptive gaming motivation, because players may also play to escape without experiencing adverse consequences (Giardina et al., 2021b; Kardefelt-Winther, 2014b).

Habit/Boredom was positively associated with negative affect and negatively with positive affect with moderate effect sizes; it was also weakly associated with perceived stress, which indicates the maladaptive nature of this motive. This is in line with previous findings. For instance, Peracchia and colleagues (2019) reported a moderate association between amotivation (i.e., one of the important motives of the Habit/Boredom higher-order motive) and anxiety and depression symptoms. Furthermore, Mills and colleagues (2018) found that amotivation was moderately related to needs frustration in daily life, namely competence, autonomy, and relatedness frustration. Similarly, Lafrenière and colleagues (2012) found that amotivation was weakly and negatively associated with perceived in-game autonomy, competence, and relatedness. These findings suggest that those individuals who play games without being motivated, or keep playing despite not perceiving any good reasons for it, are more likely to also experience psychiatric problems, stress, and needs frustration both in their lives and in games; relatedly, they are more likely to be in a negative affective state. Finally, self-esteem had negligible effect sizes on all six higher-order gaming motives, suggesting that one's subjective evaluation of own worth is not related to the reasons for play.

Age had a considerable (moderate or weak) negative association with Habit/Boredom, Social, and Competition higher-order motives. The latter two are in line with the results of other studies that reported that younger players are more competitive and more social than older players (Demetrovics et al., 2011; Yee, 2016) and that competition and social motives are strongly related (Yee, 2015b). Furthermore, it is plausible that younger players are more prone to play to avoid boredom, as they have fewer responsibilities and more free time than older players do. Gender differences in the six higher-order motives were relatively small. Female players scored higher in the Mastery and Immersion/Escapism higher-order motives. The latter is in line with previous studies (Király et al., 2015), whereas results regarding the former are controversial. In his early work, Yee (2006) found that male players had higher scores on advancement and mechanics motives, which have similar content to the Mastery higher-order motive in the

GMI. In later work (Yee, 2015a), design, completion, and discovery motives were more peculiar to females, whereas challenge and strategy motives were higher for males. These motives all appear in our higher-order motive labeled Mastery. Male players scored higher in the Competition, Stimulation, Social, and Habit/Boredom higher-order motives. These results are mostly in line with previous studies but not entirely. The competition motive was generally stronger in male players (Demetrovics et al., 2011; Yee, 2006a; Yee, 2015a), as was the stimulation motive (Yee, 2015a). The social motive was found to be stronger for females in the study of Demetrovics et al. (2011) and Yee (2006), whereas the community motive was higher for males in the Quantic Foundry model. The boredom motive was assessed only among augmented reality game players (Zsila et al., 2017), where no gender differences were found. However, boredom proneness is generally higher in males than in females (Sundberg et al., 1991), which is consistent with the result that males are more motivated to play to avoid boredom or because gaming becomes a habitual activity for them.

According to the literature, certain gaming motives (i.e., escape, competition, fantasy) mediate between psychiatric distress and problematic gaming (Ballabio et al., 2017; Bányai et al., 2019; Király et al., 2015). To further test the construct validity of the six higher-order motivational dimensions, we tested a similar model with depression symptoms as the predictor variable, the six higher-order motives as mediators, and GD symptoms and gaming time as outcome variables. We included gaming time as a second outcome variable to see how motives relate to it compared with GD.

Regarding the first outcome variable, depression symptoms had a significant direct effect on GD symptoms and an even stronger indirect effect via Immersion/Escapism, Habit/Boredom, and Competition higher-order motives, the latter having a much weaker effect size than the others. These results are in line with previous findings and suggest that depression symptoms lead to an apathetic, escapist type of play by reducing positive affect and goal-seeking behavior (Nutt et al., 2007). The individual thinks there is no point to anything, including gaming, but keeps playing to avoid boredom and negative emotions caused by real-life problems, which appears to work as a maladaptive coping mechanism and, in certain cases, may lead to negative (addiction-like) real-life consequences. However, the proposed direction of the model (i.e., depression symptoms strengthening

escapism and boredom motives and causing GD) requires further studies with a longitudinal design.

The Immersion/Escapism motivation can be considered a form of distraction, an emotion regulation strategy when the person diverts his or her attention away from an emotionally difficult situation (Sheppes & Gross, 2012). When an individual is confronted with high-intensity negative emotions, distraction can serve as an effective strategy—requiring minimal effort—to block the information related to the negative emotions by diverting attention to neutral stimuli unrelated to the original emotions (Campbel-Sills & Barlow, 2007). Unfortunately, this strategy is expected to be ineffective in the long run (Kross & Ayduk, 2008) because it hinders elaborated processing of the aversive emotional event (Campbel-Sills & Barlow, 2007; Sheppes & Gross, 2012). The individual may feel better while playing; however, the negative emotions persist and reappear as soon as the person stops playing. If the person has a rich variety of different emotion regulation strategies that can be flexibly implemented depending on the situation (Aldao et al., 2015), GD is unlikely to develop. However, if this is the main strategy that the person uses to ease feelings of distress, the risk of problematic gaming increases.

The Habit/Boredom higher-order motive includes amotivation and boredom, which were both found to be associated with problematic gaming (Mills et al., 2018; Zsila et al., 2017). It is plausible to assume that the individual whose main or only reason to play games is to decrease negative affective states such as boredom lacks the large palette of emotion regulation strategies and flexibility to adapt to different situations. However, this proposal needs further examination.

The weakest mediator was the Competition higher-order motive. In this case, a possible explanation is that players who experience depression symptoms also lack sources of success in their lives and may be more prone to play to achieve success in video games and a respected status within the gaming community. Although there is no problem with playing games to attain success, if this becomes the main or only source of success for the individual, he or she may start playing in a compulsive manner, which increases the risk of GD.

Regarding the second outcome variable, depression symptoms had a very small negative direct effect on gaming time, but had a considerable indirect effect via the

Immersion/Escapism, Habit/Boredom, and Competition higher-order motives, the latter two having much weaker effect sizes than the first. Interestingly, the direct effects between Immersion/Escapism and GD and between Immersion/Escapism and gaming time were of similar size in this study, whereas the former was much stronger in a previous study (Király et al., 2017b). It appears that Immersion/Escapism is a motive that is associated with a relatively high gaming time, followed by the Social and Competition higher-order motives, which is reasonable given that in-game activities related to these motives are highly time-consuming. For instance, immersing oneself in a character's story and escaping everyday problems via gaming, socializing, and competing with other players all need substantial amounts of time. The association of the Habit/Boredom higher-order motive and gaming time was weak, suggesting that this motive is related to less time-consuming gaming activities. Finally, the weak correlation between gaming time and GD symptoms supports previous findings, which suggest that gaming time alone is not a good predictor of gaming problems; in other words, intense video gaming in the majority of cases is not problematic (Griffiths, 2010; Király et al., 2017b).

3.3.1. Strengths and Limitations

Strengths of the study comprise the systematic literature review which was used to create the initial item pool and which contributed to the development of a truly comprehensive measure. A series of statistical analyses and numerous variables were used to validate the instrument, which shows good psychometric properties. The motivation inventory can both be used in research and in the clinical practice (see the implications in the next section).

Nevertheless, the study also has several limitations. The sample was a self-selected convenience sample; therefore, it is not representative of the entire gamer population. However, research demonstrates (Khazaal et al., 2014) that online gaming surveys primarily attract those individuals who are more involved in games, and therefore self-selected gamer samples are particularly suitable for our research aims. Moreover, the study sample was large, and the majority of respondents were highly engaged gamers who spent 28 hours per week on average playing video games, mostly first-person shooter, open-world action-adventure, RPGs, and battle royale games. Self-report assessment has its inherent limitations, such as memory recall bias and social desirability bias. The cross-

sectional study design is suitable for scale development, but it is not suitable to explore causal or temporal associations between the motives and external variables. Another limitation is the length of the questionnaire; the list of motives comprised 100 items, which may have caused fatigue in some of the respondents and led to a considerable attrition rate. Furthermore, the operationalization of items for two motives (graphics and story) was not ideal, as they were too positively phrased, which is also mirrored by the high negative skewness values of these motives. These items should be asked differently in future studies; for instance, respondents should be asked to rate the importance of these features when they play instead of whether they prefer good graphics and stories.

3.3.2. Practical Use of the Inventory, Implications, and Future Research Directions

The GMI can be used in two ways. First, it can serve as a profiling tool, useful in both research and clinical settings. Scores on the 26 motives provide a motivational profile of the individual, comprising information regarding the latent psychological needs motivating him or her in gaming, and may also provide information regarding everyday motives and behaviors. Second, given the length of the inventory (88 items), parts of it can be used alone. If, in research or clinical settings, there is a specific interest in certain motives and underlying psychological needs, subscales or specific motivation factors can be used alone to explore them. The use of GMI subscales is supported by adequate internal reliability and high factor loadings of the items (all Cronbach's alpha > .70, the majority of factor loadings between 0.6 and 0.9, and only a few above 0.5; see Supplemental Table S4 in the online supplemental materials). It remains the task of future research to develop a shorter scale covering the six higher-order motives.

The comprehensive and genre-neutral motivational item pool, and the findings regarding the 26 basic motives and the six higher-order motives, is an important contribution to the video gaming research field. Given that gaming is one of the most popular leisure time activities, it is crucial to understand why people of different genders and ages are pulled toward video games and what their main motives are to pursue this activity as a prominent hobby. Furthermore, there are important clinical implications. Research consistently shows that motivations play an important role in the development and maintenance of addictive behaviors, and this study suggests that Immersion/Escapism and Habit/Boredom motives constitute a risk factor for GD symptoms. Interventions should

always take gaming motives into account and use them to explore and address underlying psychological mechanisms that lead to pathological behavior. However, it remains the task of future research to identify and more deeply examine the psychological processes underlying gaming motives, as well as to explore their temporal stability and predictive power for GD symptoms in large-scale longitudinal studies and across cultures.

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3.5. Supplement

3.5.1. Appendix A.

Gaming Motivation Inventory (GMI) – structured version

Instruction: People play video games for different reasons. You can see such reasons listed below. Please indicate how much each statement corresponds in your case. Response options range from 1 ("It does not correspond at all") to 7 ("It corresponds exactly"). There are no right or wrong answers. We are curious to find out why you play.

Factor	Item							
Why do you play video games? I play video games…								
Advancement	1. because I like the feeling of continuous advancement	1	2	3	4	5	6	7
	2. because I like to advance in games	1	2	3	4	5	6	7
	3. because I like it when I get to the next level/stage/point in games	1	2	3	4	5	6	7
Amotivation	4. I used to have good reasons, but now I am asking myself if I should continue	1	2	3	4	5	6	7
	5. Honestly, I don't know; I have the impression that I'm wasting my time	1	2	3	4	5	6	7
	6. It is not clear anymore; I sometimes ask myself if it is good for me	1	2	3	4	5	6	7
Autonomy	7. because I can determine for myself what I do in games	1	2	3	4	5	6	7
	8. because I can play the games according to my preferences	1	2	3	4	5	6	7
	9. because they provide me with interesting options and choices	1	2	3	4	5	6	7
	10. because I experience a lot of freedom in games	1	2	3	4	5	6	7
Boredom	11. because I am bored	1	2	3	4	5	6	7
	12. to pass the time	1	2	3	4	5	6	7
	13. because there is nothing else to do	1	2	3	4	5	6	7
Competence	14. because when I perform well, it makes me feel good about myself	1	2	3	4	5	6	7
	15. because when I'm successful, it boosts my self-esteem	1	2	3	4	5	6	7
	16. because I feel very capable and effective when playing	1	2	3	4	5	6	7

Competition	17. because I like competing with others	1	2	3	4	5	6	7
	18. because I like to win	1	2	3	4	5	6	7
	19. because I like to be better than others	1	2	3	4	5	6	7
Completion	20. until I get 100% on them, completing everything possible	1	2	3	4	5	6	7
	21. until I unlock all achievements	1	2	3	4	5	6	7
	22. until I master all elements of a game	1	2	3	4	5	6	7
Coping	23. because it helps me get my anger out	1	2	3	4	5	6	7
	24. because it helps me get rid of stress	1	2	3	4	5	6	7
	25. because it helps me get into a better mood	1	2	3	4	5	6	7
Escape	26. to avoid thinking about some of my real-life problems or worries	1	2	3	4	5	6	7
	27. because gaming helps me to forget about daily hassles	1	2	3	4	5	6	7
	28. to forget about unpleasant things or offences	1	2	3	4	5	6	7
	29. because gaming helps me escape reality	1	2	3	4	5	6	7
Exploration + Mechanics	30. because I like to explore different elements or possibilities of the game	1	2	3	4	5	6	7
	31. because I like to experiment with different ways to play the game	1	2	3	4	5	6	7
	32. because I like to figure out how specific game elements work in detail	1	2	3	4	5	6	7
	33. because I like to discover/learn the game mechanics thoroughly	1	2	3	4	5	6	7
Fantasy	34. because I can do things that I am unable to do or I am not allowed to do in real life	1	2	3	4	5	6	7
	35. because I can be in another world	1	2	3	4	5	6	7
	36. to be somebody else or somewhere else for a while	1	2	3	4	5	6	7
	37. because I feel immersed in the virtual world	1	2	3	4	5	6	7
Financial	38. because I have the possibility to earn money	1	2	3	4	5	6	7
	39. because I have the chance to earn some extra income	1	2	3	4	5	6	7
	40. because I can make some money	1	2	3	4	5	6	7
Game skills	41. because I like to perform to the best of my ability	1	2	3	4	5	6	7

	42. because I like to improve specific gaming skills	1	2	3	4	5	6	7
	43. because I like to continuously improve my own gameplay	1	2	3	4	5	6	7
	44. because I like to practice and master a game	1	2	3	4	5	6	7
Identity	45. because playing games is a meaningful activity	1	2	3	4	5	6	7
	46. because it is an extension of myself	1	2	3	4	5	6	7
	47. because it is an integral part of my life	1	2	3	4	5	6	7
	48. because it has personal significance to me	1	2	3	4	5	6	7
	49. because this game/gaming is in harmony with the other activities in my life	1	2	3	4	5	6	7
Introjected regulation	50. because I must play to feel good about myself	1	2	3	4	5	6	7
	51. because otherwise I would feel bad about myself	1	2	3	4	5	6	7
	52. because I feel that I must play regularly	1	2	3	4	5	6	7
Recreation	53. because it is fun	1	2	3	4	5	6	7
	54. for recreation	1	2	3	4	5	6	7
	55. to relax	1	2	3	4	5	6	7
Skill development	56. because gaming sharpens my senses	1	2	3	4	5	6	7
	57. because it improves my skills	1	2	3	4	5	6	7
	58. because it improves my concentration	1	2	3	4	5	6	7
	59. because it improves my coordination skills	1	2	3	4	5	6	7
Social	60. because I can get to know new people	1	2	3	4	5	6	7
	61. because I like playing with others	1	2	3	4	5	6	7
	62. because I feel close to other gamers	1	2	3	4	5	6	7
	63. because I find the relationships I form in games meaningful	1	2	3	4	5	6	7
Status	64. for the prestige of being a good player	1	2	3	4	5	6	7
	65. because I gain recognition and esteem from others	1	2	3	4	5	6	7
	66. because others perceive me as skilled	1	2	3	4	5	6	7
What kind of gameplay do you prefer? I like video games that…								

Arousal-action	67. raise the level of adrenaline	1	2	3	4	5	6	7
	68. keep the players on the edge of their seats	1	2	3	4	5	6	7
	69. raise the level of excitement	1	2	3	4	5	6	7
	70. are intense and full of action	1	2	3	4	5	6	7
Cooperation	71. allow players to cooperate with others	1	2	3	4	5	6	7
	72. promote working together in a group	1	2	3	4	5	6	7
	73. require players to work together	1	2	3	4	5	6	7
Customization	74. allow players to customize their in-game objects (e.g., avatar/vehicle/stuff…)	1	2	3	4	5	6	7
	75. provide players with a lot of customization options	1	2	3	4	5	6	7
	76. allow players to personalize their objects/stuff/characters so that those can be unique	1	2	3	4	5	6	7
Destruction	77. allow players to make explosions	1	2	3	4	5	6	7
	78. involve destruction	1	2	3	4	5	6	7
	79. allow players to mess things up	1	2	3	4	5	6	7
Graphics	80. are visually breathtaking	1	2	3	4	5	6	7
	81. have outstanding graphics	1	2	3	4	5	6	7
	82. have good graphics, are beautiful	1	2	3	4	5	6	7
Story	83. involve an interesting story	1	2	3	4	5	6	7
	84. involve an elaborate story that stimulates my emotions	1	2	3	4	5	6	7
	85. involve an immersive narrative	1	2	3	4	5	6	7
Strategy	86. require strategic thinking	1	2	3	4	5	6	7
	87. require planning ahead and making strategic decisions	1	2	3	4	5	6	7
	88. require tactical decision making	1	2	3	4	5	6	7

Recommendations for administration:

(1) If the entire inventory is used in epidemiological online surveys, we recommend randomizing the items

of the two blocks for each participant individually to avoid systematic missing values on the later part of the item pool because of fatigue that may appear due to the lengths of the inventory. More specifically, we recommend randomizing items 1 to 66 of the first format "Why do you play video games? I play video games…" and then items 67 to 88 of the second format "What kind of gameplay do you prefer? I like video games that…" separately.

(2) If only specific motivational factors are used, we recommend randomizing the items of the two question formats separately for all respondents centrally or individually.

(3) If the inventory is used in the clinical setting, we recommend using the randomized version provided in Appendix B.

3.5.2. Appendix B.

Gaming Motivation Inventory (GMI) – randomized version

Instruction: People play video games for different reasons. You can see such reasons listed below. Please indicate how much each statement corresponds in your case. Response options range from 1 ("It does not correspond at all") to 7 ("It corresponds exactly"). There are no right or wrong answers. We are curious to find out why you play.

Item							
Why do you play video games? I play video games…							
1. because I like the feeling of continuous advancement	1	2	3	4	5	6	7
2. I used to have good reasons, but now I am asking myself if I should continue	1	2	3	4	5	6	7
3. because I can determine for myself what I do in games	1	2	3	4	5	6	7
4. because I am bored	1	2	3	4	5	6	7

5. because when I perform well, it makes me feel good about myself	1	2	3	4	5	6	7
6. because I like competing with others	1	2	3	4	5	6	7
7. until I get 100% on them, completing everything possible	1	2	3	4	5	6	7
8. because it helps me get my anger out	1	2	3	4	5	6	7
9. to avoid thinking about some of my real-life problems or worries	1	2	3	4	5	6	7
10. because I like to explore different elements or possibilities of the game	1	2	3	4	5	6	7
11. because I can do things that I am unable to do or I am not allowed to do in real life	1	2	3	4	5	6	7
12. because I have the possibility to earn money	1	2	3	4	5	6	7
13. because I like to perform to the best of my ability	1	2	3	4	5	6	7
14. because playing games is a meaningful activity	1	2	3	4	5	6	7
15. because I must play to feel good about myself	1	2	3	4	5	6	7
16. because it is fun	1	2	3	4	5	6	7
17. because gaming sharpens my senses	1	2	3	4	5	6	7
18. because I can get to know new people	1	2	3	4	5	6	7
19. for the prestige of being a good player	1	2	3	4	5	6	7
20. because I like to advance in games	1	2	3	4	5	6	7
21. Honestly, I don’t know; I have the impression that I’m wasting my time	1	2	3	4	5	6	7
22. because I can play the games according to my preferences	1	2	3	4	5	6	7
23. to pass the time	1	2	3	4	5	6	7
24. because when I'm successful, it boosts my self-esteem	1	2	3	4	5	6	7
25. because I like to win	1	2	3	4	5	6	7
26. until I unlock all achievements	1	2	3	4	5	6	7
27. because it helps me get rid of stress	1	2	3	4	5	6	7
28. because gaming helps me to forget about daily hassles	1	2	3	4	5	6	7
29. because I like to experiment with different ways to play the game	1	2	3	4	5	6	7
30. because I can be in another world	1	2	3	4	5	6	7

31. because I have the chance to earn some extra income	1	2	3	4	5	6	7
32. because I like to improve specific gaming skills	1	2	3	4	5	6	7
33. because it is an extension of myself	1	2	3	4	5	6	7
34. because otherwise I would feel bad about myself	1	2	3	4	5	6	7
35. for recreation	1	2	3	4	5	6	7
36. because it improves my skills	1	2	3	4	5	6	7
37. because I like playing with others	1	2	3	4	5	6	7
38. because I gain recognition and esteem from others	1	2	3	4	5	6	7
39. because I like it when I get to the next level/stage/point in games	1	2	3	4	5	6	7
40. It is not clear anymore; I sometimes ask myself if it is good for me	1	2	3	4	5	6	7
41. because they provide me with interesting options and choices	1	2	3	4	5	6	7
42. because there is nothing else to do	1	2	3	4	5	6	7
43. because I feel very capable and effective when playing	1	2	3	4	5	6	7
44. because I like to be better than others	1	2	3	4	5	6	7
45. until I master all elements of a game	1	2	3	4	5	6	7
46. because it helps me get into a better mood	1	2	3	4	5	6	7
47. to forget about unpleasant things or offences	1	2	3	4	5	6	7
48. because I like to figure out how specific game elements work in detail	1	2	3	4	5	6	7
49. to be somebody else or somewhere else for a while	1	2	3	4	5	6	7
50. because I can make some money	1	2	3	4	5	6	7
51. because I like to continuously improve my own gameplay	1	2	3	4	5	6	7
52. because it is an integral part of my life	1	2	3	4	5	6	7
53. because I feel that I must play regularly	1	2	3	4	5	6	7
54. to relax	1	2	3	4	5	6	7
55. because it improves my concentration	1	2	3	4	5	6	7
56. because I feel close to other gamers	1	2	3	4	5	6	7

57. because others perceive me as skilled	1	2	3	4	5	6	7
58. because I experience a lot of freedom in games	1	2	3	4	5	6	7
59. because gaming helps me escape reality	1	2	3	4	5	6	7
60. because I like to discover/learn the game mechanics thoroughly	1	2	3	4	5	6	7
61. because I feel immersed in the virtual world	1	2	3	4	5	6	7
62. because I like to practice and master a game	1	2	3	4	5	6	7
63. because it has personal significance to me	1	2	3	4	5	6	7
64. because it improves my coordination skills	1	2	3	4	5	6	7
65. because I find the relationships I form in games meaningful	1	2	3	4	5	6	7
66. because this game/gaming is in harmony with the other activities in my life	1	2	3	4	5	6	7
What kind of gameplay do you prefer? I like video games that…							
67. raise the level of adrenaline	1	2	3	4	5	6	7
68. allow players to cooperate with others	1	2	3	4	5	6	7
69. allow players to customize their in-game objects (e.g., avatar/vehicle/stuff…)	1	2	3	4	5	6	7
70. allow players to make explosions	1	2	3	4	5	6	7
71. are visually breathtaking	1	2	3	4	5	6	7
72. involve an interesting story	1	2	3	4	5	6	7
73. require strategic thinking	1	2	3	4	5	6	7
74. keep the players on the edge of their seats	1	2	3	4	5	6	7
75. promote working together in a group	1	2	3	4	5	6	7
76. provide players with a lot of customization options	1	2	3	4	5	6	7
77. involve destruction	1	2	3	4	5	6	7
78. have outstanding graphics	1	2	3	4	5	6	7
79. involve an elaborate story that stimulates my emotions	1	2	3	4	5	6	7
80. require planning ahead and making strategic decisions	1	2	3	4	5	6	7
81. raise the level of excitement	1	2	3	4	5	6	7

82. require players to work together	1	2	3	4	5	6	7
83. allow players to personalize their objects/stuff/characters so that those can be unique	1	2	3	4	5	6	7
84. allow players to mess things up	1	2	3	4	5	6	7
85. have good graphics, are beautiful	1	2	3	4	5	6	7
86. involve an immersive narrative	1	2	3	4	5	6	7
87. require tactical decision making	1	2	3	4	5	6	7
88. are intense and full of action	1	2	3	4	5	6	7

Motivational factors with their belonging items		
Advancement: 1, 20, 39	Amotivation: 2, 21, 40	Autonomy: 3, 22, 41, 58
Boredom: 4, 23, 42	Competence: 5, 24, 43	Competition: 6, 25, 44
Completion: 7, 26, 45	Coping: 8, 27, 46	Escape: 9, 28, 47, 59
Exploration + Mechanics: 10, 29, 48, 60	Fantasy: 11, 30, 49, 61	Financial: 12, 31, 50
Game skills: 13, 32, 51, 62	Identity: 14, 33, 52, 63, 66	Introjected regulation: 15, 34, 53
Recreation: 16, 35, 54	Skill development: 17, 36, 55, 64	Social: 18, 37, 56, 65
Status: 19, 38, 57	Arousal-action: 67, 74, 81, 88	Cooperation: 68, 75, 82
Customization: 69, 76, 83	Destruction: 70, 77, 84	Graphics: 71, 78, 85
Story: 72, 79, 86	Strategy: 73, 80, 87	

4. Gaming disorder: A summary of its characteristics and aetiology (Study 2)[5]

4.1. Introduction

In the past 60 years, videogame playing has gone from a leisure activity pursued by a narrow group of young males to one of the most popular hobbies across gender and age groups [1]. Although for most individuals gaming is a recreational activity or even a passion, a small group of gamers experiences negative symptoms which impact their mental and physical health and cause functional impairment [2]. To stimulate research in the field and help develop efficient prevention and treatment measures, the World Health Organization formally recognized 'gaming disorder' (GD) by including it in the International Classification of Diseases 11th Revision [ICD-11; 3]. According to the ICD-11 [3] GD is a *"persistent or recurrent gaming behaviour, which results in marked distress or significant impairment in personal, family, social, educational, occupational, or other important areas of functioning"*.

It is also worth to be noted that videogame playing is not the only activity which may cause severe harm for the individuals. Other common activities such as gambling, exercise, work, and internet use can also become unhealthy activities that take over individuals' lives [e.g., 4, 5, 6] resulting in 'behavioural addictions' [7]. While there is an ongoing debate whether other problematic behaviours such as the problematic engagement in pornography, social media use, and buying/shopping should be defined as mental health disorders or not [8-10], the inclusion of GD in the ICD-11 is the result of a fairly broad expert consensus [11].

One of the most important research topics in the field of GD is its aetiology. To prevent and treat the problem effectively, it is of key importance to have robust empirical knowledge concerning the course of its development. Similar to other addictions, it is the interactive co-occurrence of three factors, which in some cases leads to GD. These three factors are (i)

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the gaming-related factors (i.e., structural characteristics), (ii) the individual factors (i.e., person-based characteristics), and (iii) the environmental factors (i.e., situational characteristics) [12]. None of these alone are sufficient to cause a disordered state, only specific patterns of their co-occurrence. For instance, individuals with low self-esteem may chase in-game success and high status to feel better about themselves which may lead to disordered gaming [13], while players with impulse control problems may be especially susceptible to gambling-like mechanisms built in videogames and may end up spending large amounts of money through microtransactions [14].

In the case of substance use disorders, Khantzian [15] argued that drug addicts select their main substance in a way that its psychopharmacological effect matches the type of pain that dominates their lives (e.g., heroin and other opiates have their appeal because of their strong muting action on emotions such as rage and aggression). It was also suggested that this may be similar for behavioural addictions, namely that activities (e.g., pornography use, gambling, social media use, shopping) are purposely chosen and adjusted to personal vulnerabilities [16]. This may even be the case for gaming. Specific videogames or game genres may be preferred to cope with specific pathologies. However, this assumption needs to be investigated in future studies.

While there are reviews discussing specific topics of GD aetiology such as the role of structural game characteristics [17], personality traits [18], depression and depressive symptoms [19], gaming motivations [20], and gender [21], comprehensive reviews are lacking. Therefore, the goal of the present paper is to provide such a broad overview by discussing in detail the three factors that can influence GD, namely the gaming-related factors, the individual factors, and the environmental factors. By doing so, this will provide a general picture of the current state of aetiological research regarding GD, its most important findings, and main directions for future research.

4.2. Gaming-related factors

Videogames are the products of a profit-oriented and continuously growing industry. To maximize their revenue, companies aim to create games that are engaging and keep as many players as possible for long periods. To secure continuous play, developers use game design elements based on psychological mechanisms such as operant conditioning that

foster player engagement on a long-term basis [22]. Consequently, videogames are highly rewarding experiences and as such they have a significant addictive potential [23]. This does not mean that videogames alone can make specific individuals addicted, as the media-induced moral panic suggests [24], but it means that videogames have several structural characteristics that make them “addictive” in a way that vulnerable individuals may develop GD [25]. In the following sections, we discuss some of the most important game-related factors (e.g., structural characteristics, game design elements, monetization techniques), which increase player involvement.

4.2.1. Online vs. offline games

The aim of differentiating online and offline games is to divide games based on their social aspects, since online games often (although not always) permit playing together with others, while offline games (in general) do not. Research has consistently found that GD is more prevalent among online game players than players of offline games [26-29]. However, offline games have also been linked to GD [30, 31]. Given that loneliness, social anxiety, lower social competence, and low self-esteem are associated with the risk of GD [32-34], the most plausible explanation is that online multiplayer games provide safe environments, in which players can fulfil their social needs [35], while remaining invisible and anonymous, decreasing their anxiety from face-to-face interactions in this way [34, 36]. Therefore, players with psychosocial vulnerabilities tend to have a preference for online social interactions compared with traditional face-to-face social activities because they feel more socially competent and efficacious in these virtual environments [37] and therefore, seem particularly susceptible to problematic engagement with multiplayer online games involving social interaction [27].

4.2.2. Game genres, structural characteristics, and game design elements

Videogames can be classified into different genres such as shooter, strategy, role-playing, multiplayer online battle arena (MOBA) games, etc. although there are many different game genre classifications. There are many genres and there is much overlap between them. Moreover, a great number of games belong to simultaneous genres and due to the increasingly advanced technological development in the videogame industry, new game genres are continuously appearing, often from the fusion of existing ones. Development

and change are fast. Moreover, new and popular genres sometimes emerge so suddenly that research struggles to keep pace with them. Consequently, some research findings regarding game genres may even be outdated by the time of their publication. Nevertheless, there are several genres and standalone games that have maintained their popularity and some of these genres have higher addictive potential than others, according to the literature.

Massively multiplayer online role-playing games (MMORPGs) are by far the most researched game type genre and the one that was consistently found as being associated with problematic gaming alongside first-person/third person shooter (FPS/TPS) games, real-time strategy (RTS) games, and multiplayer online battle arena (MOBA) games [17, 38]. MMORPGs are immersive 3D virtual environments (often fantasy or science-fiction-themed worlds) that enable a considerable number of users to interact with each another via the internet, and which are permanent. This means that the world continues to exist and evolve while users are away from the game. The player takes the role of a character and competes and cooperates with other players in real-time to advance in the game by completing quests and achieving different goals. FPS games are centred on gun-based and other weapon-based combat in a first-person perspective and are usually match-based games, where players cooperate with members of their team and compete with other teams in real time in virtual environments. RTS. games require commanding large medieval, fantasy or sci-fi-themed armies and often include military base or settlement creation and resource management. Lastly, MOBAs, similar to shooter games, are match-based, where two teams compete with each other, demand high cooperativeness. The players usually use spells and skills to combat each other and during the course of the game, they can purchase special equipment to enhance and personalize their fighting style.

These genres include a combination of structural characteristics that makes them particularly appealing to players. Structural characteristics refer to those features of videogames that may facilitate initiation, development, and maintenance of playing over time and include specificities such as the permanent nature of the game world, the advancement and complex reinforcement systems, or the social interactions aspects [17, 39, 40]. MMORPGs are particularly successful at inducing operant conditioning via intermittent reinforcement, meaning that rewards are not administered every time the

desired response is performed [22], or players keep getting worthless virtual items before a big reward is provided at an unpredictable moment. These virtual rewards release dopamine in the brain [41] facilitating an euphoric state among players, and the variable-ratio reinforcement schedules keep players coming back in the hope of repeating such states and feelings. The social interactions aspect in these game genres is also very effective. In MMORPGs, players join big groups called guilds to achieve in-game goals, and form meaningful and deep relationships with fellow players while playing [42]. In FPS games, players often play in permanent teams in tight cooperation with others improving their skills both individually and as a team. Moreover, character customizations in videogames provide a way to create unique virtual avatars that can be experienced as extensions of the self, which through identification can be used to reduce self-discrepancy between the real and ideal self. This compensatory mechanic is a tool for videogame users with higher body dissatisfaction to boost their self-esteem and fulfil their social needs without the emergence of social anxiety [43]. Such structural characteristics increase involvement and may contribute to the development of GD in the case of psychologically vulnerable players [22].

