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# Game transfer phenomena as a particular form of involuntary cognitions: The role of internet gaming disorder, and other psychopathological and cognitive predictors

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ABSTRACT

Game Transfer Phenomena (GTP) refer to the involuntary transfer of video game experiences into the real world, which can manifest as altered sensory perceptions, automatic thoughts, and behaviours. This study aimed to examine whether GTP shares characteristics with other spontaneous cognitive phenomena, such as daydreaming and mind-pops. Additionally, it explored schizotypal traits and working memory capacity, which have been linked to involuntary cognitions, as well as game-related variables (e.g., Internet Gaming Disorder), psychological distress, and impulsivity as potential predictors of GTP. A total of 352 players ($M_{age} = 25.38$, $SD = 5.90$; 76 % male) participated by completing online questionnaires and working memory tasks. Hierarchical multiple regression analysis revealed that GTP was significantly predicted by Internet Gaming Disorder, positive schizotypy, daydreaming, mind-popping, anxiety, and motor impulsivity. Further mediation analysis showed that positive schizotypy and mind-popping partially mediated the relationship between Internet Gaming Disorder and GTP. These findings highlight, for the first time, the importance of psychopathological traits and the frequency of involuntary cognitions in predicting one's susceptibility to GTP. They also contribute to the theoretical understanding of GTP by suggesting that GTP may belong to a broader category of involuntary cognitive phenomena.

## 1. Introduction

Playing video games has become one of the most popular forms of entertainment among people of various ages [1,2]. In recent years, the debate about the potential negative effects of playing video games has become central due to the acknowledgment of internet gaming disorder in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* by the American Psychiatric Association [3], and its inclusion, as a formal disorder, in the 11th revision of the International Classification of Diseases (ICD-11) by the World Health Organization [4]. Symptoms of Internet Gaming Disorder include neglecting interpersonal relationships, deceiving family members, and jeopardising job and school performance [5].

In recent years, researchers have been investigating the impact of playing video games on individuals' real-world perceptions, thoughts, and behaviours. This focus goes beyond simply looking at how much time people spend playing and the outcomes of such playing [6,7,8,9,10,11,12]. A large body of research with this focus has been conducted within a broad framework of the Game Transfer Phenomena (GTP) [13], which examines a variety of involuntary phenomena, including altered sensory perceptions (e.g., visual, auditory, tactile, etc.), automatic mental processes and behaviours and actions related to video games that gamers may experience in the course of their daily life. Examples of altered visual and auditory perceptions include seeing images (e.g., health bars) overlaying physical objects or hearing voices from video game characters [14]. Automatic mental processes include a variety of spontaneous cognitions including intrusive memories, thoughts and ruminations related to gaming, as well as words, images, and music from the game popping into mind, or applying game strategies to real-life contexts. Finally, involuntary actions can manifest as automatic body movements or actions such as moving one's fingers in a repeated sequence of imagined button presses on a gamepad or mimicking movements of the game characters.

GTP are relatively common, with most players reporting having

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experienced one type of GTP over the past 12 months or at least once during their lifetime. Several studies with different samples of players from various cultural and ethnic backgrounds (N > 7,000) have reported that at least 95 % of gamers acknowledged experiencing an instance of GTP of any kind at least once in the past 12 months [13,14,15], with lower prevalence reported in only two studies (75.3 % in Cudo et al., 2022 and 82 % in Ortiz de Gortari, 2017). Despite the high prevalence of GTP, most players tend to score low to medium on the GTP-20 scale [16]. The highest scores are typically found on the automatic thoughts and auditory subscales, intermediate scores on the altered perceptions subscales and the lowest scores on the automatic behaviours and actions subscale [15,17,18].

Recent research has shown that players with higher GTP scores tend to be more susceptible to experiencing involuntary phenomena such as intrusive thoughts, dissociations and hallucinations [14,19]. In addition, some forms of GTP appear to resemble involuntary semantic memories or mind-pops [20], involuntary autobiographical memories [21] and earworms or musical imagery [22,23]. Given the similarities between GTP and various involuntary cognitive phenomena in terms of their frequency and characteristics of occurrence, the main aim of the present study is to examine a novel hypothesis that GTP may be part of a broader set of spontaneous cognitive phenomena.

### 1.1. A brief overview of research on GTP

The research on GTP began with qualitative interviews focusing on how immersion in video games affected players' perceptions, cognitions and behaviours after they stopped playing. A thematic analysis of players' reports highlighted how playing video games could spontaneously prompt intrusive thoughts, visual or auditory illusions, behavioural urges and body reflexes, and dissociative experiences in players [8]. This qualitative research was expanded later by collecting GTP experiences from online video game forums. This involved classifying players' experiences by the sensory channel (visual, auditory, body) and then by thought processes and behaviours [24,25,26].

Two scales have been validated to assess the frequency of GTP experiences in everyday life. The first scale (GTPS-20) by Ortiz de Gortari et al. [16] consists of 20 items that are based on the analysis of GTP experiences described in the initial qualitative studies of GTP which differentiated sensory channels from thoughts and behaviours. More recently, Ortiz de Gortari and Diseth [14] developed and validated a new scale, the Game Transfer Phenomena Multidimensional Scale (GTP-MDS), which enables researchers to distinguish more clearly key dimensions of GTP that had been introduced in the 20-item GTPS [16]. This new scale has been validated on a large sample ($N = 1,301$, 83.4 % male), and consists of three sub-scales: i) inner (endogenous) phenomena referring to intrusive cognitions, misperceptions (mental imagery), and inner auditory experiences; ii) outer (exogenous) phenomena referring to various perceptual distortions and hallucinatory experiences, and iii) dissociative experiences, actions, and cognitive mix-ups.

Research using these GTP scales has shown that some of the characteristics of gamers more likely to experience GTP include being a young adult (18–22 years old), having a pre-existing mental health condition (without specifying a diagnosis), playing long gaming sessions (3–6 h per day), sleeping less due to gaming, reporting distress or dysfunctional gaming due to GTP, being a hard-core or professional player, and playing video games for the sake of immersion or escaping from the real world [17].

In most cases, players who report having experienced GTP do not have a clinical condition or the experience of using drugs. However, GTP have been associated with stress, anxiety, depression, ADHD and psychosis [27,28], suggesting that those with mental disorders are more susceptible to GTP.

Studies have also consistently shown the relation between GTP, problematic gaming habits and Internet Gaming Disorder [15,29].

Regarding the appraisal of GTP, players have reported GTP as neutral or pleasant [30]. Moreover, only exogenous phenomena and dissociations have been associated with some distress but not endogenous phenomena [14]. On the other hand, GTP has been associated with cognitive failures and negative physiological states such as poor sleep hygiene and fatigue [15,17]. A more recent study conducted during COVID-19 pandemic, investigated the differences between players with and without GTP, in terms of coping strategies for dealing with pandemic stressors, resilience to stress, and emotion regulation [19]. The results showed non-significant differences between players with and without GTP regarding resilience to stress. No significant differences were found between those who had not experienced GTP and the frequency levels of GTP (mild, moderate) regarding emotion regulation, either by cognitive reappraisal or suppression strategies [19]. Overall, these results could suggest that GTP does not significantly alter psychological resilience or emotion regulation, at least in the context of pandemic-related stress. This could invite further investigation into the conditions under which GTP might influence these factors.

### 1.2. Similarities between GTP and involuntary cognitive phenomena

GTP has been conceptualised as being part of involuntary phenomena due to their spontaneous and uncontrollable nature [8,13]. So far, GTP has been associated with more pathological manifestations of spontaneous phenomena involving unusual sensory experiences, derealisation and hallucinations during wakeful and sleep-related states and dissociative experiences [14,31]. However, several unanswered questions remain about the nature and mechanisms of GTP, especially in terms of their potential relation with other more benign involuntary cognitive phenomena, which seem to share common features with GTP in terms of both content and manifestation.

Involuntary cognitions refer to a broad class of spontaneous phenomena that pop into mind without a prior intention to think about them. They tend to occur during habitual everyday activities that do not require focused attention (e.g., driving, washing up, eating, etc.). It is usually during such activities that people's mind tends to wander off to internal thoughts, musings and memories that are unrelated to current situation and activities. Apart from being unintended, another common feature that they share is that they are often triggered by incidental cues in one's immediate environment or internal thoughts [32]. Despite these similarities, involuntary cognitions have been investigated by several independent fields of enquiry such as research on mind-wandering, involuntary memories, involuntary musical imagery or earworms, intrusive memories, and spontaneous future thinking [33,34].

Although research on spontaneous cognition is often focussed on involuntary autobiographical memories (for review, see [35]), a type of involuntary memory that is closely related to GTP involves involuntary semantic memories or mind-pops, which refer to unintentional conscious retrieval of fragments of semantic knowledge rather than personally experienced events from one's past [20]. They may take a form of someone's name, a word or an image or a song popping into mind and surprise us with their irrelevance to the current situation (e.g., a national anthem popping into mind while sitting in the exam). This feature seems to distinguish mind-pops from involuntary autobiographical memories which are almost always triggered by easily detectable cues (Study 4, [20]).

