

## Original Article

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# A longitudinal study on psychosocial causes and consequences of Internet gaming disorder in adolescence

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## Abstract

**Background.** In 2013, Internet gaming disorder (IGD) was incorporated in the current version of the DSM-5. IGD refers to a problematic use of video games. Longitudinal studies on the etiology of IGD are lacking. Furthermore, it is currently unclear to which extent associated psychopathological problems are causes or consequences of IGD. In the present survey, longitudinal associations between IGD and adolescent and parental mental health were investigated for the first time, as well as the temporal stability of IGD.

**Methods.** In a cross-lagged panel design study, family dyads (adolescent with a parent each) were examined in 2016 (t1) and again 1 year later (2017, t2). Overall, 1095 family dyads were assessed at t1 and 985 dyads were re-assessed at t2 with standardized measures of IGD and several aspects of adolescent and parental mental health. Data were analyzed with structural equation modeling (SEM).

**Results.** Male gender, a higher level of hyperactivity/inattention, self-esteem problems and IGD at t1 were predictors of IGD at t2. IGD at t1 was a predictor for adolescent emotional distress at t2. Overall, 357 out of the 985 adolescents received a diagnosis of IGD at t1 or t2: 142 (14.4%) at t1 and t2, 100 (10.2%) only at t1, and 115 (11.7%) only at t2.

**Conclusions.** Hyperactivity/inattention and self-esteem problems seem to be important for the development of IGD. We found first empirical evidence that IGD could prospectively contribute to a deterioration of adolescent mental health. Only a subgroup of affected adolescents showed IGD consistently over 1 year.

## Introduction

In 2013, Internet gaming disorder (IGD) was incorporated in Section III of the current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, American Psychiatric Association, APA, 2013) as a new condition warranting more clinical research and experience. IGD refers to a problematic (online and offline) use of video games. The DSM-5 diagnostic criteria for IGD were derived from those for the diagnosis of gambling disorder and substance use disorder (Petry *et al.* 2015). According to DSM-5, IGD is characterized by nine diagnostic criteria (regarding video games): (1) excessive preoccupation; (2) withdrawal symptoms; (3) development of tolerance; (4) unsuccessful attempts to control playing; (5) loss of interest in (other) previous hobbies and leisure activities; (6) continuation of excessive playing (despite insight into the psychosocial consequences); (7) deceiving family members, therapists, and others concerning the scope of playing; (8) use of video games to escape or weaken a negative mood; and (9) risking or losing an important relationship, job, or training/career opportunity because of playing (APA, 2013). To diagnose IGD, at least five out of the nine DSM-5 criteria have to be met for the past 12 months (APA, 2013). In various surveys on IGD, the threshold of at least five criteria was underpinned empirically (Ko *et al.* 2014; Lemmens *et al.* 2015; Király *et al.* 2017; Van Rooij *et al.* 2017).

Petry *et al.* (2014) explored the fit of eight ‘...commonly utilized instruments for assessing problems with internet gaming...’ (p. 1401) that were published before the release of the DSM-5. They found that none of them covered all nine diagnostic criteria of IGD (Petry *et al.* 2014). In the meantime, several new questionnaires (e.g. Lemmens *et al.* 2015; Pontes & Griffiths, 2015; Király *et al.* 2017) and a structured clinical interview (Koo *et al.* 2017) covering all aspects of IGD were developed and published. Resting upon these new instruments first prevalence estimates of IGD in representative samples became available. Lemmens *et al.* (2015) observed a prevalence of IGD in the last year of 3.8% after a latent class analysis and of 5.4% based on the (DSM-5) cut-off value in a Dutch sample of adolescents and adults. Rehbein *et al.*

(2015) obtained a prevalence of 1.2% in a sample of ninth-graders (representative of Lower Saxony, one of the 16 federal states in Germany). Pontes *et al.* (2016) reported a prevalence of 2.5% for eighth-graders in Slovenia. Yu & Cho (2016) observed a prevalence of 5.9% for a national South Korean sample of adolescents. Wartberg *et al.* (2017c) reported a prevalence estimate of 5.7% for IGD in a representative sample of German 12- to 25-year-olds. These estimates indicate that around 1–6% of adolescents are affected by IGD, but investigations on the stability of this behavior pattern over time are currently lacking.

The evidence-based development of theoretical models on the etiology of IGD is still in its infancy. In an overview of the current state of research Király *et al.* (2015) emphasized the interplay of several key factors for the development of IGD, including structural characteristics of the video games, psychological characteristics of the gamer, and gaming motives. Currently, relations between IGD in adolescence and mental health are largely unexplained. The published findings concerning IGD are solely based on cross-sectional studies.