Finally, it should also be noted that several game genres (especially MOBA games and the 'Battle Royale' genre) have recently become extremely popular and although these have not yet been extensively studied, there is a high probability that these also have high addictive potential due to a good combination of structural features they include [44, 45].

4.2.3. Monetization techniques

The videogame industry has undergone a marked growth since its foundation becoming a multi-billion-dollar global industry. Several innovations have fuelled this growth. Perhaps the biggest one was the integration of internet technology in videogames resulting in the appearance of multiplayer online games, which permit large numbers of individuals from all over the world playing together in the same virtual space. Two other important innovations from an economic point were increasing smartphone use and their use as the most accessible gaming platform, and the introduction of digital purchase options in games. Free-to-play gaming has quickly become one of the most widespread business models [46]

in which revenues are secured from microtransactions (i.e., the purchase of additional game content in the form of virtual items such as textures/skins, weapons, currency, or levels). King and Delfabbro [47] argue that some of the monetization practices often used in the free-to-play business model can be considered "predatory" because "they involve in-game purchasing systems that disguise or withhold the true long-term cost of the activity until players are already financially and psychologically committed."

Perhaps the most relevant and highly debated monetization scheme to date is the "loot box". This refers to an in-game reward system, a consumable virtual item usually in the form of a box or crate that can be purchased for real-world money (through microtransactions), which provides players with randomized rewards of unclear value. The psychological mechanism underlying microtransactions is linked to the so-called "sunk-cost effect". The sunk-cost refers to the tendency to continue a behaviour because investments in money, effort or time have been made previously [48]. Thereby, if players have already spent money on loot boxes and did not get what they wished for, they are more likely to make further purchases to get the desired item(s). Occasionally receiving the rare, high-quality rewards they wished for acts as an intermittent reinforcement, meaning that the players get strongly reinforced to continue buying loot boxes for other valuable rewards. Furthermore, free loot boxes are usually provided at the beginning of games to get players familiar with the experience. Moreover, research shows that dopamine is released when anticipating a reward, not only when actually getting it [49]. More specifically, in the case of loot boxes, it is assumed that the brain is already flushed with "joy hormones" at the moment of opening the loot box irrespective of its content [50].

Similarities between loot boxes and slot machines have raised severe concerns, especially because unlike most slot machines, loot boxes are available to children and adolescents and they may provide a gateway to gambling [51, 52]. While some studies indicate that microtransaction spending in general is related to problematic gambling severity [53], the findings concerning the relationship between loot box expenditure and problematic gambling [51, 54-56] and excessive gaming [57] are much more consistent [58]. Based upon these findings it can be concluded that individuals who spend a lot of money on loot boxes, often called "whales" [46] are not wealthy gamers but more likely to be problematic

users [59]. Consequently, it seems that gaming companies (unintendedly or not) are disproportionately profiting from vulnerable individuals (i.e., problem gamblers), rather than high-income customers, which has implications for harm reduction and policy debates regarding loot boxes and other monetization techniques in videogames [59]. In addition to the problems caused by loot box consumption, many sites allow the use of virtual skins (i.e., a graphic download which changes the appearance of in-game items or characters) in gambling activity, further raising the risk of problematic gambling [60]. Various countries are considering regulating loot boxes after Belgium banned them in 2018 [61]. Nevertheless, besides regulation, screening and public education concerning the risks should be implemented to mitigate harm [62].

Another predatory monetization technique worth mentioning is the personalization of offers and pricing. Companies use in-game behaviour tracking to collect data about players, their playing, and spending habits [63]. Based on these data, they carry out behavioural and psychological profiling and use these profiles to tailor offers and even pricing to individual players [see patents no. US9138639B1 and US9623335B1 in 63]. More specifically, this means that the same virtual item with production costs close to zero may be offered and bought for different prices by different players. Furthermore, games may use pressuring tactics to encourage spending. One such technique is the use of “limited time offers”, which influences players to purchase items by creating artificial scarcity and making them believe that the opportunity will never be available again. Another pressuring tactic was patented by *Activision Publishing Inc.* in 2015 (Patent no. US20160005270A1). According to the patent, the system identifies an in-game item (e.g., weapon, armour) that may be relevant for a novice player, then it identifies an experienced player owning such an item, and matches the two players (i.e., places them in the same match), so that the novice player sees how good/efficient that particular item is and therefore, they are encouraged to buy it to increase their chances of winning in the subsequent matches [63].

Based on the aforementioned literature, it can be claimed that videogames have a high addictive potential and together with other factors (i.e., environmental, and individual) can contribute to the emergence, development, and maintenance of GD. Consequently, it is crucial for research to be constantly updated to understand newer genres, game design

elements, and monetization techniques. Only this way it can provide policymakers the necessary information to make effective policies for prevention and harm-reduction.

4.3. **Individual factors**

In addition to gaming-related factors and environmental factors, individual factors play a key role in the aetiology of GD. These include demographic risk factors, personality traits, motivational factors, comorbid psychopathology, genetic predisposition, and neurobiological processes. Ultimately, it is always the players and their individual vulnerabilities, which determine whether videogame playing remains a healthy passion or develops into a pathology.

4.3.1. *Demographic risk factors*

According to two recent meta-analyses involving tens of thousands of individuals from a large number of geographic regions, males are more likely to exhibit GD symptoms than females across all age groups with a 2.5:1 rate or with a moderate effect size, respectively [21, 64]. Similarly, Pontes and colleagues [65] found higher rates of problematic users among males in a large-scale worldwide study of gamers interested in esports. A plausible explanation for more GD symptoms among male players is their greater interest in videogames, which may be explained from an evolutionary perspective. More specifically, aggressiveness and inclination to fight is a masculine trait in most cultures and even though videogames are becoming more diverse, competition is still their major design element and therefore, they are more attractive to males than females. Accordingly, the gaming industry identifies males as their main target group, and keeps designing games for them, which further reinforces male dominance among videogame users [66]. In addition, differences have been found in neural activation to gaming cues between the two genders, with males demonstrating higher cue-elicited craving related neural responses [67, 68], which indicates that different processes may be responsible for the emergence of GD among males and females.

Younger participants (especially adolescents) have reported higher prevalence rates of GD [64]. On the one hand, a higher proportion of younger individuals play videogames [1] and are also more motivated to play videogames than older individuals [69]. On the other hand,

transitional traits such as impaired impulse control and novelty seeking, which are key risk factors for addictions including GD [70, 71], characterize adolescents due to maturational changes in specific brain regions characteristic to this age group [72].

The role of ethnicity is an understudied topic [73] and the few studies reporting such results are contradictory. For instance, Desai [74] reported that white boys in Connecticut had lower rates of GD symptoms than non-whites and Asian boys. Wittek et al. [75] reported that respondents living in Norway but born in Asia, Africa, Central America or South America were more likely to exhibit GD symptoms compared to those born in Norway. On the contrary, Gentile [76] found no significant differences according to the ethnicity of adolescents. Although race and ethnicity might have some importance regarding the aetiology of GD, it is very difficult to study it due to its different meaning in each culture and its strong relationship with several other relevant factors such as the socio-economic and migration status. Furthermore, findings regarding socio-economic variables are also inconsistent. A number of studies did not find any significant associations between education level, employment, marital status, income and GD symptoms [75, 77, 78], while others have reported lower prevalence rates for those who are better educated, employed, and married (e.g., [79, 80] and a negative association with income [81]. One longitudinal study examined the association with parental education and family income with 6- and 12-month follow-up periods [82], finding only significant predictive effect of higher family income at 6-month follow-up. Inconsistent findings indicate that further studies are required, and possible cultural differences may also be present.

4.3.2. Personality traits

A fairly large number of research studies have examined the association between GD symptoms and the so-called "Big Five personality traits" based on the Five-Factor Model [83]. To synthetize all available findings of the relation between GD and Big Five personality traits, two meta-analysis have been carried out [18, 84], demonstrating negative association with extraversion, conscientiousness and agreeableness and positive association with neuroticism. A plausible explanation for the association between GD symptoms and neuroticism is that neurotic individuals are prone to anxiety, depression, and stress and may use virtual game worlds as an escape because they perceive these digital environments

as more controllable and safer than their everyday lives. However, if they keep escaping in games to avoid negative affective states, gaming might become problematic [75, 85]. Individuals scoring low on consciousness have difficulties with being dutiful and self-disciplined, tend to be unstructured and less persistent in pursuing their goals and may therefore find games attractive due to the clear rules and constant positive reinforcement [75, 85]. Turning to games to satisfy their need for structure and being easily rewarded may also lead to a greater risk of developing GD. Extraversion may be negatively associated with GD symptoms because videogames provide various non-social opportunities for entertainment, while the negative association with agreeableness may be due to the conflict-avoidance of highly agreeable individuals because playing videogames online can involve stressful social situations and problematic videogame use can also cause interpersonal conflicts during everyday life [84].

Among personality factors, impulsivity stands out due to its relation with addictive behaviours in general [86]. Survey studies examining large-scale adolescent and gamer samples, as well as treatment seeking clinical samples reported a significant association between trait impulsivity and GD symptoms [32, 87-89]. Furthermore, studies with experimental design have also found significant associations between experimental impulsivity-related measures (e.g., go/no-go task, impaired ability to postpone rewards) and GD symptoms [90, 91]. A study combining survey and experimental assessment in a longitudinal setting found that more GD symptoms at T1 predicted more impulsive decision-making at T2 with a moderate effect size. Moreover, a lower inhibitory control at T2 predicted more time spent on gaming at T3 with a weak effect size [92]. Other associations were not reported. These results suggest that impulsivity may not only be a predisposing risk factor for GD, but the disorder once developed may also further decrease the decision-making abilities of individuals due to a general overvaluation of immediate rewards and/or a reduced valuation of long-term rewards. Finally and relatedly, attention-deficit hyperactivity disorder (ADHD) has also been reported as an important comorbid disorder with GD [e.g., 93] and impulsivity is assumed to be a common explanatory factor for both disorders [94, 95].

The association between GD and other personality traits has also examined in numerous studies. For example, sensation seeking has been positively associated with GD symptoms in some studies, while other studies reported no significant association [96]. It is plausible to think that seeking novel stimuli through videogame adventures and challenges can drive individuals to be addicted to such games. Additionally, narcissism was also found to be positively related to GD symptoms in several studies [96], which may be due to the reinforcing nature of several online games, where social status can be achieved through videogame-related achievements.

4.3.3. Individual vulnerabilities

Research suggests that similar to other addictions, comorbidity is rather the norm than the exception in the case of gaming disorder [97]. Among psychopathological conditions, depression and depression symptoms, as well as generalized anxiety disorder and anxiety symptoms have been consistently related to GD [19, 98, 99]. Effect sizes reported vary between weak and moderate. Players experiencing depression and anxiety symptoms may be prone to escape into videogames to avoid facing everyday difficulties and negative affective states [98, 100]. Gaming in such cases serves as a form of distraction (instead of a real solution to problems) and may lead to disordered gaming, which in turn may further increase psychopathological symptoms due to impaired functioning, decreased performance, and social isolation [32]. Relatedly, another severe concern regarding GD and comorbid depression is the heightened risk for suicidal ideation [101, 102]. In addition, comorbid polysubstance use and substance misuse have also been reported in the case of GD [103-105].

Another comorbid condition thoroughly studied is ADHD. According to a recent meta-analysis [106], both symptoms of inattention and hyperactivity, as well as the combined ADHD symptoms were moderately associated with GD. Several factors may contribute to the development of GD among individuals experiencing ADHD symptoms such as impaired social and affective functioning and/or impulsivity [106]. Furthermore, videogame players with autism spectrum disorder were also more likely to show GD symptoms with varying effect sizes [107, 108]. Proposed explanations are similar to those

provided in the case of ADHD. Both disorders involve impulse control and response inhibition deficits, which may lead to the development of GD [109]. Given the preponderance of cross-sectional design in the studies examining comorbidity of GD, the direction of the associations is uncertain. Longitudinal studies are much needed. However, most likely the association is reciprocal.

In addition to psychopathology, there are many other individual vulnerabilities. Among these, self-esteem and social competencies are of particular importance. Low self-esteem has been reported as a risk factor in developing GD symptoms in numerous studies [104, 110], as were social anxiety or poor social skills [104, 111]. Relatedly, a one-year follow up study reported the predictive effect of social vulnerability (i.e., a difficulty in establishing and maintaining close relationships) on GD symptoms, even in interaction with attention problems [112]. For individuals with low self-esteem and/or low social competence, gaming may be an easy and efficient way to compensate for these deficiencies [113], which in turn heightens the risk to develop GD.

4.3.4. Motivational factors

A lot of research has examined the role of motives in GD. Several studies reported moderate to strong associations of escapism (playing videogames to avoid everyday problems), as well as weak or moderate associations of achievement-related motives (e.g., advancement, competition) with GD [114-117]. Furthermore, several studies reported a significant and considerable mediation effect of escapism between different psychiatric symptoms (e.g., depression) and GD [116-118]. These findings suggest that those who play solely for entertainment purposes are very unlikely to develop GD. However, those who have psychiatric difficulties may use gaming as a means to avoid everyday problems or to compensate for their deficiencies, which appears to work as a maladaptive coping mechanism and if pursued for long, it may cause negative (addiction-like) consequences. The same findings were reported in two recent meta-analyses. In the first, the strongest positive association was found with escapism, followed by achievement motivation, while also weak, but positive association was found with immersion and social motivation [119]. In the other meta-analysis [120], the association of GD with escapism was also the strongest, followed by achievement motivation and immersion. Social motivation was only

significantly related to GD when a specific measurement tool (i.e., the Motives for Online Gaming Questionnaire [MOGQ; 121]) was used, but not in case of another popular tool (i.e., the Motivations for Play in Online Games Questionnaire [114]). An additional finding of this meta-analysis was that positive association was found in the case of several motivations (introjected regulation, external regulation, amotivation, autonomy and relatedness) of two self-determination theory based scales [120].

Given that escapism involves diverting attention away from an emotionally demanding situation, it can be considered a form of distraction – a strategy of emotion regulation [122]. When facing high intensity negative emotions, a powerful strategy requiring minimum effort is to obstruct the information related to the aversive affect, by distracting attention to neutral stimuli unrelated to the original emotions [123]. For instance, individuals who have experienced a family conflict may immerse themselves in videogame playing to divert attention away from uncomfortable thoughts and feelings. The problem is that this strategy hinders the elaborated processing of the negative emotional event [122, 123] and therefore, it is expected to be inefficient in the long run [124]. The gamer may feel relieved while playing. However, the aversive emotions related to the conflict persist and reappear as soon as they cease the activity. According to Sheppes and Gross [122], "distraction can be considered as a 'bandage' regulation strategy that can stop the 'bleeding' but not offer actual remedy." What is crucial, is how often the individual uses distraction to avoid negative emotions, and whether this is their only strategy to ease the feelings of distress. Those individuals who have a rich variety of different emotion regulation strategies and can use these flexibly according to the circumstances [125], are unlikely to develop GD. However, this argument needs further investigation.

The act of seeking in-game achievements is driven by the rewarding nature of videogames [23] and the process of operant conditioning [22]. Furthermore, these achievements may additionally result in higher recognition and status within the gaming community [96], which cannot be achieved by some individuals during their everyday lives. Finally, social motivation can lead to excessive use through creating an obligation to play because virtual team membership can be as important as belonging to any other groups [119]. In addition, videogames can also serve as safe environments to fulfil social needs [43]. Overall,

research greatly supports the idea that it is not gaming time in itself, which predicts GD [126], but the way gamers play, their motives, and the degree they can integrate this leisure time activity in their lives.

4.3.5. Neurobiological processes and genetic predisposition

Research suggests that neural mechanisms underlying GD resemble those of other addictions such as substance use disorder, alcohol use disorder, and gambling disorder [127]. More specifically, GD shares many of the cognitive-affective alterations typical for other addictions such as impaired decision-making, emotion processing, impulsivity, and executive functioning related to different functioning in prefrontal areas and the temporoparietal, frontolimbic and subcortical regions [128]. Besides these functional brain mechanisms, there are also structural changes associated with GD, mainly reduction in grey-matter volume in the ventromedial and dorsolateral prefrontal areas, the anterior cingulate and premotor cortices which are responsible for decision-making, emotion regulation, and cognitive/motor control [129]. Additionally, altered white-matter density has been found in several brain regions involved in behavioural inhibition, decision-making, and emotional regulation [130].

According to an early experimental study, dopamine is released in the ventral striatum during videogame play in a similar magnitude to amphetamine-induced dopamine release [41]. Studies have also reported alterations in the volume of the ventral striatum, which could reflect altered reward processing and indicate adaptive neural plasticity among highly engaged videogame players. Relatedly, research suggests that GD is associated with dysfunction in the dopaminergic brain systems and involves changes in loss of control and reward inhibitory mechanisms [131]. Additional similarities have been found with other addictions, such as with stronger activation in the dorsolateral prefrontal cortex (which was associated with higher level of craving) and different activation of the orbitofrontal cortex (indicating lower level of punishment sensitivity), when individuals with GD were compared to controls using functional near-infrared spectroscopy [132]. Finally, according to comorbidity studies, altered executive control mechanisms in ADHD may increase the vulnerability to develop GD. Relatedly, research suggests that patients with GD, ADHD,

and major depressive disorder may share specific characteristics in terms of neurochemical changes in frontal and temporal cortices [131].

Genetic factors also play an important role in the aetiology of substance use disorders [133]. Recent genome-wide linkage and association studies have identified numerous genes in relation to addictive disorders such as alcohol and tobacco [134]. Given the similar neurobiological basis of substance use disorders and GD, it is assumed that some individuals are genetically more vulnerable to develop GD than others. However, to date, there are few studies investigating this. For instance, a recent study found an association between the nicotinic acetylcholine receptor α4 subunit gene (CHRNA4) rs1044396 and GD among Korean male adults [135]. Another study investigating Korean male adolescents reported that the polymorphism of the corticotropin-releasing hormone receptor 1 (CRHR1) gene may play an important role in GD susceptibility [136]. Therefore, future research, on one hand, should examine the association of other genes and variants previously linked to addictive disorders with GD, while on the other hand, it should replicate previous findings in independent samples, and also try to determine the functional mechanisms of these genes and variants.

4.4. Environmental factors

Finally, environmental factors are influences that do not occur from within the individual but from elsewhere in the environment. Examples of environmental factors are the family and peers, work and school, and also the culture in which the gamer lives in. Besides game-related and individual factors, situational and environmental factors also play an important role in the aetiology of GD.

4.4.1. Family factors and early life experiences

As in the case of substance use and other potentially addictive behaviours, familial influences and early life experiences affect the likelihood of an individual developing GD. According to a systematic review of 14 studies examining family factors in adolescent problematic gaming [137], the majority of studies have focused on parent-child relationships (e.g., warmth, conflict, abuse) and they reported a negative association between the quality of relationships and severity of problematic gaming. Similar findings

were reported by studies not included in the review [28, 138]. A more recent systematic review focusing on associated parental and family factors [139] also reported similar findings. Positive family functioning, characterized by good parent-child communication, common social activities, cohesion, connectedness, acceptance, secure attachment, warmth, and affectivity were protective factors, while poor family functioning, conflicts, hostility and demanding, authoritarian, neglectful or permissive parenting style were risk factors for problematic gaming. More recent findings confirmed that in addition to the low quality parent-child relationship, lack of monitoring, and violent disciplining have deleterious effect [140].

Moreover, studies suggest the mediation effect of specific variables. For instance, it has been found that core-self evaluations mediate the effect of parental rejection on GD [141]. Another study reported that the relationships between attachment styles (anxious and avoidant) and GD were fully mediated by stressful events [142]. Furthermore, the importance of father-child relationship as a possible protective factor for problematic gaming has also been noted in several studies [137, 141, 143].

A two-wave longitudinal study [144] examining a sample of German students from Grades 4 to 9 (N = 406) found that 15-year-old adolescents' problematic gaming have already shown several risk factors at the age of 10 years. One important risk-factor was growing up in a single-parent family, in agreement with the results of other studies [137, 145]. The effect stayed stable with time even when controlling for parental devotion and supervision, which suggests that the risk is not due to a lack of parental care in single-parent families but the insufficient time and fewer resources to provide alternative leisure time activities for the children in a balanced way. A 12-month prospective study among 9–10-year-old children [146] showed that earlier parental marital conflict directly predicted GD symptoms at follow-up. Additionally, an indirect path was also identified. More specifically, parental marital conflict influenced GD severity of children one year later via poor father-child attachment and impaired self-esteem. Another longitudinal study found that parental involvement can attenuate the harmful effect of bullying on GD severity by preventing the development of present-oriented consideration of future consequences and promoting the development of future-orientation [147].

Review findings suggest that parental monitoring and regulation of the gaming behaviour are effective strategies for GD prevention [148]. Parents who regulate their children's gaming are also more likely to help them find and practice alternative leisure time activities [149], which is crucial in maintaining a healthy balance and is recommended as a prevention strategy [149, 150]. Another risk factor for the onset and maintenance of GD is childhood maltreatment [e.g., 139, 151, 152], which refers to emotional, sexual, or physical abuse and physical or emotional neglect. In the case of maltreatment, parents or caregivers who fail to satisfy the basic physical and psychological needs of their children (e.g., nurturing, belonging), may produce severe and long-lasting negative consequences like feelings of guilt and shame, poor self-esteem, psychological functioning and social relationships [148]. These children may use videogame playing to compensate for their unmet needs (e.g., achievement, relatedness) or cope with psychological symptoms like depression or anxiety [113].

Another relevant aspect is the ownership of gaming equipment (e.g., personal computer, videogame consoles) and its availability in adolescents' rooms. Both adolescents' access to their own gaming devices, as well as gaming in their bedrooms have been linked to increased hours of gaming [153] and to problematic gaming [144]. However, when other factors (i.e., media usage and school-related variables) were included in the model in a longitudinal design, having gaming consoles in the children's rooms at age 10 years no longer predicted problematic use five years later [144]. This suggests that seemingly simple preventive solutions such as banning gaming devices from children's rooms are not enough in themselves. Most probably, reasons underlying the development of GD are of a fundamental nature, related mostly to the personality and motives of the players. Nevertheless, keeping gaming devices in the shared spaces to ease monitoring may be a useful recommendation [149].

Findings regarding the familial influences emphasize the importance to involve families in the intervention programs targeting adolescents with GD. The efficacy of interventions involving families is less researched than interventions focusing on the individuals but there are some successful outcomes. A study by Liu et al. [154] assessed the efficacy of the multi-family group therapy (i.e., a combination of family and group psychotherapy in

which several families meet in the presence of therapists) to reduce problematic internet use among adolescents. According to the findings, the therapy was highly successful, mostly due to the improvement of the adolescents' satisfaction of their psychological needs and parent-child communication and closeness. A family approach to GD prevention and treatment recognizes the importance of dysfunctional family dynamics, an aspect also emphasized in the case of substance use disorders [155]. Relatedly, prevention programs which focus only on adolescents may be perceived as blaming by the target group and fail to address family-related issues, which may be one of the main reasons for using games excessively and problematically [137]. Consequently, prevention programs should also target parents and caregivers to reduce possible negative attitudes, unreasonable expectations, and criticism towards adolescents' videogame use.

4.4.2. Peers and school-related factors

Relationships with peers and the school environment are also crucial environmental factors in the aetiology of GD. Social integration in one's environment and peer group is of special importance for adolescents, who are in the life stage of identity formation and individuation from the family of origin [156]. Research shows that self-reported well-being at school, as well as social integration in class are protective factors [144] and these results are in agreement with other studies reporting a relation between poor social skills and problematic gaming [32, 157, 158]. Furthermore, according to a systematic review [159], GD symptoms among adolescents were correlated with problems with peers (both being bullied and bullying others), having friends whose gaming was also problematic, having low educational and career achievements (skipped school classes, truancy, and low school grades), and having poor social skills, low competence, and a low level of integration. These findings were supported by a recently published meta-analysis [160], showing that interpersonal problems, bullying perpetration, and victimization are all important risk factors for GD. Additionally, the importance of peer relationships were reported in a one-year longitudinal study [161], where the possible bidirectional effect of perceived parent-adolescent and peer attachment were tested. In this study, father or mother attachment did not predict GD at the follow-up, while peer attachment had a bi-directional association with GD.

Findings suggest that children and adolescents who have difficulties with making friends and who reported low levels of school-related well-being may use gaming as a compensation. The invisibility, anonymity, and equal/fair chances provided by virtual game worlds may be very tempting for children who are otherwise excluded and harassed by their peers because they can experience self-efficacy while playing and feel recognized by fellow gamers [144]. However, such a compensation might increase the risk of long-term psychological consequences (including the risk for GD) because real life difficulties and failures are not addressed but avoided [113].

In addition to peers, teachers also play an important role in adolescents' lives, psychosocial well-being, and identity formation. One important responsibility of teachers is to provide autonomy support for children, which refers to the extent to which students feel that their teachers offer opportunities for choice and decision-making regarding learning and classroom life (e.g., teachers ask their students what they want to learn about). According to a longitudinal study conducted among Chinese students [162], teacher autonomy support perceived in 7th grade increased basic psychological needs satisfaction (i.e., the need for competence, autonomy, and relatedness) in the 8th grade, which in turn increased school engagement (i.e., behavioural, emotional, and cognitive engagement) in 9th grade, which ultimately decreased problematic gaming in 9th grade. Additionally, teacher autonomy support in 7th grade had a direct effect on school engagement two years later, which in turn decreased problematic online gaming. These findings suggest that teacher autonomy support is also an important protective factor for the risk of adolescent GD, and school engagement and basic psychological needs satisfaction are important mediators in this association.

4.4.3. The broader context of culture

Research shows that GD is a global concern. Indeed, research related to GD has been carried out worldwide [163] (although there is a lack of research conducted in Africa, the continent with the lowest internet penetration rate, with the exception of few epidemiological studies [164]). In the meta-analysis by Stevens et al. [64], higher pooled prevalence rate was found for the prevalence of gaming disorder in Asian countries (5.08%) compared to Europe (2.72%). Cultural differences appear to determine the prevalence rates

of GD, but mainly not affecting the gender ratio of GD, as it seems to be male dominant in almost all countries, with the exception of India, where more females were reported as experiencing GD symptoms [21]. Furthermore, according to a meta-analysis of 84 independent samples comprising almost 60,000 participants from 20 countries and seven geographic regions, the associations between GD symptoms and psychological problems were moderately strong across the countries suggesting the universality of this association [163]. In line with this finding, a cross-cultural study of gamers from ten cultures (from Europe, Iran, Peru and Korea) found similar patterns of associations between variables such as GD, psychiatric symptoms, gaming motives, and gaming time across cultures [165, 166].

Nevertheless, even if the disorder is a global phenomenon and some of the major links of it appear to be global, culture most certainly plays an important role in the emergence, development, and maintenance of the disorder, as well as in the efficiency of prevention and treatment practices. For instance, Asian and Western cultures tend to view and address GD differently. While the former considers it a major public health threat, the latter are far less coercive. This disparity has deep cultural roots. In Asian countries, there is a particularly strong pressure on children and adolescents regarding academic performance because competition in employment is high. Given that videogame playing is an immersive and time-consuming leisure time activity, parents, educators, and policymakers view gaming as a severe threat for academic performance and as therefore, a dangerous activity, which may undermine an individual's career chances. In contrast, in Western cultures, academic pressure is less severe and therefore, gaming is not concerned as a public "enemy", but as a common hobby. Accordingly, in Asian countries, several policy actions have been taken at governmental level, which mostly target adolescents regardless of their degree of problematic involvement and usually aim to decrease time spent on gaming [167]. Moreover, there are numerous state-financed treatment centres across Asia. In Western countries, on the other hand, the problem is mostly addressed by the private sector, which provides expensive treatment programs for those who can afford them [23].

Some papers (seemingly using the same dataset) examined the assumed moderating role of vertical individualism (one type of cultural orientation which refers to the acceptance of social inequality as a by-product of perceived hierarchical structures within a society), on

the association between GD symptoms and comorbid stress, inattention, and depression symptoms, respectively, in a sample of massively multiplayer online (MMO) game players mostly from the US and Australia [168-170]. Results showed that gamers with a more vertically individualistic cultural orientation had stronger links between GD symptoms and comorbid stress, inattention, and depression symptoms, respectively, than gamers, who reported lower vertical individualism scores. A plausible explanation may be that more vertical individualism stresses competition and achievement as the measure of personal value, and therefore such individuals are more disposed to engage excessively in MMO games which offer the opportunity to gain recognition among peers by being a successful gamer. These players may use videogames as a means to cope with their comorbid stress, inattention, and depression symptoms, which in turn may increase the risk of problematic use [e.g., 116]. Furthermore, in a large European study [171], the protective effect of social policies (i.e., benefits for families and children such as child payments, allowances and parental leave payments) were found, while economic inequality was a risk factor for GD at the cross-national level.

To gain insight in the role of sociocultural factors on the empirical applicability of different hypotheses derived from three major theoretical perspectives on GD, Cheng et al. [163] performed a meta-analysis of 20 countries from seven geographic regions. Based on the literature, the authors claimed that GD has been defined by researchers in three different ways. According to the comorbidity hypothesis, GD is a pathology, which co-occurs with psychological problems and poor psychological well-being. According to the interpersonal impairment hypothesis, GD is a maladaptive coping with interpersonal problems rather than a pathology *per se*. Finally, the dilution effect hypothesis states that GD is a deficient self-regulation with the underlying motive to restore psychological and social well-being. As aforementioned, the results of the meta-analysis provided some support for the globality of the comorbidity hypothesis because moderately strong positive associations between GD symptoms and psychological problems were found across countries. However, the other two hypotheses appear to be impacted by cultural factors differently. The interpersonal impairment hypothesis was more defensible in countries lower in power distance (democratic countries) than in countries with higher acceptance of status differences and stronger social hierarchy. The dilution effect hypothesis, on the other hand, was more

sustainable in countries higher in national life satisfaction and lower in cultural masculinity (i.e., the extent to which members of a society embrace success and achievement as key values).

4.4.4. International growth of esports

Finally, the phenomenon and fast increasing popularity of esports needs to be mentioned. Esports is the abbreviation of 'electronic sports' and refers to the professional competitive videogame playing where teams or individuals compete against each other [172]. Esports started to gain popularity in the 2000s and skyrocketed since then with an estimated audience of 532 million individuals in 2022. Revenues in the esports sector globally were estimated to $1.38 billion (US) in 2022. However, this immense popularity is not unified, and varies across regions. Asia, and especially China has the most esports players and viewers, and the hype surrounding the esports phenomenon is also the highest in this part of the world [173]. Although information regarding the impact of esports on GD is scarce, Chung et al. [174] argued that the further promotion of videogame playing under the umbrella of esports would likely increase the prevalence of hazardous gaming and GD. Indeed, an environment, in which electronic sports is a national sport and esports players are highly paid celebrities, may further increase youth's interest in gaming, both as a leisure time activity and as a career opportunity [175]. Montag and colleagues [176] investigated this and found that professional gamers as well as videogame users with the intention to become esports players reported slightly higher level of GD severity and also higher levels of gaming motives then non-professional gamers without a plan to become one. Thereby attention should be paid to children and adolescents pursuing esports career to prevent possible future impairment.

To sum up, there is evidence that culture plays a role in the aetiology and maintenance of the disorder and may also influence the efficiency of prevention and intervention practices. While GD is a global concern with seemingly global symptoms, its manifestation, evaluation, and management vary across cultures. Therefore, it is essential for prevention and treatment programs to be adjusted to local circumstances to maximize efficiency. Nevertheless, more research is needed in this area, both regarding general cultural aspects and regarding the impact of esports.

4.5. Future research directions

Based on the gaps identified in the present review, future studies should focus on specific aspects of aetiology. For instance, there is a great need for studies exploring structural game characteristics and monetization techniques because videogames are continually changing and advancing using newer behavioural mechanics that appear to manipulate gamers to play more and spend more. Relatedly, neurobiological processes associated with these seemingly manipulative techniques should also be further investigated alongside other individual factors such as genetic predisposition, motivational factors, and comorbid psychopathology. The latter is crucial in terms of treatment because comorbid disorders can significantly hinder recovery if not treated in parallel. In addition, cultural aspects such as the parental attitude towards gaming as a hobby, the esports environment, and local policy measures are all important aspects which influence the aetiology of GD and need to be further examined empirically.