Although manifestations of GTP vary substantially, they often involve remembering scenes and actions that had happened in the game or having an experience of commands or words, images and music encountered in the game popping into mind when gamers have stopped playing and are not thinking about the game at that moment. In addition, similar to involuntary autobiographical memories and mind-pops, GTP also tend to occur while engaged in undemanding and habitual daily activities that require low levels of concentration [30].

Furthermore, some GTP experiences are elicited in a similar way as mind pops because initial qualitative studies have shown that not all GTPs are cued by environmental contexts [8,36]. This pattern has been

observed primarily in altered sensorial perceptions, which seem to happen more often without any identifiable external or internal triggers such as thoughts and sensations (e.g., *"I woke up trying to get myself out of bed, [I] saw [visualised] my hunger as the Minecraft hunger bars. It worked in getting me out of bed"*). On the other hand, GTP experiences related to spontaneous thoughts or behaviours are more likely to occur in response to external cues, which could be seen as an automatic association between physical items and video game elements (e.g., "*Every time I hear old school music, I think of Fallout 3*") [24]. The relation between GTP and other behavioural cognitive-control variables such as impulsivity is still unclear. It is, therefore, important to extend the current knowledge on these variables with standard questionnaires and more representative samples of participants.

### 1.3. Aims of the study

The study used a mixed methodology where participants answered an online survey and completed two cognitive tasks. The study had four aims. First, to investigate whether GTP share common underlying mechanisms with other spontaneous cognitions (e.g., mind-pops, mind-wandering) by examining correlations between these variables as well as associations between GTP and those personality traits and cognitive processes (e.g., positive schizotypy, working memory capacity) that have been linked to spontaneous cognitions in previous studies. Second, to examine the relationship between psychological distress (specifically depression, anxiety and stress) and impulsivity and GTP. Third, to investigate if Internet Gaming Disorder and other gaming habits (e.g., the number of hours played per week, length of gaming sessions, etc.) remained as important predictors of GTP when all the other variables of interest were entered into a hierarchical multiple regression model. Fourth, to examine if the important role of Internet Gaming Disorder in predicting GTP was fully or partially mediated by involuntary cognitive phenomena (e.g., mind-popping) and schizotypal traits, a finding that would further confirm a special connection between GTP and involuntary cognitions.

#### 1.3.1. Hypotheses

**H1. Higher rates of mind-pops, mind-wandering and schizotypal traits will be positively correlated with GTP scores.** This finding is expected because GTP often occur during diffused states of attention conducive to mind-wandering, and is showing similarities in content (e.g., words, tunes, short fragments of semantic knowledge) with mind-pops [37]. Moreover, if GTP are part of a broad set of involuntary cognitions, as proposed in the present study, then GTP should be positively associated with schizotypal traits. This finding is expected because strong links have been found between schizotypal personality traits (especially positive schizotypy) and involuntary autobiographical memories [38], musical imagery or earworms [39]; see also [23]and mind-pops [40,41]. For example, in a questionnaire study of Elua et al. [40], patients with schizophrenia reported a higher frequency of mind-pops than patients with depression and healthy controls. In a 7-day diary study, schizophrenia patients also recorded significantly more word and image mind-pops than a group of healthy controls [41].

**H2. GTP will be associated with lower levels of working memory capacity (WMC).** This finding is expected because individuals with low levels of WMC tend to report a higher frequency of task-unrelated thoughts than those with high WMC (e.g., [42,43,44]). Moreover, research has found a negative relationship between WMC and failures to sustain attention over ongoing tasks, such as in mind-wandering [42,45]. GTP has been associated with cognitive failures and attention failures [15]. video game players have also reported that game content intrudes into their thoughts or that their attention is redirected to game-related cues [46].

**H3. Higher scores on psychological distress (i.e., anxiety and depression) and impulsivity will be positively associated with GTP.** This finding is expected because certain forms of GTP manifest as impulsive actions or urges suggesting poor cognitive control [15,24]. Evidence also suggests that underlaying mental disorders facilitate GTP, however, studies have reported contradictory findings [15,36,47].

**H4. GTP will be associated with problematic gaming habits and the Internet Gaming Disorder.** Studies have highlighted the importance of dysfunctional gaming habits (including Internet Gaming Disorder) when examining variables that are associated with GTP. For example, sleep hygiene, and Internet Gaming Disorder have emerged as the most significant predictors of GTP in multiple linear regression models [15,17]. It is, however, necessary to examine if problematic gaming habits and especially levels of Internet Gaming Disorder remain significant predictors in the regression model when controlling for all other variables of interest including tendencies to experience involuntary cognitions and measures of psychopathology. In relation to this it was hypothesised that if there is a special link between involuntary cognitions and GTP then the strong association between Internet Gaming Disorder and GTP should be fully or partially mediated by measures of spontaneous cognitions and schizotypal personality traits.

## 2. Method

### 2.1. Participants

Participants were recruited from several sources, including the University website and via social media advertisements (e.g., Facebook, Twitter). To take part, participants had to meet the following inclusion criteria: (1) having played any kind of video games for at least 4 h per week regularly in the previous 12 months, (2) being between 18 to 45 years old, (3) having a minimum of 11 years of formal education and (4) having at least a medium level of proficiency in the English language (level 4 and above on a 9-point scale).

Out of 420 participants who completed the study, the data of 68 participants were not included in any analyses, with 35 participants dropping out from the study at different points, 20 reporting less than 4 h of playing per week, one participant was under age (17 years old) and another was over age (47 years old), six having less than 11 years of formal education, and three reporting English proficiency level below the cutoff point of 4. Two further participants were removed because of being clear outliers on the GTP scale, achieving a maximum score of 80 points.

The final sample comprised 352 participants (268 males; $M_{age}$ = 25.38 years; $SD$ = 5.90; age range: 18–45), majority of whom were males, and did not report ever using drugs or having a mental health condition (see Table 1 for demographic information of the sample). Most participants also identified themselves as either mid-core (49.1 %) or hardcore players (41 %) and reported playing mostly alone, for many years and most days of the week (see Table 2 for details of participants' gaming habits).

This study was reviewed and approved by the University Ethics Committee (protocol number: LMS/PGT/UH/03887). All participants provided informed consent in accordance with the Declaration of Helsinki.

### 2.2. Design

The study used a correlational within-groups design and was pre-registered on the Open Science Framework (OSF) prior to data completion (AsPredicted Pre-registration No: 34587). Originally, the study was planned to be completed face-to-face under laboratory-controlled conditions. However, due to the COVID-19 pandemic, only 64 participants were tested face-to-face on campus (18.2 %) and the remaining 288 participants were tested online (81.8 %).

**Table 1**
Participants' Demographic and Background Variables.

| Variables | Total sample (N = 352) |
|---|---|
| **Participants' Age** | |
| −Mean Age in years (SD) | 25.40 (5.90) |
| **Gender, n (%)** | |
| −Male | 268 (76.1) |
| −Female | 83 (23.6) |
| −Prefer not to say | 1 (0.3) |
| **Education (in years), mean (SD)** | 16.28 (2.98) |
| **Occupation, n (%)** | |
| −Student | 201 (57.1) |
| −Employed | 104 (29.5) |
| −Self-Employed | 30 (8.5) |
| −Unemployed | 14 (4.0) |
| −Unable to work | 1 (0.3) |
| −Homemaker | 2 (0.6) |
| **Drug use per month, n (%)** | |
| −Never | 292 (83) |
| −Once or twice | 35 (9.9) |
| −3 to 5 times | 5 (1.4) |
| −6 to 10 times | 2 (0.6) |
| −More than 10 times | 10 (2.8) |
| −Daily | 7 (2.0) |
| −More than once a day | 1 (0.3) |
| **Mental health diagnosis, n (%)** | |
| –No | 289 (82.1) |
| −Yes | 63 (17.9) |

**Table 2**
Participants' Gaming Habits.

| Variable | **Total sample** (n = 352) | **Min, Max** |
|---|---|---|
| **Video Game Experience, Mean (SD)** | | |
| −Years of playing | 16.50 (7.26) | 1, 37 |
| −Gaming hours per week | 21.30 (14.02) | 4, 87 |
| −Length of gaming sessions in hours | 3.76 (2.15) | 1, 20 |
| **Playing days per week, n (%)** | | |
| −1–2 days | 21 (6.0) | |
| −3–5 days | 142 (40.3) | |
| −6–7 days | 189 (53.7) | |
| **Type of video game player, n (%)** | | |
| −Casual | 30 (8.5) | |
| −Mid-core gamer | 173 (49.1) | |
| −Hardcore gamer | 144 (41) | |
| −Professional gamer | 5 (1.4) | |
| **Sleeping less because of gaming, n (%)** | | |
| −Never | 21 (6.0) | |
| −Rarely | 129 (36.6) | |
| −Sometimes | 144 (41.0) | |
| −Often | 45 (12.8) | |
| −Very often | 13 (3.7) | |
| **Playing Alone or accompanied, n (%)** | | |
| −Alone (offline) | 170 (48.3) | |
| −Alone (online) | 111 (31.5) | |
| −Accompanied | 71 (20.2) | |

Note: Casual/leisure gamer (e.g., I enjoy playing games, but my time/ interest is somewhat limited); Mid-core gamer (e.g., I play different kinds of games enthusiastically, but I do not play as long or as hard as a hardcore gamer); Hardcore gamer (e.g., I spend a huge amount of time playing games. I like to search the latest news and updates in gaming. I have a good console/Pc made especially for gaming) and Professional gamer (e.g., I like to play video games constantly as a fulltime job to make profit by competing in official tournaments).