Lemmens *et al.* (2015) observed statistically significant bivariate associations between IGD and lower self-esteem, less prosocial behavior, higher levels of loneliness and aggression in a mixed sample of 2444 adolescents and adults. King & Delfabbro (2016) reported statistically significant bivariate correlations between IGD and depression, anxiety and stress in 844 adolescents with an average age of 14.1 years. However, in a multivariable model (adjusted for gender, age, gaming frequency and gaming-specific cognitions) no psychopathological aspect was significantly related to IGD (King & Delfabbro, 2016). Yu & Cho (2016) obtained higher levels of anxiety, depression, impulsiveness, and physical aggression in adolescents with IGD in a sample of 2024 students with a mean age of 14.5 years. Martín-Fernández *et al.* (2017) examined a clinical sample of 86 adolescents between 2009 and 2015. Overall, 59 of these patients (average age: 14.8 years) received retrospectively a diagnosis of IGD. As a comorbidity, a disruptive behavior disorder was diagnosed most frequently (in 15 out of 59 cases), followed by the diagnosis of an affective disorder (in 12 cases), an anxiety disorder (in 12 cases) and an attention deficit hyperactivity disorder (in nine cases). Wartberg *et al.* (2017b) reported findings for 1095 family dyads (mean age: 13.0 years, this was the cross-sectional analysis for the same sample presented in this study, when only the first time of measurement was completed in 2016). Statistically significant associations between IGD and male gender of the adolescent, more adolescent antisocial behavior, anger control problems, emotional distress, self-esteem problems, hyperactivity/inattention, and parental anxiety were observed (Wartberg *et al.* 2017b).

To sum up, the results in first cross-sectional studies showed associations between the new DSM-5 diagnosis IGD and impaired adolescent mental health (e.g. anxiety, depression, and hyperactivity). According to Király *et al.* (2015), it is currently unclear if psychopathological problems are causes or consequences of IGD. Hence, there is ‘...great need for longitudinal studies that may shed light on the direction of causality’ (Király *et al.* 2015, p. 258). Since all findings on the new DSM-5 diagnosis IGD were based on cross-sectional research designs, so far it remains unclear, whether the psychopathological problems are also predictors for the development of this disorder. It is also conceivable that IGD promotes the emergence of mental health problems. These important questions regarding the etiology of IGD can only be answered by using longitudinal research designs. Before the release of the DSM-5 and the diagnostic criteria of IGD a

few longitudinal studies concerning adolescent mental health and a pathological use of computer and video games were conducted and published (Gentile *et al.* 2011; Lemmens *et al.* 2011; Brunborg *et al.* 2014; Scharkow *et al.* 2014). However, to the best of our knowledge, epidemiological longitudinal studies on IGD (based on the DSM-5 criteria) are currently still lacking.

The primary objective of the present longitudinal survey was thus to examine the relationships between IGD and adolescent and parental mental health (measured in 2016 and again in 2017). Furthermore, we aimed to determine the stability of IGD in adolescence. Specifically, we investigated the following research questions:

- (1) Which aspects of adolescent and parental mental health are predictive of IGD a year later?
- (2) Is IGD predictive for any aspect of adolescent and parental mental health a year later?
- (3) How stable is the behavior pattern of Internet Gaming Disorder in adolescents over 1 year?

## Methods

### Participants

The sample comprised a total of 1095 family dyads (an adolescent aged 12–14 years and a related caregiver each) and was assessed for the first time in 2016 (first quarter, t1). One year later (first quarter of 2017, t2), 985 of the 1095 family dyads (attrition rate 10.0%) could be re-assessed. Cross-sectional results for this sample were previously published in Wartberg *et al.* (2017b, only t1 data), whereas in the present survey longitudinal associations (cross-lagged panel design for t1 and t2) are presented. At t1 the sample consisted of 49.2% female (539 cases) and 50.8% male adolescents (556 cases) and at t2 of 49.3% girls (486 cases) and 50.7% boys (499 cases). The mean age of adolescents was 12.99 years (*SD* = 0.82 years) at t1 and 13.89 years (*SD* = 0.89 years) at t2. At t1 98.8% of caregivers were biological parents (931 mothers and 151 fathers) and at t2 98.9% (836 mothers and 138 fathers). In the following, all caregivers are labeled consistently as parents. The average age of the parents was 41.63 years (*SD* = 5.76 years) at t1 and 42.60 years (*SD* = 5.58 years) at t2. Based on the current school performance of the adolescent, every parent was requested to predict the prospective level of graduation of her or his child (forecast). At t2, the parents predicted a graduation on a high educational level for 40.8% of the adolescents, on a medium educational level for 49.2% and on a low level for 9.9% of the sample.