Moreover, future research needs to explore the specific interactions between the three aetiological factors outlined in the present review. It is plausible to assume that there are particular interactional profiles which need specific types of prevention and treatment. This is in line with Ko et al.'s [177] clinical observations who argued that there are common types of GD patients, such as male patients with ADHD, dysphoria patients with dysfunctional coping skills, or isolated patients with social anxiety. Future studies should be conducted to explore such profiles to help develop personalized treatment protocols.

4.6. Conclusion

Three interrelated factors play a role in the development and maintenance of gaming disorder: gaming-related factors, individual factors, and environmental factors. Videogames are designed in a way to maximize player engagement by involving numerous psychological mechanisms such as operant conditioning. Individual factors play a crucial role in the development and maintenance of gaming disorder through the individual's psychological and neurobiological vulnerabilities. Last, environmental factors such as the family or even the broader cultural environment heavily influence how individuals play and whether gaming may become problematic. Consequently, prevention and intervention of gaming disorder at both the community level and the individual level require multi-

professional action (e.g., from caregivers, educators, researchers, therapists, policymakers) due to its multifactorial nature regarding etiology.

4.7. References

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5. The emerging evidence on the association between symptoms of ADHD and gaming disorder: A systematic review and meta-analysis (Study 3)[6]

5.1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is characterized by *"a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development"* (American Psychiatric Association, 2013, p. 59-66). Three types of diagnosis are used to cover the variation of symptom occurrence: (i) combined presentation (when both symptoms co-occur), (ii) predominantly inattentive presentation (when only the criterion for inattentive symptoms is fulfilled), and (iii) predominantly hyperactive/impulsive presentation (when only the criterion for hyperactive/impulsive symptoms is fulfilled). ADHD is primarily prevalent among the child/adolescent population, and the overall pooled prevalence in this age group has been reported to be 7.2% (Thomas et al., 2015). While symptoms usually disappear with aging, approximately 2.5% of the adult population still experiences them (Simon et al., 2009).

The higher prevalence of ADHD among those dependent on psychoactive substances is well-known. Approximately quarter of individuals with substance use disorder have comorbid ADHD (van Emmerik-van Oortmerssen et al. 2014)), which poses an additional challenge in terms of treatment. This widely established comorbidity is not limited to substance use-related disorders, a higher co-occurrence of ADHD has also been reported among individuals with non-substance use related addictive disorders such as gambling disorder, gaming disorder, and other problematic behaviors such as binge-eating, problematic internet use and compulsive sexual behaviors (Dullur et al., 2020; Karaca et al., 2017; Savard et al., 2021). Disorders due to addictive behaviors or behavioral addictions is a relatively new area with a strong research interest and a continuously growing number of studies (Billieux et al., 2015) due to the large number of individuals

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affected globally (e.g., Alimoradi et al., 2022). Individuals suffering from behavioral addictions endure severe distress and functional impairment due to specific rewarding behaviors (e.g., playing video games), similar to what individuals with substance use disorders experience (Billieux, et al., 2017). The clinical relevance of these conditions is also demonstrated by the World Health Organization's (WHO) decision to create a new category in the most recent version of the International Classification of Diseases (ICD-11) called "Disorders due to addictive behaviours" and include gaming disorder, gambling disorder, as well as other specified and unspecified disorders due to addictive behaviors in this category (World Health Organization, 2019).

Possible negative consequences of excessive video gaming have long been acknowledged both among researchers and in the clinical field. As a consequence, in 2013, Internet Gaming Disorder (IGD) was included in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) in Section III ('Emerging Measures and Models') as a non-substance-related disorder with a recommendation for further research (American Psychiatric Association, 2013). However, this led to an intense debate between scholars. The most important concerns regarding the inclusion were the following: research underlying the decision was of low quality; the operationalization leaned too much on substance use and gambling criteria; there was a huge variation in symptomatology and assessment of problematic gaming; and making GD a formal diagnosis would cause stigma to the millions of children who play video games in a healthy manner (Aarseth et al., 2017; Ko et al., 2020). Furthermore, some of the IGD criteria (e.g., preoccupation, tolerance, withdrawal) were also heavily criticized as not being suitable to differentiate individuals with GD from gaming enthusiasts (Griffiths, et al., 2015; Király et al., 2015). After thoroughly discussing these concerns, the WHO decided that including GD in the ICD-11 as an official diagnosis had more advantages than disadvantages. Moreover, to address the critiques of specific criteria, the ICD-11 diagnosis only comprises those criteria, which have wide support, especially among professionals from the clinical field (Castro-Calvo, et al., 2021). Nevertheless, the inclusion was highly criticized by the gaming industry and some researchers, majority of whom were working in the field of media psychology and gaming studies (Ferguson & Colwell, 2020; Galanis et al., 2021).

According to the WHO, GD is a persistent and recurrent pattern of gaming behavior, characterized by loss of control over video game use and neglect of other important areas of life (such as relationships, occupation and/or education), which persist despite the emergence of several negative consequences that clinically impair day-to-day activities (World Health Organization, 2019). A meta-analysis examining studies between 2009 and 2019 found that the worldwide prevalence of gaming disorder was 1.96% in samples with more strict sampling criteria (stratified random sampling) and occurring more frequently among male and adolescent populations (Stevens et al., 2020). Numerous studies have reported associations between GD and other psychopathologies. The most frequently reported comorbidities are anxiety, depression, ADHD, social phobia, obsessive-compulsive symptoms (González-Bueso et al., 2018), and autism spectrum disorder (Murray et al., 2021).

A systematic review of Dullur et al. (2020) showed that the problematic use of video games (and in the more extreme cases, gaming disorder) is associated with ADHD. Recent findings not included in the review by Dullur et al. also reported an association between GD and ADHD (Cabelguen et al., 2021). This is also the case in longitudinal designs, where the association between preceding ADHD symptoms and subsequent GD severity has been shown to be mediated by a lower level of self-control and a higher level of aggression (Jeong et al., 2020).

5.1.1. Research aims

Considering the clinical relevance and frequent co-occurrence of ADHD and GD, the present study had three goals: (i) to test the association between the symptoms of two disorders; (ii) to assess the quality of studies examining the comorbidity of the two disorders; and (iii) to estimate the effect of potential moderators in the association between the two disorders, such as age, gender, culture, methodological characteristics (assessment tool and informant), and overall study quality.

5.2. Methods

5.2.1. Systematic search

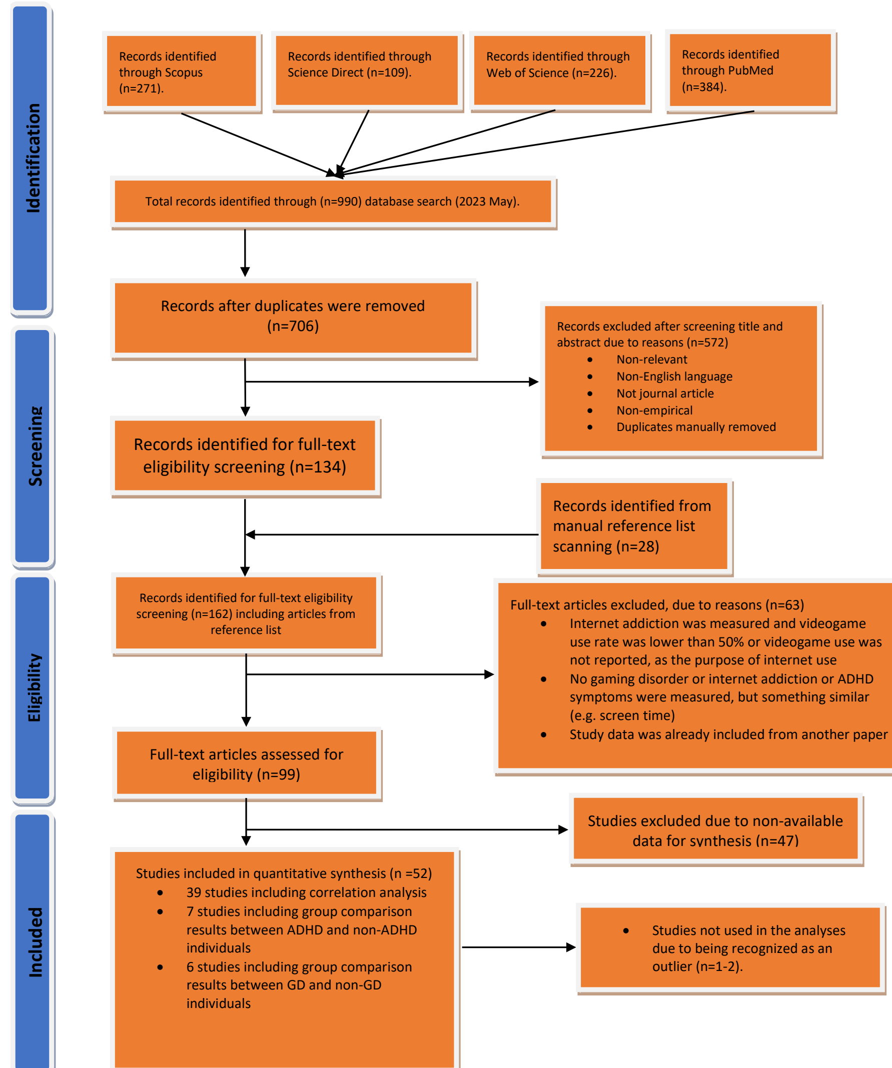
A systematic literature search was carried out using four different scientific databases: *Scopus, Science Direct, Web of Science* and *PubMed* with the following keywords: “ADHD” AND (“game” OR “gaming” OR “videogame”) AND (“addiction” OR “problematic” OR “pathological” OR “disorder” OR “compulsive” OR “dependent” OR “excessive”) NOT “gambling”. Searches were carried out in three phases, and the final search was on June, 2022, resulting in 839 hits in total . After the deletion of duplicates, 606 papers remained. All findings were exported to *EndNote* (6.0.1 version) software.

5.2.2. Eligibility screening, identification of additional studies

All of the titles and abstracts of the papers were scanned for eligibility by two doctoral students. Disagreements were resolved through discussion. Full texts were scanned to exclude studies (i) that did not assess gaming disorder/problematic internet use in relation to ADHD, but similar constructs (such as screen time), (ii) where problematic internet use was assessed, but the rate of video game use was not reported or less than 50% of the study sample reported playing video games, or (iii) that reported on data from the same database which was already identified in another paper in the present meta-analysis. A total of 95 full-text papers were screened for appropriate data for the meta-analysis. A total of 47 studies were excluded where necessary data were not reported in the paper, and the authors of those studies did not respond to the request through e-mail to provide the missing data. Study authors who were contacted were also asked to share any research related to the association between gaming disorder and ADHD symptoms that had not been published. However, no additional studies were identified through this request. The present authors participated in two additional data collections in Hungary, which provided appropriate, but as yet unpublished data for the association in question. The first study was the Budapest Longitudinal Study (BLS), in which data were collected from a representative sample of fifth grade students. The other was a convenience sample of video game users, which were used to the develop the Gaming Motivation Inventory, a comprehensive tool that assesses motives for video game use (Király et al., 2022). Following this process, 48 studies remained for meta-analysis (see Figure 1). This process was executed following PRISMA guidelines (Moher et al., 2009). All included studies can be found in the Supplementary File (S1).

Figure 1

Flowchart of the Systematic Database Search and Screening Process



5.2.3. Inclusion and exclusion criteria

The following eligibility criteria were used: empirical studies that reported results of a quantitative analysis concerning the association between GD and ADHD, either cross-sectionally or longitudinally, including a correlation coefficient or a group difference (e.g., ADHD/non-ADHD on symptoms of GD or GD/non-GD on symptoms of ADHD) reported), being published in the English language, and being published in a peer-reviewed

journal. There was no restriction on publication date. Studies were excluded, where the purpose of internet use was not reported or lower than 50% of the sample reported gaming.

5.2.4. Coding process and type of data

Coders were undergraduate and graduate students. All coders were trained by the first author. Coding was done in pairs including a graduate and a PhD student, or two BA students under the supervision of the first author. In case of a disagreement between two coders, the first and the second authors were included to resolve the disagreement through discussion.

Three types of outcome data were identified in the primary studies: correlation coefficients (between two numerical variables); the means and standard deviations for symptoms of gaming disorder or problematic internet use in case of a comparison between a sample with and without ADHD; and the means and standard deviations for ADHD symptom severity in case of a comparison between participants with and without gaming disorder or problematic internet use. These were analyzed in three separate meta-analyses. In the first case, the correlation coefficients were coded as an effect size, while in the latter two analyses, Hedges' *g* was calculated for the standardized mean difference between the groups. In case of correlations, the type of correlation (Pearson or Spearman) was also coded in order to investigate whether they could be merged in the same analysis. Data related to ADHD symptom severity was coded for the two subdomains of ADHD separately (inattention and hyperactivity/impulsivity) if the data were available.

In case of longitudinal studies, cross-sectional data from the first data collection phase was coded with one exception. The one exception was the study by Marmet et al. (2018), where the use of the data from the third wave was recommended by the authors, as at that time point no modifications were applied to the assessment tool (i.e., Gaming Addiction Scale), and probably resulting in more reliable estimates.

The following moderator variables were coded: sample type (clinical/non-clinical), mean age of the sample, gender distribution in the sample, country data were collected in, year of data collection, ADHD assessment tool and the informant (self-report/parent report/teacher

report/professional rating), GD/IA assessment tool and the informant (self-report/parent report/teacher report/professional rating), and the type of addiction (only gaming-related problems or problems partly related to gaming and partly to any other internet-based activities). Samples were categorized as clinical, when the participants were recruited from mental healthcare institutions and where they received official diagnosis, while samples were categorized as non-clinical when they were recruited from other places than mental healthcare institutions (e.g., schools, gaming-related sites and forums). For the year of data collection, if it was not reported in the paper, the value was imputed by the publication year -2 formula (for a similar procedure, see Protzko, 2020). Where data were collected over two years, the mean of the publication years was coded. To unify the different scale names used in the studies, five review studies were used (i.e., Collett et al., 2003; Taylor et al., 2011; Laconi et al., 2014; King et al., 2013, 2020). Inter-rater reliability was calculated separately for effect size data (sample sizes, correlation coefficients, means, and standard deviations) and for moderators (mean age, gender distribution, year of data collection, etc.). The inter-rater reliability percentages were acceptable for both the outcome measures (97%) and the moderators (95%).

5.2.5. Contact with the study authors

Study authors were contacted through e-mail to collect information not reported in their studies, such as data to calculate an effect size and values for moderator variables. Additionally, authors with multiple papers were asked questions regarding possible overlap of the samples in these studies. Non-independent samples were removed from the final database in order to make sure that participants were only included once in the analyses.

5.2.6. Quality assessment

For the assessment of the methodological quality of the studies included in the present meta-analysis, the protocol of Murray et al. (2021) was followed, and studies were rated on five criteria: (i) the relevancy and importance of research question; (ii) the evidence and appropriateness of study design; (iii) the possibility of sampling bias; (iv) how well-defined and robust the ADHD assessment was; and (v) how well-defined and robust GD assessment was. All criteria were rated on a 0-2 scale by graduate students in pairs. If any disagreement

occurred, it was resolved by discussion with the inclusion of one of the authors. Overall study quality score ranged between 0-10. Studies were rated as (i) high quality with a score of 8 or more; (ii) medium quality with a score of 3 to 7.5; and low quality with a score below 3.

5.2.7. Statistical analysis

Data were analyzed using the *Comprehensive Meta-Analysis Version 3.0* software (Borenstein, Hedges, Higgins, & Rothstein, 2009). The random-effects model was used in all analyses. For correlational data, results were inspected using both the correlation coefficient and Fisher's z-values as the effect size. Results were very similar regarding these two values so results of correlation coefficients are reported. For data regarding group differences, the means and standard deviations were used to calculate the standardized mean difference Hedges' *g* as the effect size. Additional studies not suitable for data synthesis (because of the low number of such studies with decent heterogeneity in the reported statistical indicators) were included with their results being reported qualitatively. These studies utilized ratings made by professionals (clinicians) for the diagnosis of both disorders reporting the rates of having an ADHD diagnosis in groups with and without GD. Furthermore, a qualitative description of the longitudinal studies was also included.

Outliers exceeding a standardized residual of +/-3.29 were removed from the analyses. The software weights the studies according to the inverse of the standard error so that studies with larger samples have more weight in the average effect. The possibility of publication bias was tested in all analyses using the funnel plot method (Egger et al., 1997). In case asymmetry was identified, Duval and Tweedie's (2000) trim and fill method was utilized to adjust the average effect size. Additionally, Rosenthal's fail-safe N method (Rosenthal, 1979) was used to calculate the number of studies required to turn the results non-significant. As a rule of thumb, an estimate exceeding 5k+10 can be interpreted as reflecting a robust average effect. Heterogeneity of the average effects was assessed using the Q-statistic and I^2 (Borenstein et al., 2009).

In cases of notable heterogeneity, meta-regressions were run to test the effect of the sample's mean age, gender distribution, and the year of data collection. Subgroup analyses

were carried out if more than two studies reported sufficient data to perform subgroup analysis between at least two subgroups for the following variables: sample type, country of data collection, ADHD assessment tool and informant (for ADHD), GD/IA assessment tool and informant (for GD/IA). For the interpretation of Cohen's *d* and Pearson Product Moment *r* values, the guidelines of Cohen (1988) were used.

The correlation between GD and the two subdomains of ADHD was also explored using a structural equation model (SEM) meta-analysis (Cheung & Chan, 2009). This approach allowed for the simultaneous analysis of GD and both ADHD subdomains within a single model, considering their correlation. By combining the outcomes in this way, the analysis benefits from increased statistical power, enabling more precise estimates and potentially more reliable results (Harrer et al., 2021).

5.3. Results

5.3.1. Descriptive statistics

From the 39 studies reporting correlational data, 43 independent samples were identified (Table 1). More specifically, 32 effect sizes were found for the correlation between GD and inattention symptoms and 31 effect sizes were found for the correlation between GD and hyperactivity/inattention symptoms. Seven studies comprising seven effect sizes reported on group comparisons between ADHD and non-ADHD individuals regarding GD symptom severity (Table 2). Finally, six studies reporting seven effect sizes were found comparing groups of GD and non-GD responders regarding ADHD symptom severity (Table 3).

Table 1

Characteristics of Studies Included in the Meta-Analysis (Studies Including Results of Correlation Analyses)

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Andreassen et al. 2016	Non-clinical	23533	35.8	35	Norway	2014	Adult Self Report Scale-18	Self-report	Game Addiction Scale-7	Self-report
Bielefeld et al. 2017	Clinical	29	34.08	66	Germany	N.R.	Conners' Adult ADHD Rating Scale	Self-report	Internetsuchtskala	Self-report
BLS study	Non-clinical	1400	10.71	48.9	Hungary	2018	Strengths and Difficulties Questionnaire	Self-report	Internet Gaming Disorder Test-10	Self-report
Chen et al. 2021	Non-clinical	1236	20.39	39.8	China	2018	Adult Self Report Scale-6	Self-report	Internet Gaming Disorder Scale-9	Self-report
Concerto et al. 2021	Non-clinical	4260	N.R.	84.13	Italy	2020.5	Adult Self Report Scale-18	Self-report	Internet Gaming Disorder Scale-9	Self-report
Demirtas et al. 2021	Clinical	95	14.35	75.8	Turkey	2018	Conners' Parent Rating Scale-48	Parent-report	Internet Addiction Test	Self-report
Evren, B. et al. 2017	Non-clinical	1010	21.85	40	Turkey	2017.5	Adult Self Report Scale-6	Self-report	Internet Addiction Test-12	Self-report

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Evren, C. et al. 2019	Non-clinical	987	23.65	57.44	Turkey	2018	Adult Self Report Scale-6	Self-report	Internet Gaming Disorder Scale-9	Self-report
Ferguson & Ceranoglu 2014	Non-clinical	144	12.7	52.8	USA	2012.5	Child Behavior Checklist (CBCL)	Parent-report	7-item scale of pathological gaming	Self-report
Jung et al. 2020	Non-clinical	51	23.1	100	South Korea	N.R.	Conners' Adult ADHD Rating Scale	Self-report	Internet Game Addiction Questionnaire	Self-report
Kahraman & Demirci 2018	Clinical	111	13.9	N.R.	Turkey	2014.5	Atilla Turgay DSM-IV-Based Child and Adolescent Disruptive Behavioral Disorders Screening and rating Scale	Parent-report	Young Internet Addiction Scale	Self-report
Kandeger et al. 2022	Non-clinical	376	21.83	100	Turkey	2020	Adult Self Report Scale-6	Self-report	Internet Gaming Disorder Scale-9	Self-report
Kawabe et al. 2019	Clinical	55	13.4	76.36	Japan	2017.5	ADHD Rating Scale-IV	Parent-report	Internet Addiction Test	Self-report
Kietglaiwansiri & Chonchaiya 2018	Non-clinical	102	10.09	50	Thailand	2015	Swanson, Nolan, and Pelham-IV Questionnaire	Teacher-report	Game Addiction Screening Test	Parent-report
Kim et al. 2020	Clinical	94	20.25	100	South Korea	N.R.	ADHD Rating Scale-IV	Parent-report	Young Internet Addiction Scale	Self-report

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Lee et al. 2018	Non-clinical	2801	22.43	93	Mixed (USA, Canada, Sweden, Germany, others unknown)	2013.5	Conners' Adult ADHD Rating Scale	Self-report	Internet Addiction Test	Self-report
Lefler et al. 2022	Non-clinical	1489	19.13	30.06	USA	N.R.	DSM-V criteria	Self-report	11-item Pathological-Gaming Scale based on the DSM–IV gambling criteria	Self-report
Li et al. 2016	Non-clinical	73	22.56	53.4	China	N.R.	Adult Self Report Scale-18	Self-report	Chen Internet Addiction Scale	Self-report
Marmet et al. 2018	Non-clinical	5501	25.44	100	Switzerland	2017	Adult Self Report Scale-6	Self-report	Game Addiction Scale-7	Self-report
Masi et al. 2021	Clinical	280	7.68	65.4	Canada	2017	Questionnaire on Attention and Computers	Parent-report	Questionnaire on attention and computers	Parent-report

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Masklavanou et al. 2022	Non-clinical	515	26.8	86.35	Greece	2022	ADHD Rating Scale-IV	Self-report	Internet Gaming Disorder Scale-9	Self-report
Mazurek & Engelhardt 2013_1	Clinical	44	11.7	100	USA	2011	Vanderbilt ADHD Rating Scale	Parent-report	Problem Videogame Playing Scale	Parent-report
Mazurek & Engelhardt 2013_2	Clinical	56	11.1	100	USA	2011	Vanderbilt ADHD Rating Scale	Parent-report	Problem Videogame Playing Scale	Parent-report
Mazurek & Engelhardt 2013_3	Non-clinical	41	12.2	100	USA	2011	Vanderbilt ADHD Rating Scale	Parent-report	Problem Videogame Playing Scale	Parent-report
Menéndez-García et al. 2022	Clinical	112	N.R.	36.61	Spain	N.R.	ATENTO	Parent-report	ADITEC	Parent-report
Panagiotidi 2017	Non-clinical	205	27.4	48.78	UK	N.R.	Adult Self Report Scale-18	Self-report	Problem Videogame Playing Scale	Self-report
Peeters et al. 2018	Non-clinical	544	13.9	48.9	Netherlands	2015.5	ADHD-Vragenlijst (AVL)	Self-report	Internet Gaming Disorder Scale-9	Self-report
Schoenmacker et al. 2020	Clinical	362	15.93	80.66	Mixed (Germany, Netherlands, Belgium)	2004.5	Parental Account of Childhood Symptoms	Parent-report	Game Addiction Scale-21-modified	Self-report

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Stavropoulos et al. 2019_1	Non-clinical	163	23.01	75.4	Australia	2016.5	Adult Self Report Scale-18	Self-report	Internet Gaming Disorder Scale-9	Self-report
Stavropoulos et al. 2019_2	Non-clinical	398	25.25	58.11	USA	2016	Adult Self Report Scale-18	Self-report	Internet Gaming Disorder Scale-9	Self-report
Stavropoulos et al. 2020	Non-clinical	1031	25.74	48.7	Mixed (Australia, United States of America, United Kingdom, Canada, New Zealand)	2018.5	Adult Self Report Scale-18	Self-report	Internet Gaming Disorder Scale-9	Self-report
Taner et al. 2022	Non-clinical	290	20	38.27	Turkey	2019.5	Adult Self Report Scale-18	Self-report	Computer Gaming Addiction Scale	Self-report
The Gaming Motivation Inventory study	Non-clinical	12842	24.1	89.3	Hungary	2020	Adult Self Report Scale-6	Self-report	Internet Gaming Disorder Test-10	Self-report
Tolchinsky & Jefferson 2011	Non-clinical	216	N.R.	43.98	USA	N.R.	Assessment of Hyperactivity and Attention (AHA)	Self-report	Problem Videogame Playing Scale	Self-report
Tzang, Chang, Chang 2022	Clinical	102	11.27	68.6	Taiwan	2020	Swanson, Nolan, and Pelham-IV Questionnaire	Parent-report/ Teacher report	Chen Internet Addiction Scale	Self-report

Study	Sample type	Sample size	Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
Vadlin et al. 2016_1	Clinical	242	15.39	30.2	Sweden	2014.5	Adult Self Report Scale-18	Self-report	Gaming Addiction Identification Test	Self-report
Vadlin et al. 2016_2	Non-clinical	1868	13.9	44.6	Sweden	2012	Adult Self Report Scale-18	Self-report	Gaming Addiction Identification Test	Self-report
Vally 2021	Non-clinical	214	20.64	44.9	United Arab Emirates	2019.5	Adult Self Report Scale-18	Self-report	Internet Gaming Disorder Scale-9	Self-report
Walther et al. 2012	Non-clinical	2553	16.7	50.7	Germany	2010	Rating Scale for Attention-Deficit/Hyperactivity Disorder	Self-report	Video Game Dependency Scale	Self-report
Wartberg et al. 2019	Non-clinical	1095	12.99	50.8	Germany	2016	Strengths and Difficulties Questionnaire	Parent-report	Internet Gaming Disorder Scale-9	Self-report
Wichstrøm et al. 2019	Non-clinical	702	10.5	48.6	Norway	2014	Child and Adolescent Psychiatric Assessment	Professional-rating	Internet Gaming Disorder Interview	Professional-rating
Yilmaz et al. 2015	Non-clinical	640	16.0	48.3	Turkey	N.R.	Conners-Wells' Adolescent Self-Report Scale-27	Self-report	Internet Addiction Scale	Self-report
Yoo et al. 2004	Non-clinical	535	11.0	49.4	South Korea	N.R.	ADHD Rating Scale-IV	Parent-report, Teacher-report	Internet Addiction Test	Self-report

Note. N.R.=not reported.

Table 2

Characteristics of Studies Included in the Meta-Analysis (Group Comparison Studies Between GD and Non-GD Individuals)

Study	GD/IA group		Non-GD/IA group		Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
	Sample type	Sample size	Sample type	Sample size								
Berloffa 2022	Clinical	48	Clinical	60	11.7	88.88	Italy	2020.5	Conners' Parent Rating Scale-27	Parent-report	Internet Gaming Disorder Scale-9	Self-report
Cao & Su 2007	Non-clinical	64	Non-clinical	64	14.7	82.81	China	N.R.	Strengths and Difficulties Questionnaire	Parent-report	Young Internet Addiction Scale	Self-report
Melek & Eroğlu 2019	Clinical	100	Non-clinical	95	N.R.	57.7	Turkey	N.R.	DSM-V criteria	Professional-rating	Internet Addiction Test	Self-report
Pearcy et al. 2017	Non-clinical	34	Non-clinical	370	23.8	70.01	Mixed (Australia, USA, etc.)	2015	Adult Self Report Scale-18	Self-report	Personal Internet Gaming Disorder Evaluation-9	Self-report
Seong et al. 2019	Clinical	152	Non-clinical	138	26.06	89.7	South Korea	2018	ADHD Rating Scale-IV	Self-report	Internet Addiction Test	Self-report

Study	GD/IA group		Non-GD/IA group		Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
	Sample type	Sample size	Sample type	Sample size								
Starcevic et al. 2020	Cinical	36	Clinical	64	21.2	94	South Korea	N.R.	Adult Self Report Scale-18	Self-report	Gaming Diagnostic Interview	Professional-rating

Note. N.R.=not reported.

Table 3

Characteristics of Studies Included in the Meta-Analysis (Group Comparison Studies Between ADHD and Non-ADHD Individuals)

Study	ADHD group		Non-ADHD group		Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
	Sample type	Sample size	Sample type	Sample size								
Başgül et al. 2020	Clinical	100	Non-clinical	100	11.68	71	Turkey	N.R.	Medical record	Professional-rating	Computer Game Addiction Scale for Children	N.R.
Evren, C. et al. 2021	Non-clinical	143	Non-clinical	602	23.06	68.9	Turkey	2019	Adult Self Report Scale-6	Self-report	Internet Gaming Disorder Scale-9	Self-report

Study	ADHD group		Non-ADHD group		Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
	Sample type	Sample size	Sample type	Sample size								
Gentile 2009	Non-clinical	144	Non-clinical	984	13.2	49.92	USA	2007	Medical record	Professional-rating	11-item Pathological-Gaming Scale based on the DSM–IV gambling criteria	Self-report
Kwak et al. 2020	Clinical	14	Non-clinical	12	N.R.	N.R.	South Korea	2017	ADHD Rating Scale-IV	Self-report	Young Internet Addiction Scale	Self-report
Paulus et al. 2018	non-clinical	91	Non-clinical	1176	5.8	49.9	Germany	2011.5	Diagnostik-System für psychische Störungen nach ICD-10 und DSM-IV für Kinder und Jugendliche-II	Parent-report	Young Children-Computer Gaming Disorder questionnaire	Parent-report
Razjouyan et al. 2020	Clinical	99	Non-clinical	99	N.R.	67	Iran	N.R.	Conners' ADHD Rating Scale	Self-report	Internet Addiction Test	Self-report

Study	ADHD group		Non-ADHD group		Mean age	Gender distribution (male %)	Country (of sample)	Date of data collection	ADHD measurement	Source of data (ADHD)	GD/IA measurement	Source of data (GD/IA)
	Sample type	Sample size	Sample type	Sample size								
Weinstein et al. 2015	Clinical	50	Non-clinical	50	13.88	100	Israel	2015	Medical record	Professional-rating	Internet Addiction Test	Self-report

Note. N.R.=not reported.

5.3.2. Preliminary subgroup analysis for studies with parametric and non-parametric correlation

A preliminary analysis tested whether the effect sizes based on non-parametric correlation analyses (i.e., Spearman's correlation coefficients) had a different average effect size compared to the effect sizes using parametric correlation results (i.e., Pearson's correlation coefficients) using mixed effect model estimates for the association between GD and combined ADHD, inattention, and hyperactivity/impulsivity scores. The average effect size was similar in studies reporting non-parametric correlation statistics (r=.308, k=6, SE=0.0334, 95% CI=[.241; .372], p<.001) compared to parametric statistics (r=.294, k=35, SE=0.0171, 95% CI=[.260; .327], p<.001)(Q=0.140, df=1, p=.708) with combined ADHD scores.

Secondly for the analysis including inattention scores, no difference was found between the average effect sizes of studies reporting non-parametric correlation statistics (r=.331, k=4, SE= 0.0569, 95% CI=[.215; .438], p<.001) compared to parametric statistics (r=.302, k=27, SE= 0.0219, 95% CI=[.258; .344], p<.001)(Q=0.222, df=1, p=.637). Similarly, the subgroup analysis did not indicate difference between the average effect sizes of studies reporting non-parametric correlation statistics (r=.297, k=4, SE= 0.0538, 95% CI=[.188; .399], p<.001) compared to parametric statistics (r=.260, k=25, SE=0.0217, 95% CI=[.217; .302], p<.001) (Q=0.408, df=1, p=.523) including hyperactivity/impulsivity scores. Given the analyis found no indication that different correlation coefficients may overestimate or underestimate the association, no studies were excluded from the analysis where Spearman's correlation was used.