### 2.3. Materials (Questionnaires, validated scales and tasks)

#### 2.3.1. Demographics questionnaire

A brief 7-item questionnaire was developed to obtain information about participants' demographic profile (age, gender, education, English proficiency, occupation, country of residency, history of mental health conditions and experience with drugs).

#### 2.3.2. Gaming habits questionnaire

A 15-items questionnaire was developed to measure gaming habits (e.g., years of playing, hours played per week, per session, type of video game player, sleep deprivation due to gaming) as well as gaming proficiency, playing alone or accompanied online-offline, and type of video games genres most played.

#### 2.3.3. Game Transfer phenomena scale (GTPS)

The GTP scale was developed by Ortiz de Gortari et al. [16] to measure the frequency of GTP experiences in video game players during the past 12 months. The scale was first validated in a heterogenous sample of English-speaking players and has been further validated in different languages including Turkish, Polish and Spanish [48,49,50]. The scale consists of 20 items with response options ranging from 0 (*Never*), 1 (*Once*), 2 (*A few times*), 3 (*many times*), and 4 (*All the time*). It has a five-factor structure with four items each, based on the analysis of gamer's self-reports comprising the following dimensions: (1) altered visual perceptions, (2) altered body perceptions (3) altered auditory perceptions, (4) automatic mental processes, and (5) behaviours and actions. Examples of the items included are: *"seen* video *game images with eyes open when not playing", "heard game music when not playing",* and *"wanted or felt the urge to do something in real life after seeing something that reminded of the* video *game"*. It is important to note that in this study, we slightly changed some of the response options in the scale to avoid the situation where participants did not choose the maximum point of 4 "*All the time*". In most previous studies, GTP total scores ranged between low to medium levels and having the option "*all the time*" might not reflect the frequency accurately and reduce the chances of obtaining higher scores on the GTP scale. The modified response options used in this study were as follows: 0 = *Never*, 1 = *Once or twice*, 2 = *A few times*, 3 = *Several times*, and 4 = *Many times*. The Cronbach's alpha in the current study was 0.92.

#### 2.3.4. Scales assessing involuntary cognitions

*2.3.4.1. Mind-Popping questionnaire (MPQ −4).* The 4-item questionnaire was developed by Kvavilashvili and Mandler [20] to assess the nature and frequency of involuntary semantic memories or mind-pops in everyday life. The MPQ briefly describes the phenomenon and how it differs from involuntary autobiographical memories. In the first question, participants indicate whether they have ever experienced the phenomenon of mind-popping (*Yes/No*). If *yes* response is chosen, in the second question, participants are asked to rate the frequency of its occurrence on an 8-point scale where 1 = *only a few times in my entire life*, 2 = *once or twice a year*; 3 = *once or twice per 6 months*; 4 = *once or twice a month*; 5 = *once or twice a week*; 6 = *three or four times a week*; 7 = *once or twice a day*, and 8 = *three or more times a day*. Question 3 requires participants to indicate the content of those mind pops that they have experienced at least once in their life, and participants can choose as many options as they want out of nine options (e.g., a word or a phrase/ sentence in native language, a proper name, a visual image, melody, or a sound, etc.). Finally, in the last question, participants have the option to provide examples of their mind-popping experiences. For this study, mind-popping frequency was assessed by participants' responses to Questions 1 and 2 with a minimum score of 0 (for participants who responded negatively to Question 1) and a maximum score of 8 points (for participants who chose the option "three or more times a day" in Question 2).

*2.3.4.2. Daydreaming frequency scale (DDFS).* The 12-item DDFS is part of the Imaginal Process Inventory with 28-subscales [51]. For this study, only the daydreaming sub-scale was used, which assesses the frequency of mind-wandering or task-unrelated thoughts in everyday life (e.g., "*When I am not paying attention to some job, book, or TV, I tend to be daydreaming*" or "*On a long bus, train, or aeroplane ride I daydream"*) [52].

Each item is rated on a 5-point Likert scale where "A = 1" represents the lower frequency score and "E = 5" the highest. The total daydreaming frequency score is computed by adding scores on each question of the scale. The scores on this scale range from 12 to a maximum score of 60. The Cronbachs alpha in the current study was 0.94.

### 2.3.5. Scales measuring psychopathology variables

*2.3.5.1. Internet gaming Disorder scale short – Form (IGDS9-SF).* The short form of IGD-9 contains nine items [5], and is used to evaluate nine criteria for Internet Gaming Disorder suggested by the American Psychiatric Association. It has been found to be valid across different cultures and is highly suitable for measuring Internet Gaming Disorder. Responses on *IGDS9-SF* are provided on a 5-point Likert scale ranging from 1 (*Never*) to 5 (*Very often*), with total scores ranging from 9 to 45. The Cronbachs alpha in the current study was 0.85.

*2.3.5.2. Multidimensional schizotypy scale – Brief version (MSS-B).* The 38-item MSS-B using a *Yes-No* answer format was used to assess Schizotypal personality in three dimensions [53]. The positive or psychotic-like dimension contains 13 items and involves disruptions in the content of thoughts (ranging from odd beliefs to delusions), and perceptual oddities (including illusions, hallucinations, and paranoia). The negative or deficit dimension comprises 13 items, and involves diminished functioning such as alogia, avolition, anhedonia, flattened affect, and disinterest in others and the world. Finally, the disorganised sub-scale has 12 items, and include items measuring disruptions in the ability to organise and express thoughts and behaviours ranging from mild disturbances to formal thought disorder to grossly disorganised actions. The scale was adapted from the full-length multidimensional schizotypy scale and has been cross validated [53]. To measure schizotypal personality, we computed the total score on each dimension taking into consideration reversed scores for items 4, 10, 25, and 37. The maximum score for the disorganised and negative dimensions is 12, while for the positive dimension, it is 13 points. In the current study, Cronbachs alphas for the positive, negative and disorganised dimensions were 0.78, 0.64 and 0.85, respectively.

*2.3.5.3. Short version of the Depression, Anxiety, and stress scale (DASS-21).* The short version of DASS-21 contains 21 items to measure depression, anxiety, and stress [54]. It has a three-factor structure with 7-item self-report scales taken from the full version. Participant's responses are provided on a 4-point Likert scale ranging from 0 (*Did not apply to me at all*) to 3 (*Applied to me very much, or most of the time)*. The maximum score for each dimension is 21 points. In the current study, Cronbachs alphas for depression, anxiety and stress sub-scales were 0.89, 0.81 and 0.83, respectively.

*2.3.5.4. Short form of the Barrat Impulsiveness scale (BIS-15).* BIS-15, with 15-items, evaluates impulsivity in three different dimensions. The motor impulsivity (M−IMP) is defined as the tendency to act without thinking and includes items related to motor impulses (e.g., "*I do things without thinking*"). Non-planning impulsivity (NP-IMP) refers to the lack of future orientation and includes items relating to planning (e.g., "*I plan tasks carefully*") and self-control (e.g., "*I save regularly*"). Finally, attentional impulsivity (A-IMP) is defined as the inability to concentrate or focus attention [55] and includes items to assess cognitive instability (e.g., "*I am restless at lectures or talks*"). Each dimension comprises 5 items, and answers are rated on a 4-point Likert scale (1 = *rarely/never,* 2 = *occasionally,* 3 = *often*, 4 = *Almost Always/ Always).* The total score for each dimension is computed by adding up response options while using reversed scores for items 1, 5, 7, 8, and 15. The maximum score for each dimension is 20 points [56]. In the current, Cronbachs alphas for motor impulsivity, non-planning impulsivity and attentional impulsivity dimensions were 0.82, 0.77, and 0.74, respectively.

### 2.3.6. Tasks measuring working memory capacity

All instructions and practice trials for tasks measuring working memory capacity were given prior to completing two main tasks of working memory capacity, which lasted for about 30 min. Both tasks were administered using Inquisit software [57].