### Measures

To assess IGD within the last 12 months, we applied the Internet Gaming Disorder Scale (IGDS, Lemmens *et al.* 2015) at t1 and t2. The IGDS consists of nine items (binary response format: 0 = ‘no’, 1 = ‘yes’) on the presence of IGD symptoms. In our sample, the reliability coefficients of the IGDS were 0.82 (t1) and 0.83 (t2). By summing up the nine responses, an IGDS sum score was computed. A higher score in the IGDS indicates a higher severity of IGD. Following Lemmens *et al.* (2015), adolescents who answered yes to five or more of the nine criteria (positive screening result) were classified as having IGD.

Adolescent mental health was measured at t1 and t2 with the German adaptation of the Reynolds Adolescent Adjustment Screening Inventory (Reynolds, 2001; Screening psychischer

Störungen im Jugendalter-II, SPS-J-II, Hampel & Petermann, 2012). The instrument consists of 32 items with a three-level response format (0 = 'never or almost never', 1 = 'sometimes', 2 = 'nearly all the time'). The SPS-J-II is divided into four subscales evaluating the frequency of antisocial behavior, anger control problems, emotional distress (a combined measure of anxiety and depressiveness), and self-esteem problems within the last 6 months. The reliability coefficients (Cronbach's  $\alpha$ ) in our sample were satisfactory (antisocial behavior t1:  $\alpha = 0.75$ , t2:  $\alpha = 0.76$ ; anger control problems t1:  $\alpha = 0.81$ , t2:  $\alpha = 0.76$ ; emotional distress t1:  $\alpha = 0.82$ , t2:  $\alpha = 0.83$ ; self-esteem problems t1:  $\alpha = 0.74$ , t2:  $\alpha = 0.75$ ). In every subscale, a higher sum score indicates a greater degree of psychopathological problems.

For a parental rating of adolescent hyperactivity/inattention within the last six months, we used the subscale hyperactivity/inattention of the Strengths and Difficulties Questionnaire (SDQ, Goodman, 1997) at t1 and t2. The subscale consists of five items with a three-level response format (0 = 'not true', 1 = 'somewhat true', 2 = 'certainly true'). Cronbach's  $\alpha$  for the subscale was 0.72 (t1) and 0.73 (t2). A higher score in this subscale indicates a higher level of adolescent hyperactivity/inattention.

Parental depression was measured at t1 and t2 with the Patient Health Questionnaire-2 (PHQ-2, Kroenke *et al.* 2003). The PHQ-2 instrument consists of two items rating the frequency of depressed mood and anhedonia over the last two weeks (four-level response format: 0 = 'not at all', 1 = 'several days', 2 = 'more than half the days', 3 = 'nearly everyday'). Cronbach's  $\alpha$  for the PHQ-2 was 0.67 (t1) and 0.73 (t2). A higher score in the PHQ-2 indicates a higher severity of depression.

Parental anxiety within the last 2 weeks was assessed at t1 and t2 using the Generalized Anxiety Disorder Scale-2 (GAD-2, Kroenke *et al.* 2007). The questionnaire consists of two questions rating nervousness and worrying with a 4-level response format (0 = 'not at all', 1 = 'several days', 2 = 'more than half the days', 3 = 'nearly everyday'). Cronbach's  $\alpha$  for the GAD-2 was 0.69 (t1) and 0.78 (t2). A higher sum in the GAD-2 indicates a higher severity of anxiety. Additionally, demographic data of the adolescent and his or her parent (e.g. gender and age) were also collected at t1 and t2.

### Procedure

To achieve a sufficiently high number of affected persons in the longitudinal course of the study, adolescents with subjectively perceived problems in digital media use were oversampled in the present survey. Thereto, the adolescents (more specifically the family dyad) were assigned to a group with more subjectively perceived problems in digital media use (higher risk group) or to a group with less subjectively perceived problems (lower risk group). The allocation to the higher or the lower risk group was based on adolescent and parental responses to two screening items (assessing the self-perceived frequency of adolescent excessive media use and the severity of problematic media use). To realize an oversampling, we predefined that 70% of the sample should be higher risk group family dyads. By using this strategy for recruitment a higher percentage of adolescents with problematic use of digital media were attained than represented in general population samples.

