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## Neuroticism and introversion mediates the relationship between probable ADHD and symptoms of Internet gaming disorder: results of an online survey

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### ABSTRACT

**OBJECTIVES:** The aim of the present study was to evaluate relationship of probable attention deficit hyperactivity disorder (ADHD) with severity of the Internet gaming disorder (IGD), neuroticism and extraversion.

**METHODS:** The study was conducted with online survey among 457 volunteered university students in Ankara and people who play games on the Internet and who are in the e-mail database of a company located in Istanbul that organizes e-sports tournaments. Participants were evaluated by applying the Adult ADHD Self-Report Scale (ASRS-v1.1), the 9-item Internet Gaming Disorder Scale (IGDS) and the Eysenck Personality Questionnaire Revised-Abbreviated Form (EPQR-A).

**RESULTS:** Age was lower among those with the probable ADHD ( $n = 102$ , 22.3%) and those without ( $n = 355$ , 77.7%). Gender, educational status, and type of the participants did not differ between the groups. Severity of IGD symptoms and neuroticism were higher among those with the probable ADHD, whereas extraversion was lower. In logistic regression analysis, severity of IGD symptoms predicted the probable ADHD in the first Step, whereas when extraversion and neuroticism were included in the analysis as independent variables, low extraversion (introversion) and high neuroticism predicted the probable ADHD and severity of IGD symptoms was no longer a predictor.

**CONCLUSION:** These findings suggest that the severity of IGD symptoms is related with the probable ADHD and low extraversion (introversion) and high neuroticism may have mediator effect on this relationship.

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ADHD; extraversion; Internet gaming disorder; neuroticism; online survey; university students

## Introduction

Over the last decade, many efforts have been made to define and measure the concept of pathological involvement with computer or video games. Although playing video games is not considered intrinsically pathologic or problematic, gaming can become pathological for some players when the activity becomes dysfunctional, harming an individual's social, occupational, family, school, and psychological functioning [1]. In general, "pathological gaming" can be described as persistent, recurrent, and excessive involvement with computer or video games that cannot be controlled, despite associated problems [2,3].

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) included "Internet gaming disorder" (IGD) as a condition that needs further research before being fully recognized and accepted as an independent disorder in subsequent publications of the DSM [4–6]. The proposed criteria for IGD in the DSM-5 included nine criteria (*preoccupation, tolerance, withdrawal, persistence, escape, problems,*

*deception, displacement, and conflict*) [4,5]. To be diagnosed as a disordered gamer, five (or more) out of these criteria need to be endorsed over a period of 12 months [5]. The prevalence of IGD in the total samples ranged from 0.7% to 27.5% [7]. The prevalence was higher among males than females in the vast majority of studies and tended to be higher among younger rather than older people in some studies [7]. A recent meta-analysis reported that the prevalence of ADHD among patients with Internet addiction (IA) were 21.7% [8]; however, the possible mechanisms that contribute to this high comorbidity of ADHD are still under debate.

Although ADHD is a childhood-onset psychiatric disorder, around two-thirds of the patients with childhood ADHD may still have ADHD symptoms during their adulthood [9–11], about 15% still meet the DSM-IV criteria for the full ADHD syndrome, and the rest meet the criteria for the DSM-IV diagnosis of "ADHD in partial remission" [10]. Ramos-Quiroga et al. [12] indicated that the presentation of ADHD

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symptoms can change from adolescence to adulthood with less overt hyperactivity but ongoing attentional problems, disorganization, and symptoms of emotional dysregulation like mood swings, temper outbursts, and irritability. These symptoms may overlap with behavioural addiction (i.e. IA, IGD), which is one of the most common comorbid diagnosis with ADHD. Some symptoms such as “being easily bored” and “having an aversion for delayed reward” reported in ADHD [12,13], may also commonly be seen among university students with IA. Yoo et al. [14] suggested that the children with ADHD had higher IA scores compared with the non-ADHD group. In a systematic review, Carli et al. [15] have reported that symptoms of ADHD appeared to have the most significant and consistent correlation with IA. The comorbidity of these two disorders may indicate the causal relationship among them or common etiology shared by them. Finally, a recent systematic review and meta-analysis found that IA was positively associated with ADHD among adolescents and young adults [16]. The study suggested that clinicians and parents should pay more attention to the symptoms of ADHD in individuals with IA, and the monitoring of Internet use of patients suffering from ADHD [16].