*2.3.6.1. Automated symmetry task [58].* Automated symmetry task assesses visuospatial working memory capacity. Participants have to judge whether a figure is symmetrical across a vertical axis, followed by remembering the location of a distractor stimulus (e.g., a coloured square) in a 4 x 4 grid. This process is repeated several times until a recall screen appears (this will depend on the size of the span), and participants must indicate the locations of coloured squares in the same order as they were presented to them [59]. The experimental set-up consisted of 4 practice trials of recalling sequences of squares of set sizes of 2 to 3 in ascending order, 15 practice trials of symmetry judgments of images and three combined practice trials of recalling sequences of squares (set size two only) and symmetry judgements, with each square being preceded by either a symmetrical or an asymmetrical image. The main automated symmetry task consisted of 12 trials with three repetitions of four set sizes in ascending order. This included recalling sequences of squares (sets of 2–5), with each square being preceded by either a symmetrical or an asymmetrical image, by clicking the cells on the 4 x 4 grid. This task was scored using the total span score, which is the sum of all correctly recalled sets.

*2.3.6.2. Automated reading span task [58].* This complex span task has been designed to assess working memory capacity and reading comprehension. Participants need to make a judgment about whether a short phrase makes sense, followed by remembering a distractor stimulus (a random letter). This process is repeated several times until a recall screen appears (this will depend on the size of the span) with a 4 x 3 grid filled with random letters, including the ones shown before, and participants must indicate all the letters seen and in the order in which they appeared [59,60]. The experimental set-up consisted of four practice trials of recalling sequences of letters of set sizes 2–3 in ascending order, 15 practice trials of semantic evaluations and three trials of the combined practice of recalling the sequence of letters (all set in size 2) and semantic evaluations of sentences with each letter being preceded by either a sentence that made sense or did not make sense (3 trials). Letter recall was completed by picking out letters from a letter matrix provided. The test session consisted of 15 trials of recalling sequences of letters with set sizes of 3 to 7, and each letter was preceded by either a sentence that did or did not make sense (15 = 3 repetitions of 5 set sizes; order of set sizes was randomly determined). Letter recall was achieved by picking out letters from a provided letter matrix. The task was scored by calculating the sum of all correctly recalled sets.

## 2.4. Procedure

Participants were recruited via advertisements posted on the University and social media websites (e.g., X, Facebook). Every participant who contacted the researcher received an information sheet via email and signed a digital consent form before starting the study. After this, an anonymous ID was created for each participant and access to the study was granted. All participants completed the questionnaires and scales in the following order: Demographics and gaming habits questionnaires, the MPQ-4, the GTPS, the DDFS, MSS-B, DASS-21, BIS-15, and IGDS9-SF. All questionnaires were hosted on Qualtrics platform [61], and detailed instructions about how to complete each questionnaire were given to each participant. After this, participants were requested to complete two final working memory capacity tasks which were hosted using an online experiment platform INQUISIT [57]. The procedure was identical for face-to-face and online participants. However, face-to face participants had to complete the study in one laboratory session which

took approximately 90 min: 60 min for questionnaires and 30 min for the two working memory capacity tasks (a brief break period was granted between questionnaires and the cognitive task if needed). All participants who were tested online had the option to complete the study in two sessions if needed (for questionnaires and working memory capacity tasks, respectively).

### 2.5. Statistical analysis

#### 2.5.1. Power analysis, missing data, and assumptions of regression analysis

Most of the statistical analyses were performed with the IBM SPSS Statistics version 28, and PROCESS package, version 4.1 from Hayes [62] was used for the mediation analysis [62]. An a-priori power analysis was performed using G-power to determine the required sample size for the hierarchical regression analysis [63] (G-power for Mac version 3.1.9.3), with a medium effect size of 0.15, alpha of 0.05, power of 0.85 and 20 predictors. Based on these values, a minimum of 171 participants was required.

Since only some of the participants were recruited face-to-face due to the COVID-19 pandemic, the data of the outcome variable across online and face-to-face testing were compared. A total of 64 participants were recruited face-to-face, and the remaining 288 were recruited and tested online in either one or two sessions. An independent samples *t*-test showed that there were no differences in participants' total GTP scores between face-to-face ($M = 18.42$, $SD = 13.34$) and online testing ($M = 17.46$, $SD = 14.98$) conditions, $t\ (350) = 0.505$, $p = 0.615$. Also, there were no significant differences between online and face-to-face groups regarding their scores on all predictor variables (all $p_s = > 0.05$).

Once all the data was collected, an Expectation Maximization (EM Algorithm) was conducted; a total of two missing values in the outcome GTP variable were found, and another four in the schizotypal traits variable, representing 0.8 % and 0.021 %, respectively. This approach was adopted to perform maximum likelihood estimation in the presence of latent variables to optimise and merge missing data.

#### 2.5.2. Regression and mediation analyses

Before conducting the regression analysis, the assumptions of linearity, independence, homoscedasticity, and normality of residuals were tested, and no significant violations were found. Overall, multicollinearity was low except for the correlation between anxiety and stress ($r = 0.75$, $n = 352$, $p < 0.001$) as well as depression and stress ($r = 0.70$, $n = 352$, $p < 0.001$). To ensure reliability of the data, the variable stress was removed from further analyses. The regression analysis showed a variance inflation factor (VIF) of around 1 among predictors. Continuous variables had an approximately normal distribution with no significant outliers except for two cases with a maximum score of 80 on the GTP scale, which were removed from all analyses.

## 3. Results

### 3.1. Descriptive statistics

The majority of participants (97 %) reported that they had experienced at least one type of GTP within past 12-months indicating very high prevalence of GTP in the sample. Within GTP subscales, higher prevalence was found for altered auditory perceptions (88.6 %) and automatic mental processes (80.1 %), followed by altered visual perceptions (68.7 %), behaviours and actions (65.6 %), and altered body perceptions (67 %). Furthermore, most participants had experienced mind-pops at least once in their lifetime (72 %), while mind-wandering was reported by almost all the participants (99.7 %). It is also important, that only 18 participants (5.13 %) scored above the recommended clinical cut-off score of 32 on *IGDS9-SF* [5] suggesting the gaming disorder in these participants [64] (see Table 3 for means and descriptive statistics for GTP scale and all other questionnaires). Out of the 352 participants who completed the questionnaires and scales, 236 (67.0 %) completed the first working memory capacity task, and 222 (63.1 %) completed both working memory capacity tasks. The lower completion rates for the working memory capacity tasks likely resulted from the option to complete these tasks in a separate session, with some participants not returning.

**Table 3**
Descriptive Statistics for Scores on Questionnaires, Validated Scales and Working Memory Tasks in a Sample of 352 Participants.

| Variable | Mean (SD) | Min, Max[a] |
|---|---|---|
| GTP total score | 17.64 (14.68) | 0, 74 |
| – Automatic Mental Processes | 4.07 (3.75) | 0, 16 |
| – Altered Auditory Perceptions | 5.37 (4.32) | 0, 16 |
| – Altered Bodily Perceptions | 2.70 (3.32) | 0, 16 |
| – Altered Visual Perceptions | 2.77 (3.15) | 0, 16 |
| – Altered Behaviours and Actions | 2.70 (3.20) | 0, 15 |
| Internet Gaming Disorder | 19.10 (7.04) | 9, 45 |
| Mind-popping | 3.37 (2.68) | 0, 8 |
| Daydreaming | 29.64 (9.13) | 10, 50 |
| Positive schizotypy | 2.86 (2.75) | 0, 11 |
| Disorganised schizotypy | 3.44 (3.52) | 0, 12 |
| Negative schizotypy | 3.22 (2.60) | 0, 11 |
| Anxiety | 10.14 (8.72) | 0, 42 |
| Depression | 12.64 (10.50) | 0, 42 |
| Stress | 12.42 (9.13) | 0, 42 |
| Non-planning impulsivity | 14.60 (2.37) | 8, 20 |
| Motor-impulsivity | 11.20 (2.21) | 5, 17 |
| Attentional-impulsivity | 11.23 (1.84) | 7, 18 |
| Working memory (total reading span)[b] | 42.86 (17.6) | 0, 75 |
| Working memory (total symmetry span)[c] | 25.06 (9.35) | 2. 42 |

[a] Min and Max represent the minimum and maximum scores obtained by the sample;
[b] the mean for the total working memory reading span was calculated using a sample size of N = 236; [c] the mean for the total memory symmetry span was based on a sample size of N = 222.

### 3.2. Bivariate correlation analysis

The GTP scale consists of three sub-scales measuring Altered Perceptions, Automatic Mental Processes, and Behaviours and Actions. However, for all the analyses in this study, the GTP total score was used as the only outcome variable due to the very high correlations between the three sub-scale scores (see Table 4).

Further Pearson bivariate correlations were conducted to examine the relationship between GTP and all the variables of interest (see Table 5 for correlations). The variables of internet gaming disorder, mind-popping, daydreaming, positive schizotypy, disorganised schizotypy, stress and anxiety had the highest correlations with total GTP scores (all $r_s = > 0.30$).