The study was approved by the ethics commission of the German Psychological Association (DGPs). All data were collected by interviewers of an experienced market research firm in face-to-face interviews at the family's home (separately with the adolescent and his or her parent) in all 16 German federal states

and before the start of the survey, in each family informed consent was obtained by the interviewer. The data collection was carried out in 1095 families (approximately twice as many families were requested for participation at t1, a more detailed description of the initial recruitment process can be found in Wartberg *et al.* 2017a). Every family received 10 € at t1 and another 10 € at t2 for participation. The predefined target values for the market research firm for t1 were 700 higher risk group families (70% of the whole sample) and 300 lower risk group families (30%). The target achievement was 757 higher risk group families (or 69.1%) and 338 lower risk group families (30.9%) at t1 and 679 higher risk group families (or 68.9%) and 306 lower risk group families (31.1%) at t2.

### Statistical analyses

The statistical analyses were performed on all 1095 family dyads (regardless of whether an adolescent was assigned to the higher or lower risk group). All adolescents who stated that they never play video games did not have to answer the nine IGDS items (we asked for all types of online or offline games played on a computer, tablet computer, game console and smartphone). These cases were assigned to the group without IGD and their IGDS sum score was set to 0.

We used SPSS version 22.0 (IBM, 2013, New York, USA) to calculate frequencies, means, standard deviations, a contingency table, and concordance. For the contingency table, a diagnosis of IGD was based on the IGDS cut-off point  $\geq 5$  (Lemmens *et al.* 2015). Furthermore, we used Mplus version 7.2 (Muthén & Muthén, 2012) to calculate structural equation models (SEMs). The dependent variables in the SEMs were the IGDS sum score, adolescent antisocial behavior, anger control problems, emotional distress, self-esteem problems, hyperactivity/inattention and parental depression and anxiety at t2. As explanatory variables in the SEMs, we used the gender and age of the adolescent as well as the IGDS sum score, adolescent antisocial behavior, anger control problems, emotional distress, self-esteem problems, hyperactivity/inattention, and parental depression and anxiety at t1. First, we calculated an SEM without restrictions. This was a full path model with zero degrees of freedom. To be able to determine the goodness-of-fit indices for the model (the normed  $\chi^2$  index, the root-mean-square error of approximation or RMSEA, the standardized root-mean-square residual or SRMR, the Comparative Fit Index or CFI and the Tucker-Lewis index or TLI), we fixed the regressions coefficients to be equal for both sexes and calculated a second model. Schermelleh-Engel *et al.* (2003) recommended as cut-off values for a good model fit: Normed  $\chi^2$  index  $< 2$ , RMSEA  $\leq 0.05$ , CFI  $\geq 0.97$  and TLI  $\geq 0.97$ .

## Results

### Structural equation model without restrictions

The correlations for all included variables within and between t1 and t2 are presented in Table 1. In the SEM without restrictions, we found numerous statistical significant associations between the ten explanatory variables and the eight dependent variables (see Table 2). In answer to the first research question, we observed male gender, a higher level of hyperactivity/inattention (t1), self-esteem problems (t1) and Internet Gaming Disorder (t1) to be predictive of IGD a year later (t2). Comparing the degree of these associations, we obtained a substantial effect size for

