Academic outcomes and cognitive performance in problematic Internet users

Rendimiento académico y cognitivo en el uso problemático de Internet

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Abstract

Only few studies have examined the relationship between problematic Internet use (PIU) and cognitive and academic performance in adolescents. The aim of this study was to analyze the differences in academic and cognitive performance (perception, attention, memory, verbal fluency and abstract reasoning) between adolescents with and without PIU. A total of 575 students from different high schools of the region of Alicante participated. Students were divided into two groups: adolescents with and without PIU (PIU and NPIU, respectively). Several questionnaires were administered to assess problematic Internet use, as well as students' academic performance. Substance use (alcohol / cannabis) was also assessed as exclusion criteria. A battery of neuropsychological tests was used to assess cognitive abilities. On the one hand, PIU users group obtained poorer academic results than NPIU, in terms of lower marks and more failed subjects. On the other hand, PIU group had a better hit ratio in the perception test than NPIU group. However, PIU adolescents got higher error rates for the abstract reasoning test. This greater number of errors, plus a similar number of hits compared to the NPIU group, could indicated a higher response rate for the PIU group, which may might be associated with greater impulsivity. As occurs in other addictive and non-substance-related problems studies, these results could mean difficulties in impulse control and regulation of response inhibition circuits in PIU users group. Future research is needed to analyze in depth the results presented in this paper.

Keywords: Internet Problematic Use; Cognitive Performance; Academic Outcomes; Adolescents; Alcohol.

Resumen

Son escasos los estudios que hayan analizado la relación entre el uso problemático de Internet (UPI) y el rendimiento cognitivo y académico en adolescentes. El objetivo de este estudio fue analizar las diferencias en rendimiento académico y cognitivo (percepción, atención, memoria, fluidez verbal y razonamiento abstracto) en una muestra de estudiantes de Secundaria con y sin UPI. Participaron un total de 575 estudiantes de diferentes institutos de la provincia de Alicante, que fueron divididos en dos grupos: adolescentes con y sin uso problemático de Internet (UPI y NUPI, respectivamente). Se administraron varios cuestionarios para evaluar el uso problemático de Internet de los sujetos, su rendimiento académico, su consumo de sustancias (alcohol/cannabis) como criterios de exclusión, así como una batería de pruebas neuropsicológicas para evaluar sus habilidades cognitivas. Por un lado, los adolescentes con UPI mostraron un peor rendimiento académico que los estudiantes del grupo NUPI, presentando una nota media más baja y un mayor número de asignaturas suspendidas. Por otro lado, el grupo UPI obtuvo una mayor tasa de aciertos en el test de percepción que el grupo NUPI. Sin embargo, los adolescentes con UPI obtuvieron una mayor tasa de errores para el test de razonamiento abstracto. Este mayor número de errores, sumado a un número similar de aciertos que NUPI, indicaría una mayor tasa de respuesta total para el grupo UPI, que podría estar asociada a mayor impulsividad. Concretamente, tal y como se ha observado en otros problemas adictivos con y sin sustancia, estos resultados podrían indicar en los sujetos del grupo UPI dificultades en el control de impulsos y en la regulación de los circuitos de inhibición de respuesta. Resultan necesarios, no obstante, futuros estudios que profundicen en las conclusiones presentadas en este trabajo.

Palabras clave: Uso problemático Internet; Rendimiento cognitivo; Rendimiento académico; Adolescentes; Alcohol.

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The use of Information and Communication Technologies (ICTs) is becoming ever more widespread in our society, especially among the adolescent population. According to data from the National Institute of Statistics, in 2015 99% of boys and girls between 16 and 24 years of age used the Internet in the previous month, and 92.8% used it daily in the previous 3 months on at least 5 days a week (Instituto Nacional de Estadística, 2015).

Such massive Internet use has given rise to the appearance of negative effects related to its excessive use (Herrera, Pacheco, Palomar & Zavala, 2010; Secades-Villa et al., 2014), which in recent years has led in turn to an increase in the number of studies that have attempted to define this complex phenomenon, often categorized under the name "Problematic Internet Use" (PIU) (Jelenchick & Christakis, 2014; Rial, Gómez, Isorna, Araujo & Varela, 2015; Starcevic, 2010).

PIU has been defined in the scientific literature in terms similar to substance use disorders and pathological gambling, as described in the Diagnostic and Statistical Manual of Mental Disorders (DSM, American Psychiatric Association, 2013). More specifically, PIU has been conceptualized in relation to the negative effects caused by excessive use, including symptoms such as tolerance, a negative effect on daily life (eg. reducing other activities), loss of control, and the desire to be online (Beranuy, Chamarro, Graner & Carbonell, 2009). However, in contrast to Internet gaming disorder or video game addiction (Bertrán & Chamarro, 2016; Carbonell, 2014; Li, O'Brien, Snyder & Howard, 2016), it is important to note that PIU has not yet been included in the DSM-5 classification.