In addition, the variables of hours per week, hours per session, depression, motor impulsivity, non-planning impulsivity, and sleeping less due to gaming were also significantly correlated with GTP scores, just with lower coefficients (all $r_s < 0.30$). There were no significant correlations between years of playing, negative schizotypy, attentional impulsivity and GTP. In addition, there were no significant correlations between GTP and the two tasks assessing working memory capacity: reading span total and symmetry span total.

**Table 4**
Correlations between GTP and the Sub-Scales.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| GTP Total Score | 1 | | | |
| Altered Perceptions | 0.95*** | 1 | | |
| Automatic Mental Processes | 0.83*** | 0.67*** | 1 | |
| Behaviours and Actions | 0.84*** | 0.71*** | 0.66*** | 1 |

*** $p < 0.001$.

**Table 5**
Correlations of the Outcome Variable Game Transfer Phenomena (GTP) with Predictor Variables.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. GTP total score | 1 | | | | | | | | | | | | | | | | | | |
| 2. Gaming hours per Week | 0.13* | 1 | | | | | | | | | | | | | | | | | |
| 3. Hours per Session | 0.12* | 0.63** | 1 | | | | | | | | | | | | | | | | |
| 4. Years of playing | 0.01 | −0.06 | −0.12* | 1 | | | | | | | | | | | | | | | |
| 5. Sleeping less due to gaming | 0.23** | 0.16** | 0.15** | −0.12* | 1 | | | | | | | | | | | | | | |
| 6. Internet Gaming Disorder | 0.46** | 0.20** | 0.25** | −0.06 | 0.35** | 1 | | | | | | | | | | | | | |
| 7. Mind-popping frequency | 0.42** | 0.07 | 0.07 | −0.02 | 0.10 | 0.21** | 1 | | | | | | | | | | | | |
| 8. Daydreaming frequency | 0.41** | 0.05 | 0.05 | −0.06 | 0.14* | 0.33** | 0.34** | 1 | | | | | | | | | | | |
| 9. Positive Schizotypy | 0.47** | 0.03 | 0.08 | −0.16** | 0.17* | 0.40** | 0.21** | 0.34** | 1 | | | | | | | | | | |
| 10. Disorganised Schizotypy | 0.32** | 0.03 | 0.11* | −0.06 | 0.22** | 0.50** | 0.28** | 0.38** | 44** | 1 | | | | | | | | | |
| 11. Negative Schizotypy | 0.05 | 0.06 | 0.05 | 0.10 | 0.11* | 0.13** | 0.03 | 0.14** | 0.15** | 19** | 1 | | | | | | | | |
| 12. Depression | 0.28** | 0.02 | 0.06 | −0.03 | 0.18** | 0.43** | 0.20** | 0.40** | 0.35** | 0.57** | 0.28** | 1 | | | | | | | |
| 13. Anxiety | 0.43** | 0.04 | 0.11* | −0.08* | 0.15** | 0.49** | 0.32** | 0.38** | 0.40** | 0.56** | 0.07* | 0.64** | 1 | | | | | | |
| 14. Stress | 0.40** | −0.05 | 0.02 | −0.00 | 0.16** | 0.48** | 0.25** | 0.40** | 0.33** | 0.60** | 0.04 | 0.71** | 0.75* | 1 | | | | | |
| 15. Attentional Impulsivity | 0.08 | −0.15** | −0.03 | −0.09 | 0.04 | 0.24** | 0.08 | 0.23** | 0.14** | 0.33** | 0.06 | 0.27** | 0.23** | 31** | 1 | | | | |
| 16. Motor Impulsivity | 0.22** | −0.11* | −0.06 | 0.04 | −0.03 | 0.01 | 0.13* | 0.04 | 0.14** | 0.05 | 0.01 | 0.01* | 0.18** | 0.18** | 0.20** | 1 | | | |
| 17. Non-planning Impulsivity | −0.15** | −0.15** | 0.05 | 0.06 | −0.02 | −0.21** | −0.08 | −0.16** | −0.11** | −28** | 0.06 | −0.15** | −0.21** | −0.30** | −0.51** | −35** | 1 | | |
| 18. WM Reading Span | −0.04 | −0.04 | −0.03 | −0.08 | −0.03 | −0.10 | −0.09 | −0.02 | 0.08 | −0.08 | 0.02 | −0.05 | −0.11 | −0.05 | 0.01 | 0.02 | 0.07 | 1 | |
| 19. WM Symmetry Span | 0.04 | 0.00 | −0.04 | 0.06 | −0.03 | −0.05 | −0.15* | −0.20** | −0.02 | −0.17** | 0.03 | −0.12 | −0.11 | −0.08 | −0.07 | −0.03 | 0.05 | 0.30** | 1 |

* $p < 0.05$, ** $p < 0.01$.

### 3.3. Steps in regression analysis (5 blocks)

A multiple (5-block) hierarchical regression analysis using the method ENTER was conducted with the GTP total score as the dependent variable to examine direct associations of GTP frequency with the variables that emerged as significant among the gaming-related variables, involuntary cognitions phenomena, personality traits, and psychopathological factors. This analysis was conducted with two main purposes in mind. First, to examine if internet gaming disorder and playing time remained as significant predictors of GTP after entering other individual difference variables that correlated with GTP scores. Second, to examine if variables measuring involuntary cognitions and their significant correlates (e.g., positive schizotypy) emerged as predictors of GTP and could further explain variance in GTP frequency, confirming that GTP share characteristics with involuntary cognitions.

The first step consisted of entering gaming-related variables: gaming hours per week, per session, sleeping less due to gaming habits and internet gaming disorder. These variables were entered in Block 1 because we wanted to control for factors directly associated with GTP and gaming [36], and that have been identified as strong predictors of GTP in previous multiple hierarchical regression analyses [15].

The second step (in Block 2) involved entering variables related to the susceptibility to involuntary cognitions that share phenomenological characteristics with GTP (e.g., form of manifestation and frequency), such as mind-popping and daydreaming. The third step consisted of entering positive schizotypy and disorganised schizotypy in Block 3, because schizotypal traits have been shown to be strongly associated with various forms of involuntary cognitions (e.g., [40,41,65]).

The fourth step in Block 4 involved entering psychological distress variables such as anxiety and depression. GTP experiences have been reported in conditions of stress and anxiety [8] and stress has been associated with GTP [66]. Moreover, anxiety and depression disorders tend to be comorbid with internet gaming disorder [67] that is strongly associated with GTP.

Finally, impulsivity-related variables, such as non-planning and motor impulsivity, were entered in Block 5 as previous studies have found associations between GTP and failures in cognitive control [13] particularly when players execute actions without awareness [25].

### 3.4. Results of regression analysis

In Block 1 of the hierarchical multiple regression, sleeping less due to gaming, gaming hours per week, per session, and internet gaming disorder accounted for a significant 22 % of the variance in GTP, $p < 0.0001$. Nonetheless, internet gaming disorder was the only significant predictor in Block 1. When mind-popping and daydreaming were entered in Block 2, the variables accounted for an additional and significant 14 % of the variance in the GTP frequency, $R^2 = 0.36$, $\Delta R^2 = 0.14$, $p < 0.0001$. Both mind-popping and daydreaming, together with internet gaming disorder, were significant predictors. When the scores of positive and disorganised schizotypal traits were added as predictors in Block 3, they accounted for an additional and significant 6 % of the variance in GTP frequency, $R^2 = 0.42$, $\Delta R^2 = 0.059$p $< 0.0001$. However, only positive schizotypy was the significant predictor out of the two added variables. In Block 4, when depression and anxiety scores were added as predictors, they accounted for an additional 2 % of the variance, $R^2 = 0.43$, $\Delta R^2 = 0.019$p $< 0.001$, although anxiety was the only significant predictor. In the final Block 5, motor impulsivity and non-planning impulsivity predictors accounted for an additional and significant 2.0 % of the variance in the frequency of GTP, $R^2 = 0.45$, $\Delta R^2 = 0.020$, $p < 0.001$, but only motor impulsivity was a significant predictor.

The full hierarchical regression model explained a total of 45.6 % in the variance of GTP frequency. This 5-block hierarchical model revealed that the strongest predictors of GTP were the internet gaming disorder, mind-popping, daydreaming and positive schizotypal traits. The results of each step in the regression analysis and individual beta coefficients with associated significance are reported in Table 6.

To corroborate that any specific dimension of GTP *(Altered Perceptions, Automatic Mental Processes or Behaviours and Actions)* was particularly contributing to the pattern of results obtained in the analysis, several simple linear regression analyses were conducted using each dimension as an outcome variable. All models using this analysis showed significant differences at $p < 0.001$. Therefore, it was decided to use the overall GTP score as the only outcome variable.