**Table 1.** Correlations within and between t1 and t2 for all included variables

		Gender <sup>a</sup>	Age	Antisocial behavior		Anger control problems		Emotional distress		Self-esteem problems		Hyperactivity/inattention		Parental depression		Parental anxiety		Internet Gaming Disorder	
				t1	t2	t1	t2	t1	t2	t1	t2	t1	t2	t1	t2	t1	t2	t1	t2
Age	t1	-0.01	-																
Antisocial behavior	t1	-0.11 <sup>b</sup>	0.12 <sup>b</sup>	-															
	t2	-0.10 <sup>b</sup>	0.11 <sup>b</sup>	0.43 <sup>b</sup>	-														
Anger control problems	t1	-0.09 <sup>b</sup>	0.04	0.66 <sup>b</sup>	0.34 <sup>b</sup>	-													
	t2	-0.08 <sup>c</sup>	0.04	0.38 <sup>b</sup>	0.64 <sup>b</sup>	0.42 <sup>b</sup>	-												
Emotional distress	t1	0.04	0.09 <sup>b</sup>	0.57 <sup>b</sup>	0.30 <sup>b</sup>	0.57 <sup>b</sup>	0.33 <sup>b</sup>	-											
	t2	0.03	0.06	0.23 <sup>b</sup>	0.58 <sup>b</sup>	0.29 <sup>b</sup>	0.59 <sup>b</sup>	0.40 <sup>b</sup>	-										
Self-esteem problems	t1	-0.05	0.09 <sup>b</sup>	0.42 <sup>b</sup>	0.32 <sup>b</sup>	0.43 <sup>b</sup>	0.25 <sup>b</sup>	0.45 <sup>b</sup>	0.22 <sup>b</sup>	-									
	t2	-0.07 <sup>c</sup>	0.07 <sup>c</sup>	0.31 <sup>b</sup>	0.42 <sup>b</sup>	0.28 <sup>b</sup>	0.39 <sup>b</sup>	0.26 <sup>b</sup>	0.38 <sup>b</sup>	0.44 <sup>b</sup>	-								
Hyperactivity/inattention	t1	-0.17 <sup>b</sup>	0.04	0.43 <sup>b</sup>	0.34 <sup>b</sup>	0.44 <sup>b</sup>	0.27 <sup>b</sup>	0.37 <sup>b</sup>	0.23 <sup>b</sup>	0.41 <sup>b</sup>	0.32 <sup>b</sup>	-							
	t2	-0.18 <sup>b</sup>	0.01	0.24 <sup>b</sup>	0.42 <sup>b</sup>	0.24 <sup>b</sup>	0.42 <sup>b</sup>	0.24 <sup>b</sup>	0.38 <sup>b</sup>	0.22 <sup>b</sup>	0.36 <sup>b</sup>	0.47 <sup>b</sup>	-						
Parental depression	t1	-0.04	0.03	0.37 <sup>b</sup>	0.21 <sup>b</sup>	0.35 <sup>b</sup>	0.26 <sup>b</sup>	0.35 <sup>b</sup>	0.24 <sup>b</sup>	0.29 <sup>b</sup>	0.16 <sup>b</sup>	0.35 <sup>b</sup>	0.21 <sup>b</sup>	-					
	t2	-0.03	-0.00	0.19 <sup>b</sup>	0.35 <sup>b</sup>	0.17 <sup>b</sup>	0.35 <sup>b</sup>	0.17 <sup>b</sup>	0.39 <sup>b</sup>	0.20 <sup>b</sup>	0.29 <sup>b</sup>	0.24 <sup>b</sup>	0.32 <sup>b</sup>	0.29 <sup>b</sup>	-				
Parental anxiety	t1	-0.04	0.03	0.33 <sup>b</sup>	0.22 <sup>b</sup>	0.36 <sup>b</sup>	0.25 <sup>b</sup>	0.33 <sup>b</sup>	0.22 <sup>b</sup>	0.30 <sup>b</sup>	0.17 <sup>b</sup>	0.29 <sup>b</sup>	0.21 <sup>b</sup>	0.66 <sup>b</sup>	0.27 <sup>b</sup>	-			
	t2	-0.06	0.05	0.22 <sup>b</sup>	0.38 <sup>b</sup>	0.17 <sup>b</sup>	0.37 <sup>b</sup>	0.20 <sup>b</sup>	0.41 <sup>b</sup>	0.23 <sup>b</sup>	0.33 <sup>b</sup>	0.23 <sup>b</sup>	0.33 <sup>b</sup>	0.29 <sup>b</sup>	0.72 <sup>b</sup>	0.33 <sup>b</sup>	-		
Internet Gaming Disorder	t1	-0.40 <sup>b</sup>	0.03	0.44 <sup>b</sup>	0.28 <sup>b</sup>	0.42 <sup>b</sup>	0.25 <sup>b</sup>	0.34 <sup>b</sup>	0.21 <sup>b</sup>	0.39 <sup>b</sup>	0.26 <sup>b</sup>	0.45 <sup>b</sup>	0.31 <sup>b</sup>	0.23 <sup>b</sup>	0.17 <sup>b</sup>	0.25 <sup>b</sup>	0.22 <sup>b</sup>	-	
	t2	-0.37 <sup>b</sup>	0.03	0.30 <sup>b</sup>	0.46 <sup>b</sup>	0.28 <sup>b</sup>	0.42 <sup>b</sup>	0.21 <sup>b</sup>	0.38 <sup>b</sup>	0.29 <sup>b</sup>	0.38 <sup>b</sup>	0.38 <sup>b</sup>	0.47 <sup>b</sup>	0.15 <sup>b</sup>	0.29 <sup>b</sup>	0.15 <sup>b</sup>	0.31 <sup>b</sup>	0.57 <sup>b</sup>	-

<sup>a</sup>Male gender = 0, Female gender = 1.<sup>b</sup> $p < 0.01$ .<sup>c</sup> $p < 0.05$ .