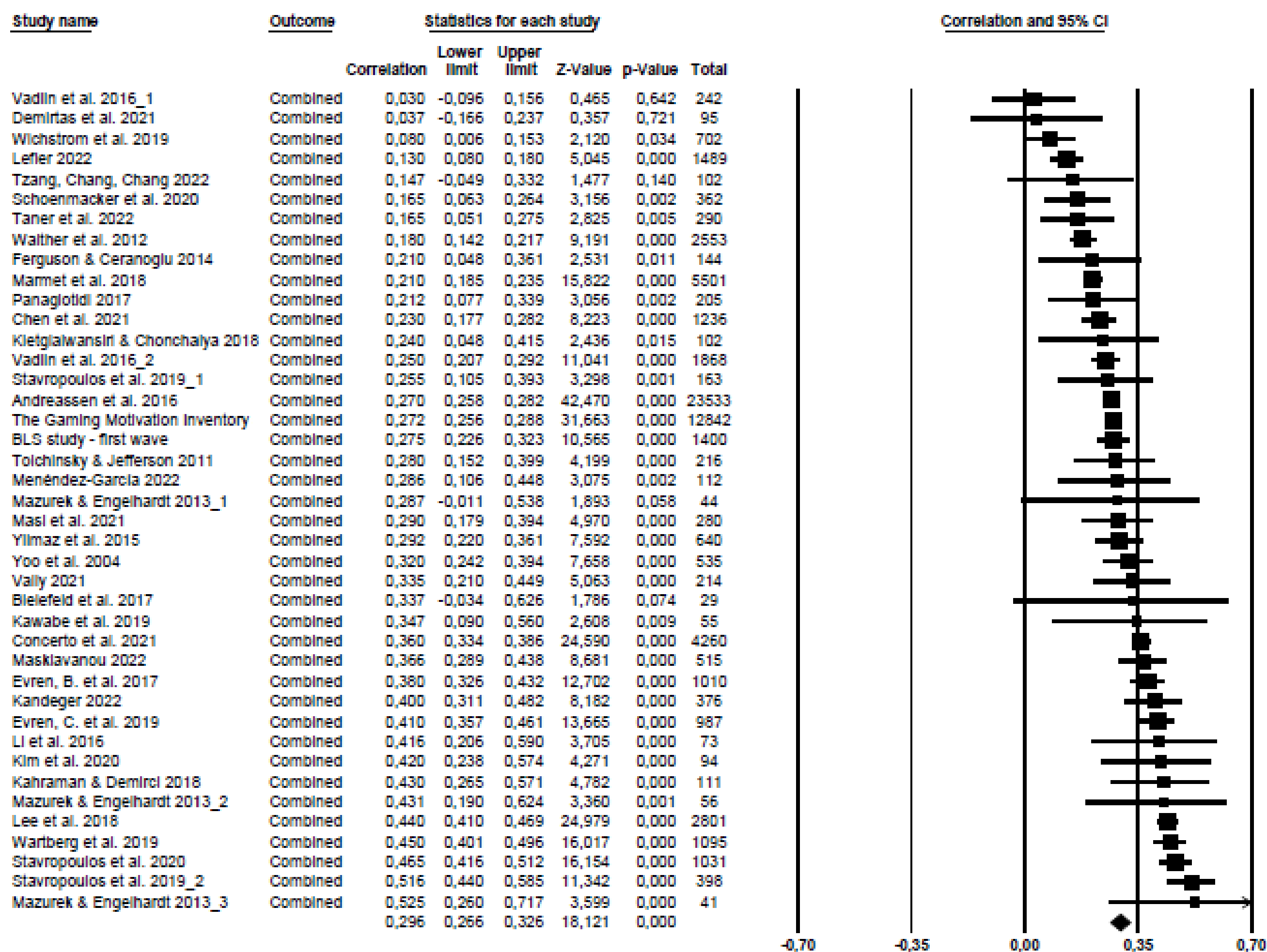
5.3.3. Meta-analysis of studies reporting on correlational analyses

A medium-sized, significant positive association was found between combined ADHD scores and gaming disorder symptom severity: r=.296, k=41, SE= 0.0153, 95% CI=[.266, .326], p<.001 (Figure 2). More specifically, gaming disorder symptom severity also showed moderate-sized significant average correlations with both ADHD inattention scores (r=.306, k=31, SE=0.0202, 95% CI=[.266, .345], p<.001) (Figure 3) and ADHD hyperactivity/impulsivity scores (r=.266, k=29, SE= 0.0202, 95% CI=[.226, .305], p<.001)

(Figure 4). In all three average effects, there was significant heterogeneity between the studies (Q=481.003, df=40, $p<.001$, $I^2=92\%$ for the effect sizes with combined ADHD scores; Q=306.437, df=30, $p<.001$, $I^2=90\%$ for the effect sizes with ADHD inattention scores; Q=258.426, df=28, $p<.001$, $I^2=89\%$ for the effect sizes with ADHD hyperactivity/impulsivity scores).

Figure 2

Forest Plot for Studies With Correlation Data of the Association Between Gaming Disorder Symptom Severity and Combined ADHD Scores



Study name	Outcome	Correlation	Lower limit	Upper limit	Z-Value	p-Value	Total
Vadlin et al. 2016_1	Combined	0,030	-0,096	0,156	0,465	0,642	242
Demirtas et al. 2021	Combined	0,037	-0,166	0,237	0,357	0,721	95
Wichstrom et al. 2019	Combined	0,080	0,006	0,153	2,120	0,034	702
Lefler 2022	Combined	0,130	0,080	0,180	5,045	0,000	1489
Tzang, Chang, Chang 2022	Combined	0,147	-0,049	0,332	1,477	0,140	102
Schoenmacker et al. 2020	Combined	0,165	0,063	0,264	3,156	0,002	362
Taner et al. 2022	Combined	0,165	0,051	0,275	2,825	0,005	290
Walther et al. 2012	Combined	0,180	0,142	0,217	9,191	0,000	2553
Ferguson & Ceranoglu 2014	Combined	0,210	0,048	0,361	2,531	0,011	144
Marmet et al. 2018	Combined	0,210	0,185	0,235	15,822	0,000	5501
Panagiotidi 2017	Combined	0,212	0,077	0,339	3,056	0,002	205
Chen et al. 2021	Combined	0,230	0,177	0,282	8,223	0,000	1236
Kietglaiwansiri & Chonchaiya 2018	Combined	0,240	0,048	0,415	2,436	0,015	102
Vadlin et al. 2016_2	Combined	0,250	0,207	0,292	11,041	0,000	1868
Stavropoulos et al. 2019_1	Combined	0,255	0,105	0,393	3,298	0,001	163
Andreassen et al. 2016	Combined	0,270	0,258	0,282	42,470	0,000	23533
The Gaming Motivation Inventory	Combined	0,272	0,256	0,288	31,663	0,000	12842
BLS study - first wave	Combined	0,275	0,226	0,323	10,565	0,000	1400
Tolchinsky & Jefferson 2011	Combined	0,280	0,152	0,399	4,199	0,000	216
Menéndez-García 2022	Combined	0,286	0,106	0,448	3,075	0,002	112
Mazurek & Engelhardt 2013_1	Combined	0,287	-0,011	0,538	1,893	0,058	44
Masi et al. 2021	Combined	0,290	0,179	0,394	4,970	0,000	280
Yilmaz et al. 2015	Combined	0,292	0,220	0,361	7,592	0,000	640
Yoo et al. 2004	Combined	0,320	0,242	0,394	7,658	0,000	535
Vally 2021	Combined	0,335	0,210	0,449	5,063	0,000	214
Bielefeld et al. 2017	Combined	0,337	-0,034	0,626	1,786	0,074	29
Kawabe et al. 2019	Combined	0,347	0,090	0,560	2,608	0,009	55
Concerto et al. 2021	Combined	0,360	0,334	0,386	24,590	0,000	4260
Maskiavanou 2022	Combined	0,366	0,289	0,438	8,681	0,000	515
Evren, B. et al. 2017	Combined	0,380	0,326	0,432	12,702	0,000	1010
Kandeger 2022	Combined	0,400	0,311	0,482	8,182	0,000	376
Evren, C. et al. 2019	Combined	0,410	0,357	0,461	13,665	0,000	987
Li et al. 2016	Combined	0,416	0,206	0,590	3,705	0,000	73
Kim et al. 2020	Combined	0,420	0,238	0,574	4,271	0,000	94
Kahraman & Demirci 2018	Combined	0,430	0,265	0,571	4,782	0,000	111
Mazurek & Engelhardt 2013_2	Combined	0,431	0,190	0,624	3,360	0,001	56
Lee et al. 2018	Combined	0,440	0,410	0,469	24,979	0,000	2801
Wartberg et al. 2019	Combined	0,450	0,401	0,496	16,017	0,000	1095
Stavropoulos et al. 2020	Combined	0,465	0,416	0,512	16,154	0,000	1031
Stavropoulos et al. 2019_2	Combined	0,516	0,440	0,585	11,342	0,000	398
Mazurek & Engelhardt 2013_3	Combined	0,525	0,260	0,717	3,599	0,000	41
		0,296	0,266	0,326	18,121	0,000	

Figure 3

Forest Plot for Studies With Correlation Data of The Association Between Gaming Disorder Symptom Severity and ADHD Inattention Scores

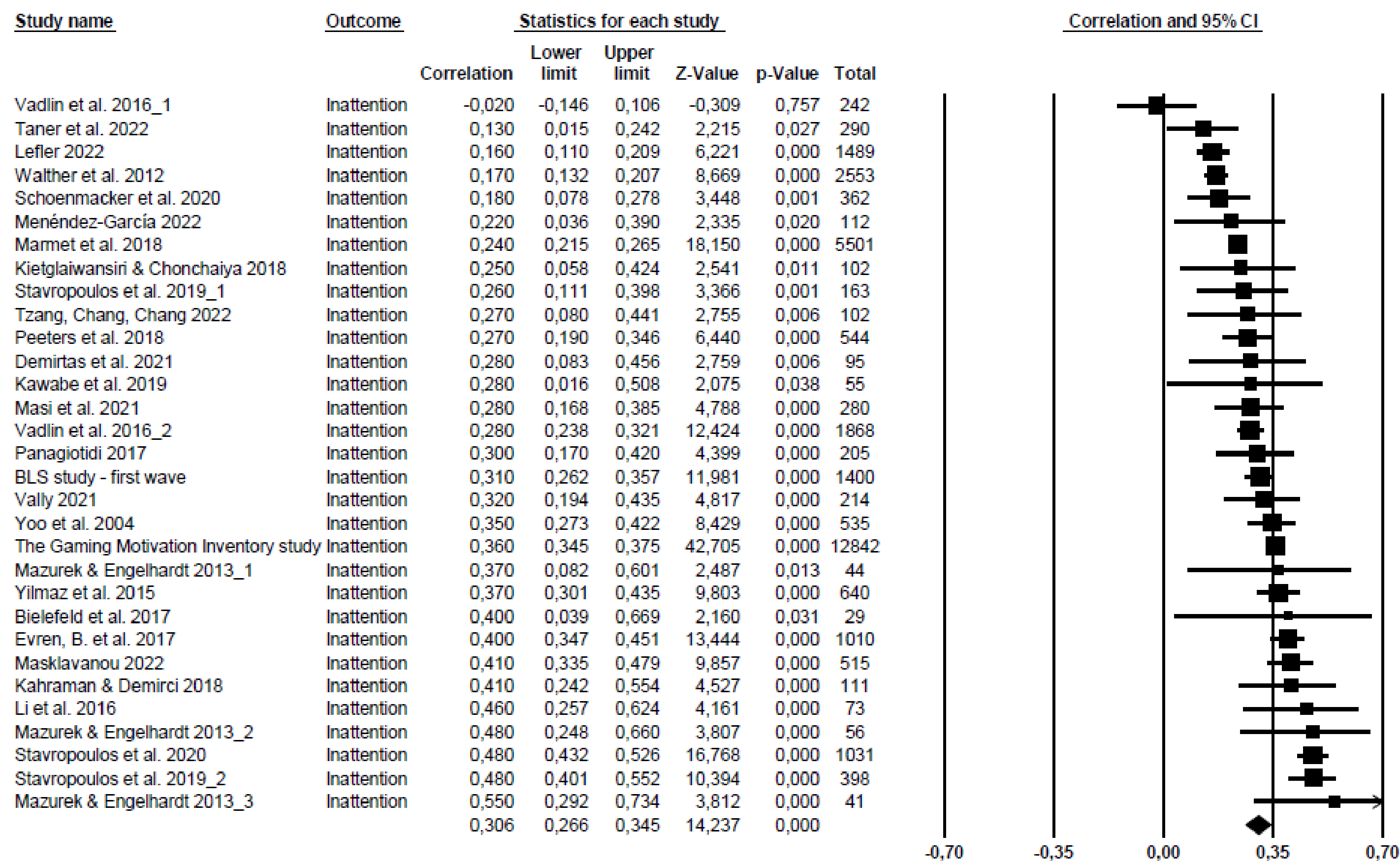
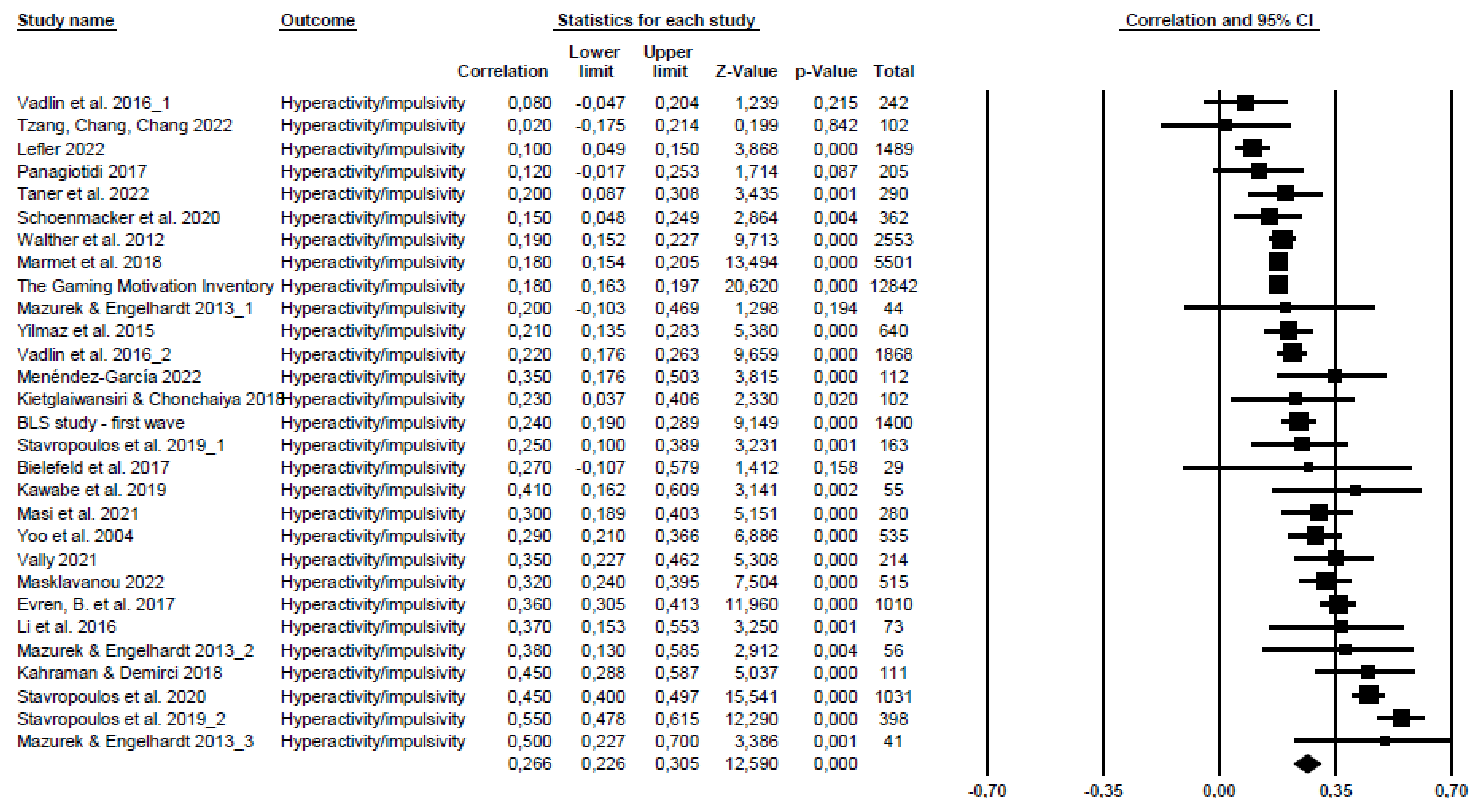


Figure 4

Forest Plot for Studies with Correlation Data of the Association Between Gaming Disorder Symptom Severity and ADHD Hyperactivity/Impulsivity Scores



According to the classic fail-safe N method these average effects were robust (i.e., 31,960 non-significant studies would be needed to turn the average effect non-significant in case of combined ADHD symptom severity scores, 13,912 studies in case of ADHD inattention symptom severity scores, and 8016 studies in case of ADHD hyperactivity/impulsivity severity scores). Funnel plots including the combined and the subdomain scores of ADHD showed some slight asymmetry. Duval and Tweedie's Trim and Fill method indicated one trimmed study for studies with combined ADHD scores, where the adjusted average effect remained significant (r=.294, 95% CI=[.264; .324], p<.001)(Figure 5). Regarding ADHD inattention scores, three trimmed studies were identified, where the average effect size, again, remained significant (r=.291, 95% CI=[.251; .330], p<.001) (Figure 6). Finally, in the case of ADHD hyperactivity/impulsivity scores, six trimmed studies were calculated, resulting in a significant adjusted average effect size (r=.2223, 95% CI=[.180; .265], p<.001) (Figure 7).

Figure 5

Funnel Plot for Studies with Correlation Data of the Association Between Gaming Disorder Symptom Severity and Combined ADHD Scores

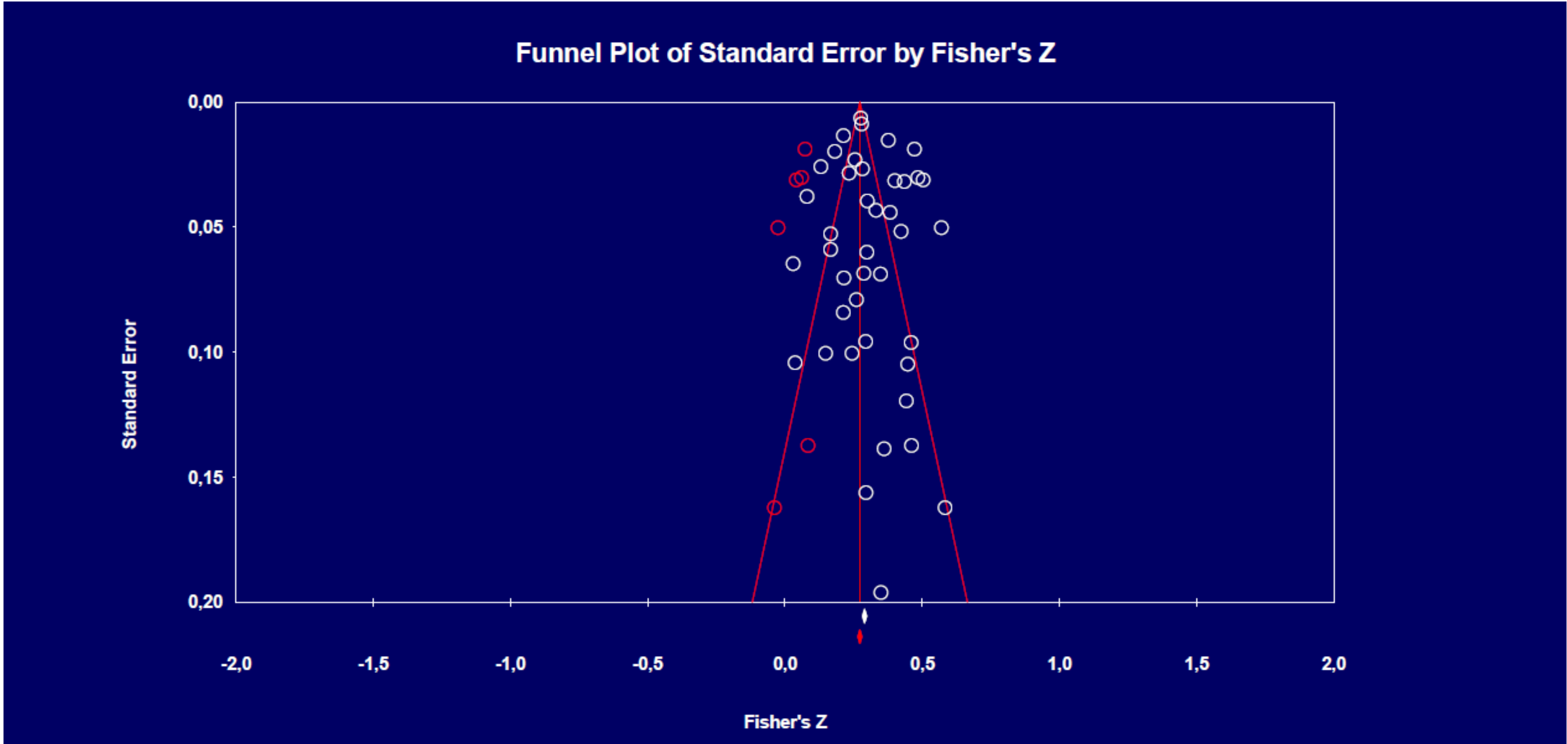


Figure 6

Funnel Plot for Studies with Correlation Data of the Association Between Gaming Disorder Symptom Severity and Inattention ADHD Scores

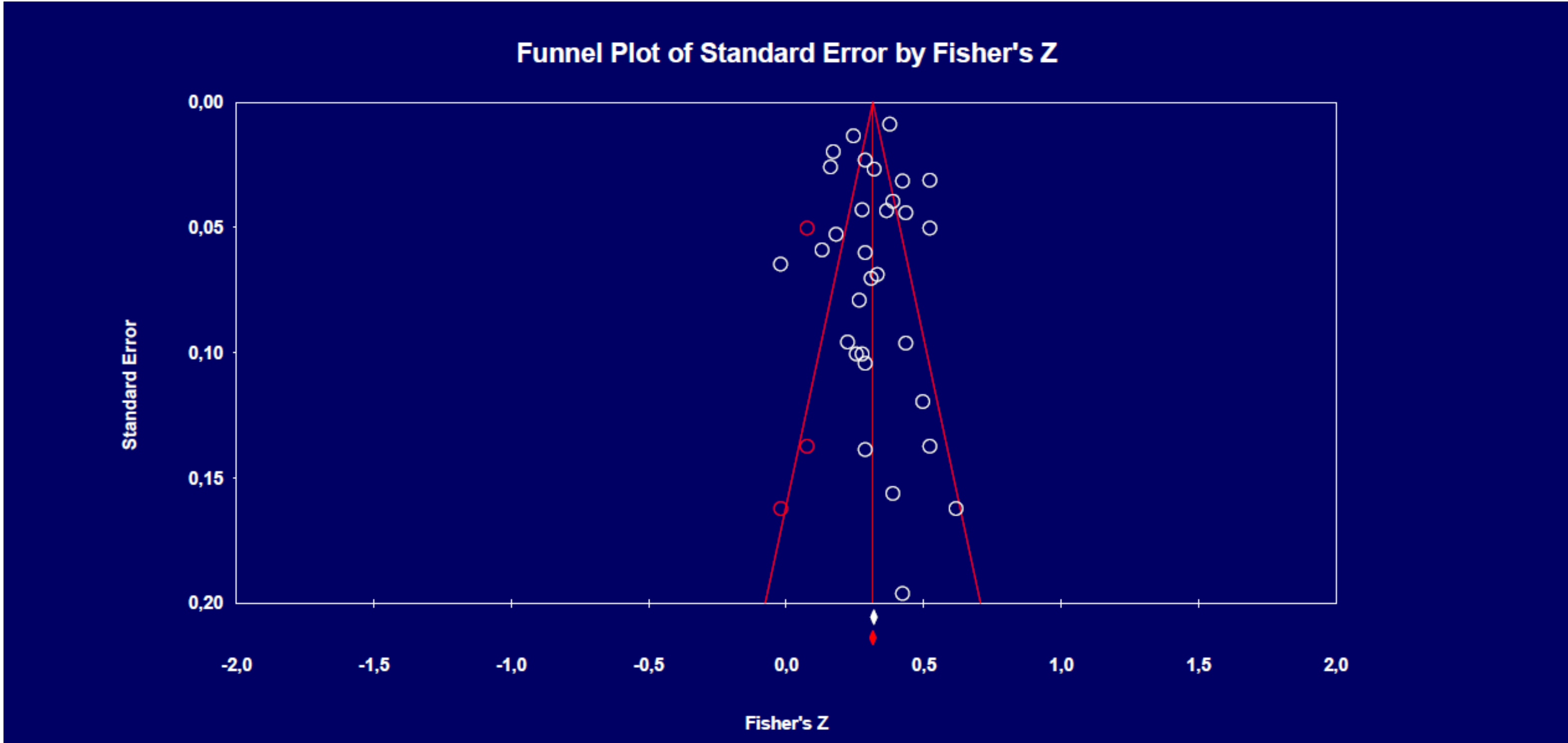
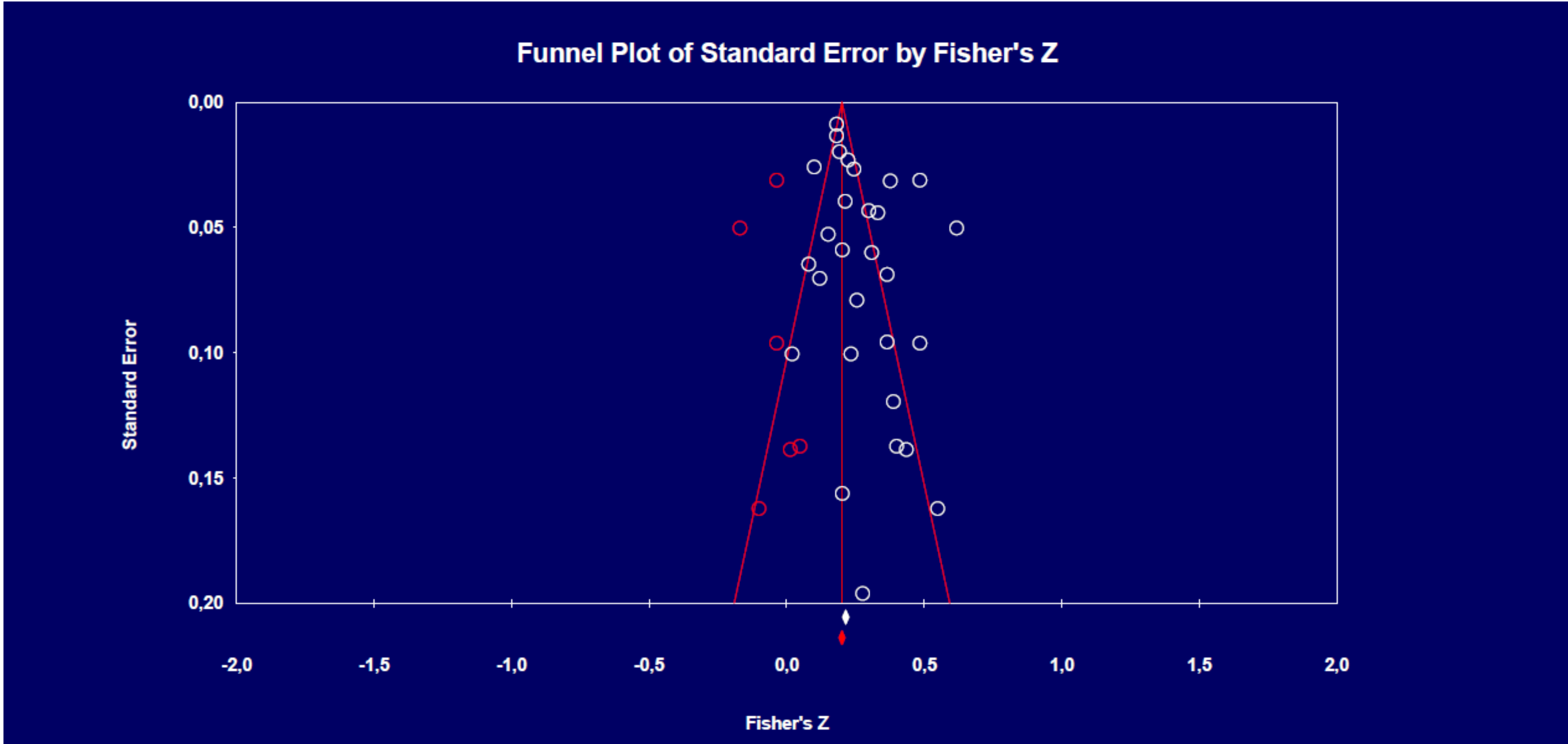


Figure 7

Funnel Plot for Studies With Correlation Data of the Association Between Gaming Disorder Symptom Severity and Hyperactivity/Impulsivity ADHD Scores



As a result of the subgroup analysis comparing the effect sizes between the two types of disorders assessed, significantly larger correlation coefficient estimates between GD symptom scores and ADHD inattention subdomain scores were found for studies assessing problematic internet use in predominantly video game user samples compared to studies where purely gaming disorder severity was assessed (Figure 8). Furthermore, gender ratio positively predicted the correlation coefficient between gaming disorder severity and combined ADHD scores (Figure 9), suggesting that the association is larger for males, but the effect estimate was negligible Neither the remaining subgroup analyses (clinical versus non-clinical samples, country of data collection (Germany, Turkey, USA), GD assessment tools (Internet Addiction Test, Internet Gaming Disorder Scale Short-Form, Problem Videogame Playing Scale) and source (self-report versus parent-report), ADHD assessment tools (ADHD Rating Scale-IV, Adult Self Report Scale 6-item screener version, Adult Self Report Scale 18-item version) and source (self-report or parent-report), nor the other meta-regressions (mean age of the sample, year of data collection, overall study quality) performed on the average correlation coefficients including any ADHD data type (combined, inattention, hyperactivity/impulsivity) resulted in significant results regarding potential moderators (Tables 4-7). Average effect sizes in all categories in the subgroup analyses showed moderately-sized significant positive correlations between GD and ADHD symptoms, irrespective of the characteristics of the sample or the assessment tool used (Table 4-6).

Table 4

Subgroup Analyses Results of Correlation Coefficients Using Combined ADHD Scores

Moderators	Average effect size							Difference between groups		
	r	k	n	SE	LL	UL	p	Q	df (Q)	p
Sample type										
Clinical	.255	12	1582	0.0434	.168	.338	<.001			
Non-clinical	.307	29	66220	0.0166	.274	.339	<.001			
Total Between								1.288	1	.256
Country										
Germany	.324	3	3677	0.1161	.078	.533	.011			
Turkey	.321	7	3509	0.0385	.244	.395	<.001			
USA	.338	7	2388	0.0796	.173	.485	<.001			
Total Between								0.035	2	.983
GD measure										
IAT	.242	3	685	0.0931	.051	.416	.014			
IGDS9-SF	.385	10	10275	0.0265	.332	.436	<.001			
PVP	.356	6	3363	0.0556	.243	.461	<.001			
Total Between								2.386	2	.303
GD source										
Parent-report	.310	6	635	0.0365	.237	.380	<.001			
Self-report	.300	34	66465	0.0161	.269	.332	<.001			

Total Between								0.058	1	.809
ADHD measure										
ADHD-RS	.349	4	1199	0.0255	.298	.398	<.001			
ASRS-18	.306	11	32277	0.0296	.246	.363	<.001			
ASRS-6	.312	6	21952	0.0288	.255	.368	<.001			
Total Between								1.484	2	.476
ADHD source										
Parent-report	.321	12	2489	0.0449	.230	.406	<.001			
Self-report	.302	25	63872	0.0174	.267	.335	<.001			
Total Between								0.158	1	.691
Type of addiction										
Gaming disorder	.291	31	65058	0.0171	.257	.324	<.001			
Internet addiction mixed with GD	.320	10	2744	0.0314	.257	.380	<.001			
Total Between								0.631	1	.427

Note. IAT=Internet Addiction Test, IGDS9-SF=Internet Gaming Disorder Scale-9, PVP=Problem Videogame Playing Scale, ADHD-RS=ADHD Rating Scale-IV, ASRS-6=Adult Self Report Scale-6 (6-item screener), ASRS-18=Adult Self Report Scale-18. 95% confidence intervals were calculated. CI = confidence interval, LL =lower limit; UL =

upper limit, GD = Gaming Disorder, IA = Internet Addiction. Mixed effects analyses results are reported here.

95% confidence intervals were calculated.