In terms of prevalence, rates ranging from 3.7% to 9.9% have been estimated for Spain, with greater problematic use among the youngest users (Carbonell, Fúster, Chamarro & Oberst, 2012).

The negative consequences of PIU have been the focus of various studies, some of which have concentrated on the impact such use has on the brain functioning of excessive users. This approach has seen different investigations using neuroimaging techniques to verify alterations in the prefrontal cortex in subjects with PIU, which results in problems of cognitive flexibility (Dong, Lin, Zhou & Lu, 2014), decision making (D'Hondt, Billieux & Maurage, 2015), working memory (Dong, Devito, Du & Cui, 2012) and executive control. These characteristics are consistent with disorders found in other behavioral addictions, such as pathological gambling (Brand, Young & Laier, 2014). Some studies have also analyzed the cognitive functioning of these subjects using classical neuropsychological tests, such as the Stroop test (as a measure of response inhibition ability) or general intelligence questionnaires where longer reaction times, more frequent errors, as well as difficulties in comprehension were found in the PIU group in comparison with a control group (Dong, Zhou & Zhao, 2011; Rücker, Akre, Berchtold & Suris, 2015). Furthermore, significant differences were found between subjects with and without problematic Internet use in terms of their verbal fluency, with PIU subjects faring worse in tasks that evaluated verbal semantic fluency (Nie, Zhang & Liu, 2017).

In light of such data, numerous studies have suggested that neurobiological substrates and cognitive functioning in PIU may resemble not only that found in other behavioral addictions but also that observed in substance use disorders (Bauernhofer, Papousek, Fink, Unterrainer & Weiss, 2015; Brand et al., 2014; Yuan et al., 2016; Zhang et al., 2015).

In addition, research has also found a relationship between PIU and academic performance among students. On the one hand, PIU has been shown to be a predictor of poor academic performance due to lack of sleep and concentration related to Internet abuse (Stavropoulos, Alexandraki & Motti-Stefanidi, 2013). On the other hand, low school performance has been found to cause PIU (Huang et al., 2009). Given cross-sectional nature of most of these studies, the direction of influence of both variables is still unclear.

Despite the growing interest in the influence of PIU on the cognitive skills and academic performance of young people, studies that have linked these variables are still few and far between, and conclusive evidence has yet to be found (Park et al., 2011). Also, there is a scarcity of studies investigating these variables through specific neuropsychological tests. The objective of the present study is therefore to analyze the relationship between the problematic use of the Internet and the academic and cognitive performance of a sample of secondary students.

Our variables have been selected on the basis of previous evidence in the field of neuropsychological assessment and academic performance, both in regard to PIU and other addiction disorders. Given these previous studies, our hypotheses are: (a) students with PIU will achieve worse academic outcomes in terms of lower average school grades and a greater number of suspended subjects than adolescents who use the Internet in a non-problematic way (NPIU); (b) students with PIU will reveal worse cognitive performance in all neuropsychological tests used, in the form of a higher rate of errors and a lower hit rate, than the adolescents with NPIU.