**Table 2.** Results of the structural equation model without restrictions

	Internet Gaming Disorder (t2, adolescent) <sup>a</sup> Standardized Beta	Antisocial behavior (t2, adolescent) <sup>a</sup> Standardized Beta	Anger control problems (t2, adolescent) <sup>a</sup> Standardized Beta	Emotional distress (t2, adolescent) <sup>a</sup> Standardized Beta	Self-esteem problems (t2, adolescent) <sup>a</sup> Standardized Beta	Hyperactivity/inattention (t2, adolescent) <sup>b</sup> Standardized Beta	Parental depression (t2, parent) <sup>b</sup> Standardized Beta	Parental anxiety (t2, parent) <sup>b</sup> Standardized Beta
Internet Gaming Disorder (t1, adolescent) <sup>a</sup>	0.41***	0.02	0.02	0.08*	0.01	0.07	0.04	0.08*
Antisocial behavior (t1, adolescent) <sup>a</sup>	0.03	0.27***	0.10*	-0.09*	0.09*	-0.02	0.02	0.06
Anger control problems (t1, adolescent) <sup>a</sup>	-0.01	0.03	0.25***	0.07	0.03	-0.02	-0.03	-0.08
Emotional distress (t1, adolescent) <sup>a</sup>	-0.00	0.02	0.06	0.32***	0.00	0.09*	0.00	0.02
Self-esteem problems (t1, adolescent) <sup>a</sup>	0.06*	0.11**	0.02	0.01	0.33***	-0.01	0.07	0.07*
Hyperactivity/inattention (t1, adolescent) <sup>b</sup>	0.14***	0.14***	0.04	0.05	0.14***	0.39***	0.11**	0.07*
Parental depression (t1, parent) <sup>b</sup>	-0.02	-0.02	0.06	0.10*	-0.03	0.00	0.16***	0.07
Parental anxiety (t1, parent) <sup>b</sup>	-0.03	0.04	0.04	0.01	-0.01	0.05	0.10*	0.22***
Gender <sup>c</sup>	-0.18***	-0.03	-0.03	0.05	-0.02	-0.09**	0.02	0.00
Age	0.01	0.06*	0.01	0.03	0.02	-0.02	-0.02	0.02
R <sup>2</sup>	0.37	0.23	0.21	0.18	0.22	0.24	0.12	0.15

<sup>a</sup>Ratings by adolescents.<sup>b</sup>Ratings by parents.<sup>c</sup>0 = male, 1 = female.\*\*\* $p < 0.001$  \*\* $p < 0.010$  \* $p < 0.05$ .

Internet Gaming Disorder (t1) and clearly lower, rather small effect sizes for male gender, hyperactivity/inattention (t1) and self-esteem problems (t1). The model explained 37% of the variance of IGD at t2 (Table 2). In answer to the second research question, we found IGD (t1) to be predictive of IGD, and additionally of emotional distress and parental anxiety at t2 (both rather small effect sizes, see Table 2).

### Structural equation model with restrictions

In the SEM with regressions coefficients restricted to be equal for both sexes, we observed a good fit for the model. The Normed  $\chi^2$  index ( $\chi^2/df$ ) was 1.57 ( $\chi^2 = 127.26$ ,  $df = 81$ ,  $p = 0.001$ ), RMSEA = 0.03, SRMR = 0.02, CFI = 0.99 and TLI = 0.97 (all observed fit indices clearly reached the recommended cut-off values for good model fit of Schermelleh-Engel *et al.* 2003). IGD (t2) was predicted by a higher level of hyperactivity/inattention (t1), self-esteem problems (t1), and IGD (t1) (see Table 3, explained variance was 0.23 for females and 0.27 for males). Again, we observed a substantial effect size for IGD (t1) as well as clearly lower effect sizes for hyperactivity/inattention (t1) and self-esteem problems (t1). IGD (t1) was predictive of emotional distress (t2, rather a small effect size), (see Table 3, explained variance was 0.17 for females and 0.18 for males). In contrast to the findings in the model without restrictions, IGD (t1) predicted hyperactivity/inattention a year later (t2, rather a small effect size), but was not a statistically significant predictor for parental anxiety (t2, see Table 3).

### Stability of IGD in adolescence over 1 year

To determine the stability of IGD over a period of 1 year (answer to the third research question), we used the Internet Gaming Disorder Scale (IGDS) data of the 985 adolescents who had participated in the survey both times (t1 and t2). Altogether, 142 out of the 985 adolescents (14.4%) were classified as having IGD (IGDS sum value  $\geq 5$ ) both at t1 and t2. Further, 100 adolescents (10.2%) exceeded the cut-off value ( $\geq 5$ ) at t1, but undercut it at t2. Conversely, 115 adolescents (11.7%) fall below the cut-off value ( $\geq 5$ ) at t1, but exceeded it at t2. Overall, 628 boys and girls (63.8%) come below the cut-off value ( $\geq 5$ ) at t1 and t2. We observed a kappa coefficient of 0.42 ( $p < 0.001$ , 78.2% absolute match). According to Altman (1991) a kappa coefficient of 0.42 indicates a moderate concordance.