Table 5

Subgroup Analyses Results of Correlation Coefficients Using ADHD Inattention Scores

Moderators	Average effect size							Difference between groups		
	r	k	n	SE	LL	UL	p	Q	df (Q)	p
Sample type										
Clinical	.265	11	1488	0.0449	.175	.351	<.001			
Non-clinical	.322	20	31414	0.0227	.276	.365	<.001			
Total Between								1.293	1	.255gdgd
GD measure										
IAT	.335	3	685	0.0342	.267	.401	<.001			
IGDS9-SF	.380	6	2865	0.0424	.294	.460	<.001			
Total Between								0.675	1	.411
GD source										
Parent-report	.324	6	635	0.0480	.227	.415	<.001			
Self-report	.302	25	32267	0.0217	.259	.344	<.001			
Total Between								0.179	1	.672
ADHD measure										
ADHD-RS	.375	3	1105	0.0260	.323	.425	<.001			
ASRS-18	.305	9	4484	0.0584	.196	.406	<.001			

ASRS-6	.333	3	19353	0.0464	.239	.421	<.001			
Total Between								1.727	2	.422
ADHD source										
Parent-report	.309	9	1156	0.0398	.229	.385	<.001			
Self-report	.304	19	31007	0.0245	.255	.351	<.001			
Total Between								0.014	1	.906
Type of addiction										
Gaming disorder	.288	22	30252	0.0242	.240	.335	<.001			
Internet addiction mixed with GD	.374	9	2650	0.0168	.340	.406	<.001			
Total Between								8.636	1	.003

Note. IAT=Internet Addiction Test, IGDS9-SF=Internet Gaming Disorder Scale-9, ADHD-RS=ADHD Rating Scale-IV, ASRS-6=Adult Self Report Scale-6 (6-item screener), ASRS-18=Adult Self Report Scale-18. 95% confidence intervals were calculated. CI = confidence interval, LL =lower limit; UL = upper limit, GD = Gaming Disorder, IA = Internet Addiction. Mixed effects analyses results are reported here.

95% confidence intervals were calculated.

Table 6

Subgroup Analyses Results of Correlation Coefficients Using ADHD Hyperactivity/Impulsivity Scores

Moderators	Average effect size							Difference between groups		
	r	k	n	SE	LL	UL	p	Q	df (Q)	p
Sample type										
Clinical	.253	10	1393	0.0477	.157	.344	<.001			
Non-clinical	.271	19	30870	0.0230	.226	.316	<.001			
Total Between								0.122	1	.727
GD source										
Parent-report	.312	6	635	0.0362	.239	.381	<.001			
Self-report	.258	23	31628	0.0217	.215	.300	<.001			
Total Between								1.622	1	.203
ADHD measure										
ADHD-RS	.310	3	1105	0.0270	.256	.362	<.001			
ASRS-18	.296	9	4484	0.0559	.183	.402	<.001			
ASRS-6	.234	3	19353	0.0347	.165	.301	<.001			
Total Between								3.025	2	.220
ADHD source										
Parent-report	.327	8	1061	0.0475	.231	.417	<.001			
Self-report	.258	18	30463	0.0237	.211	.304	<.001			
Total Between								1.624	1	.202
Type of addiction										
Gaming disorder	.256	21	29708	0.0222	.212	.299	<.001			

Internet addiction mixed with GD	.296	8	2555	0.0408	.215	.375	<.001			
Total Between								0.748	1	.387

Note. ADHD-RS=ADHD Rating Scale-IV, ASRS-6=Adult Self Report Scale-6 (6-item screener), ASRS-18=Adult Self-Report Scale-18. 95% confidence intervals were calculated. CI = confidence interval, LL =lower limit; UL = upper limit, GD = Gaming Disorder, IA = Internet Addiction. Mixed effects analyses results are reported here. 95% confidence intervals were calculated.

Table 7

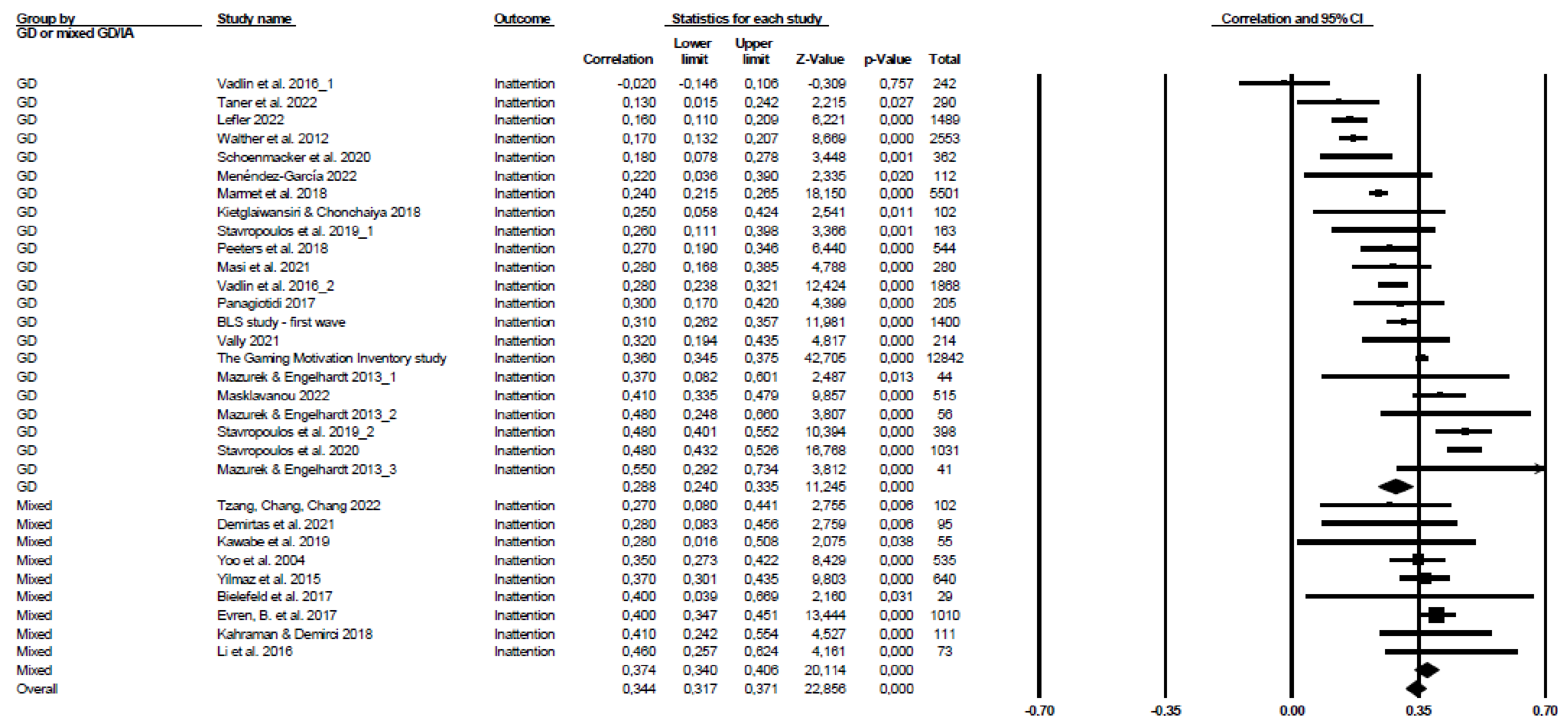
Results of Meta-Regression Analyses on Correlation Coefficients Using Combined, Inattention and Hyperactivity/Impulsivity ADHD Scores

Predictor	Coefficient	k	SE	LL	UL	p
Combined ADHD						
Mean age	0.0049	38	0.0030	-0.0009	0.0108	.096
Gender distribution	0.0018	40	0.0008	0.0001	0.0035	.033
Data collection year	0.0033	41	0.0041	-0.0048	0.0114	.427
Overall study quality	0.0071	41	0.0136	-0.0196	0.0337	.600
Inattention						
Mean age	0.0054	30	0.0038	-0.0020	0.0127	.153
Gender distribution	0.0020	30	0.0011	-0.0002	0.0042	.079
Data collection year	0.0010	31	0.0048	-0.0084	0.0104	.834
Overall study quality	0.0189	31	0.0171	-0.0145	0.0523	.267
Hyperactivity/impulsivity						
Mean age	0.0036	28	0.0038	-0.0038	0.0110	.338
Gender distribution	0.0006	28	0.0011	-0.0017	0.0025	.729
Data collection year	0.0015	29	0.0049	-0.0080	0.0110	.756
Overall study quality	-0.0027	29	0.0163	-0.0347	0.0292	.867

Note. CI = confidence interval, LL =lower limit; UL = upper limit. Random effects analyses results are reported here. 95% confidence intervals were calculated.

Figure 8

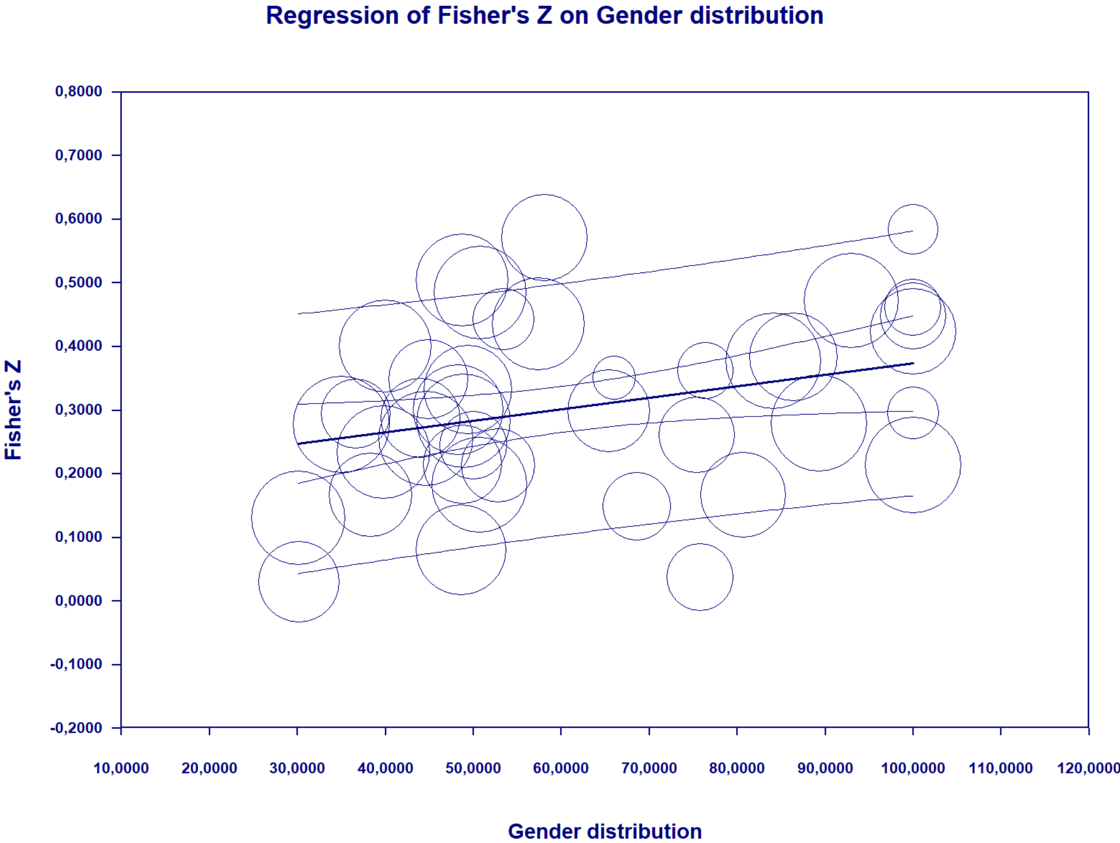
Forest Plot for the Comparison of Correlation Estimates of the Association Between Gaming Disorder and ADHD Inattention Scores Between Studies Measuring Gaming Disorder and Internet Addiction Mixed with Gaming Disorder



Group by GD or mixed GD/IA	Study name	Outcome	Correlation	Lower limit	Upper limit	Z-Value	p-Value	Total
GD	Vadlin et al. 2016_1	Inattention	-0,020	-0,146	0,106	-0,309	0,757	242
GD	Taner et al. 2022	Inattention	0,130	0,015	0,242	2,215	0,027	290
GD	Lefler 2022	Inattention	0,160	0,110	0,209	6,221	0,000	1489
GD	Walther et al. 2012	Inattention	0,170	0,132	0,207	8,669	0,000	2553
GD	Schoenmacker et al. 2020	Inattention	0,180	0,078	0,278	3,448	0,001	362
GD	Menéndez-García 2022	Inattention	0,220	0,036	0,390	2,335	0,020	112
GD	Marmet et al. 2018	Inattention	0,240	0,215	0,265	18,150	0,000	5501
GD	Kietglaiwansiri & Chonchaiya 2018	Inattention	0,250	0,058	0,424	2,541	0,011	102
GD	Stavropoulos et al. 2019_1	Inattention	0,260	0,111	0,398	3,366	0,001	163
GD	Peeters et al. 2018	Inattention	0,270	0,190	0,346	6,440	0,000	544
GD	Masi et al. 2021	Inattention	0,280	0,168	0,385	4,788	0,000	280
GD	Vadlin et al. 2016_2	Inattention	0,280	0,238	0,321	12,424	0,000	1868
GD	Panagiotidi 2017	Inattention	0,300	0,170	0,420	4,399	0,000	205
GD	BLS study - first wave	Inattention	0,310	0,262	0,357	11,981	0,000	1400
GD	Vally 2021	Inattention	0,320	0,194	0,435	4,817	0,000	214
GD	The Gaming Motivation Inventory study	Inattention	0,360	0,345	0,375	42,705	0,000	12842
GD	Mazurek & Engelhardt 2013_1	Inattention	0,370	0,082	0,601	2,487	0,013	44
GD	Masklavanou 2022	Inattention	0,410	0,335	0,479	9,857	0,000	515
GD	Mazurek & Engelhardt 2013_2	Inattention	0,480	0,248	0,660	3,807	0,000	56
GD	Stavropoulos et al. 2019_2	Inattention	0,480	0,401	0,552	10,394	0,000	398
GD	Stavropoulos et al. 2020	Inattention	0,480	0,432	0,526	16,768	0,000	1031
GD	Mazurek & Engelhardt 2013_3	Inattention	0,550	0,292	0,734	3,812	0,000	41
GD			0,288	0,240	0,335	11,245	0,000	
Mixed	Tzang, Chang, Chang 2022	Inattention	0,270	0,080	0,441	2,755	0,006	102
Mixed	Demirtas et al. 2021	Inattention	0,280	0,083	0,456	2,759	0,006	95
Mixed	Kawabe et al. 2019	Inattention	0,280	0,016	0,508	2,075	0,038	55
Mixed	Yoo et al. 2004	Inattention	0,350	0,273	0,422	8,429	0,000	535
Mixed	Yilmaz et al. 2015	Inattention	0,370	0,301	0,435	9,803	0,000	640
Mixed	Bielefeld et al. 2017	Inattention	0,400	0,039	0,669	2,160	0,031	29
Mixed	Evren, B. et al. 2017	Inattention	0,400	0,347	0,451	13,444	0,000	1010
Mixed	Kahraman & Demirci 2018	Inattention	0,410	0,242	0,554	4,527	0,000	111
Mixed	Li et al. 2016	Inattention	0,460	0,257	0,624	4,161	0,000	73
Mixed			0,374	0,340	0,406	20,114	0,000	
Overall			0,344	0,317	0,371	22,856	0,000	

Figure 9

Meta-Regression Analysis of Gender Distribution on Correlation Estimates Between Combined ADHD Scores and Gaming Disorder Symptom Severity



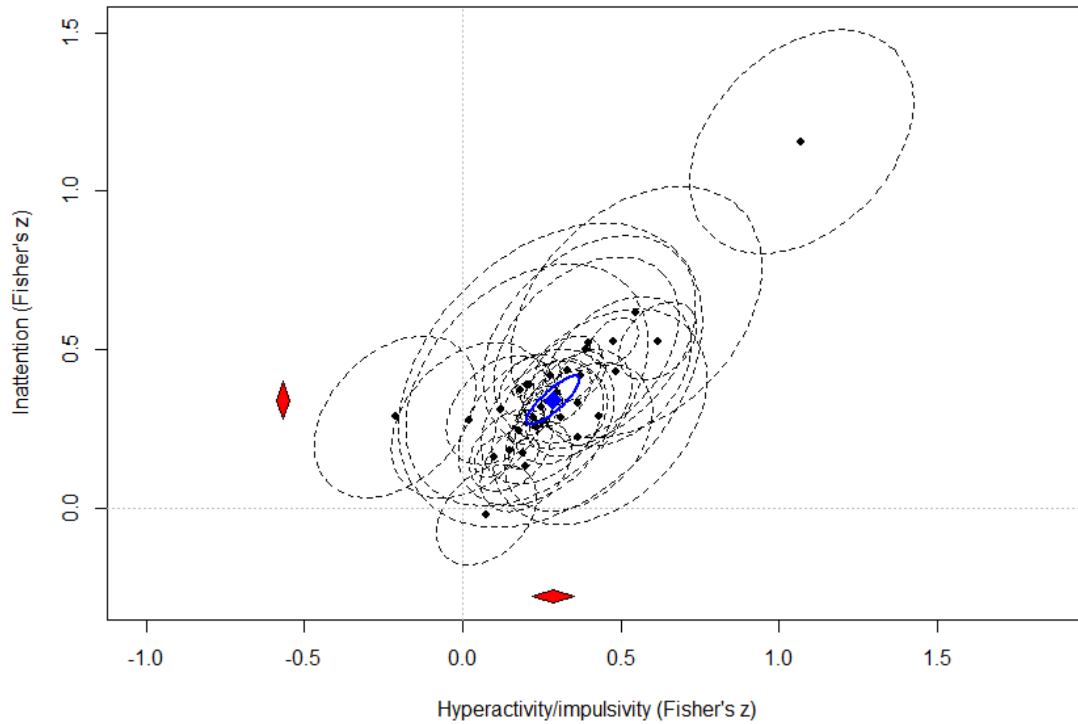
5.3.4. SEM meta-analysis

In the first step of the analysis, we examined the data from thirteen studies that provided information on the correlation between Hyperactivity/Impulsivity and Inattention. Combining the data, we found that the weighted mean correlation between these two outcomes was $r = 0.35$. Subsequently, we calculated the study-level covariances of the two outcomes that we used to fit the model (Cheung & Chan, 2009).

We found that the univariate effect sizes for the relation between symptoms of ADHD and GD were both significantly larger than zero. For Hyperactivity/Impulsivity, the correlation was $r = .28$ (95%CI [.22, .34] $z = 8.37$, $p < .001$). Similarly, for Inattention, the correlation was $r = .33$ (95%CI [.27, .38] $z = 10.91$, $p < .001$). Both effects displayed substantial heterogeneity, exceeding 95%. Moreover, we found a strong positive association between the two effects ($r = .90$). In other words, individuals who exhibit higher levels of GD are likely to experience both Hyperactivity/Impulsivity and Inattention symptoms of ADHD concurrently.

Figure 10

Univariate and bivariate effects from the SEM meta-analysis model



Note. The plot shows the individual effect sizes (black dots) and their confidence intervals (dashed ellipses). Red diamonds show the univariate effects, blue diamond shows the bivariate effect with a confidence interval (blue ellipsis). Both outcomes have a significant positive pooled effect, and there is a strong positive within-studies correlation between the two effects.

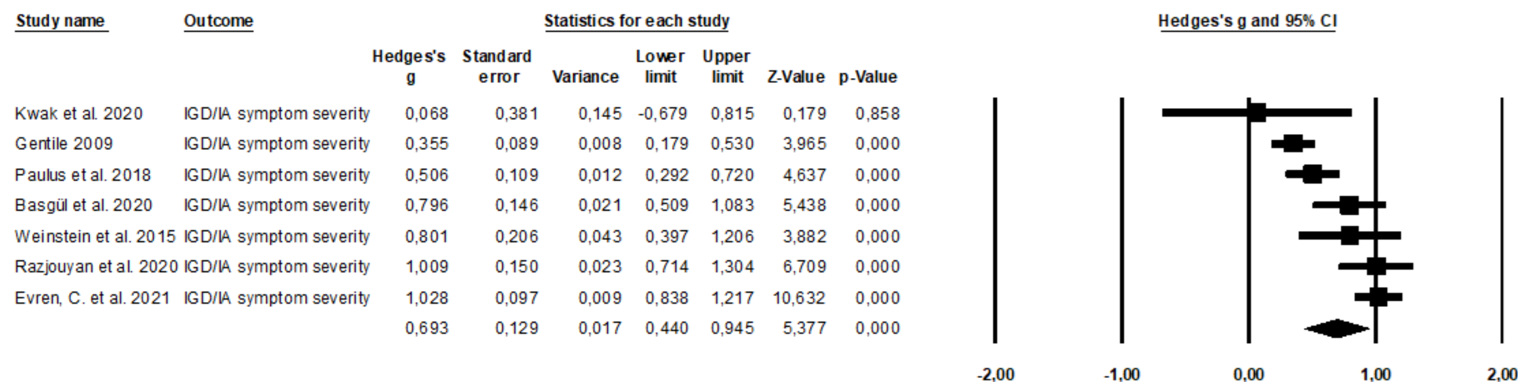
5.3.5. Meta-analysis on studies including group comparison results

In studies where individuals with and without an ADHD diagnosis were compared, a moderate-to-large positive difference was found regarding GD symptom severity: *g*=.693, k=7, SE=.129, 95% CI=[.440, .945], *p*<.001 (Figure 11). Similarly, studies comparing individuals with and without gaming disorder also showed a significant, large difference: *g*=.854, k=7, SE=.226, 95% CI=[.411, 1.296], *p*<.001 (Figure 12). The analyses indicated significant heterogeneity among the studies (Q=37.010, df=6, *p*<.001, I^2=84% for GD

symptom severity in ADHD/non-ADHD comparison; Q=60.921, df=6, p<.001, I^2=90% for ADHD symptom severity in GD/non-GD comparison).

Figure 11

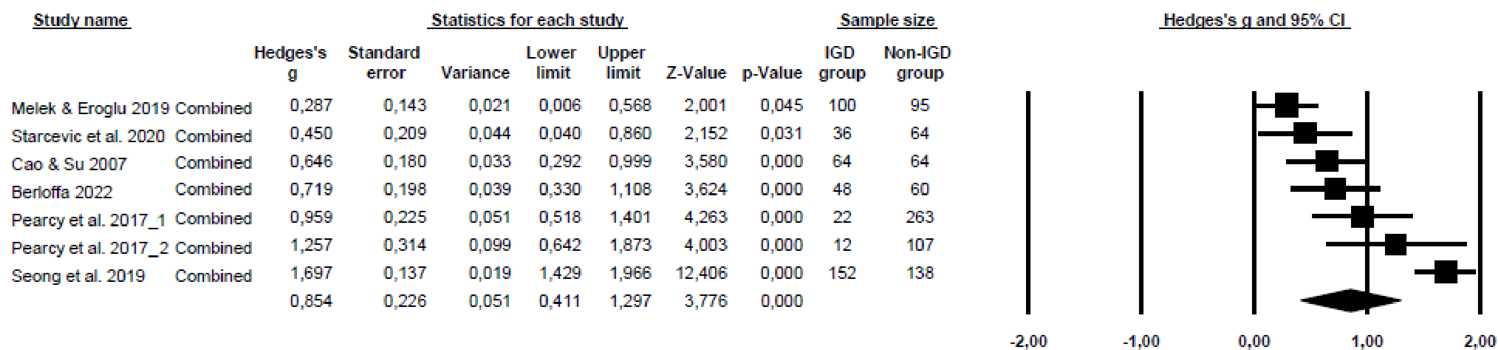
Forest Plot for Studies With Gaming Disorder Symptom Severity Differences Between ADHD and Non-ADHD Groups



Study name	Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Kwak et al. 2020	IGD/IA symptom severity	0,068	0,381	0,145	-0,679	0,815	0,179	0,858
Gentile 2009	IGD/IA symptom severity	0,355	0,089	0,008	0,179	0,530	3,965	0,000
Paulus et al. 2018	IGD/IA symptom severity	0,506	0,109	0,012	0,292	0,720	4,637	0,000
Basgül et al. 2020	IGD/IA symptom severity	0,796	0,146	0,021	0,509	1,083	5,438	0,000
Weinstein et al. 2015	IGD/IA symptom severity	0,801	0,206	0,043	0,397	1,206	3,882	0,000
Razjouyan et al. 2020	IGD/IA symptom severity	1,009	0,150	0,023	0,714	1,304	6,709	0,000
Evren, C. et al. 2021	IGD/IA symptom severity	1,028	0,097	0,009	0,838	1,217	10,632	0,000
		0,693	0,129	0,017	0,440	0,945	5,377	0,000

Figure 12

Forest Plot for Studies With Combined ADHD Score Differences Between GD and Non-GD Groups



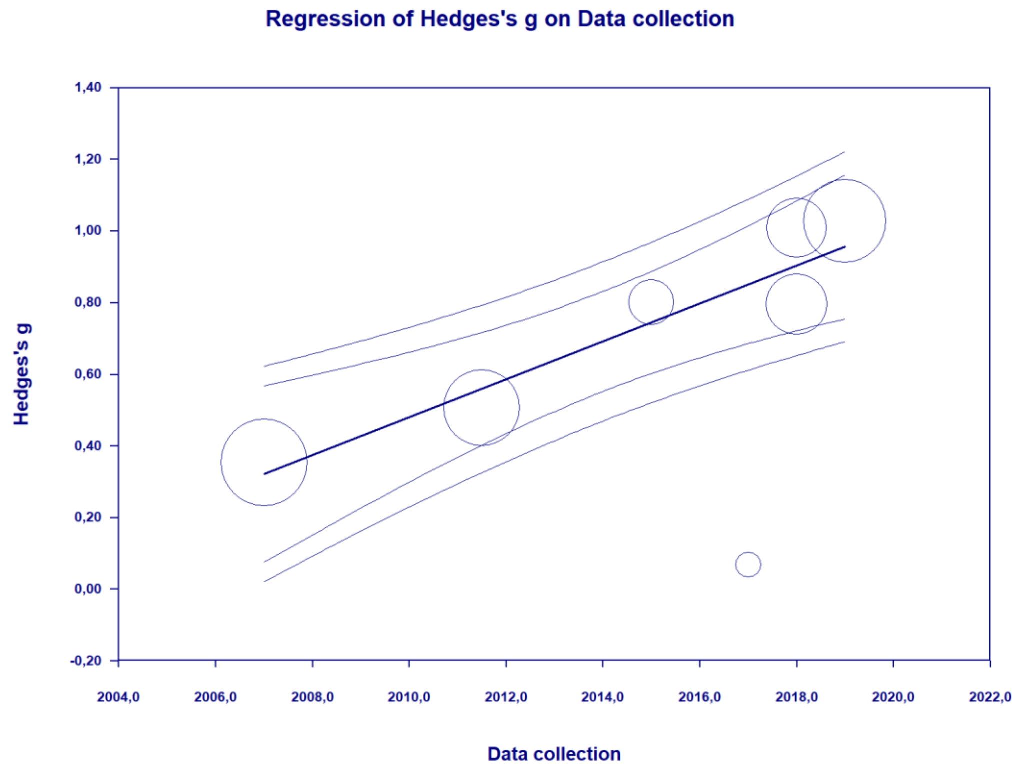
Study name		Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	IGD group	Non-IGD group
Melek & Eroglu 2019	Combined	0,287	0,143	0,021	0,006	0,568	2,001	0,045	100	95
Starcevic et al. 2020	Combined	0,450	0,209	0,044	0,040	0,860	2,152	0,031	36	64
Cao & Su 2007	Combined	0,646	0,180	0,033	0,292	0,999	3,580	0,000	64	64
Berloffa 2022	Combined	0,719	0,198	0,039	0,330	1,108	3,624	0,000	48	60
Pearcy et al. 2017_1	Combined	0,959	0,225	0,051	0,518	1,401	4,263	0,000	22	263
Pearcy et al. 2017_2	Combined	1,257	0,314	0,099	0,642	1,873	4,003	0,000	12	107
Seong et al. 2019	Combined	1,697	0,137	0,019	1,429	1,966	12,406	0,000	152	138
		0,854	0,226	0,051	0,411	1,297	3,776	0,000		

The classic fail-safe N method indicated that 321 non-significant results would be necessary to turn the average difference between the ADHD and non-ADHD groups non-significant and 261 for the group comparison between GD and non-GD groups. These results suggest robust effects. The funnel plots showed symmetrical distributions. Duval and Tweedie's Trim and Fill method did not indicate any trimmed studies for either the ADHD/non-ADHD, or for the GD/non-GD comparison. Therefore, no evidence of publication bias was found and the average effects were robust.

Although the number of available studies was quite low, moderator analyses were carried out where appropriate. Only one continuous moderator showed a significant effect in these group comparison meta-analyses. The year of data collection (ranging from 2007 to 2019) positively predicted the size of the difference in gaming disorder symptom severity between ADHD and non-ADHD individuals in the available seven studies (i.e., more recent studies tended to find a larger difference; Figure 13). This was a small association showing 0.05 point of increase in symptom severity of GD with every year. All other meta-regressions showed non-significant results (Table 8).

Figure 13

Meta-Regression Analysis of Data Collection Date on Gaming Disorder Symptom Severity Differences Between ADHD and Non-ADHD Groups



Subgroup analyses could only be performed for the type of addiction measured for the group mean difference estimates of combined ADHD symptom severity between GD and non-GD groups. When pooling effect sizes in studies measuring gaming disorder showed a significant, large difference (g = 0.798, k = 4, SE = 0.156, 95% CI = [0.493, 1.105], p<.001), while studies assessing problematic internet use in predominantly video game user samples showed a large average difference that failed to reach significance (g = 0.879, k = 3, SE = 0.457, 95% CI = [-0.017, 1.775], p=.054)(Q = 0.028, df=1, p=.868).

Subgroup analyses were performed for studies where ADHD and non-ADHD individuals were compared for the person of informant and the sample type of the ADHD group (clinical or non-clinical). Professional ratings showed a significant, moderate-sized effect (g = 0.623, k = 3, SE = 0.173, 95% CI = [0.285, 0.962], p<.001), while pooling self-reported

ratings resulted in a large average difference (g = 0.877, k = 3, SE = 0.173, 95% CI = [0.539, 1.216], p p<.001) of gaming disorder symptoms severity when ADHD and non-ADHD individuals were compared. (Q= 1.081, df=1, p=.299). A similar result was found when attempting to compare the effects found in clinical and non-clinical samples. Studies including clinical samples showed a large average difference (g = 0.795, k = 4, SE = 0.132, 95% CI = [0.537, 1.053], p<.001), while studies applying non-clinical samples found a moderate-sized difference (g = 0.630, k = 3, SE = 0.211, 95% CI = [0.530, 0.968], p=.003)(Q = 0.446, df=1, p=.504).

Table 8

Results of Meta-Regression Analyses on Hedges's G Values Using Gaming Disorder Symptom Severity Scores in Case of Comparison Between ADHD and Non-ADHD Groups and Combined ADHD Scores in Case of Comparison Between GD and Non-GD Groups

Predictor	Coefficient	k	SE	LL	UL	p
Gaming disorder severity						
Mean age	0.0301	5	0.0208	-0.0107	0.0709	.148
Gender distribution	0.0099	6	0.0066	-0.0029	0.0228	.130
Data collection year	0.0528	7	0.0118	0.0296	0.0760	<.001
Overall study quality	-0.0297	7	0.1454	-0.3148	0.2554	.838
Combined ADHD						
Mean age	0.0501	6	0.0345	-0.0175	0.1178	.146
Gender distribution	0.0047	7	0.0160	-0.0267	0.0361	.771
Data collection year	0.0108	7	0.0524	-0.0918	0.1135	.836
Overall study quality	0.1841	6	0.2773	-0.3594	0.7277	.501

Note. CI = confidence interval, LL =lower limit; UL = upper limit. Random effects analyses results are reported here. 95% confidence intervals were calculated.

In summary, medium-to-large significant, positive differences were found in all subgroup analyses of ADHD/non-ADHD and GD/non-GD group comparison with one exception: no significant difference was found in studies where GD and non-GD groups were compared using measurement for problematic internet use in predominantly video game user samples.

5.3.6. Studies with professional/clinical diagnosis of both ADHD and GD

Two small scale studies found substantially different rates of ADHD among GD patients: 12.5% (Van Rooij, Schoenmakers, Van de Mheen 2017) and 83.3% (Bozkurt et al., 2013), while a large-scale study including 755 GD patients reported the rate of co-existent ADHD in 32.7% of the cases (Han et al., 2018). One case-control study reported rates of ADHD diagnosis among GD patients and an age, gender and education level matched control group, indicating that it is more than 13 times more likely to have a diagnosis of ADHD among individuals with GD (Yen et al., 2017).