When specifically considering IGD, it has been consistently associated with ADHD [17,18]. ADHD seems to be a factor predicting loss of self-control associated with excessive Internet game play, which may disturb an individual’s daily life [19,20]. Ha et al. [21] reported high IGD and ADHD comorbidity in Korean children. Finally, the results of a recent study suggested that IGD is associated with ADHD among young adults, and that young adults with both IGD and ADHD have higher impulsivity and hostility, which mediate the association between ADHD and IGD [22]. Thus, evaluating factors related with comorbidity between ADHD and IGD may shed a light on treatment of these disorders.

Personality is a special focus within IA research [23]. One of the main reasons for the focus on personality is the potential link between personality traits like extraversion and neuroticism and a predisposition for addiction [24], such as IA [17,23]. Previous studies that used Eysenck Personality Questionnaire (EPQ) suggested a relationship between low extraversion (introversion) and IA [25–27]. Moreover, among university students, high neuroticism predicted IA [26,27].

Several studies provided evidence that adults diagnosed with ADHD tend to demonstrate increased levels of neuroticism compared with nonclinical controls [28–31], whereas measures of extraversion have reported mixed results [28–32]. A recent study on this subject found that adult ADHD patients scored comparable with nonclinical individuals on extraversion [31]. In a recent study conducted among the Turkish university students, those with probable ADHD had higher scores from neuroticism than those

without, whereas extraversion did not differ between these groups [32].

Evidence support a causal relation between ADHD and IGD is still lacking and evaluating factors related with this comorbidity may help clinicians to evaluate causal relation between these disorders. Thus, it is important to evaluate the relationship between probable ADHD and IGD symptom severity in young adults (university students, amateur, and professional e-sport gamers). Also, since neuroticism and extraversion are associated with both of these diagnoses, our task was to check the effects of these variables on the relationship between probable ADHD and IGD symptoms.

## Materials and methods

### Subjects and procedure

The present study was conducted with cross-sectional online self-report survey among volunteered university students in Ankara and people who play games on the Internet and who are in the e-mail database of a company located in Istanbul that organizes e-sports tournaments (ESL Turkey Amateur e-sport players). We included latter group because we wanted to conduct a validation study of the IGDS [33], which was published previously [34], thus including this group of participants who play games in the Internet was necessary.

A website was prepared for online participation. Approval from the Ethical Committee of the Cankaya University was taken. The institutional review board approval date was 30 May 2017 and the number was 80281877-050.07-02628-01542.

The students were asked to fill out the form on the website anonymously. Informed consent was approved by students online before continuing with further questions. Exclusion criteria were unfilled forms.

For controlling the duplicate data entry, we checked the e-mail addresses, the nicknames and we also checked for Internet Protocol (IP) Address of the participants.

Total of 457 participants were included in the study. Among these 172 were male (37.6%) and 285 were female (62.4%), 6 (1.3%) were educated from elementary school, 24 (5.3%) were educated from high school, 298 (65.2%) were student in university, and 129 (28.2%) were educated from university.

Among participants 7 (1.5%) are e-sports professional gamers (regularly receives monthly salary), 14 (3.1%) are e-sports amateur gamers (has a team and participates to the tournaments and makes money in the tournament), 138 (30.2%) plays games for his/her own pleasure and/or follow e-sports, 111 (24.3%) are a university student and play games on the Internet, and 187 (40.9%) are a university student and do play games on the Internet.

Average hours of online play (not for work/not academic) per day over the past year was less than 1 hour for 280 (61.3%), was more than 1 hour, less than 3 hours for 93 (20.4%), was more than 3 hours, less than 6 hours for 52 (11.4%), was more than 6 hours, less than 9 hours 26 (5.7%) and was more than 9 hours for 6 (1.3%).

The subjects with probable ADHD ( $n = 102$ , 22.3%) were not sent for clinical examination, since this was a survey study.