### Discussion

This is the first study to investigate the stability of IGD in adolescence and its longitudinal relationships to adolescent and parental mental health. In the cross-sectional analysis of the same sample (Wartberg *et al.* 2017b, based on t1 data only) IGD was significantly associated with adolescent male gender, more adolescent antisocial behavior, anger control problems, emotional distress, self-esteem problems, hyperactivity/inattention and more parental anxiety. In contrast, in the SEMs of the cross-lagged panel design apart from male gender and IGD (strongest predictor with the largest effect size) at the first assessment, only hyperactivity/inattention and self-esteem problems (t1) predicted IGD 1 year later (both with a rather small effect size). The results on hyperactivity/inattention and self-esteem were consistent across the analyses (SEM with and without restrictions). This finding corroborates a report by Lemmens *et al.* (2011) who found lower self-esteem to predict an increase in pathological video game use 6 months later

and confirms the important role of self-esteem for the new DSM-5 diagnosis of IGD.

Interestingly, emotional distress was associated with IGD in the cross-sectional analysis (Wartberg *et al.* 2017b), but did not predict IGD 1 year later (t2). In contrast, however, IGD (t1) was a consistent predictor (but with a rather small effect size) for emotional distress 1 year later (t2) in both analyses. This is in line with previous findings by Gentile *et al.* (2011) and Brunborg *et al.* (2014) on pathological use of computer and video games. Gentile *et al.* (2011) identified pathological video game use as a predictor of anxiety and depression (as well as of social phobia) in adolescence 2 years later. It also fits in with findings by Brunborg *et al.* (2014) who reported pathological video game use to be associated with higher depression and conduct problems 2 years later. As the emotional distress subscale in the present study is a combined measure of anxiety and depressiveness, we could confirm the results of Gentile *et al.* (2011) for the new DSM-5 diagnosis IGD.

IGD (t1) was a statistically significant predictor for hyperactivity/inattention a year later (t2) only in the SEM with restrictions, whereas in the SEM without restrictions this association failed to reach statistical significance ( $p = 0.054$ ). Due to the lack of stability of the finding, further longitudinal studies are required to clarify whether there is a reciprocal relationship between hyperactivity/inattention and IGD or whether the relationship is unidirectional, with hyperactivity/inattention predicting the development of IGD in adolescence rather than vice versa.

Concerning parental mental health, parental anxiety was related to adolescent IGD in the cross-sectional analysis (Wartberg *et al.* 2017b), but was no predictor for IGD 1 year later (t2). Conversely, IGD (t1) was a predictor for parental anxiety a year later (t2) in the SEM without restrictions. However, in the second SEM analysis (structural equation model with restrictions) this effect did not reach statistical significance. Considering these inconsistent results, further longitudinal surveys are needed to clarify if such transgenerational (mental health) influences are verifiable for the development and maintenance of IGD in adolescence.

Concerning the stability of IGD in adolescence, we found a moderate concordance. Only a subgroup of affected adolescents showed IGD consistently over 1 year. This high variability may be explained by the age of the sample (t1: 12–14 years), since biological, mental, and social changes are common in this stage of life. These extensive changes in adolescence (or puberty) could potentially affect diverse behavior patterns more rapidly or intensely than in other stages of life (e.g. adulthood). Scharrow *et al.* (2014) observed a pathological video game use over 2 years only in 1% of their sample (nine out 902 persons, mixed sample of adolescents and adults) and in the 5-year longitudinal study of Konkolý Thege *et al.* (2015) three out of four affected adults reported only once (in five waves of data collection) about significant problems caused by overinvolvement in video games, whereas none of the respondents gave account of five times (empirical indications of rather low stability). Gentile *et al.* (2011) reported that 183 of the investigated 2532 adolescents (time 3, p. e321) showed pathological video game use in the first time of measurement and still 2 years later (approximately 7% of the sample), whereas in our sample 14.4% were classified as having IGD both at t1 and t2. Obviously, these results are extremely heterogeneous, maybe caused by the different applied measuring instruments or the new diagnostic criteria of IGD. In any case, the stability of IGD should be investigated further on.