5.3.7. Findings of longitudinal studies

We found six studies that reported on longitudinal links between ADHD and GD. The question of a possible longitudinal association between the symptoms of the two disorders was first explored in the study of Ferguson & Ceranoglu (2014). In their study, pre-existing attention problems predicted problematic gaming later after controlling for gender (β=0.19), but the opposite direction was non-significant. Peeters and colleagues (2018) only tested the effect of earlier inattentive symptoms on later GD symptoms, which was found to be significant after controlling for gender. The association between the two problems was stronger for socially vulnerable individuals with low life-satisfaction. Wartberg and colleagues (2018) tested both directions of predictive effect and similar to previous research findings, only previously present ADHD symptoms were predicting subsequent GD symptoms (β=0.14). In contrast, both directions were significant in a large-scale study of Marmet and colleagues (2018), indicating a bidirectional association between the symptoms of the two disorders (probit=0.066 for the prediction of GD symptoms from earlier ADHD symptoms; probit=0.058 for the prediction of ADHD symptoms from earlier GD symptoms). In further analysis, the same association was tested including the two subdomains of ADHD in the same model, finding reciprocal association only in case of inattentive symptoms (probit=0.090 for the prediction of GD symptoms from earlier inattention symptoms; probit=0.044 for the prediction of inattention symptoms from earlier GD symptoms), but not hyperactivity/impulsivity. One additional study of only ADHD affected individuals indicated that inattentive symptoms, but not hyperactivity symptoms predict GD symptom severity (Schoenmacker, 2020). In contrast to the previous findings,

the prospective association between earlier ADHD symptoms and later GD symptoms was not significant in the study of Wichstrøm and colleagues (2019).

5.3.8. Quality assessment

Based on the quality assessment, no low-quality studies were identified, and most of the studies (38 out of 52) were rated as high-quality in general (Table 9-11). Among studies reporting correlation analysis, only the possibility of sampling/selection bias was identified as a common problem (Table 9). In studies including group comparisons between ADHD and non-ADHD individuals, sampling/selection bias and the use of less reliable GD/IA assessment tools were identified, affecting general study quality (Table 10). Ratings of studies including a comparison between GD and non-GD samples were all rated high in all aspects, with no systematic quality issue (Table 11).

Table 9

Quality Assessment of Studies with Correlation Analysis Results

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Andreassen et al. 2016	2	2	Cross-sectional	1.5	2	2	9.5
Bielefeld et al. 2017	2	1.5	Cross-sectional	1	2	2	8.5
BLS study	2	2	Longitudinal	2	1	2	9
Chen et al. 2021	2	2	Cross-sectional	1.5	2	2	9.5
Concerto et al. 2021	1	2	Cross-sectional	1	2	2	8
Demirtas et al. 2021	1.5	1.5	Cross-sectional	1.5	2	2	8.5
Evren, B. et al. 2017	2	1.5	Cross-sectional	1.5	2	2	9

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Evren, C. et al. 2019	2	2	Cross-sectional	2	2	2	10
Ferguson & Ceranoglu 2014	1.5	2	Longitudinal	1	2	1	7.5
Jung et al. 2020	2	1.5	Cross-sectional	1	2	2	8.5
Kahraman & Demirci 2018	2	2	Cross-sectional	1	1	2	8
Kandeger et al. 2022	2	1.5	Cross-sectional	1	2	2	8.5
Kawabe et al. 2019	1	1	Cross-sectional	1	2	2	7
Kietglaiwansiri & Chonchaiya 2018	1	1.5	Cross-sectional	1	2	2	7.5
Kim et al. 2020	2	2	Cross-sectional	1.5	2	2	9.5
Lee et al. 2018	1	1.5	Cross-sectional	1.5	2	2	8
Lefler et al. 2022	2	2	Cross-sectional	1.5	2	1.5	9
Li et al. 2016	2	2	Cross-sectional	1.5	2	2	9.5
Marmet et al. 2018	2	2	Longitudinal	2	2	2	10
Masi et al. 2021	1.5	1.5	Cross-sectional	1.5	1.5	1	7
Masklavanou et al. 2022	1	1	Cross-sectional	1	2	2	7

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Mazurek & Engelhardt 2013	2	1.5	Cross-sectional	1	2	1	7.5
Menéndez-García et al. 2022	0	2	Cross-sectional	1.5	0	0.5	4
Panagiotidi 2017	1	1.5	Cross-sectional	0	2	1	5.5
Peeters et al. 2018	2	2	Longitudinal	1	2	2	9
Schoenmacker et al. 2020	2	2	Longitudinal	1.5	0.5	1	8.5
Stavropoulos et al. 2019	2	2	Cross-sectional	1.5	2	2	9.5
Stavropoulos et al. 2020	2	1.5	Cross-sectional	2	2	2	9.5
Taner et al. 2022	1	1	Cross-sectional	1	2	1	6
The Gaming Motivation Inventory study	1.5	2	Cross-sectional	2	2	2	9.5
Tolchinsky & Jefferson 2011	2	2	Cross-sectional	0.5	1	1	6.5
Tzang, Chang, Chang 2022	2	2	Cross-sectional	2	2	1.5	9.5
Vadlin et al. 2016	2	2	Cross-sectional	1	1.5	2	8.5
Vally 2021	1	1.5	Cross-sectional	1.5	2	2	8
Walther et al. 2012	2	2	Cross-sectional	2	1	1.5	8.5

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Wartberg et al. 2019	2	2	Longitudinal	2	1	2	9
Wichstrøm et al. 2019	2	2	Longitudinal	2	2	1.5	9.5
Yilmaz et al. 2015	2	2	Cross-sectional	2	2	2	10
Yoo et al. 2004	2	2	Cross-sectional	2	2	1	9

Table 10

Quality Assessment of Studies With Group Comparison Results Between ADHD and Non-ADHD Participants

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Başgül et al. 2020	1	2	Cross-sectional	2	2	0.5	7.5
Evren, C. et al. 2021	2	2	Cross-sectional	1.5	2	2	9.5
Gentile 2009	2	2	Cross-sectional	2	1.5	0.5	8
Kwak et al. 2020	2	2	Longitudinal	1	2	2	9
Paulus et al. 2018	1.5	2	Cross-sectional	2	2	0.5	8
Razjouyan et al. 2020	0.5	1.5	Cross-sectional	0.5	2	2	6.5
Weinstein et al. 2015	2	2	Cross-sectional	1	2	2	9

Table 11

Quality Assessment of Studies With Group Comparison Results Between GD and Non-GD Participants

Study	Research question	Research design rating	Research design	Sampling/selection bias	Reliability of ADHD measure	Reliability of GD/IA measure	Overall quality score
Berloffa 2022	1	1.5	Cross-sectional	1	2	2	7.5
Cao & Su 2007	1.5	2	Cross-sectional	2	1	1	7.5
Melek & Eroğlu 2019	1	2	Cross-sectional	1.5	2	2	8.5
Pearcy et al. 2017	2	1.5	Cross-sectional	1	2	2	8.5
Seong et al. 2019	2	2	Cross-sectional	2	2	2	10
Starcevic et al. 2020	2	2	Cross-sectional	2	2	2	10

5.4. Discussion

Data from all available studies focusing on the association between ADHD and GD symptoms were synthesized in the present study to estimate the average size of the relationship, examine the effect of publication bias, and to explore the effect of potential moderators. Based on cross-sectional correlational results, a medium-sized significant positive correlation was found between the two disorders, which was true for the association with both inattention and hyperactivity/impulsivity subdomain scores. A SEM meta-analysis that controlled for the correlation between the two dimensions of ADHD symptoms did not only confirm that both aspects are related to GD symptoms but suggested that individuals who exhibit higher levels of GD are likely to experience both hyperactivity/impulsivity and inattention symptoms of ADHD concurrently. This finding suggests a common underlying mechanism or shared risk factors contributing to the co-

occurrence of GD and both subtypes of ADHD. In the meta-analysis of studies applying group comparison, moderate-to-large differences were found in both studies where the GD and non-GD individuals were compared using ADHD symptom severity scores and in studies where ADHD and non-ADHD individuals were compared using GD symptom severity scores. The present study extends the knowledge regarding common GD comorbidities, as previously the co-occurrence of depression and sub-clinical depressive symptoms (Ostinelli et al., 2021) and autism spectrum disorder (Murray et al., 2020) were confirmed using meta-analysis methodology.

The present meta-analysis also provides an overview of the field in regards to research methods. We found that the majority of the studies reported cross-sectional results based on self-report. Interestingly, the single study, which reported a correlation coefficient based on professional rating (clinicians' rating) for both ADHD and GD found only a weak relationship, which warrants for further studies using professional assessment as opposed to self-report. On the contrary, studies reporting the diagnostic status of participants based on professional rating (clinicians' rating) found considerable rates of ADHD among GD patients. We also unveiled a lack of longitudinal designs and measures based on clinicians' ratings in the field. Accordingly, it should be noted that the present results are not informative regarding causality or even the direction of the effect or temporal precedence. When qualitatively assessing the available six studies regarding longitudinal links, we found contrasting results. Four studies only found a link between pre-existing ADHD symptoms (especially inattention) and later GD symptoms. One study found evidence for a bidirectional relationship, while another failed to find any longitudinal links. Thus, it seems that emerging evidence highlights the potential in investigating the co-occurence of the two disorders, however, future studies with more methodological rigor including longitudinal studies and clinicians' ratings will be needed 1. to confirm this association and 2. to establish temporal precedence and the direction of the association. Finally, future studies might also aim to further investigate the question whether there is a causal relationship between the two or the association is due to common vulnerabilities (e.g., common genetic factors) or confounds (e.g., an overlap in the diagnostic criteria) (Stander et al., 2014).

Even though there is still relatively little data to estimate the effect of potential moderators, the results did not show significant effects of almost any of the moderators, such as age, country, sample type, tool of assessment or informant and only a negligible effect for gender ratio between GD and combined ADHD symptoms association. This might indicate that the association between GD and ADHD is universal, however it should be considered that the moderator analyses might have been underpowered with the relatively small amount of studies that we could include in this meta-analysis. Previous studies have suggested that ADHD and GD are more prevalent among younger populations (Simon et al., 2009, Wilcutt et al., 2012, Stevens et al., 2020). The present study found no proof for the effect of age on the association between the two disorders, and neither for the ADHD sub-domains. Based on these findings, maturation may not lead to a decrease in GD vulnerability among individuals affected by ADHD symptoms. In addition, GD is more prevalent among the male population (Stevens et al., 2020), and ADHD-affected males show higher symptom severity on both subdomains compared to ADHD-affected females (Gershon, 2002), and this factor did moderate the association between the two disorders, indicating stronger association for samples where most of the participants are males, but the related effect estimate (coefficient=0.0018, 95% CI=[.0001; .0035], $p<.05$) was negligible. Furthermore, correlation coefficients calculated from clinical samples did not result in a different estimate of the association as compared to correlation coefficients from non-clinical samples. The study did not find a larger difference in GD symptoms between ADHD and non-ADHD groups, neither when clinical ADHD groups were compared to non-clinical control groups, nor when non-clinical ADHD groups were compared to non-clinical control groups. Testing the effect of culture was only feasible for the association between combined ADHD scores and GD scores between German and Turkish samples. This comparison did not indicate a significant difference in the association between the two countries. However, when interpreting these results, it should be noted that these non-significant results might be due to low statistical power and thus should be interpreted with caution.

The operationalization of psychological problems can affect prevalence estimates (Kim et al., 2022). Therefore the effect of assessment tools, informants, and type of addiction were tested. The most frequently used instruments to assess gaming disorder severity were the

Internet Addiction Test (Young, 1998), the Internet Gaming Disorder Scale Short-Form (Pontes & Griffiths, 2015), and the Problem Video Game Playing scale (Salguero, Morán, 2002). For assessment of ADHD, the ADHD Rating Scale (DuPaul, 1998), the six-item and 18-item Adult Self-Report Scale (Kessler et al., 2005; Ustun et al., 2017), along with parental reports in case of children. The comparison of specific tools or different informants did not produce different estimates for the association between the two disorders, neither for combined ADHD scores, nor for the subdomain scores of ADHD. This is in line with the findings of another meta-analysis, in which the association between ADHD and the problematic use of the internet (PUI) was not affected by the person of the informant (self- vs. parent-rating) (Werling, Kuzhippallil, Emery, Walitza, & Drechsler, 2022).

Since several tools were used to assess problematic use of the internet, most often among samples of gamers, instead of using gaming disorder instruments, the present study compared the potential effect of the disorder type assessed. A significantly stronger association was found between GD symptoms and inattentive symptoms in studies assessing problematic internet use in predominantly video game user samples compared to studies where purely gaming disorder severity was assessed. These results might indicate that the presence of inattentive symptoms of ADHD is a risk factor for the problematic use of numerous other online activities, such as addictive use of social media (Andreassen et al., 2016), online problematic pornography consumption (Bőthe et al., 2017), and online problem gambling (Theule et al., 2019), rather than online gaming only. These findings are in line with the findings of the aforementioned meta-analysis, where the association between ADHD and PUI was explored (Werling et al., 2022).

Finally, we examined the quality of the primary studies as a moderator in addition to the year of data collection. Study quality did not moderate the association between GD and combined ADHD, inattention or hyperactivity/impulsivity symptom severity. In other words, the association found between GD and ADHD in the present meta-analysis cannot be attributed to the quality of studies. Conflicting results were found for the year of data collection. While correlation estimates and ADHD symptom severity differences in group comparison between GD and non-GD individuals were not associated with the year of data collection, newer studies reported larger differences in GD symptom severity between

ADHD and non-ADHD individuals. However, as this association was only found in one analysis, it is unclear whether the association may be strengthening over time. The result might simply be the consequence of a confounding variable such as a change in methodology, a trend in different assessment instruments for instance.

Although the present results cannot establish causality or even the temporal direction of the association, several underlying mechanisms could be involved. A major factor to explain the association between the two disorders is impulsivity (Yen et al., 2017, Li et al., 2016). One important characteristic of children with ADHD is the preference of immediate over delayed rewards (delay aversion) (Sonuga-Barke, 2002). Regarding excessive gaming, there are a wide range of experimental neurocognitive studies showing on average a moderate difference in response inhibition between GD individuals compared to healthy controls (Argyriou et al., 2017). Lower level of inhibitory control can lead to more hours spent on gaming, but impulsive decision making can also be a consequence of pre-existent GD (Kräplin et al., 2021). Brain imaging studies also found corresponding evidence of alterations in the prefrontal-striatal circuitry, which may be responsible for the comorbidity through enhanced reward craving and deficits in behavioral control (Gao et al., 2021).

Affective functioning may be another important area of consideration. Patients with comorbid ADHD and GD show more internalizing symptoms, especially withdrawal and depression (Berloffa et al., 2022). A study of Chen and colleagues (2021) demonstrated that depression severity and hopelessness mediate the relationship between the symptoms of the two disorders and problematic gaming can lead to progression of disruptive mood dysregulation among ADHD patients (Tzang, Chang, Chang, 2022). Patients suffering from both ADHD and GD are also characterized with higher negative urgency (a tendency to immediately react inadequately, when facing negative emotions) (Cabelguen et al., 2021), leading to higher tendency to escape into video games, as an attempt to cope with negative feelings. In addition to the emotional disturbances and maladaptive responsiveness, technology use can also result in higher level of daytime sleepiness for individuals living with ADHD (Bourchtein et al., 2019), potentially affecting the presentation of both GD and ADHD symptoms.

Social functioning in ADHD affected individuals, presenting in the form of intrusiveness and aggressivity have several consequences, such as unpopularity, peer rejection or lack of reciprocal relationships (Nijmeijer et al., 2008). Social difficulties are a risk factor for GD, as online video games can be used to compensate for needs that are hard or impossible to satisfy in everyday life (Király et al., 2023). In accordance with this, predominantly inattentive type ADHD individuals are often characterized by social anxiety (Koyuncu et al., 2015) and it was demonstrated that social phobia may contribute to a higher risk of developing problematic internet use of ADHD individuals (Demirtas et al., 2021). Purely ADHD sample based studies of Chou and colleagues (Chou et al., 2015; 2017) also support this hypothesis. Both dissatisfaction with family relationships (2015) and social skill deficits (2017) are associated with a heightened risk for problematic internet use. Beyond that, low self-esteem was also found to be predictive for the comorbidity between ADHD and GD (Cabelguen et al., 2021).

Research of Volkow and colleagues (2011) showed that D2/D3 dopamine receptor availability may be responsible for motivation deficits in individuals with ADHD. Boredom proneness is a characteristic associated with symptoms of ADHD (Malkovsky et al., 2012). Therefore, one idea is that ADHD individuals may have a greater need for highly stimulating activities, such as video games (Chou, Chang, Yen 2018) to reach an optimal level of arousal (Paulus et al., 2018 in Dullur, Krishnan, Diaz et al., 2020). The higher tendency of ADHD individuals for immersion into video games may be one factor contributing to greater vulnerability for problematic use (Jung et al., 2020), which may be a manifestation of ADHD-related hyperfocus (Hupfeld, Abagis, Shah 2018). Findings of decreased gray matter volume and lower activity in patients with both GD and ADHD in the insula supports this idea by showing that lower cognitive control, increased distractibility, and motivational deficits typical in ADHD and habituation to gaming-related and desensitization to conventional stimuli in GD have common neural foundations (Gao et al., 2021).

5.4.1. Limitations

While the present meta-analysis aimed to synthesize evidence from different research designs, mostly cross-sectional studies using self-report measures were available and could

be quantitatively synthesized. Only a handful of studies reported on longitudinal associations with conflicting results. Thus, causality or even the direction of effect could not be determined at this point. Thereby, it is possible that ADHD symptoms may cause the emergence of gaming disorder, or it is also possible that gaming (or problematic gaming) may cause ADHD symptoms. Alternatively, a bi-directional association is also possible, as proposed by Marmet and colleagues (2018). Finally, another possible explanation is that a third factor may explain the co-occurrence of the two disorders, such as impaired decision-making or self-regulation, which can be the result of a previously present deficit in the ventromedial prefrontal cortex (Schettler, Thomasius, & Paschke, 2022), or common vulnerabilities such as genetic risks.

The large-scale methodological heterogeneity found between studies led to some difficulties in analysis and interpretation. Most of the studies included in the meta-analysis comprised correlation coefficients because these types of data were reported most often, while some studies, where mostly clinical groups of ADHD or GD individuals were compared to control groups, reported mean differences and standard deviations. Thereby, these types of data were not suitable to be merged into one analysis, which led to lower numbers of studies in all three data analysis types.

Furthermore, as a result of the methodological heterogeneity in categorical data (e.g., use of different assessment tools or the implementation of a scale in modified format), running subgroup analysis was not possible on the studies reporting on group comparisons. It was only feasible in case of some categorical moderators for correlations. Finally, there were relatively few studies resulting in the possibility of low statistical power. This was especially the case for moderator analyses where only a low number of studies could be included. Therefore, non-significant results should be interpreted with caution.

5.5. Conclusion

Overall, the study found small-to-large associations between the symptoms of gaming disorder and both attention-deficit/hyperactivity disorder subdomains (inattention and hyperactivity/impulsivity) and combined ADHD symptom severity. A stronger association was found between ADHD inattentive symptoms and GD symptom severity among studies

assessing problematic internet use in predominantly video game user samples compared to studies where purely gaming disorder severity was assessed. Similarly, the significant effect of year of data collection was only found in one analysis: when GD symptom severity was compared between ADHD and non-ADHD individuals. All studies were rated medium-to-high quality as far as cross-sectional studies are concerned. However, the results show that there is a great need for longitudinal studies to establish temporal precedence and the direction of the effect in addition to assessment based on clinicians' ratings or diagnosis.

The use of robust psychometric instruments suitable for cross-culturally comparison is highly recommended, such as the IGDT-10 (Király et al., 2017, 2019) or the IGDS-9SF (Pontes & Griffiths, 2015). Moderator analyses should be run again in the future, when more data are available in the different categories (sample type, country, assessment tool, informant, type of disorder examined). The present results highlight the co-occurence of the two disorders, however, further research with more rigorous methodology are needed to confirm the association and investigate the temporal direction and possible causation. On a practical note, screening of both disorders is recommended in the presence of either.

5.6. References

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5.7. Supplement S1

List of studies included in the quantitative synthesis

5.7.1. Studies including correlation analyses

Andreassen et al. 2016

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Bielefeld et al. 2017

Bielefeld, M., Drews, M., Putzig, I., Bottel, L., Steinbüchel, T., Dieris-Hirche, J., ... & Theodor te Wildt, B. (2017). Comorbidity of Internet use disorder and attention deficit hyperactivity disorder: Two adult case–control studies. *Journal of Behavioral Addictions*, *6*(4), 490-504.

BLS study

Unpublished.

Chen et al. 2021

Chen, C., Dai, S., Shi, L., Shen, Y., & Ou, J. (2021). Associations retween attention deficit/hyperactivity disorder and internet gaming disorder symptoms mediated by depressive symptoms and hopelessness Among college students. *Neuropsychiatric Disease and Treatment*, *17,* 2775.

Concerto et al. 2021

Concerto, C., Rodolico, A., Avanzato, C., Fusar-Poli, L., Signorelli, M. S., Battaglia, F., & Aguglia, E. (2021). Autistic traits and attention-deficit hyperactivity disorder symptoms predict the severity of internet gaming disorder in an Italian adult population. *Brain Sciences*, *11*(6), 774.

Demirtas et al. 2021

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Evren, B. et al. 2017

Evren, B., Evren, C., Dalbudak, E., Topcu, M., & Kutlu, N. (2018). Relationship of internet addiction severity with probable ADHD and difficulties in emotion regulation among young adults. *Psychiatry Research*, *269*, 494-500.

Evren, C. et al. 2019

Evren, C., Evren, B., Dalbudak, E., Topcu, M., & Kutlu, N. (2019). Relationships of Internet addiction and Internet gaming disorder symptom severities with probable attention deficit/hyperactivity disorder, aggression and negative affect among university students. *ADHD Attention Deficit and Hyperactivity Disorders*, *11*(4), 413-421.

Ferguson & Ceranoglu 2014

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Jung et al. 2020

Jung, D., Shim, E. J., Park, H., Lee, K., Lee, S., Kim, E. Y., ... & Hahm, B. J. (2020). The association between excessive internet gaming behavior and immersive tendency, mediated by attention deficit/hyperactivity disorder symptoms, in Korean Male University students. *Psychiatry Investigation*, *17*(5), 403-411.

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Kandeger et al. 2022

Kandeğer, A., & Egilmez, Ü. (2022). Dissociative Absorption May Contribute to Internet Gaming Disorder Independent of Childhood Trauma and ADHD Symptoms Among Male University Students. *The Eurasian Journal of Medicine*, 54(3), 259-263.

Kawabe et al. 2019

Kawabe, K., Horiuchi, F., Miyama, T., Jogamoto, T., Aibara, K., Ishii, E., & Ueno, S. I. (2019). Internet addiction and attention-deficit/hyperactivity disorder symptoms in adolescents with autism spectrum disorder. *Research in Developmental Disabilities*, *89*, 22-28.

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Kietglaiwansiri, T., & Chonchaiya, W. (2018). Pattern of video game use in children with attention-deficit–hyperactivity disorder and typical development. *Pediatrics International*, *60*(6), 523-528.

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Lefler et al. 2022

Lefler, E. K., Alacha, H. F., Vasko, J. M., Serrano, J. W., Looby, A., Flory, K., & Hartung, C. M. (2022). Sex differences in ADHD symptoms, problematic gaming, and impairment in college students. *Current Psychology*. https://doi.org/10.1007/s12144-022-03469-1

Lee et al. 2018

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Li et al. 2016

Li, W., Zhang, W., Xiao, L., & Nie, J. (2016). The association of Internet addiction symptoms with impulsiveness, loneliness, novelty seeking and behavioral inhibition system

among adults with attention-deficit/hyperactivity disorder (ADHD). *Psychiatry Research*, *243*, 357-364.

Marmet et al. 2018

Marmet, S., Studer, J., Grazioli, V. S., & Gmel, G. (2018). Bidirectional associations between self-reported gaming disorder and adult attention deficit Hyperactivity disorder: Evidence from a sample of young Swiss men. *Frontiers in Psychiatry*, *9*, 649.

Masi et al. 2021

Masi, L., Abadie, P., Herba, C., Emond, M., Gingras, M. P., & Amor, L. B. (2021). Video games in ADHD and non-ADHD children: Modalities of use and association with ADHD Symptoms. *Frontiers in Pediatrics*, *9*, 632272. https://doi.org/10.3389/fped.2021.632272

Masklavanou et al. 2022

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Mazurek & Engelhardt 2013

Mazurek, M. O., & Engelhardt, C. R. (2013). Video game use in boys with autism spectrum disorder, ADHD, or typical development. *Pediatrics*, *132*(2), 260-266.

Menéndez-García et al. 2022

Menendez-García, A., Jiménez-Arroyo, A., Rodrigo-Yanguas, M., Marin-Vila, M., Sánchez-Sánchez, F., Roman-Riechmann, E., & Blasco-Fontecilla, H. (2022). Internet, video game and mobile phone addiction in children and adolescents: A case-control study. *Adicciones*, 34(3), 208-216.

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Panagiotidi, M. (2017). Problematic video game play and ADHD traits in an adult population. *Cyberpsychology, Behavior, and Social Networking*, *20*(5), 292-295.

Peeters et al. 2018

Peeters, M., Koning, I., & van den Eijnden, R. (2018). Predicting Internet Gaming Disorder symptoms in young adolescents: A one-year follow-up study. *Computers in Human Behavior*, *80*, 255-261.

Schoenmacker et al. 2020

Schoenmacker, G. H., Groenman, A., Sokolova, E., Oosterlaan, J., Rommelse, N., Roeyers, H., ... & Buitelaar, J. K. (2020). Role of conduct problems in the relation between attention-deficit hyperactivity disorder, substance use, and gaming. *European Neuropsychopharmacology*, *30,* 102-113.

Stavropoulos et al. 2019

Stavropoulos, V., Adams, B. L., Beard, C. L., Dumble, E., Trawley, S., Gomez, R., & Pontes, H. M. (2019). Associations between attention deficit hyperactivity and internet gaming disorder symptoms: Is there consistency across types of symptoms, gender and countries? *Addictive Behaviors Reports*, *9*, 100158.

Stavropoulos et al. 2020

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Taner et al. 2022

Taner, H. A., Sarı, B. A., Kulaçoğlu, K. C., Mayalık, A., Mecit, H., Özekicioğlu, K., & Zorbaz, Z. O. (2022). Internet gaming disorder's correspondence with attention deficit hyperactivity disorder and game/in-game purchases among university students. *Entertainment Computing*, 42, 100486.

The Gaming Motivation Inventory study

Király, O., Billieux, J., King, D. L., Urbán, R., Koncz, P., Polgár, E., & Demetrovics, Z. (2022). A comprehensive model to understand and assess the motivational background of video game use: The Gaming Motivation Inventory (GMI). *Journal of Behavioral Addictions*. https://doi.org/10.1556/2006.2022.00048

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Tolchinsky, A., & Jefferson, S. D. (2011). Problematic video game play in a college sample and its relationship to time management skills and attention-deficit/hyperactivity disorder symptomology. *Cyberpsychology, Behavior, and Social Networking*, *14*(9), 489-496.

Tzang, Chang, Chang 2022

Tzang, R. F., Chang, C. H., & Chang, Y. C. (2022). Structural equation modeling (SEM): Gaming disorder leading untreated attention-deficit/hyperactivity disorder to disruptive mood dysregulation. *International Journal of Environmental Research and Public Health*, 19(11), 6648.

Vadlin et al. 2016

Vadlin, S., Åslund, C., Hellström, C., & Nilsson, K. W. (2016). Associations between problematic gaming and psychiatric symptoms among adolescents in two samples. *Addictive Behaviors*, *61*, 8-15.

Vally 2021

Vally, Z. (2021). Symptoms of internet gaming disorder, inattention, and impulsivity: A cross-sectional study conducted in the United Arab Emirates. *Psychiatric Quarterly*, *92*(1), 301-310.

Walther et al. 2012

Walther, B., Morgenstern, M., & Hanewinkel, R. (2012). Co-occurrence of addictive behaviours: personality factors related to substance use, gambling and computer gaming. *European Addiction Research*, *18*(4), 167-174.

Wartberg et al. 2019

Wartberg, L., Kriston, L., Zieglmeier, M., Lincoln, T., & Kammerl, R. (2019). A longitudinal study on psychosocial causes and consequences of internet gaming disorder in adolescence. *Psychological Medicine*, *49*(2), 287-294.

Wichstrøm et al. 2019

Wichstrøm, L., Stenseng, F., Belsky, J., von Soest, T., & Hygen, B. W. (2019). Symptoms of internet gaming disorder in youth: predictors and comorbidity. *Journal of Abnormal Child Psychology*, *47*(1), 71-83.

5.7.2. Studies comparing means of ADHD severity scores between GD and non-GD individuals

Berloffa 2022

Berloffa, S., Salvati, A., D'acunto, G., Fantozzi, P., Inguaggiato, E., Lenzi, F., ... & Masi, G. (2022). Internet gaming disorder in children and adolescents with attention deficit hyperactivity disorder. *Children*, *9*(3), 428.

Cao & Su 2007

Cao, F., & Su, L. (2007). Internet addiction among Chinese adolescents: Prevalence and psychological features. *Child: Care, Health and Development*, *33*(3), 275-281.

Melek & Eroğlu 2019

Melek, L. U. Ş., & Eroğlu, M. Z. (2019) Internet addiction among adolescents with attention-deficit/hyperactivity disorder. *Cukurova Medical Journal*, *44*, 140-147.

Pearcy et al. 2017

Pearcy, B. T., McEvoy, P. M., & Roberts, L. D. (2017). Internet gaming disorder explains unique variance in psychological distress and disability after controlling for comorbid depression, OCD, ADHD, and anxiety. *Cyberpsychology, Behavior, and Social Networking*, *20*(2), 126-132.

Seong et al. 2019

Seong, W., Hong, J. S., Kim, S., Kim, S. M., & Han, D. H. (2019). Personality and psychological factors of problematic internet gamers seeking hospital treatment. *Frontiers in Psychiatry*, *10*, 583.

Starcevic et al. 2020

Starcevic, V., Choi, T. Y., Kim, T. H., Yoo, S. K., Bae, S., Choi, B. S., & Han, D. H. (2020). Internet gaming disorder and gaming disorder in the context of seeking and not seeking treatment for video-gaming. *Journal of Psychiatric Research*, *129*, 31-39.

5.7.3. Studies comparing means of GD severity scores between ADHD and non-ADHD individuals

Başgül et al. 2020

Başgül, Ş. S., Bekar, B., & Luş, M. G. (2020). Associations between computer game addiction and attention deficit and hyperactivity disorder - An emprical study. *Addicta: The Turkish Journal on Addictions*, *7*(2), 122-128.

Evren, C. et al. 2021

Evren, C., Evren, B., Dalbudak, E., Topcu, M., & Kutlu, N. (2021). The relationship between probable ADHD and playing MMORPGs with the severity of disordered gaming: The effect of gaming motivations. *Dusunen Adam*, *34*(2), 200-211.

Gentile 2009

Gentile, D. (2009). Pathological video-game use among youth ages 8 to 18: A national study. *Psychological Science*, *20*(5), 594-602.

Kwak et al. 2020

Kwak, K. H., Hwang, H. C., Kim, S. M., & Han, D. H. (2020). Comparison of behavioral changes and brain activity between adolescents with internet gaming disorder and student pro-gamers. *International Journal of Environmental Research and Public Health*, *17*(2), 441.

Paulus et al. 2018

Paulus, F. W., Sinzig, J., Mayer, H., Weber, M., & von Gontard, A. (2018). Computer gaming disorder and ADHD in young children — A population-based study. *International Journal of Mental Health and Addiction*, *16*(5), 1193-1207.

Razjouyan et al. 2020

Razjouyan, K., Khademi, M., Dorandish, Z. Y., & Davari-Ashtiani, R. (2020). An investigation into the frequency of addiction to video games in children with attention-deficit hyperactivity disorder. *Journal of Family Medicine and Primary Care*, *9*(2), 669.

Weinstein et al. 2015

Weinstein, A., Yaacov, Y., Manning, M., Danon, P., & Weizman, A. (2015). Internet addiction and attention deficit hyperactivity disorder among schoolchildren. *The Israel Medical Association Journal: IMAJ, 17*(12), 731-734.

6. Gender-specific motivational pathways in ADHD-related inattention and gaming disorder symptoms (Study 4)[7]

6.1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by inattention and hyperactivity/impulsivity symptoms. Apart from academic and occupational problems, ADHD is associated with difficulties in social relationships, higher tendency for accidents and obesity, development of conduct disorder and antisocial personality disorder, and higher risk of substance use disorders (APA, 2013). The range of addiction susceptibility is not limited to substance-related issues (Lee et al., 2011). Previous studies have found that problematic internet use and gaming disorder (GD) are associated with ADHD (Koncz et al., 2023; Werling et al., 2022).