### 3.5. Mediation analysis with Internet gaming Disorder as a predictor of GTP and mind-popping and positive schizotypy as mediators (Model 6)

Further analyses were conducted to assess whether mind-popping and positive schizotypy serially mediated the relationship between Internet Gaming Disorder and GTP. Before conducting the mediation analyses, the total effect of Internet Gaming Disorder on GTP without the presence of mediators was significant ($c = 0.46$, $p < .001$). The subsequent mediation analyses were conducted using GTP as an outcome variable and Internet Gaming Disorder as a predictor variable with the presence of mind-popping frequency and positive schizotypy trait as mediators (see Fig. 1). This model indicated that the effect of Internet Gaming Disorder on GTP remained significant and was partially mediated by mind-popping and positive schizotypy ($c' = 0.28p < .001$), which means that the ability of Internet Gaming Disorder to predict GTP is influenced by mind-popping and positive schizotypy as mediators. The indirect effects were assessed using a 95 % bias-corrected confidence interval based on 5,000 bootstrap samples with a total completely standardized indirect effect of 0.18. All three indirect effects were significantly above zero when holding the other mediators constant. This demonstrated with 95 % confidence that all the indirect effects were positive, with the largest indirect effect attributed to the positive schizotypy mediator (see Table 7 for all coefficients of the model 6 mediation analysis).

## 4. Discussion

This study investigated a broad selection of theoretically important cognitive and psychopathology-related variables as predictors of GTP in a sample of adult video game players who were predominantly male, mid- to hard-core players, playing approximately 3 h per day. Most did not meet the criteria for clinical disorders, including Internet Gaming Disorder, and had no experience of using drugs. Several novel findings were obtained supporting the idea that GTP can be considered as part of a broad spectrum of cognitive phenomena characterised by involuntary retrieval processes [34].

### 4.1. H1. GTP associated with daydreaming, mind-pops, and schizotypal traits

Previous studies have found that GTP are associated with a broad variety of phenomena, including intrusive thoughts, earworms, hallucinations and mobile phone intrusions [66]. Notably, GTP manifestations encompass visualisations such as hypnagogic images, often occurring during transitional states between wakefulness and sleep, seemingly independent of significant contributions from the declarative memory syste [68]. Similarly, mind-pops or involuntary semantic memories, the focus of this study, arise without any deliberate attempt to recall them. The results showed significant associations between GTP scores and self-reported mind-popping and daydreaming frequency. Interestingly, GTP shared important similarities with these two types of cognitions in terms of content and manifestation. These findings provide strong initial support for considering GTP as being part of a family of diverse spontaneous cognitive phenomena. Both mind-popping and mind-wandering explained a significant variance in GTP frequency within the hierarchical regression model, even after controlling for

**Table 6**
Hierarchical Multiple Linear Regression for Variables Predicting the Outcome Variable of GTP Frequency (Five Blocks).

| *Block* | *Predictors* | *Unstandardised coefficients* | | *Standardised coefficients* | | $R^2$ | *Adjusted* $R^2$ | $\Delta R^2$ | *F change* | *p-value* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | β | SE | β | *p-value* | | | | | |
| 1 | Sleeping less due to gaming | 1.11 | 0.83 | 0.06 | 0.18 | 0.22 | 0.21 | 0.22 | 24.31 | 0.001*** |
| | Gaming hours per week | 0.05 | 0.06 | 0.05 | 0.4 | | | | | |
| | Gaming hours per session | −0.17 | 0.42 | −0.02 | 0.68 | | | | | |
| | Internet Gaming Disorder | 0.9 | 0.1 | 0.43 | 0.001*** | | | | | |
| 2 | Sleeping less due to gaming | 0.9 | 0.76 | 0.05 | 0.24 | 0.36 | 0.35 | 0.14 | 37.3 | 0.001*** |
| | Gaming hours per week | 0.03 | 0.06 | 0.04 | 0.5 | | | | | |
| | Gaming hours per session | −0.09 | 0.39 | −0.01 | 0.82 | | | | | |
| | Internet Gaming Disorder | 0.65 | 0.1 | 0.31 | 0.001*** | | | | | |
| | Mind-popping | 1.48 | 0.25 | 0.27 | 0.001*** | | | | | |
| | Daydreaming | 0.33 | 0.08 | 0.21 | 0.001** | | | | | |
| 3 | Sleeping less due to gaming | 0.83 | 0.73 | 0.05 | 0.25 | 0.42 | 0.4 | 0.06 | 17.43 | 0.001*** |
| | Gaming hours per week | 0.05 | 0.05 | 0.05 | 0.36 | | | | | |
| | Gaming hours per session | −0.11 | 0.37 | −0.01 | 0.76 | | | | | |
| | Internet Gaming Disorder | 0.52 | 0.11 | 0.25 | 0.001*** | | | | | |
| | Mind-popping | 1.43 | 0.24 | 0.26 | 0.001*** | | | | | |
| | Daydreaming | 0.26 | 0.07 | 0.16 | 0.001*** | | | | | |
| | Positive schizotypy | 1.51 | 0.25 | 0.28 | 0.001*** | | | | | |
| | Disorganised schizotypy | −0.32 | 0.21 | −0.08 | 0.13 | | | | | |
| 4 | Sleeping less due to gaming | 1 | 0.72 | 0.06 | 0.16 | 0.43 | 0.42 | 0.02 | 5.8 | 0.003* |
| | Gaming hours per week | 0.06 | 0.06 | 0.05 | 0.29 | | | | | |
| | Gaming hours per session | −0.16 | 0.36 | −0.02 | 0.65 | | | | | |
| | Internet Gaming disorder | 0.46 | 0.11 | 0.22 | 0.001*** | | | | | |
| | Mind-popping | 1.28 | 0.24 | 0.23 | 0.001*** | | | | | |
| | Daydreaming | 0.26 | 0.08 | 0.16 | 0.001*** | | | | | |
| | Positive schizotypy | 1.41 | 0.25 | 0.26 | 0.001*** | | | | | |
| | Disorganised schizotypy | −0.42 | 0.23 | −0.1 | 0.07 | | | | | |
| | Anxiety | 0.33 | 0.1 | 0.2 | 0.001*** | | | | | |
| | Depression | −0.14 | 0.08 | −0.1 | 0.07 | | | | | |
| 5 | Sleeping due to gaming | 106 | 0.71 | 0.06 | 0.13 | 0.45 | 0.44 | 0.02 | 6.15 | 0.002* |
| | Gaming hours per week | 0.07 | 0.05 | 0.07 | 0.19 | | | | | |
| | Gaming hours per session | −0.16 | 0.36 | −0.02 | 0.66 | | | | | |
| | Internet Gaming Disorder | 0.49 | 0.11 | 0.23 | 0.001*** | | | | | |
| | Mind popping | 1.19 | 0.24 | 0.21 | 0.001*** | | | | | |
| | Daydreaming | 0.27 | 0.07 | 0.17 | 0.001*** | | | | | |
| | Positive schizotypy | 1.31 | 0.25 | 0.25 | 0.001*** | | | | | |
| | Disorganised schizotypy | −0.36 | 0.23 | −0.08 | 0.12 | | | | | |
| | Anxiety | 0.29 | 0.1 | 0.17 | 0.003** | | | | | |
| | Depression | −0.15 | 0.08 | −0.11 | 0.056 | | | | | |
| | Motor impulsivity | 0.99 | 0.3 | 0.15 | 0.001** | | | | | |
| | Non-planning impulsivity | 0.06 | 0.28 | 0.01 | 0.81 | | | | | |

Note. N = 352; $\Delta R^2 = R^2$ Change, * $p < 0.05$, **$p < 0.01$, *** $p < 0.001$.

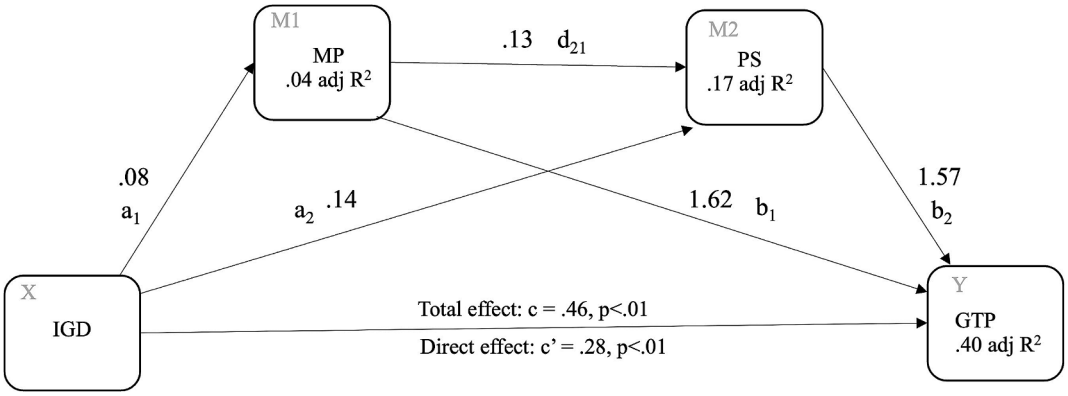


**Fig. 1.** Mediation Analysis with 2 Mediators (model 6). Internet Gaming Disorder (IGD) as a Predictor of Game Transfer Phenomena (GTP) and Mind-popping (MP), and Positive Schizotypy (PS) as Mediators. Note. Path $a_1$ = the effect of IGD on MP; Path $a_2$ = the effect of IGD on PS; Path $b_1$ = the effect of MP on GTP; Path $b_2$ = the effect of PS on GTP; Path $d_{21}$ = the effect of MP on PS.