The present longitudinal survey has several limitations. First, we can only draw conclusions in regard to the development of

**Table 3.** Results of the structural equation model with restrictions

	Internet Gaming Disorder (t2, adolescent) <sup>a</sup>		Antisocial behavior (t2, adolescent) <sup>a</sup>		Anger control problems (t2, adolescent) <sup>a</sup>		Emotional distress (t2, adolescent) <sup>a</sup>		Self-esteem problems (t2, adolescent) <sup>a</sup>		Hyperactivity/inattention (t2, adolescent) <sup>b</sup>		Parental depression (t2, parent) <sup>b</sup>		Parental anxiety (t2, parent) <sup>b</sup>	
	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta	Standardized Beta
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Internet Gaming Disorder (t1, adolescent) <sup>a</sup>	0.37***	0.41***	0.01	0.01	0.01	0.01	0.06*	0.08*	0.00	0.00	0.06*	0.07*	0.05	0.06	0.05	0.06
Antisocial behavior (t1, adolescent) <sup>a</sup>	0.04	0.04	0.25***	0.28***	0.11**	0.11**	-0.09*	-0.10*	0.08*	0.09*	-0.01	-0.01	0.04	0.04	0.04	0.04
Anger control problems (t1, adolescent) <sup>a</sup>	-0.02	-0.02	0.03	0.03	0.26***	0.25***	0.07	0.08	0.04	0.04	-0.02	-0.01	-0.04	-0.04	-0.04	-0.04
Emotional distress (t1, adolescent) <sup>a</sup>	-0.00	-0.00	0.01	0.01	0.06	0.05	0.33***	0.30***	0.00	0.00	0.10*	0.08*	0.00	0.00	0.00	0.00
Self-esteem problems (t1, adolescent) <sup>a</sup>	0.08*	0.07*	0.10**	0.12**	0.02	0.02	0.01	0.01	0.32***	0.34***	-0.02	-0.02	0.07*	0.07*	0.07*	0.07*
Hyperactivity/inattention (t1, adolescent) <sup>b</sup>	0.14***	0.13***	0.13***	0.15***	0.04	0.04	0.05	0.05	0.14***	0.15***	0.40***	0.40***	0.09**	0.09**	0.09**	0.09**
Parental depression (t1, parent) <sup>b</sup>	-0.03	-0.02	-0.01	-0.01	0.07	0.06	0.11*	0.11*	-0.03	-0.03	0.00	0.00	0.14**	0.13**	0.14**	0.12**
Parental anxiety (t1, parent) <sup>b</sup>	-0.03	-0.03	0.02	0.03	0.03	0.03	0.00	0.00	-0.02	-0.02	0.05	0.04	0.16***	0.15***	0.16***	0.15***
Age	0.00	0.00	0.06*	0.06*	0.00	0.00	0.03	0.03	0.02	0.02	-0.02	-0.02	0.00	0.00	0.00	0.00
R <sup>2</sup>	0.23	0.27	0.19	0.24	0.21	0.20	0.17	0.18	0.20	0.24	0.22	0.22	0.13	0.13	0.13	0.13

<sup>a</sup>Ratings by adolescents.<sup>b</sup>Ratings by parents.Model fit:  $\chi^2/df = 1.57$ , RMSEA = 0.03, SRMR = 0.02, CFI = 0.99, TLI = 0.97.\*\*\* $p < 0.001$  \*\* $p < 0.010$  \* $p < 0.05$ .

IGD over a period of 1 year. To what extent our results can be generalized to longer time-periods remains uncertain. Additionally, the utilized instruments assess different time periods (the IGDS 12 months, the SPS-J-II and the SDQ 6 months, the PHQ-2 and the GAD-2 2 weeks, all original timeframes for the questionnaires were maintained in our study). In this respect, the generalizability of the results over 1 year is not completely ensured. Furthermore, we did not investigate a representative sample of adolescents, but a sample with a higher percentage of persons with a problematic use of digital media than general population samples and we lost 10% of the sample between t1 and t2. We investigated several aspects of adolescent and parental mental health in our survey, but certainly not all of the relevant factors (especially concerning parental psychopathology). Therefore, we cannot rule out an unmeasured confounding of the results. Further longitudinal studies are necessary to investigate to which extent the findings are transferable to the general population or different age groups.

Despite the above-mentioned limitations, this longitudinal study provides some remarkable findings for the new DSM-5 diagnosis IGD. We found empirical evidence that IGD could prospectively contribute to a deterioration of mental health (e.g. emotional distress). Furthermore, hyperactivity/inattention and self-esteem problems seem to play an important role in the development of IGD in adolescence. These findings could be taken into account in the development of preventive approaches. Moreover, the results indicate that it could be promising to consider psychological co-morbidities in interventions for IGD. Further longitudinal studies (especially over longer periods of time) are necessary, on the etiology of IGD and to investigate further relevant issues (e.g. social aspects, familial interactions, structural characteristics of the video games).

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**Declaration of Interest.** None.

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