GD has now been formally recognized as a mental health disorder by the World Health Organization (2019) and listed as a tentative disorder that requires further research by the American Psychiatric Association (2013). The rationale for researching comorbidities lies in the observation that co-existing symptoms of other mental health problems can affect the incidence of GD (Jeong et al., 2020; Liu et al., 2021) and the outcomes of GD treatment (Chang et al., 2020; Han et al., 2018; Lee et al., 2021). Although the time spent playing videogames is moderately related to symptom severity of GD (Pontes et al. 2022), high amounts of time spent gaming are not necessarily related to psychiatric symptoms (Griffiths, 2010; Király et al., 2017b).

6.1.1. Theories of gaming disorder and vulnerability factors

Several theories have emerged to explain the acquisition, development and maintenance of GD. In the self-medication hypothesis, Khantzian (1997) posited that addictive behaviors develop to alleviate painful current psychological states in the absence of effective alternative coping skills. The model of compensatory internet use (Kardefelt-Winther,

[7] The published version of this study is the following: „ Koncz, P., Demetrovics, Z., Urbán, R., Griffiths, M. D., & Király, O. (2024). Gender-specific motivational pathways in ADHD-related inattention and gaming disorder symptoms. *Addictive Behaviors*, 158, 108120. https://doi.org/10.1016/j.addbeh.2024.108120”

2014) posited that in the presence of unsatisfied needs as a result of psychosocial difficulties when individuals tend to use the internet in order to compensate for these deficiencies, negative outcomes occur. The Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2016, 2019) describes the temporal dynamic of the development and maintenance of specific internet use disorders, such as gaming disorder. The model describes the aetiology of online addictive behaviors by identifying predisposing risk factors (e.g., genetics, psychopathology, needs, and motivation) and the process of gratification, reinforcing cognitive and affective response patterns (e.g., cue-reactivity and attentional biases) which as a consequence, form internet use-related behavioral decisions. The model has also integrated the idea of compensatory use, appearing in later stages of problematic use alongside craving, responsible for the maintenance and exacerbation of the disorder. Despite the differences among these theories, the common observations are that underlying psychological difficulties are important, and the behavior is engaged in to restore balance in these areas.

The addiction vulnerability of ADHD is not an exception, because social and emotional difficulties frequently appear among individuals with ADHD, including higher susceptibility to intrusiveness, aggression, social anxiety, and depression, which can lead to worse peer functioning, low self-esteem, and more frequent social withdrawal. Individuals with ADHD may tend to look for alternative ways to regulate their emotional burden, which when paired with negative urgency (an inclination to act immediately and inadequately when facing negative emotions), can drive them to overuse videogames, which are widely accessible with great capacity for rapid immersion. Additionally, due to the characteristics of the online environments (e.g., anonymity), videogames can be used to meet social needs, which would be more difficult to satisfy in-person for individuals with ADHD (Koncz et al., 2023).

6.1.2. The role of motivations in gaming

Studies have consistently demonstrated the viability of studying motivations for gaming as potential correlates of GD (Bäcklund et al., 2022; Wang, Cheng 2022) and time spent gaming (Johnson, John, Penny, 2016; Király et al., 2017b; Ryan, Rigby, Przybylski, 2006).

Kardefelt-Winther (2017) suggests that the exploration of GD-related risk factors should be in conjunction with motivations to play as mediators of these associations to describe why individuals are driven to overuse online applications (such as gaming). The role of motivations as mediators is also justified by being proximal factors for GD symptoms, according to the integrated network model of personality-emotion-motivation (Zhou et al., 2023).

Research has shown that the motives of escapism (playing as means of self-distraction to avoid emotional pain stemming from problems and difficulties experienced during daily life), fantasy (playing to experience narratives not possible in real life), coping (playing in order to regulate uncomfortable mood and emotions), competition (playing to compare skills and to experience victory over others) and habit/boredom (playing without intention, to pass time or get rid of boredom) can effectively mediate the association between psychiatric symptoms (e.g., symptoms of depression, anxiety) and psychosocial problems (e.g., loneliness) (Király et al., 2015, 2022; Montag et al., 2019).

To date, only two studies have explored the motivational differences in gaming among individuals with ADHD and those without, both finding higher videogame use motivation levels among those who experienced ADHD symptoms (Evren et al., 2021, Montag et al., 2019. Moreover, most of these motives mediate the effect of ADHD symptoms on GD symptom severity, except for social and fantasy motivations (Montag et al., 2019). Even though these studies hold great value, several motivational components were not included (e.g., obtaining status among the gamer community being an important aspect of competitive play, cooperation being an important aspect of social motivation, habitual/boredom-reduction-oriented videogame use being present among gamers). Therefore, a study including these features would complement earlier research findings.

6.1.3. Gender-specific processes

Dong and Potenza (2022) posited that different processes may be responsible for the development, maintenance, and successful recovery from GD for males and females. Impulsivity and impaired behavioral control, aggressivity, and stronger cue-elicited craving

are factors that are more likely to play a role in the development of GD for males, while loneliness and psychological distress reduction-oriented gameplay is more likely to be a female characteristic (Király et al., 2015). Higher reward sensitivity has been associated with positive reinforcement processes and the reduction of inhibitory control and are also typical maintenance factors for male gamers compared to females (Ko et al., 2023). The possibility of unique underlying psychosocial processes calls for further examination of this widely reported comorbidity.

6.1.4. The present study's hypotheses

Based on the previous literature, five hypotheses were proposed. More specifically, it was hypothesized that:

- H_1: Both subdomains of ADHD would be positively related to GD symptoms (based on Koncz et al. [2023]) (H_1).
- H_2: Inattention symptoms would positively predict all motivation factors (in accordance with Evren et al., 2021; Montag et al., 2019).
- All motivation factors would be positively related to GD symptoms (based on Bäcklund et al. [2022]) (H_3).
- More involved players would be characterized by higher levels of mastery, immersion/escapism, competition, and social motivation (based on Johnson et al. [2016]; Király et al. [2017b]; Ryan et al. [2006]) (H_4).
- H_5: There would be a positive indirect association between ADHD inattention symptoms and GD symptoms through motivations such as escapism and competition (based on Kiraly et al. [2015]; Montag et al. [2019]) (H_5).
- There would be a stronger association between immersion/escapism and GD symptoms for females compared to males (based on Király et al. [2015]) (H_6).

6.2. Materials and methods

6.2.1. Participants and procedure

A sample of highly engaged gamers (i.e., playing videogames for 27 hours a week on average) was recruited through paid Facebook advertisements distributed in collaboration

with a popular Hungarian gaming magazine (GameStar.hu) with a large follower base (over 100,000 individuals. Shopping vouchers of different values (€1500 total prize pool was separated into vouchers worth €30, €60, and €300) were distributed among those who completed the survey following a prize draw. Data were collected between March and April 2020, during a period when the first wave of COVID-19 restrictions were operating in Hungary and neighboring countries. Only Hungarian-speaking individuals were able to participate in the study. Confidentiality and anonymity were provided during the study, and participants were required to fill out an informed consent form to participate in the study. Only individuals older than 14 years old were allowed to participate. Those aged between 14 and 17 years were instructed to ask for parental permission before starting the survey. The present study is a part of a larger research project. Another publication using the same dataset but with a very different focus has also been submitted (blinded for review). This study was approved by the Institutional Review Board of (blinded for review), and the study was performed in line with the Helsinki Declaration.

6.2.2. Measures

Data regarding age, gender, marital status, number of years spent studying, current study and work status were collected. Participants were asked to rate what percentage of their gaming time (0-100%) was spent on 12 prespecified gaming genres (see Table 1). Similarly, participants reported the percentage of their gaming time spent on four different platform categories. Participants reported the average hours spent gaming during weekdays and weekend days (to one decimal place). A maximum of 12 hours daily gaming time was allowed to be reported. Those reporting higher daily amounts were instructed to report 12 hours. The average weekly gaming time was calculated from these data.

The six-item version of the Adult ADHD Self-Report Scale (ASRS) (Kessler et al., 2005) was used to assess the symptom severity of the two ADHD subdomains: inattention was assessed with four items, hyperactivity-impulsivity was assessed with two items. The scale is suitable for screening ADHD symptoms in both community and clinical samples, in unweighted form and has outperformed the full (18-item) version (Kessler et al., 2005). Based on previous studies, the Adult ADHD Self-Report Scale has been shown to be a

psychometrically valid tool to assess ADHD symptoms among adolescents, and to differentiate between ADHD affected and non-affected adolescents (Adler et al., 2012; Somma et al., 2019). Participants were asked to report how frequently they experienced different symptoms of ADHD in the past six-month period on a five-point scale (0=never, 4=very often). To control the measurement error of the ADHD subdomains, inattention and hyperactivity/impulsivity were entered into the model as latent variables.

Motivations to play videogames were assessed using the Gaming Motivation Inventory (GMI) (Király et al., 2022). The GMI comprises 88 items assessing 26 gaming motivations. All motivations were assessed on a scale from 1(*"It does not correspond at all"*) to 7 (*"It corresponds exactly"*). The 26 motivations were clustered into six higher-order motivational dimensions (i.e., mastery, immersion/escapism, competition, stimulation, social, habit/boredom) using a series of exploratory factor analyses and exploratory structural equation modeling (ESEM) analysis. In the present study, these six higher-order motivational factors were used as latent variables defined by their related first-order motivations (for more details, see Király et al., 2022).

GD symptoms were assessed using the Ten-Item Internet Gaming Disorder Test (IGDT-10) (Király et al., 2017a). Studies testing the psychometric properties of the scale have reported good validity and reliability (e.g., Chiu, Pan, Lin, 2018; Evren, 2020; Király et al., 2019; Männikkö et al., 2019). The IGDT-10 assesses the symptoms of IGD as proposed in the DSM-5 (APA, 2013). Participants rate the frequency of their symptoms during the past 12 months on a three-point scale (0=never, 1=sometimes, 2=often). Responses are then recoded into a binary variable to follow the dichotomous structure of the DSM-5, where answers of "never" and "sometimes" are coded as 0, and only answers of "often" are coded as 1 (meaning that the criterion is met). Two items (Items 9 and 10) assess the same symptoms (gaming leads to negative consequences in social and educational/occupational functioning). Therefore, they are combined together for the estimation of GD symptom severity. One item, assessing the tendency to play videogames as an escape from emotional difficulties was not included during the calculation of the mean severity scores, due to the overlap between this item and the immersion/escapism higher-order motivational factor.

Composite reliability of the IGDT-10 comprising only the eight dichotomized items in the present study was 0.88.

6.2.3. Statistical analysis

To test the association between the study variables, two similar models were created (one for males and one for females), where the predictors were inattention, hyperactivity/ impulsivity symptom severity, and the six higher-order gaming motivations. The outcomes of the models were GD symptom severity and time spent gaming. Both models were controlled for age. Due to the non-normal distribution of the scale scores in the present study, the robust maximum likelihood estimation (MLR) method was used. To estimate model fit, Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI) and chi-square values of model fit for baseline models were calculated. Values above 0.9 for the CFI, and values below 0.08 for the RMSEA and SRMR were considered to indicate acceptable fit of the models (Browne, 1993, Kline 2015). For descriptive statistics, independent samples t-tests and chi-square tests for group comparison between genders were used in SPSS Statistics version 28 (IBM, 2021). For analyses performed in SPSS, cases were removed analysis by analysis if there were missing data. Therefore, no data imputation was implemented. For analyses ran in Mplus, full information maximum likelihood (FIML) method was used to handle missing values. The eighth version of Mplus was used for model estimation (Muthén & Muthén, 1998-2017).

6.3. Results

6.3.1. Descriptive statistics

After data cleaning, responses from 14,740 individuals were analyzed. The majority of the sample was male (89.3%), with a mean age of 24.14 years (SD=6.95), ranging between ages of 14-75 years. Males reported lower frequency of being in a relationship, having a part-time job, using smartphones and other mobile devices for playing, and preferring role-playing games, MMORPGs, card games, simulators, or another type of games. On the other hand, males spent less time in education and reported higher time spent playing videogames. Males were also proportionally more likely to be single, had a full-time job,

preferred PC/laptop and consoles for playing, and preferred shooter, battle royale and sports games. Descriptive statistics and group comparisons are reported in Table 1.

Table 1 *Descriptive statistics for the male and female subsamples*

		Male subsample (N=13,157)	Female subsample (N=1,581)	t/χ^2 (p)
Age (years), Mean (SD)		24.15 (7.0)	24.05 (6.0)	0.639 (0.523)
Education (number of years completed), Mean (SD)		12.94 (2.7)	13.74 (2.6)	-10.918 (<.001)
Marital status, N (%)	Single	6547 (50.0%)$_a$	530 (33.5%)$_b$	153.24 (<.001)*
	In a relationship but living separately	2913 (22.1%)$_a$	444 (28.1%)$_b$	
	Married/living in a partnership	3573 (27.2%)$_a$	593 (37.5%)$_b$	
	Divorced	64 (0.5%)$_a$	11 (0.7%)$_a$	
	Widowed	7 (0.1%)$_a$	0 (0.0%)$_a$	
Student status, N (%)	Studying currently	6988 (53.1%)	820 (51.9%)	0.90 (.343)
	Not studying currently	6166 (46.9%)	761 (48.1%)	
Work status, N (%)	Not working currently	4769 (36.2%)$_a$	609 (38.5%)$_a$	60.22 (<.001)
	Has a full-time job	6730 (51.2%)$_a$	718 (45.4%)$_b$	
	Has a part-time job	638 (4.8%)$_a$	144 (9.1%)$_b$	
	Has ad ad-hoc jobs	1015 (7.7%)$_a$	110 (7.0%)$_a$	
Average weekly		27.8 (14.9)	26.2 (14.3)	4.13 (<.001)

gaming time, Mean (SD)				
Platform preference for gaming, N (%)	PC/laptop	6361 (48.4%)$_a$	661 (41.8%)$_b$	100.53 (<.001)
	Console (e.g., *Xbox, PlayStation, Nintendo Wii*)	4804 (36.5%)$_a$	526 (33.3%)$_b$	
	Smartphone	1814 (13.8%)$_a$	358 (22.6%)$_b$	
	Other mobile devices (e.g. tablet)	176 (1.3%)$_a$	36 (2.3%)$_b$	
Game genre preference, N (%)	Shooter (FPS, TPS) games	3456 (26.3%)$_a$	241 (15.3%)$_b$	458.021 (<.001)
	Battle royale games	1387 (10.5%)$_a$	102 (6.4%)$_b$	
	MOBAs	885 (6.7%)$_a$	122 (7.7%)$_a$	
	Auto chess/auto battler games	296 (2.3%)$_a$	43 (2.7%)$_a$	
	Open world action-adventure games	2246 (17.1%)$_a$	258 (16.3%)$_a$	
	Role-playing games	1474 (11.2%)$_a$	293 (18.5%)$_b$	
	MMORPGs	670 (5.1%)$_a$	128 (8.1%)$_b$	
	Strategy (RTS, TBS) games	491 (3.7%)$_a$	48 (3.1%)$_a$	
	Card games	168 (1.3%)$_a$	32 (2.0%)$_b$	
	Sport games	1314 (10.0%)$_a$	67 (4.2%)$_b$	
	Simulators	446 (3.4%)$_a$	112 (7.1%)$_b$	
	Other (e.g. puzzle, platformer)	324 (2.5%)$_a$	135 (8.6%)$_b$	

Note: The reported numbers were rounded up in some cases for gaming-related variables. Therefore, the percentages in the table do not precisely add up to 100%. FPS=First-Person Shooter, TPS=Third Person Shooter, MOBA=Multiplayer Online Battle Arena, RTS=Real-Time Strategy, TBS=Turn-Based Strategy. t/χ^2

(p) = This column contains *t*-values reported in the case of independent sample *t*-tests (used in the case of group mean comparisons) and chi-square values in the case of chi-square tests (for frequency data comparisons) and associated *p*-values to indicate statistical significance. The values presented in the table with different subscripts (a, b) indicate significant differences in column proportions, while the same subscripts indicate the absence of significant difference (a, a). *: Divorced and widowed categories are collapsed in the statistics.

6.3.2. Mediation analysis

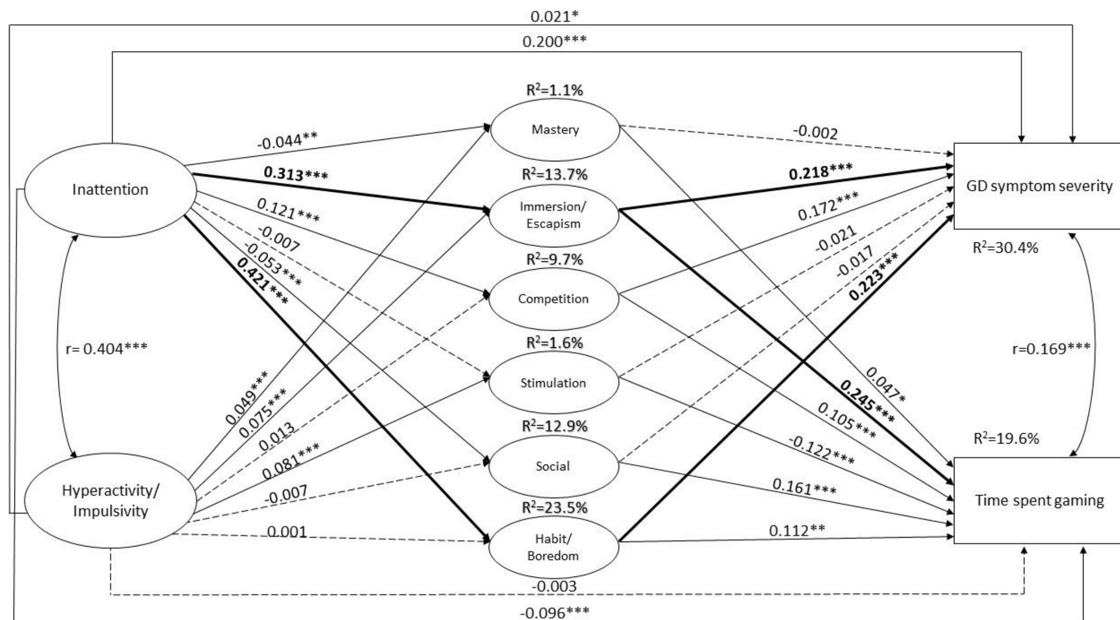
Subdomain scores of ADHD and gaming motivation scores were introduced in the model as continuous latent variables. Both GD symptom severity and weekly time spent gaming were introduced in the model as continuous observed variables. Two structural equation models were tested to explore potential underlying gender-specific mechanisms. Due to the lack of measurement invariance of the GMI scale, model parameters between male (N=13157) and female (N=1581) gamers could not be compared.

6.3.2.1. Mediation model for males

Analysis indicated that model fit was acceptable for male gamers ($\chi^2(407)=11881.420$, $p<.001$; CFI=0.934; RMSEA=0.046; SRMR=0.027). Inattention had a significant positive direct effect on GD symptoms (β = .200, $p<.001$), and a significant negative effect on time spent gaming (β = -.096, $p<.001$). Moreover, it had a considerable positive effect on habit/boredom (β = .421, $p<.001$), immersion/escapism (β = .313, $p<.001$) and competition (β = .121, $p<.001$) motives. Associations between inattention and the other motives were negligible (standardized beta coefficients <0.1). Associations between hyperactivity/impulsivity and all endogenous variables were non-significant or had negligible effect sizes. Regarding the associations between the motives and the two outcome variables, habit/boredom, immersion/escapism and competition motives had significant effects on GD symptoms (β = .223, $p<.001$; β = .218, $p<.001$; and β = .172, $p<.001$ respectively), and immersion/escapism, social, stimulation, habit/boredom and competition motives had non-negligible effects on time spent gaming (β = .245, $p<.001$; β = .161, $p<.001$; β = .122, $p<.001$; β = .112, $p<.001$ and β = .105, $p<.001$ respectively). ADHD subdomain scores were moderately positively correlated in the model (r = .404; $p<.001$), while GD symptom severity was weakly, positively associated with time spent gaming (r = .169; $p<.001$). The model explained 30.4% of the variance of GD symptoms

and 19.6% of time spent gaming (see Figure 1 for the model and Supplementary Table S1 for the correlation coefficients between the included variables).

Figure 1 *The mediation model for males*



Note: N=13,157; Both subdomains of attention-deficit/hyperactivity disorder (inattention and hyperactivity/impulsivity) were entered into the model as latent variables, assessed using their related Adult ADHD Self-Report Scale items (not represented in the figure). Gaming motives were also introduced in the model as latent variables. The explained variances of the endogenous variables and the standardized path coefficients for all associations are presented. This model was controlled for age (not represented in the figure). GD symptom severity score does not include the escape motive. Dashed lines represent non-significant path coefficients and simple lines represent significant path coefficients. Bold lines indicate standardized beta coefficients above 0.2. **p*<.05, ***p*<.01, ****p*<.001.

Total, direct and indirect effects for the model among males are shown in Table 2. Considerable total effect size (β = .385; *p*<.001) was only found between inattention and GD symptom severity. The indirect effect (β = .184; *p*<.001) between these variables accounted for almost half of the total effect, and the main mediation pathways were via habit/boredom (β = .094; *p*<.001), immersion/escapism (β = .068; *p*<.001) and competition (β = .021; *p*<.001) motives.

Table 2 *Total, direct, and indirect effects for the male model*

Predictor: Inattention		GD symptom severity	Time spent gaming	Predictor: Hyperactivity/ Impulsivity		GD symptom severity	Time spent gaming
Total effect		0.385***	0.030*	Total effect		0.038**	0.015
Direct effect		0.200***	-0.096***	Direct effect		0.021*	0.003
Total indirect effect		0.184***	0.127***	Total indirect effect		0.017**	0.011*
Specific indirect paths	Via Mastery	0.000	-0.002*	Specific indirect paths	Via Mastery	0.000	0.002
	Via Immersion/ escapism	0.068***	0.077***		Via Immersion/ escapism	0.016***	0.018***
	Via Competition	0.021***	0.013***		Via Competition	0.002	0.001
	Via Stimulation	0.000	0.001		Via Stimulation	-0.002	-0.010***
	Via Social	0.001	0.009***		Via Social	0.000	-0.001
	Via Habit/ Boredom	0.094***	0.047***		Via Habit/ Boredom	0.000	0.000

Note: N=13157. *p<.05, **p<.01, ***p<.001.

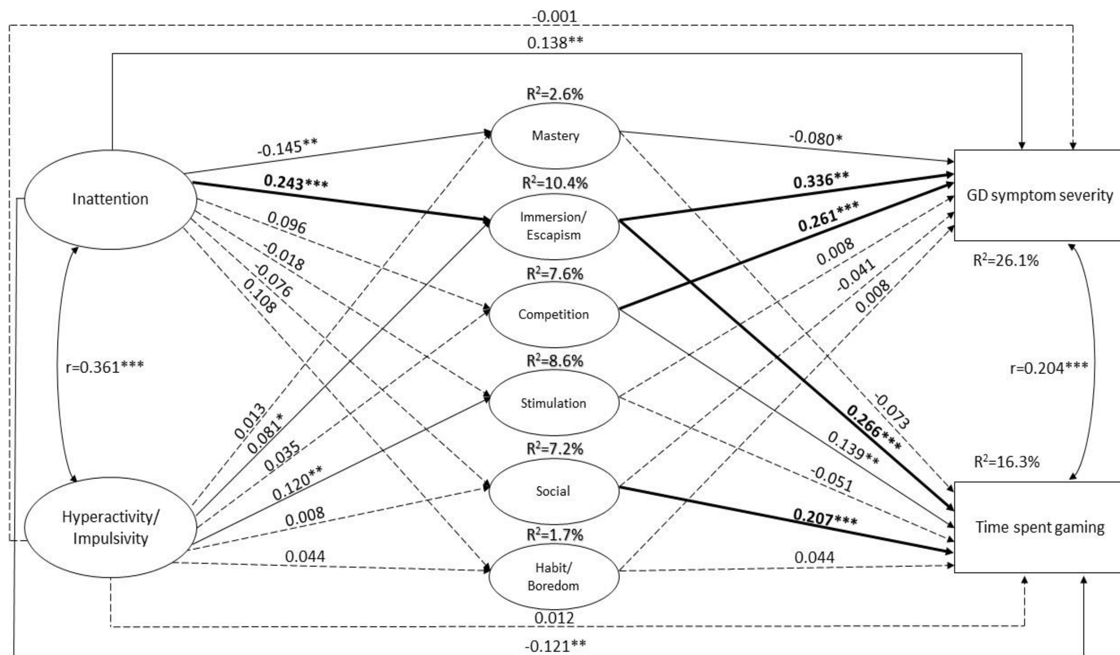
6.3.2.2. Mediation model for females

Analysis also indicated that model fit was acceptable for female gamers ($\chi^2(407)=2195.9$, $p<.001$; CFI=0.918; RMSEA=0.053; SRMR=0.033). Inattention had a significant positive direct effect on GD symptoms (β = .138; p<.01), and a significant negative effect on time spent gaming (β = -.121; p<.01). Moreover, it had a positive effect on the immersion/escapism (β = .243; p<.001) motive and a negative effect on the mastery (β = -.145; p<.01) motive. All remaining associations between inattention and other motives were not significant or negligible.

Only stimulation motivation had a significant, non-negligible association with hyperactivity/impulsivity (β = .120; p<.01) among all motivations. Significant, non-negligible associations were found between the motives and the two outcome variables: immersion/escapism and competition motives had positive effects on GD symptoms (β =

.336, *p*<.01 and β = .261, *p*<.001) while immersion/escapism, social and competition motives had positive effects on time spent gaming (β = .266, *p*<.001; β = .207, *p*<.001 and β = .139, *p*<.01). Similar to the male model, ADHD subdomain scores were positively, weakly correlated in this model (*r* = .361, *p*<0.001), and GD symptom severity was positively, weakly associated with time spent gaming (*r* = .204; *p*<.001). The model explained 26.1% of the variance of GD symptoms, and 16.3% of time spent gaming (see Figure 2 for the model and Supplementary Table S2 for the correlation coefficients between the included variables).

Figure 2 *The mediation model for females*



Note: N=1,581; Both subdomains of attention-deficit/hyperactivity disorder (inattention and hyperactivity/impulsivity) were entered into the model as latent variables, assessed using their related Adult ADHD Self-Report Scale items (not represented on the figure). Gaming motives were also introduced in the model as latent variables. The explained variances of the endogenous variables and the standardized path coefficients for all associations are presented. This model was controlled for age (not represented in the figure). GD symptoms score does not include the escape motive. Dashed lines represent non-significant path coefficients and simple lines represent significant path coefficients for the model. Bold lines indicate standardized beta coefficients above 0.2. **p*<.05, ***p*<.01, ****p*<.001.

Total, direct and indirect effects for the model among females are shown in Table 3. Similar to the male model, considerable total effect size (β = .260; *p*<.001) was only found

between inattention and GD symptom severity. The indirect effect (β = .122; *p*<.001) between these variables accounted for almost half of the total effect, but the only significant mediation pathway was via the immersion/escapism (β = .081; *p*<.05) motive.

Table 3 *Total, direct, and indirect effect estimates for the female model*

Predictor: Inattention		GD symptom severity	Time spent gaming	Predictor: Hyperactivity/ Impulsivity		GD symptom severity	Time spent gaming
Total effect		0.260***	-0.042	Total effect		0.035	0.035
Total direct effect		0.138**	-0.121***	Total direct effect		-0.001	0.023
Total indirect effect		0.122***	0.078***	Total indirect effect		0.036	0.012
Specific indirect paths	Via Mastery	0.012	0.011	Specific indirect paths	Via Mastery	-0.001	-0.001
	Via Immersion/ escapism	0.081*	0.065***		Via Immersion/ escapism	0.027*	0.022*
	Via Competition	0.025	0.013		Via Competition	0.009	0.005
	Via Stimulation	0.000	0.001		Via Stimulation	0.001	-0.006
	Via Social	0.003	-0.016		Via Social	0.000	0.002
	Via Habit/ Boredom	0.001	0.005		Via Habit/ Boredom	0.000	0.002

Note: N=1581. **p*<.05, ***p*<.01, ****p*<.001.

6.4. Discussion

The study's findings indicated that ADHD, and in particular inattention, predicted the symptoms of GD, which partially supported H_1. Inattention symptoms also predicted specific motivations to play, especially immersion/escapism and habit/boredom (but the latter was only found for males), partially supporting H_2. This aligns with the observation that poor emotional regulation is a central characteristic of children with ADHD (Graziano

& Garcia, 2016) and coping difficulties are also frequently observed. The use of more emotion-oriented and less task-oriented coping strategies has been widely reported (Al-Yagon et al., 2020; Barra et al., 2021; Hampel et al., 2008; Young, 2005). Individuals with ADHD react to stress with greater levels of confrontation and aggression, as well as rumination, resignation, social withdrawal, self-pity and self-blame, and use more escape or avoidance-oriented coping strategies (Barra et al., 2021; Hampel et al., 2008; Young, 2005).

Significant associations were found between GD symptom severity and several motivations to play (immersion/escapism, competition in both models and habit/boredom in the male model), partially supporting H_3. This is in line with the findings showing that gaming disorder is also characterized by maladaptive coping strategies, such as denial and behavioral disengagement, as well as self-distraction or self-blame (Bányai et al., 2021; Schneider et al., 2017). Moreover, although most of the motivations predicted time spent gaming (in accordance with H_4), some important differences were also noticed between the two main outcomes. First, a greater proportion of GD symptoms compared to that of time spent gaming was explained by motivations to play and symptoms of psychopathology. This is in line with earlier research by Király et al. (2017). Second, for females, habit/boredom-oriented play was unrelated to time spent gaming, but a positive association was found with time spent gaming for males. These findings suggest that playing without motivation, or to get rid of boredom seems to determine both the intensity and the severity of problematic videogame use among males, but does not seem to predict gaming behavior among females, which may be due to the presence of female-oriented harassment in videogames provoking resistance toward and disengagement from daily habitual play (Kaye & Pennington, 2016; McLean & Griffiths, 2019).

Regarding the mediation effects, the association between inattention symptoms and GD symptom severity mostly mediated through immersion/escapism motivation among males and females, and through competition motivation among males, and confirmed H_5. Therefore, deficits in stress and emotion regulation, and to a lesser degree, the drive to compete and achieve social status among males in the gaming world, seem to be

responsible for the emergence and maintenance of GD symptoms among ADHD-affected individuals.

Another considerable mediated path was found between inattention symptoms and GD symptoms among males, which can be characterized by a boredom-reduction-oriented routine associated with a psychological state lacking any substantial motivation to play. ADHD is generally portrayed as a disorder of attention and impulsivity, but motivational deficits have been found in school settings that seem to be responsible for the general low academic performance and the specific low reading performance (Smith & Langberg 2018). For ADHD-affected individuals, low motivational levels are present in all settings (Volkow et al., 2011), which does not explain how this contributes to the overuse of a recreational activity instead of more meaningful and future-oriented life goals. The possible explanation comes from experimental research which shows a greater tendency of ADHD-affected individuals to prefer immediate over delayed rewards (Luman et al., 2005) which is more likely to be attained in a videogame, than in the non-virtual world. This preference can lead to an escalating habitual retreat into videogame playing, resulting in real-life conflicts and dependence (Soares et al., 2023).

Even though H_6 could not be tested due to the lack of measurement invariance of the motivational scale, differences were found in the mediating motivational patterns between males and females. The most surprising difference was that habit/boredom motivation only mediated the association between inattention and GD symptoms severity among males, which may lie in the unique impact of ADHD on these two genders. Males with comorbid ADHD are more likely to be characterized by externalizing, rule-breaking behavior and impaired educational functioning, while females show more internalizing symptoms and peer functioning deficits (Faheem et al., 2022; Gershon, Gershon, 2002; Skogli et al., 2013). The externalizing behavior of males may lead them to lower academic and vocational success (lower rates of graduation, postsecondary education and occupation, higher levels of job instability and job performance impairments) (Gordon & Fabiano, 2019; Loe & Feldman, 2007) which in turn with less purposeful opportunities to seek, can result in habitual, boredom-reduction-oriented videogame play. The more severe emotional

difficulties and the lack of fulfilling social connections of females with ADHD symptoms can explain why they typically tend to use videogames in a problematic manner as an attempt to self-regulate their emotions.