several other predictor variables confirming our hypothesis. The connection between mind-wandering (daydreaming) and GTP is more conventional, given that engaging in daydreaming states during habitual daily activities may be conducive to re-experienced game content as part of a train of thought during a particular mind-wandering episode. By contrast, the similarities between instances of GTP and mind-popping are more novel and stronger, given that the content of both phenomena include images, tunes and fragments of semantic knowledge. Moreover, the occurrences tend to last for a short period of time (seconds or minutes) and arise while being engaged in

**Table 7**
Results Mediation Analysis with IGD as a Predictor of GTP and Mind Popping and Positive Schizotypy as Mediator Variables.

| Path | Variable | Standardised Coefficients | SE | t | p | Adj. $R^2$ | 95 % CI low | 95 % CI high |
|---|---|---|---|---|---|---|---|---|
| | Outcome: Mind-popping | 0.21 | | | | 0.04 | | |
| $a_1$ | IGD > Mind-popping | 0.08 | 0.02 | 4.16 | 0<.001 | | 0.04 | 0.12 |
| | Outcome: Positive Schizotypy | 0.42 | | | | 0.17 | | |
| $a_2$ | IGD > Positive Schizotypy | 0.14 | 0.02 | 7.50 | 0<.001 | | 0.10 | 0.18 |
| $d_{21}$ | Mind-popping > Positive Schizotypy | 0.13 | 0.05 | 2.54 | 0.01 | | 0.02 | 0.23 |
| | Outcome: GTP | 0.65 | | | | 0.40 | | |
| $b_1$ | Mind-popping > GTP | 1.62 | 0.24 | 6.84 | 0<.001 | | 1.15 | 2.09 |
| $b_2$ | Positive Schizotypy > GTP | 1.57 | 0.24 | 6.41 | 0<.001 | | 1.10 | 2.05 |
| c' | Direct effect | 0.58 | 0.10 | 9.72 | 0<.001 | | 1.15 | 0.46 |
| c | Total effect | 0.96 | 0.10 | 6.03 | 0<.001 | | 0.77 | 0.27 |
| Path | Indirect effects | StandardisedCoefficients | SE | 95 % CI low | 95 % CI high | | | |
| $a_1b_1$* | IGD > Mind-popping > GTP | 0.06 | 0.01 | 0.03 | 0.10 | | | |
| $a_2b_2$* | IGD > Positive Schizotypy > GTP | 0.11 | 0.02 | 0.06 | 0.16 | | | |

Note. CI = confidence interval; IGD = Internet Gaming Disorder; GTP = Game Transfer Phenomena; SE = Standard Error; Adj. $R^2$ = Adjusted R-squared (standardized); * $p < 0.05$.

undemanding daily activities [20,69]. In addition, both GTP and mind-popping can be triggered by external or internal cues, but they can also occur without any triggers [13], indicating that both phenomena are not always cue-dependent [13,14,20].

Further support for the H1 about GTP being strongly related to involuntary cognitive phenomena, comes from the finding that GTP frequency was significantly predicted by positive schizotypy. This finding aligns well with a clinical case of a patient with schizophrenia who reported experiencing GTP at an early age [70] and previous research on schizophrenia patients who report increased experiencing of not only clinically relevant intrusions such as auditory and visual hallucinations, but also more benign forms of spontaneous cognitions such as involuntary autobiographical memories [65,38], mind-pops [40,41] and mind-wandering [71]. Similarly, positive schizotypy has been found to increase the frequency of involuntary autobiographical memories [72], intrusive memories [73] and mind-wandering thoughts related to worry and more fantastical daydreams [23,74]. Moreover, individuals with higher schizotypal traits [75] are characterised by abnormal perceptual experiences and magical ideation and show lower ability to control or filter out irrelevant auditory stimuli, which can make them more prone to experiencing involuntary auditory imagery and earworms.

We propose that GTP experiences may be linked with activations in specific hubs of the Brain's Default Mode Network (DMN), most notably in the Posterior Cingulate Cortex, [75]. The DMN is a set of interconnected nodes or hubs in the brain (most notably Medial Prefrontal Cortex, Posterior Cingulate Cortex, and Inferior Parietal Lobe) that show increased activations when individuals are focused on their inner train of thoughts and decreased activations when focusing on external stimuli as part of ongoing cognitively demanding tasks and activities [76].

Our speculation is based on a large body of neuroscientific evidence from fMRI studies of mind-wandering and other forms of spontaneous cognitive phenomena that show their frequency and occurrence during cognitively undemanding tasks or when resting in the scanner are linked to increased activity in the DMN (for a review see [34]). There is also a growing body of research showing that patients with schizophrenia and individuals at risk of schizophrenia (e.g., first degree relatives) show increased hyperactivity within the key hubs of the DMN, as well as hyperconnectivity between the hubs and these processes, have been associated with disturbances of thoughts and hallucinations in schizophrenia and the risk of mental health conditions (for a review see [76]). It is recommended that future studies directly investigate the possible relation between GTP and hyperactivity in the DMN in players with high and low positive schizotypal traits, as frequent GTP could be an early sign of vulnerability to developing certain mental health conditions as previously has been noticed in a clinical case on GTP in an individual with psychosis [70].

Furthermore, the correlations between GTP and disorganised schizotypy may not be surprising since, in the continuum of schizotypy, individuals with disorganised traits often present spontaneous thoughts but usually with abnormal content [77]. Similarly, automatic mental processes are one of the most commonly reported types of GTP among players [14]. The relationship between schizotypal traits and mind-wandering has been also established. A study using various assessment tools of schizotypal traits indicated that mind-wandering was a predictor of disorganized schizotypy [77]. Nonetheless, it is crucial to acknowledge that the association between GTP frequency and disorganised schizotypy was not found in the multiple hierarchical analyses, which suggests that the relationship among these variables disappears when controlling for other variables such as positive schizotypy, Internet Gaming Disorder and mind-wandering.

### 4.2. H2. GTP and lower levels of working memory capacity

Contrary to our predictions of GTP being associated with lower working memory capacity, typically observed in those with a tendency to mind-wandering, none of the measures of working memory were correlated with GTP frequency (Table 5) and therefore, these measures were not subjected to further analyses. One of the explanations for this finding relies upon the fact that the relationship between working memory capacity and spontaneous cognitions may be mediated by attentional demands of ongoing tasks [78,79]. Given that the GTP scale does not distinguish between GTP occurring during demanding versus undemanding ongoing activities, it is perhaps less surprising that no correlation was found between GTP scores and working memory tasks. Another possible reason for this finding is that on-line measurements of working memory capacity may not be reliable [80]. Previous studies employing online cognitive tasks found that only commission errors in the Sustained Attention to Response Task (SART) were associated with GTP, while failures of cognitive control and attention, measured by self-report questionnaires, were reliably related to GTP [15]. It is also important to mention that approximately 25 % of the whole sample did not complete the working memory capacity tasks. However, given the sample size used to analyse the WMC data ($n = 222$), it is unlikely that the missing data significantly influenced the results because most of the correlation coefficients between working memory tasks and the other variables were near zero (Table 5), indicating a very weak or non-existent relationships.

### 4.3. H3. GTP and its relation with other indices of psychopathology

The correlation analyses showed that several measures of psychopathology (e.g., depression, anxiety, stress, motor and non-planning impulsivity) were associated with GTP. However, in the hierarchical regression analyses, only anxiety and motor impulsivity scores remained significant predictors, adding a small but significant amount of variance

(around 2 %) to the model (Table 6). Particularly, anxiety emerged as a significant and independent predictor of GTP, which appears to be in line with previous literature showing significant associations between anxiety and spontaneous cognitions such as mind-wandering [81], earworms [82]and involuntary autobiographical memories [83]. Qualitative research on GTP has reported GTP under situations of stress and anxiety [24,25,26]. Stress during the COVID pandemic also emerged as the most important factor associated with a variety of intrusions on video game players including GTP, intrusive thoughts, hallucinations, earworms, and mobile phone intrusions [66].

The lack of a predictive relationship between depression and GTP compared to anxiety, in the hierarchical regression analysis, may be due to differences in cognitive processes involved in these conditions. Depression has been primarily associated with negative mood and rumination, which tend to direct attention inward toward self-referential thoughts rather than external stimuli, potentially reducing the likelihood of GTP [84]. This could therefore suggest that anxiety, through its effects on attentional bias and cognitive intrusion, may be a stronger predictor of GTP compared to depression [85]. Although some studies have identified links between spontaneous cognitive phenomena and depression, findings remain inconsistent [86].