## Measures

### The IGDS

Lemmens et al. [33] created three items for each of the 9 previously identified criteria – *preoccupation, tolerance, withdrawal, persistence, escape, problems, deception, displacement, and conflict* – resulting in a total of 27 items [33]. They also created the short, 9-item polytomous IGDS, which was strongly correlated with the 27-item polytomous IGDS ( $r = 0.98$ ,  $p < .001$ ) and showed good reliability, with a Cronbach's alpha of 0.95. The IGDS rated all items on a six-point ordinal-frequency scale: (0) *never*, (1) *one to four times in the last year*, (2) *five to 11 times in the last year*, (3) *about once to three times a month*, (4) *once or more a week*, and (5) *every day or almost every day* [33]. The results of the validity and reliability testing of the Turkish version of the nine-item IGDS (Cronbach's  $\alpha$  of 0.93) were found to be similar with the findings of the original scale [34].

### Adult ADHD Self-Report Scale (ASRS-v1.1)

ADHD symptoms were measured with the ASRS [35], an 18-item scale based on DSM Fourth Edition (DSM-IV-TR) criteria [36]. The Turkish version of ASRS has demonstrated good reliability and validity in university students [37]. Reliability analysis showed that the Turkish version of ASRS has a high level of internal consistency (Cronbach's  $\alpha = 0.88$ ). Cronbach's alpha coefficients for "inattention" and "hyperactivity/impulsivity" subscales were also high (0.82 and 0.78).

Developed under the auspices of the World Health Organization, ASRS is also a short six-item screening instrument, the questions in which were extracted, using stepwise logistic regression, from a larger survey of 18 questions comprising the Adult Self-Report Survey that taps the 18 specific "Criterion A" symptoms defining the disorder in DSM-IV. The ASRS 6-item screen was developed for community-based studies and exhibits strong concordance with clinician diagnoses as well as sound psychometric properties [38–40].

The 5-point Likert-type scale ranges from "0" (never) to "4" (very often). Thus, the possible range of scores on the ASRS screening version is 0–24, with

higher scores indicating more ADHD symptomology. Each response of sometimes or greater (2 or more) on screening items 1–3 equated to 1 point; each response of 10 or greater (3 or more) on screening items 4–6 resulted in a point. A total score of 4 or more indicated probable ADHD. We, therefore, used this recommended definition to identify highly likely ADHD cases in our sample and named as "probable ADHD." Nevertheless, the result of the test does not replace a clinical diagnosis and the clinician must take false positives into consideration by evaluating the ASRS positives with gold standard scales.

### Eysenck personality questionnaire revised abbreviated form (EPQR-A)

The EPQR-A includes 24 items in four personality traits: "neuroticism/stability" trait was used to assess the stability of emotion; "extraversion/introversion" trait was used to assess the tendency of extraversion and introversion; "psychoticism/socialization" trait was used to assess the subjects' psychiatric characteristics and "lie" trait was used as the validity scale [41]. Similar to the original scale, factor analysis of the Turkish version yielded four factors; the neuroticism, extraversion, psychoticism, and lie traits [42]. The reliability and validity of the questionnaire were supported in a Turkish university student sample [42]. Kuder–Richardson alpha coefficients for the extraversion, neuroticism, psychoticism, and lie traits were 0.78, 0.65, 0.42, and 0.64, respectively, and the test–retest reliability of the traits was 0.84, 0.82, 0.69, and 0.69, respectively.

### Data analysis

The statistical package SPSS 17.0 for Windows (SPSS, 278 Chicago, IL, U.S.A.) was used for all the analyses. Categorical sociodemographic variables were compared by means of the  $\chi^2$  statistics. Odds ratios (ORs) and 95% confidence intervals were calculated. We used Student's  $t$ -test to compare the groups on continuous variables. Taken the presence of probable ADHD as dependent variable, and IGDS score, neuroticism and extraversion as independent variables, a logistic regression model was performed. For all statistical analyses,  $P$  values were two tailed, and differences were considered significant at  $P < .05$ .

## Results

Among the university students who participated in the present study, rates of those with probable ADHD was 22.3% ( $n = 102$ ), whereas those without ADHD was 77.7% ( $n = 355$ ). Age was lower among those with the probable ADHD and those without ( $n = 355$ , 77.7%). Gender, educational status, and type of the participants did not differ between the groups (Table 1).