Overall, the present study's results provide a foundation for personalized GD interventions recommended by Wang and Cheng (2022) including individuals with ADHD to provide specific care for specific needs (Király et al., 2023) and offer targeted replacement behaviors (Steadman, 2019). Techniques used to improve emotion regulation, such as mindfulness-based approaches (Chambers et al., 2009) could be a direction to mitigate the ADHD-affected problematic players' urge to be immersed and to escape by gaming. Moreover, existential therapy and logotherapy could support ADHD affected male players' need to find subjectively meaningful alternatives for gaming (Wong, 2016), while also beneficially affecting the symptoms of other comorbid disorders (Vos et al., 2015). In addition to common mechanisms among males and females, therapists informed about gender-specific processes can become more effective (Owen et al., 2009) by adjusting their approaches to the needs of their clients (Kiselica & Englar-Carlson, 2010).

6.4.1. Limitations, strengths and future directions

Some methodological and statistical limitations need to be mentioned. Due to the cross-sectional nature of the data, the directions of the presented model paths are only based on theoretical assumptions. The current results may not be generalizable to the whole gamer population, since recruitment was potentially affected by self-selection bias. The use of self-report data also carries some inevitable weaknesses due to social desirability and recall bias. The factor Hyperactivity/Impulsivity was defined by only two items, which may not be covering the complete content of that subdomain. Additionally, the seemingly differing model parameter estimates were not comparable statistically due to the lack of measurement invariance of the motivational scale (which is why H_6 could not be tested). It should also be noted that the different sample sizes of males and females resulted in a significantly stronger statistical power to detect mediation effects in the male sample. A significant strength of the present study was the large sample comprising highly engaged videogame players appropriate to examine the processes of problematic use and the

boundary with healthy engagement. Additionally, the Gaming Motivation Inventory is a comprehensive and up-to-date psychometric instrument encompassing the full range of motivations to play videogames. Longitudinal studies focusing on the stability and change of underlying motivations and interventional studies with specific emphasis on modifying such drivers among ADHD affected individuals could be a direction for future research.

6.4.2. Conclusion

The present study showed that the risk contribution of ADHD was again demonstrated for the emergence of gaming disorder symptoms, with inattention symptoms appearing to have the most pronounced effect. Inattention symptoms may contribute to the development of the disorder in both sexes partly through reinforcing the motivation to use videogames as a tool for immersion and escapism. A significant additional mediating effect was also observed, suggesting that habitual, boredom management-oriented use of videogames may also contribute to the problematic pattern of use among males with attention difficulties. Although motivations account for a significant proportion of the association between the two disorders, there seem to be other effects of ADHD symptoms that are independent of motivational drivers, and it is therefore not enough to only identify and address the underlying causes of motivations without applying appropriate treatment for the symptoms of ADHD.

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7. General discussion

7.1. Summary of results

The aims, methods and results of the studies are summarized in the following table (Table 1).

Table 1 *Detailed summary of the main results (Study 1-4)*

Study	Aims	Methods (procedure and analyses)	Results
Study 1	Execute a qualitative synthesis of the previous gaming motivation theories and construct a comprehensive measurement tool that can broadly explore the drivers of video game use while taking their overlap into consideration.	**Stage 1:** PubMed, ScienceDirect, Web of Science, and Scopus were screened to identify studies including measurement of video game motives. **Stage 2-4:** an online, self-report survey was designed and administered in Qualtrics distributed in collaboration with a popular Hungarian gamer magazine (GameStar) to recruit a large sample of Hungarian-speaking video game players (N=14,740, 89.3% male, mean age 24.1 years). The survey consisted of sociodemographic measures, questions related to video game use habits, the survey constructed at Stage 1 for gaming motivation	**Stage 1:** 100 items were generated based on previous instruments which covered 27 theoretical motivational factors. **Stage 2:** 26 first-order factors were identified using CFA (*first step*), which were clustered into six higher order factors during two independent EFA (*second and third step*). The factors were named as Mastery, Immersion/Escapism, Competition, Stimulation, Social and Habit/Boredom. The ESEM model had confirmed the model resulted from the earlier EFAs (*fourth step*). The ESEM model had shown adequate fit to the data ($\chi2$ (184) = 3,264.4, $p < 0.001$; CFI = 0.944; TLI = 0.901; RMSEA = 0.059, 90% confidence interval 0.057–0.060; SRMR = 0.021).

		measurement, and several previously validated scales measuring sociability, competitiveness, sensation seeking, general self-esteem, self-esteem when playing video games, positive and negative affect traits, perceived stress, GD symptoms and depression symptoms.	**Stage 3:** several significant, positive path coefficients were found between main motives and theoretically related psychological and personality variables, including (in ascending order) negative affect and Immersion/Escapism motivation ($\beta = 0.242$, $p < 0.001$), sociability and Social motivation ($\beta=0.261$, $p<0.001$), positive affect and Mastery motivation ($\beta=0.344$, $p<0.001$), competitiveness and Competition motivation ($\beta=0.604$, $p<0.001$). Additionally, video game genre preference had shown distinguishable motivational profiles. **Stage 4:** results had verified a similar pattern of association compared to earlier, similar models: the effect of depression symptoms and GD symptoms (total effect: $\beta=0.375$, $p<0.001$) was partially mediated via Immersion/escapism (indirect effect: $\beta=0.089$, $p<0.001$) and via Competition (indirect effect: $\beta=0.016$, $p<0.001$). Additionally, the model had shown a relatively strong indirect association via Habit/Boredom (indirect effect: $\beta=0.089$,
		Stage 1: most frequently used instruments measuring gaming motives were used to identify underlying motives and generate a comprehensive item pool for their assessment. **Stage 2:** at the *first step*, a confirmatory factor analysis (CFA) was used to validate 27 theoretically proposed motivational factors. Then the total sample was divided into three non-overlapping random samples. At the *second step*, exploratory factor analysis (EFA) was used to test how the motivational factors found at step one	

		cluster into higher-order factors. At the *third step*, an independent sub-sample was used to cross-validate the model found at the second step. At the *fourth step*, exploratory structural equation modeling (ESEM) was used to cross-validate the hierarchical structure found at the second and third step. To evaluate model fit, chi-square ($\chi 2$) test of exact model fit was performed and Comparative Fit Index (CFI), Tucker-Lewis index (TLI), root-mean square error of approximation (RMSEA) and standardized root-mean-square residual (SRMR) were estimated. **Stage 3:** multiple indicators, multiple causes (MIMIC) analysis was used to cross-validate the six higher-order motivational factors with the measured psychological and personality variables. **Stage 4:** a parallel mediation model was constructed within structural equation	$p<0.001$) not covered in earlier path models.

		modeling (SEM) to test the mediation role of the six higher-order motivations. This analysis was expected to further validate the model by showing similar patterns of association as in earlier, similar research (Király et al., 2015; Ballabio et al., 2017).	
Study 2	Write a narrative review of available empirical research on the etiological factors of GD to support and/or refute previous models. Additionally, provide a summary of areas not	The authors collected, processed and narratively described the most recent and relevant research findings explaining the characteristics and etiological factors of GD based on their scientific knowledge. An initial goal was to include studies covering the following three main areas of interest: individual, environmental	A large set of research (N = 177) was identified and narratively summarized in structured format covering a wide range of variables found to play a role in the emergence, development and maintenance of GD: 1. **Gaming-related factors:** online vs. offline games; game genres, structural characteristics, and game design elements;

	covered in earlier models: role of external (e.g. culture, peers, family etc.) and game related (e.g. game genres, structural characteristics etc.) factors.	and gaming-related factors.	monetization techniques. 2. **Individual factors:** demographic risk factors, personality traits, individual vulnerabilities, motivational factors, neurobiological processes and genetic predisposition. 3. **Environmental factors:** family factors and early life experiences; peers and school-related factors; the broader context of culture; international growth of esports.
Study 3	Provide a quantitative synthesis of studies focusing on the ADHD-GD association and supplement earlier research with qualitative summary of the potential mediators explaining the underlying process of this association.	**Articles search** was done systematically on Scopus, Science Direct, Web of Science, and PubMed to identify studies relating to the association between ADHD and GD. Studies were included, if at least one of the following was reported: 1. a correlation coefficient regarding ADHD-GD association; 2. group means and SDs of ADHD symptom severity (between GD and non-GD individuals);	**Articles search and data extraction:** 52 studies were found suitable for data synthesis (39 studies with correlation estimates, 7 studies comparing GD severity of ADHD and non-ADHD affected individuals, 6 studies comparing ADHD severity of GD and non-GD individuals). **Data synthesis:** pooled estimates of correlation between GD and ADHD were all significant, indicating a positive, moderate association with combined ADHD scores ($r = 0.296$, $p < 0.001$), inattention scores ($r = 0.306$, $p < 0.001$), and

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<td>3. group means and SDs of GD symptom severity (between ADHD and non-ADHD individuals).
Data extraction was performed with the inclusion of BA, MA and PhD students.</td>
<td rowspan="2">hyperactivity/impulsivity scores ($r = 0.266$, $p < 0.001$). These results were confirmed by structural equation meta-analysis. A large average difference was found in GD severity between ADHD affected and non-ADHD affected individuals ($g = 0.693$, $p < 0.001$). A large average difference was found in ADHD severity between GD affected and non-GD affected individuals ($g = 0.854$, $p < 0.001$).
Publication bias tests: no evidence was found for considerable publication bias for any data type (correlation and group difference estimates).
Moderator analyses: significant effects were found in case of three moderators:
1. Stronger positive correlation was found between combined ADHD and GD scores in studies with higher percentage of males (coefficient = 0.0018, $p < 0.05$);
2. Stronger positive correlation was found between combined ADHD and GD scores in studies where not only GD, but a mixture of</td>
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<td>Data synthesis was executed using random-effects model and confirmed in structural equation meta-analysis, heterogeneity estimates were calculated (Q and I^2 statistics) and figures (forest plots), were created for illustration. All analyses were performed on either the combined ADHD symptom severity, and/or on ADHD subdomain (inattention and hyperactivity/impulsivity) severity scores. Findings not suitable for data synthesis were reported qualitatively.
Publication bias tests were implemented (funnel plot, trim-and-fill method, Rosenthal's fail-safe N method)</td>
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		to test the robustness of findings to systematic missingness due to selective publication practice. **Moderator analyses** were performed using several potential moderators (age, gender ratio, year of data collection, study quality, sample type, country of origin, GD measure and source, ADHD measure and source, type of addiction examined). **Quality assessment** was provided for the included research articles. **Theoretical summary** was provided to explain the role of all intervening factors of the association.	GD and internet addiction (IA) was measured ($r = 0.288$, $p < 0.001$ for only GD; $r = 0.374$, $p < 0.001$ for mixed measurement $Q(1) = 8.636$, $p < 0.003$); 3. Larger difference was found in GD symptom severity between ADHD affected and non-ADHD affected individuals in more recent studies (coefficient = 0.0528, $p < 0.001$). **Quality assessment:** no low-quality studies were found and most of the studies (38 out of 52) were found to be of high quality. **Theoretical summary:** the co-occurrence of ADHD and GD symptoms was explained by impulsivity, difficulties in affective and social functioning, and motivational deficits.
Study 4	Test the potential mediator role of video game motivations in the association between ADHD, GD and average time spent playing.	All analyses were based on the data collected during Study 1 (for further information, see methods section of Study 1, Stage 2-4). A parallel mediation model was tested in SEM using robust maximum likelihood	**Male model:** the male model had shown adequate fit to the data ($\chi2$ (df = 407) = 11881.4, p < 0.001; CFI = 0.934; RMSEA = 0.046; SRMR = 0.027). The effect of inattention to GD (total effect: β=0.385, p<0.001) was partially mediated via

		estimation (MLR). ADHD subdomain (inattention and hyperactivity/impulsivity) severity scores and higher-order motivations (for further information, see Study 1, Stage 2, *second step*) were used as predictors, and GD symptom severity (without escapism symptom) and time spent gaming were the outcomes. Both models were controlled for age. Models were tested separately for males and females. For model fit evaluation chi-square (χ2) test of exact model fit was performed and RMSEA, SRMR, CFI were calculated.	Immersion/escapism (indirect effect: $\beta=0.068$, $p<0.001$), via Competition (indirect effect: $\beta=0.021$, $p<0.001$) and Habit/Boredom (indirect effect: $\beta=0.094$, $p<0.001$). The effect of hyperactivity/impulsivity to GD (total effect: $\beta=0.038$, $p<0.01$) was partially mediated via Immersion/Escapism (indirect effect: $\beta=0.016$, $p<0.001$). **Female model:** the female model had shown adequate fit to the data (χ2(df = 407) = 2195.9, $p < 0.001$; CFI = 0.918; RMSEA = 0.053; SRMR = 0.033). The effect of inattention to GD (total effect: $\beta=0.260$, $p<0.001$) was partially mediated via Immersion/escapism (indirect effect: $\beta=0.081$, $p<0.05$).

7.2. Contribution to theory and remaining research gaps

The multivariate nature of GD was well-known after the release of the I-PACE model (Brand et al., 2016; Brand et al., 2019), but a comprehensive qualitative summary of the most recent findings from a wide area of research was due (Study 2). The current etiological review widened the scope of research and theory and is expected to replace the pre-existent, in most cases exclusively personal factor-oriented view on GD development. Although there is a significant research interest in investigating such a wide range of risk factors, due to lack of time and access to resources, further research had to be directed at exploring a narrower, yet comprehensive area in GD research, which are in case of this dissertation, the role of motivational drivers, ADHD and their interrelationship. As the study of addictive aspects of video games is becoming more and more viable by the development of assessment tools (Saini et al., 2024), the possible interaction between game-related characteristics and personal vulnerabilities (e.g. Szolin et al., 2022) requires further discovery. Another field of research requiring additional efforts in this field is the gaming-gambling intersection (King, Delfabbro, 2020) and the shift of originally gaming-related media sources towards gambling content live-streaming for partially minor viewers (Koncz et al., 2023).

Escapism is a widely reported risk factor for GD (Bäcklund et al., 2022). It is mainly recognized in gaming motivation research (Demetrovics et al., 2011; Yee, 2006), but it is also already part of the DSM diagnostic criteria (World Health Organization, 2019). Different concepts have recurrently aimed to describe the same phenomena, the components model of addiction calls it "mood modification" (Griffiths, 2005), the component model of addiction treatment refers to it as negative urgency (Kim, Hodgins, 2018), it occurs in the cognitive-behavioral model of IGD as "stress relief" (Dong, Potenza, 2014) and "urge to mood regulation" in the I-PACE model (Brand et al., 2016; Brand et al., 2019). Reinforcement theory mentions it in relation to the alleviation of negative affective states that emerge due to the core symptoms of addiction (e.g. withdrawal, craving) and it appears in substance use motivation research recognized as "coping motivation" (Votaw, Witkiewitz, 2021). Independently of research focusing on problematic use, mood management theory attempts to capture a similar phenomenon, stating that in general the

function of using digital media (originally referring to traditional media such as television but further applied to "modern forms" including video games and social media) is to improve or maintain positive mood (Reinecke, 2017). This theory has received partial empirical support by demonstrating that adolescents using digital media rather maintain, than enhance their positive mood, while in contrast to this, more depressed adolescents rarely use digital media for mood enhancement (Dillman Carpentier et al., 2008).

Current results on the one hand further verify the association between escapism and GD (Study 1 and 2), while on the other hand, that it clusters into a higher-order motivation (Immersion/Escapism) with fantasy, coping, identity and introjected regulation (Study 1). This greatly demonstrates that even though videogames lack the physiological effect of substances, they can provide relief from uncomfortable experiences by being highly capable of absorbing the attention of users with the use of carefully constructed fantasy worlds and virtual identities. While this capability of video games can be used beneficially in the right hands (Alonso Puig et al., 2020; Jameson et al., 2011), it can also lead to serious harm if used extensively (Düll et al., 2024). Further studies focused on the application of video games for their beneficial effects should also investigate the tendency of users to develop GD through this process, especially among individuals with co-occurring risk factors.

Further theory and research should focus on conceptualizing escapism in relation to video game use. Several different concepts of escapism exist. One concept is escaping from the self (Baumeister, 1991), in which case being highly focused on a behavior (e.g. intensive physical activity, binge eating, suicide planning) is an attempt to decrease self-awareness that can lead to distress if a person is unable to meet the standards of them or the others. The relevance of this concept has received great empirical support from GD research, on the one hand, by showing the association between GD and self-esteem is generally negative (Kavanagh et al., 2023), while on the other hand, by showing that identification with virtual avatars could serve as a tool to decrease discrepancy between the ideal and real self (Szolin et al., 2022). Escaping from everyday life (Cohen, Taylor, 1992) could be another type of escapism, which is driven by a desire to (at least occasionally) remove daily stress originating from the incompatibility of society defined ideal life path and an individually

defined identity. This is supported by our findings by showing that both fantasy and escapism first-order motivations are clustered into the same higher-order motivation (Immersion/Escapism), showing that the tendency of escaping into videogames is closely related to the motivation to explore unknown worlds and try alternative identities (which are rarely or never possible on a day-to-day basis). A third idea could be that escapism is a form of exploration of the adventurous side of life (Tutenges, 2012). Based on this concept escapism is directed to remove social norms to experience extreme situations, such as high amounts of alcohol consumption paired up with more frequent sexual interactions and even physical conflicts. Video games provide simulated stimuli which limits the realism of the experiences; thus, it may be less preferable by individuals who are attracted to such intense conditions. However, video games also have the capacity to remove social barriers, thereby allowing more aggression (Kou et al., 2020) especially among more problematic players (Li et al., 2023), while consumption of performance enhancers among more competitive players (Ip et al., 2021) and daily substance use among problematic players (Di Carlo et al., 2023) have been recognized in previous research.

Another distinction in the definition of escapism should be made, as it could cover both a tendency to avoid uncomfortable affection by high immersion into video games, and a tendency to use video games to fulfill needs which cannot be fulfilled during daily life (generally referred to as compensation) (Giardina et al., 2024a). The avoidance of uncomfortable situations can theoretically be problematic as it can take the form of postponing and neglecting important areas of life and responsibilities, which are generally prerequisites for long-term goals (e.g. career and relationships). Empirical research has verified that avoidance-oriented escapism (escaping failure and withdrawing into the virtual world) seems to be related to problematic use, while compensation-oriented "active escapism" is only related to gaming passion (Giardina et al., 2024b). Additionally, coping research implies that flexibly applying problem focused (for controllable stressors) and emotion focused strategies (for uncontrollable stressors) is related to better outcomes (Stephenson, DeLongis, 2020), thus the flexibility of switching between avoidance, compensation and other, not video game related strategies is expected to be more strongly related to healthy functioning, but this requires verification from further research.

Habit/Boredom higher-order motivation had been shown as another important correlate and predictor of GD (Study 1). Amotivation first-order factor was found to have the largest factor loading on this second-order factor, one of the main components of SDT emerging from the frustration of basic psychological needs (Ryan, Rigby & Przybylski 2006; Przybylski et al., 2010). Previous studies had shown that amotivation is related to lower well-being and disengagement (Ryan, Rigby & Przybylski 2006; Przybylski et al., 2010), burnout and lower performance in occupational setting (Van den Broeck et al., 2021) and in the field of gaming psychology research related it not only to problematic use, but depression/anxiety, social withdrawal/loneliness (Von der Heiden et al., 2019; Wang et al., 2021). Habit/Boredom driven video game use is still less understood in relation to GD, it can be presumably a state of existential vacuum (Frankl, 1985), which may be characterized by a lack of motivating goals. Additionally, it should be clarified what external events and personal factors (personality factors, comorbidities, habits) could lead to the development of this motivation, while it could be also explored how this motivation is related to the intention to change. It is possible that in the predominance of this motivation, GD affected individuals could more likely be at or over the contemplation phase (see the Transtheoretical model; Prochaska, DiClemente, 1982). While video game use lacking motivation has mostly negative affective correlates, this factor is explored as no motivation towards video game use, but it remains unclear if amotivation is typically concurrently present in other areas of life (e.g. school/work, hobbies, personal relations). An additional question is if amotivation towards games is not necessarily co-occurring with amotivation in other areas of life, how discrepancy in amotivation can be associated with problematic use and mental health.

The numerous areas where ADHD can negatively impact the mental health, quality of life and daily functioning of individuals are progressively being more and more visible (French et al., 2024). The current meta-analysis (Study 3) has shown that GD is not an exception, the relationship between ADHD and GD received support from all over the world, thus the association does not seem to depend on either the measurement tool used, nor the source of information and the results cannot be attributed to publication bias. Several issues of ADHD affected individuals have been shown that could potentially explain why it may be a risk factor for GD, such as the capacity of online games allowing social need satisfaction

despite social deficits or the greater accessibility of predictable and immediate positive feedback compared to non-computerized tasks. Further research could focus on explaining the interrelationship between different, impaired areas of functioning of ADHD, for example how the general motivation deficit and low performance in school setting (Smith et al., 2018) could be related to GD, as it could be a compensatory attempt to satisfy the basic psychological need for competence. Upcoming psychology research could benefit from treating the association between ADHD and GD not only as a threat to mental health, but also as an indication of different needs, which present an opportunity for the developing interventions tailored for the ADHD-affected youth and adults (Bubnik et al., 2015; Fang et al., 2025).

Going beyond seeing comorbidities and motives as simple risk factors of GD other than interrelated factors is inevitable at the current state of the field. Our results have shown that complex motivations can effectively explain the association of GD to two frequently reported comorbid disorders: depression and ADHD (Study 1 and 4). Both the effect of depression and inattentive symptoms of ADHD were mediated by Immersion/Escapism, demonstrating the crucial role of maladaptive coping in the development of GD in the presence of other mental health issues. Habit/Boredom motivation has been also a considerable mediator of these relationships, but only in case of males experiencing inattentive symptoms of ADHD (gender specificity of this path was untested for depression). Lastly, a relatively weaker, but significant positive path was found for Competition higher-order motivation, demonstrating that videogames are field where ADHD affected individuals are motivated to compete. These findings considering the lower educational motivation of ADHD affected individuals and supplemented by earlier research showing "equalizing effect" of video games on performance among ADHD affected individuals (Bioulac et al., 2014; Shaw et al., 2005) indicate that people with ADHD may become problematic users through finding videogames a fair field of competition, where demonstrating and experiencing relative competence is accessible. These studies are in line with the practical argument of the I-PACE model, which states that "Moderator and mediator variables are important components of theoretical models for psychiatric/psychological disorders, because pharmacological and psychological interventions may address moderating and mediating variables effectively…" (Brand et al.,

2016, pp. 253). Subsequent research should discover the utility of testing the mediating role of gaming motivations in the relationship between GD and other risk factors (e.g. Montag et al., 2019). Likewise, similar models could be tested for other problematic behaviors, including not only behavioral, but also substance related addictions.

7.3. Practical implications

Recognizing the main characteristics of a disorder is crucial to determine the focus of interventions, while understanding key etiological determinants are necessary for effective preventive program planning. Earlier findings support the short term-effectiveness of CBT (Stevens et al., 2019) and the relatively higher effectiveness of combined CBT and pharmacotherapy treatment (Zajac et al., 2020). Supplementing additional methods of intervention to the usual treatment that are focused on managing videogame related and external risk factors is necessary to provide comprehensive intervention. Considering video game characteristics could help GD patients recognize personal vulnerabilities and even open a possibility for specific self-exclusion (e.g. avoidance of loot boxes during play). A complex intervention could include family therapy to improve impaired family functioning among GD affected individuals (Wang et al., 2024) or cyberbullying prevention could remove a considerable risk factor of GD (Gao, Wang, Dong, 2022). The usage of complex programs is an ongoing direction to enhance treatment effectiveness, a great example is the PIPATIC program (Torres-Rodríguez et al., 2018a; Torres-Rodriguez 2018b), which is built upon CBT but does incorporate elements aimed to improve intrapersonal, interpersonal and family functioning.

The usage of gaming motivations (beyond their contribution to theoretical models) offer various options for intervention:

1. While finding alternative activities for GD affected individuals can be difficult for practitioners (especially for those unfamiliar with video game mechanics), using a tool to explore the motivational profile of a patients could help **finding well-suited alternative replacement behaviors** (Steadman, 2019).
2. As different personality profiles of patients may require different treatment (Billieux et al., 2015; Lee, Lee, Choo 2017), gaming motivations could also be used to **customize interventions** for GD patients: patients characterized by high

Immersion/Escapism could receive emotion regulation and coping oriented treatment; patients with high Competition motivation could benefit from switching to group-based sports and hobbies with high skill ceiling; highly Mastery oriented players could try implementing diaries or goal setting and tracking applications towards not-gaming related goals to increase their perception of progression during daily life while also utilize gamification to improve their ability of dealing with responsibilities.

3. Motivations could be used as additional, marginal **indicators of treatment progression**. Decrease of interest in other activities is one symptom of GD (American Psychiatric Association, 2013; World Health Organization, 2019), thus combined assessment of motivations towards gaming related and non-gaming related activities could help temporal tracking the dynamic determinants of GD, which could help in fine-tuning the necessary intensity of focus on specific motivations to achieve behavioral change.

Comprehensive prevention and treatment of GD should consider ADHD as a vulnerability factor, affecting either or both the development and maintenance of GD. One direction for treatment is taking into consideration the strengths and weaknesses of ADHD affected individuals during goal setting and lifestyle planning. ADHD affected individuals generally underperform in tasks requiring sustained attention, perseverance and convergent thinking, but excel when divergent thinking is necessary and more frequently experience hyperfocus compared to healthy comparison (Groen et al., 2020; Grotewiel et al., 2022; Hupfeld et al., 2019; Marchetta et al., 2008; Schippers et al., 2024; Stolte et al., 2022). Building upon the unique strengths of ADHD affected individuals could help orienting them towards a life with fitting goals, providing more frequent positive feedback, a sense of control and competence, which is also less likely to drive them toward a constructed virtual world, where these experiences are perceived to be more achievable. Another direction is the mitigation of ADHD symptoms to achieve symptom reduction in related disorders, including, but not necessarily limited to GD. A recent study has found pharmacological treatment of ADHD effective in reducing IA symptoms (besides other addictions), indicating that IA symptom reduction is related to several frequent correlates of ADHD,

including sluggish cognitive tempo, attentional impulsivity and mood and anxiety symptoms (Grassi et al., 2024).

Dong and Potenza (2022) drew the attention to the necessity of considering gender specific characteristics for the management of GD, by highlighting that that males could be more drawn towards game rewards and aggressive content, while females may be more likely to use games to alleviate psychological distress, loneliness and social phobia. Our results partially confirm the gender specificity of gaming motivations as mediators in the association between the inattentive symptoms of ADHD and GD. Meanwhile enhancement of emotion regulation skills is necessary regardless of gender, on the contrary, males with GD would require additional care which can reduce their propensity to play as a habit, without motivation, simply to reduce boredom. For this cause, finding replacement behaviors and using interventions which support the pursuit for meaning (Wong et al., 2016) are expected to be specifically beneficial for males.

7.4. Limitations

The research presented in this dissertation has a few limitations. Firstly, two articles (Study 2 and 3) present the qualitative synthesis of previous findings, rather than presenting results from the collection and analysis of new and original data. The simple narrative description of these findings does not make it possible to assess the methodological shortcomings or the strength of the effects of the research mentioned. This did not apply to the meta-analysis between ADHD and GD symptoms (Study 3) which did implement quality assessment and a quantitative collection and synthesis of most of the results.

Secondly, all individual empirical studies reported in this dissertation and most of the studies presented in the reviews (apart from the longitudinal studies mentioned in Study 3) are observational studies using a cross-sectional design. The drawback of such studies is that they do not allow to clarify which one is the cause and the effect, nor do they allow testing two-way relationships. This is particularly true for the two parallel mediation models (Study 1 and Study 4), given that these models are typically process models, intended to describe the mechanisms underlying the relationship between variables.

Thirdly, all empirical studies and a large proportion of qualitative summaries are based on responses to psychological questionnaires (except for the studies presenting results based on genetic sampling and brain imaging mentioned in Study 2 and Study 3). This data collection procedure has several biases: reference bias (data collected during the completion of questionnaires are influenced by who the respondents compare themselves to), recall bias (participants may inaccurately recall events which happened long time ago), misinterpretation bias (bias due to misunderstanding the questions). In addition to this, research typically collects and analyses data from self-reports, which carry additional potential biases, such as social-desirability bias (preference of responses which are perceived to be socially acceptable or favorable) and introspection bias (bias arising from lack of introspection). The meta-analysis presented (Study 3) investigated this by analyzing how the source of information affects the results. However, this analysis did not detect any significant difference, so it appears that these limitations do not apply to the association between ADHD and GD symptoms.

Finally, the presented comprehensive motivational model (Study 1) and the parallel mediation analysis which was built upon the previous motivational model describing the relationship between ADHD and GD (Study 4) was constructed from data of a Hungarian-speaking sample. An international validation of the motivational model is necessary to determine whether the first-order motivations can be clustered into the six higher-order factors described and whether they show a similar factor loading pattern as the result of analysis done on the Hungarian-speaking sample. Furthermore, a replication study of the parallel mediation model describing the relationship between ADHD and GD through motivations would be necessary to support the international generalizability of the findings.

7.5. Future research directions

Besides filling the research gaps in relevant topics, methodological improvements are also necessary to produce clearer and more accurate conclusions. Upcoming research on this field should go beyond the usage of observational, cross-sectional design. Experimental methods are hard to implement due to ethical reasons in the exploration of the relationship between ADHD and GD symptoms. One direction is the usage of longitudinal research in which the prospective predictive relationship (cross-lagged panel models; Marmet et al.,

2018) or the interrelationship of change (growth models; Lee et al., 2021) could be modeled between ADHD and GD. The appropriate age group for this could be youth where issues could emerge due to the increasing educational expectations and where the usage of video games tends to become more frequent (Ream et al., 2013). A different option is the follow-up of young adults with childhood ADHD diagnosis with the intent to compare individuals with permanent symptoms to those with declining symptoms (Sasser et al., 2016). Similar research design can be applied to track the course of video game motivations and their interrelationship with gaming related problems (Wang et al., 2021). A sufficiently long-term and large-sample study can model the shift between gratification and compensation and verify the role these play in the aetiology of GD (Brand et al., 2016; Brand et al., 2019).

Another direction is applying interventions to modify risk factors of GD and track how changes transfer to a symptom reduction or relapse prevention (at post-treatment) (Han et al., 2018; Lee et al., 2021). Treatment of ADHD symptoms can be achieved by pharmacotherapy (Grassi et al., 2024), reduction of Immersion/Escapism motivation could be accomplished by applying mindfulness-based stress reduction techniques (Garland, 2013; Li, Garland, Howard, 2018). As some studies indicate reverse or bi-directional relationship between ADHD and GD (Marmet et al., 2018), similar procedure should be applied, namely treating GD early with the expectation to decrease or prevent the increase of ADHD symptoms.

Meanwhile self-reported surveys are a central part of data collection in psychological science, due to the biases emerging from their usage and their limited ecological validity, improvements could be applied in the field. The usage "digital footprints" from digital behavioral tracking application is still mostly neglected. By applying pattern analysis, these could presumably be used as markers of sociality, mood or personality, without the necessity of effort from participants to provide data (Montag et al., 2022). Besides the increased validity of using combined data from different sources, this could also support participant retention, a significant issue of longitudinal research (Gustavson et al., 2012).

Lastly, the comprehensive gaming motivation model (Study 1) and the study built upon it (Study 4) is made on a Hungarian-speaking sample, thus international validation and

replication is a clear direction for further research. Testing cross-cultural measurement invariance of this tool is essential to study the culture dependence of motivational risk factors of GD. The usage of this tool for between-group comparison (e.g. adolescents vs. adults) still requires verification. In the final study (Study 4), measurement invariance was not found between the subgroup of males and females, thus the tool should be modified before parameters can be statistically compared. Testing the applicability of this tool in clinical samples and over time is needed, and revision may become necessary with the evolution of the video game industry.

7.6. Conclusion

GD is a complex issue, determined by the combination of internal, external and gaming-related causes. The exploration of the motivational drivers of problematic use has shown useful results in both theoretical understanding and practical management of GD, especially by demonstrating the mediating role of Immersion/Escapism, Habit/Boredom and Competition higher-order motivations between symptoms of depression and GD. ADHD symptoms show a robust, moderate positive association with GD, and although many ideas have been raised to explain this relationship (discussing the role of impulsivity, emotion regulation, social functioning and motivational problems), exploration of the motivational drivers of video game use among individuals experiencing ADHD symptoms has also yielded promising results in this area. Similar motivational patterns appear to be responsible for the co-occurrence of depressive and ADHD symptoms with GD symptoms but displaying a gender-specific pattern in case of ADHD, demonstrating Immersion/Escapism as a common, but Habit/Boredom as a male-specific pathway for GD development and maintenance.

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