The finding that motor impulsivity predicts GTP supports previous observations indicating that some players have difficulties controlling their impulses toward game-related cues. These experiences are classified as automatic behaviours and actions within the framework of GT P [13,25]. Motor impulsivity may be linked to control of impulses emanating from past experiences with video game content. For instance, a previous study showed that high reactivity to game-related cues in participants who play video games excessively was a result of constant exposure to video games (10 hrs across 5 consecutive days). Results from an fMRI-study showed that most of the brain reactivity toward video game-related cues occurred in the ventrolateral prefrontal cortex, which is involved in self-control functions [87].

### 4.4. H4. GTP and its relation to gaming habits and Internet gaming Disorder

Studies have found discrepancies regarding the relationship between hours playing, session length and GTP [36]. In the current study, it was expected that gaming habits such as the frequent and prolonged exposure to the game would be related to higher frequencies of GTP. Both, hours playing per week and session length were associated with GTP. However, neither of these variables, similar to results of Ortiz de Gortari and Panagiotidi [15], emerged as a predictor of GTP. The only significant gaming-related variable was Internet Gaming Disorder, and it was one of the strongest predictors in the main multiple hierarchical regression model. The links between GTP and Internet Gaming Disorder including disorders such as ADHD, sleep disorders [15,17] and spontaneous cognitions of clinical relevance such as intrusive thoughts, rumination and hallucination have been established in previous research [14,15,66].

Overall, the current 5-block multiple regression model revealed an important finding that may explain why some players with very similar gaming habits (e.g., similar years of experience, hours played per week and per session) might not experience GTP with the same frequency or even not at all. It appears that even when playing excessively under potentially addictive and unhealthy settings, characteristic of Internet Gaming Disorder, it is important to consider other predisposing traits, such as positive schizotypy, anxiety, and motor impulsivity, as well as frequency of involuntary cognitions when predicting one's tendency to experience GTP.

The results of the mediation analysis also supported the importance of Internet Gaming Disorder in predicting GTP frequency. Interestingly, while Internet Gaming Disorder remained the strongest predictor of GTP, its effects on GTP were partially mediated by scores on mind-popping and positive schizotypy. The results confirm and expand upon earlier research on GTP by demonstrating that Internet Gaming Disorder is a particularly strong predictor of GTP [15].

The results also confirm the significance of the susceptibility to involuntary phenomena for GTP, and further support the main proposal of the present investigation that conceptualises GTP as a particular type of spontaneous cognition that has been overlooked in cognitive psychology. Further investigation of GTP has the potential to expand the understanding of involuntary cognitive phenomena and their potential connections with indicators of psychopathology.

### 4.5. Limitations

The findings of the present study are subject to some limitations. First, the study was conducted mostly under COVID-19 lockdown conditions, which could have influenced the results. Lockdowns have been linked to increased psychological distress, sleep disturbances, elevated screen time, and changes in daily routines, all of which might affect cognitive performance and responses to self-report measures. Prior research has documented poor sleep quality and its connection to heightened mental health issues, such as anxiety and depression, during lockdown periods [88,89]. In addition, increased screen exposure and shifts in behavioural habits have been shown to correlate with adverse mental health outcomes, particularly among younger individuals [90]. These factors may have introduced variability into the findings, and thus, replication under more typical conditions is recommended. Second, more caution may be needed when assessing participants' cognitive abilities such as WMC under online settings. It is important to note that the WMC tasks used in this study are complex and cognitively demanding, which may have affected participants' performance in non-controlled settings. Third, this study measured the frequency of GTP with online questionnaire requiring participants to assess GTP occurrence in previous 12 months which opens the possibility of recall bias.

Fourth, the relationship between GTP and mind-popping requires further investigation as it is surprising that the correlation between scores on the mind-popping questionnaire and the GTP scale were not stronger in the present study. This could be due to several factors, and especially to how these phenomena were measured. The GTP scale requires that participants report the frequency of any kind of GTP experiences in the past 12 months, while the mind-popping questionnaire does not specify the time frame. In addition, we changed some of the response options in the GTP scale (e.g., 4 = *All the time* for 4 = *Many times*) because it is less likely that any particular type of GTP is being experienced 'all the time'. However, it is interesting that making this minor change in the rating scale, the mean GTP score obtained in this study did not increase in comparison to scores reported in previous studies [15,30,91]. Future research can also use the newly developed 38-item GTP Multiple Dimensions Scale (GTP-MDS; [14]) that has an improved item structure and 12 items that specifically measure internal involuntary cognitions represented by three sub-scales of intrusive thoughts, involuntary mental imagery and involuntary auditory imagery.

Fifth, the gender distribution in this study was predominantly male (76 %), which may limit the generalizability of the findings. While men have historically been overrepresented in gaming, recent data suggest a more balanced gender distribution [92]. If gender influences susceptibility to GTP, the observed effects may not be equally applicable across genders. Previous research on GTP and gender differences has yielded mixed results, with some studies reporting no significant differences and others indicating higher GTP scores in males [13]. Given the complex interplay between gender, cognition, and gaming behaviours, future research should aim for a more balanced gender representation or examine gender as a moderating factor.

Lastly, we recognise that GTP may be related to other involuntary phenomena not examined in the present study. Future research should include several additional measures of spontaneous cognition. For example, the Involuntary Autobiographical Memory Inventory (IAMI;

[96]) can be used to measure the frequency of involuntary autobiographical memories and involuntary future thoughts. In addition, instead of the Daydreaming Frequency Scale (DDFS), one can use more recent scales such as the Mind-wandering Questionnaire (MWQ; [93]) or a questionnaire developed by Carriere, Seli and Smilek, [94], that distinguishes spontaneous unintentional mind-wandering from intentional mind-wandering. Future studies should also examine associations of GTP with the susceptibility to perceptual and sensory phenomena such as illusions and neural adaptations, as evidence shows sensory sensitivity in those with GTP [31].

### 4.6. Conclusions, implications and future directions

Several important findings were obtained with both theoretical and practical implications. Theoretically, the fact that mind-pops and mind-wandering emerged as strong predictors of GTP scores, together with indices of psychopathology (e.g., positive schizotypy, anxiety) commonly linked with spontaneous cognitive phenomena provided strong initial evidence supporting the hypothesis that the GTP may be part of a broader set of spontaneous cognitive phenomena (e.g., involuntary memories, mind-wandering, earworms, spontaneous future thinking, etc). Additional support for the hypothesis was obtained via the mediation analysis, which showed that the effect of Internet Gaming Disorder on GTP was partially mediated by mind-popping frequency and positive schizotypy. This finding further emphasises the importance of conducting more systematic research on the relation of GTP with spontaneous cognitions, using several other validated questionnaires of spontaneous cognitions to gain knowledge about the possible similarities between various forms of GTP and spontaneous cognitions, and to further understand these experiences in individuals with gaming disorder.

Additionally, linking GTP experiences to activations in specific hubs of the Brain's DMN implies a convergence between gaming-related phenomena and spontaneous cognitive processes like mind-wandering. This suggests that GTP may arise from similar neural mechanisms involved in generating spontaneous thoughts during periods of low cognitive demand. Understanding the neural correlates of GTP within the DMN context could shed light on the cognitive consequences of extensive gaming and deepen our understanding of the underlying cognitive and neural processes involved in gaming-related phenomena. Future studies should investigate this using neuroimaging techniques such as fMRI to directly examine the relationship between GTP experiences and activations in specific hubs of the Brain's DMN. To achieve this, a vigilance task to elicit involuntary autobiographical memories [32,95], could be applied in a paradigm involving words with game-related cues.

The lack of predictability of hours gaming or session length highlights the importance of taking into account predisposing traits such as positive schizotypy, anxiety, and motor impulsivity, as well as the frequency of involuntary cognitions such as mind-popping when predicting an individual's tendency to experience GTP. This is true even for those who play excessively in potentially addictive and unhealthy settings, which are characteristic of Internet Gaming Disorder.

The study also provided important methodological insights by showing that the results remained the same regarding the outcome variable (total GTP score) when participants were tested online or face-to-face ($n = 64$). Moreover, when the hierarchical multiple regression analysis was conducted on these 64 participants, the pattern of findings remained similar to the main analyses. These findings indicate that future studies on GTP may continue using online testing to have large samples without compromising the quality of results. However, more caution will be needed when employing online cognitive tasks measuring working memory capacity. Finally, future studies may use a mixture of online and face-to-face testing methods as well as diary and experience sampling methods to complement the results of questionnaire studies of GTP with more naturalistic in vivo observations of GTP in everyday life.

## CRediT authorship contribution statement

**Julio C. Llamas-Alonso:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Lia Kvavilashvili:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Conceptualization. **George Georgiou:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Formal analysis, Data curation. **Angelica B. Ortiz de Gortari:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

Data will be made available on request.

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