**Table 1.** Comparing scale scores according to presence of probable ADHD.

	Probable ADHD Absent <i>n</i> = 355, 77.7%		Probable ADHD present <i>n</i> = 102, 22.3%		<i>t</i>	<i>p</i>
	Mean	SD	Mean	SD		
Age	24.48	5.44	23.43	3.63	2.285	.023
IGDS 9-item	5.84	8.17	8.48	10.74	-2.303	.023
Neuroticism	3.01	1.88	3.72	1.66	-3.408	.001
Extraversion	3.92	2.05	3.30	2.10	2.641	.009
	<i>n</i>	%	<i>n</i>	%	$\chi^2$	<i>P</i>
Probable Internet Gaming Disorder	10	2.8	9	8.8	7.174	.020 <sup>a</sup>
Gender					0.618	.432
Male	137	38.6	35	34.3		
Female	218	61.4	67	65.7		
Educational Status					3.289	.349
Educated from elementary school	5	1.4	1	1.0		
Educated from high school	19	5.4	5	4.9		
Student in university	107	30.1	22	21.6		
Educated from university	224	63.1	74	72.5		
Type of participant					4.229	.376
Professional e-athlete <sup>b</sup>	10	2.8	4	3.9		
Amateur e-athlete <sup>c</sup>	115	32.4	23	22.5		
Plays games for his/her own pleasure and/or follow e-sports	5	1.4	2	2.0		
University student and play games on the Internet	139	39.2	48	47.1		
University student and do play games on the Internet	86	24.2	25	24.5		

Note: IGDS: Internet Gaming Disorder Scale.

<sup>a</sup>Fisher's exact test, odds ratio (95% C.I.): 3.339 (1.318–8.455).

<sup>b</sup>Regularly receives monthly salary.

<sup>c</sup>Has a team and participates to the tournaments and makes money in the tournament.

In the present study, using nine-item IGDS and accepting the answers of “(4) once or more a week, and (5) every day or almost every day” to meet the criteria of each item, prevalence of IGD was 4.2% (*n* = 19), since according to DSM-5, individuals with the presence of at least five items among nine items are considered as probable IGD. Among these seven were e-sports amateur gamers (50.0%), nine were those who play games for his/her own pleasure and/or follow e-sports (6.5%), and three were university students who play games on the Internet (2.7%). Probable IGD was 3.34 times higher among participants with probable ADHD (*n* = 9, 8.8%) than participants without probable ADHD (*n* = 10, 2.8%) (Table 1).

Severity of IGD and neuroticism were higher among those with the probable ADHD, whereas extraversion was lower (Table 1).

Evaluating both zero order and partial correlations among the scales suggested no multicollinearity. In logistic regression analysis, severity of IGD symptoms predicted the probable ADHD in the first Step. In Step 2 neuroticism and in Step 3 extraversion was

entered in the analyses as independent variables additional to severity of IGD symptoms, and both variables predicted the probable ADHD together with the severity of IGD symptoms. Finally, in Step 4 neuroticism and extraversion were included in the analysis together as independent variables additional to severity of IGD symptoms, and in this analysis low extraversion (introversion) and high neuroticism predicted the probable ADHD and severity of IGD was no longer a predictor (Table 2).

## Discussion

The important finding of the present study is that probable IGD was 3.34 times higher among participants with probable ADHD than participants without probable ADHD. The present study also suggested a positive relation between the probable ADHD and severity of IGD. While low extraversion (introversion) or high neuroticism alone was partial mediator on this relationship, together they become mediators. In any case, the association between ADHD and IGD might suggest that people with ADHD should be an

**Table 2.** Predictors of probable ADHD according to Adult ADHD Self-Report Scale (ASRS-v1.1).

	<i>B</i>	SE	Wald	df	<i>p</i>	OR	95% C.I.		
							Lower	Upper	
Step 1	IGDS 9-item	0.030	0.012	6.848	1	.009	1.031	1.008	1.055
Step 2	IGDS 9-item	0.024	0.012	3.967	1	.046	1.024	1.000	1.048
	Neuroticism	0.190	0.065	8.609	1	.003	1.210	1.065	1.374
Step 3	IGDS 9-item	0.029	0.012	6.005	1	.014	1.029	1.006	1.053
	Extraversion	-0.131	0.054	5.999	1	.014	0.877	0.790	0.974
Step 4	IGDS 9-item	0.023	0.012	3.734	1	.053	1.023	1.000	1.047
	Neuroticism	0.172	0.066	6.751	1	.009	1.188	1.043	1.352
	Extraversion	-0.109	0.055	4.007	1	.045	0.896	0.805	0.998

Note: Nagelkerke  $R^2$ : Step 1 = 0.022, Step 2 = 0.051, Step 3 = 0.041, Step 4 = 0.064, OR: odds ratio, C.I.: confidence interval.

important target group of preventive scheduling for IGD. Also, low extraversion (introversion) and high neuroticism can be considered as risk factors for both disorders and comorbidity of them.

Previous study found that 14% of adults with IA were diagnosed with ADHD [43]. Another study also reported that 7 out of 12 children with IA were diagnosed with ADHD [21]. Yen and colleagues found that university students with IA had significantly higher ADHD symptoms than those without IA and ADHD symptoms were the most significantly associated symptoms of IA [44]. Among the manifesting ADHD symptoms, attention deficit was the most associated one with IA, and the association was more prominent among females [44].

ADHD patients have poor self-control ability, so they are more easily to sustain an addiction to substances as well as Internet. But studies have reported that striatal dopamine could help game users focus and gain better performance while playing Internet games [45], which let ADHD patients compensate for the failure in real-life and prefer into the virtual world. Compared with real life, Internet users would get response, reward, and establish interpersonal relationships more easily online. A systematic review and meta-analysis demonstrated that patients with IA were present with more severe symptoms of ADHD than healthy control, so that IA may also have influence on ADHD [16]. Ko et al. [46] reported that ADHD could predict the occurrence of IA in the two-year follow-up. Chen et al. [47] also reported that high ADHD symptoms were significantly associated with the occurrence of IA. In summary, IA and ADHD may interact with each other. IGD is a psychiatric disorder instigated by excessive and prolonged Internet gaming, which shared many pathological symptoms with ADHD. A recent study suggested that video game addicts had poorer mental health and cognitive functioning including poorer impulse control and ADHD symptoms compared to matched non-addict controls [48]. Regarding that IGD and ADHD (which is one of the most common psychiatric comorbidities of IGD) demonstrate common neuropsychological impairments in executive functions and working memory, one plausible explanation for the high coexistence of IGD and ADHD is that these two conditions are both related to a comparable deviance of the prefrontal cortical maturation [49].

In the previous study conducted among the Turkish university students, the severity of ADHD symptoms has predicted the severity of IA, together with low extraversion (introversion), high neuroticism, depression and anxiety symptoms [50]. Severity of neuroticism was higher and extraversion was lower among those with the probable ADHD in the present

study. Also low extraversion (introversion) and neuroticism predicted the probable ADHD. According to Eysenck's theory, neurotic people – who have low activation thresholds, and unable to inhibit or control their emotional reactions, experience negative affect (fight-or-flight) in the face of very minor stressors – are easily nervous or upset. Introverts are chronically over-aroused and jittery and are, therefore, in need of peace and quiet to bring them down to an optimal level of performance. Previous studies suggested a relationship between introversion personality trait and IA [25–27]. Also, high neuroticism predicted IA among university students [26,27]. Several studies provided evidence that adults diagnosed with ADHD tend to demonstrate increased levels of neuroticism compared with nonclinical controls [28–31], whereas ADHD patients scored comparable with nonclinical individuals on extraversion [31]. In a recent study conducted among the Turkish university students, those with probable ADHD had higher scores from neuroticism than those without, whereas extraversion did not differ between these groups [32]. The reason for this difference according to extraversion may be that the present study included amateur and professional e-sports gamers, additional to the university students.

The present study has some limitations. First, because of excluding criteria, a total of 65 students were excluded from the study, whom may represent ADHD symptoms, thus indicating a possible type II error. Nevertheless, the response rate (87.5%) found in the present study was higher than the response rate (65.4%) found in the previous study with similar methodology [51]. Second, because of the shortcoming of the sociodemographic form, which included only information of gender and age, detailed information about significant variables, such as previous diagnoses, consumption of any medicine and substance abuse could not be provided. Third, severe ADHD symptoms may be associated with weaker cognitive performance, which makes results less reliable since we used self-rating scales in the present study. Fourth, self-rating scales may only show high risk rather than the diagnosis. Also the variance explained in the regression analysis is limited. Finally, because our study is not prospective in structure, it is not possible to demonstrate the casual relationships between low extraversion/high neuroticism, probable ADHD, and IGD exactly. But at least these findings demonstrate that, although probable ADHD and severity of IGD is related, low extraversion and high neuroticism are important factors mediating this relationship in university students.

### Disclosure statement

No potential conflict of interest was reported by the authors.

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