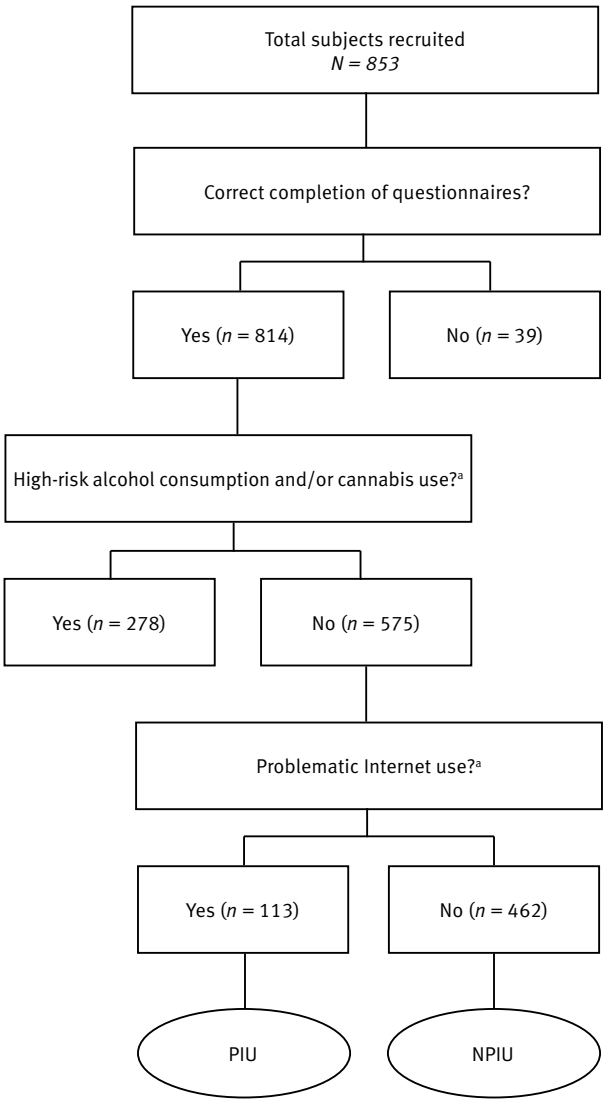
Method

Participants

Initially, 8 public secondary schools (IES) were selected, randomly chosen from among the 40 high schools in the cities of Alicante and Elche. The random procedure was performed by rolling a die and using the numbers produced to select the different schools from a list.

Two of the schools contacted refused to take part in the study, so finally the sample was taken from 6 schools. The participating schools were all state funded and located in neighborhoods of average socioeconomic level. With a total of 31,280 students enrolled in these high schools at the time of sample collection, and taking into account the estimated average prevalence of PIU in Spanish adolescents of 10% (95% confidence, ± 2.5 margin of error), the minimum sample required for this study was 544 participants. After receiving the authorization of the heads of study of each school, 47 classes of the 3rd and 4th years of compulsory secondary education (ESO) were randomly selected, resulting in an initial total of 853 students recruited.

Since different studies have shown that both cannabis use (Shrivastava, Johnston & Tsuang, 2011) and excessive alcohol consumption (Geil et al., 2014; Parada et al., 2012) have a negative effect on cognitive performance, the following exclusion criteria were set to eliminate possible biases in measuring cognitive abilities: (a) cannabis use once a month or more and (b) high-risk alcohol consumption. These variables were assessed using a questionnaire based on the ESTUDES survey of the National Plan on Drugs (Ministerio de Sanidad, Servicios sociales e Igualdad, 2013) to collect data on the frequency of alcohol and cannabis use during their lifetime, in the last month, and the last week. In the case of alcohol, the intensity of use was also collected, measured in SDUs consumed in the last month.



Note. PIU: Students with problematic Internet use
NPIU: Students with non-problematic Internet use
[a] Cannabis: once a month or more; Alcohol: ≥ 6/4 SDUs (boys and girls, respectively).
[b] Score ≥ 34 on IREQ.

Figure 1. Sample selection

In this study, high-risk alcohol consumption is understood as binge drinking, which involves the consumption of at least 6 standard drink units (SDU) (1 SDU = 10 grams of pure ethanol) in the case of boys and 4 SDUs in that of girls concentrated within the space of two hours (National Institute on Alcohol Abuse and Alcoholism, 2004).

An exploratory analysis of the initial sample thus resulted in a total of 278 cases (32.5%) being rejected for not meeting the inclusion criteria to participate in the study or for not correctly completing the tests, leaving a final sample of 575 participants. The participants were between 13 and 17 years old, with a mean age of 14.67 ± 0.79 years, and 55.7% (n = 314) of them were in the 3rd year of compulsory secondary education at the time of the study. The average mark for the previous school year of the total sample was 7.08 ± 1.58, while the number of fails stood at an average of 0.93 ± 2.12. Girls made up 42.1% (n = 239) of the sample.

As for Internet use, 82.6% (n = 470) of the total sample reported using the Internet on a daily basis, and 21.2% (n = 121) reported being online for more than three hours per day. In terms of the preferred use of the Internet, the adolescents mainly used social networks when online (87.4%, n = 450).

Participants were classified into two groups according to whether they had PIU (19.7%; n = 113) or not (NPIU) (80.3%; n = 462). To measure this classification criterion the Internet-Related Experiences Questionnaire - IREQ (Beranuy et al., 2009) was used, in which a cut-off score of greater than or equal to 34 is considered an indication of PIU. The sample selection diagram is shown in Figure 1.

Variables and instruments

A series of self-reports and neuropsychological tests were used to measure problematic Internet use, frequency and type of use, alcohol and cannabis consumption, as well as the cognitive and academic performance of subjects. The instruments were chosen on the basis of their use in other similar studies conducted on addictive disorders (Carballo, García, Jáuregui, Marín & Pérez-Jover, 2011; Carballo et al., 2013) and on their ease of use when applied in a group format. The different types of variables assessed were as follows:

- *Sociodemographic variables*: Information was collected regarding the sex, age and school year of the participants.
- *Internet use*: An ad-hoc three-item questionnaire was used to measure the frequency of Internet use during the week and the number of hours spent online daily, as well as the preferred type of Internet use (social networks, study, online games, etc.).
- *Problematic Internet use*: This was assessed with the Internet-Related Experiences Questionnaire - IREQ (Beranuy et al., 2009), a 10-item self-administered questionnaire with a 4-point Likert-type response scale, based on DSM-IV-TR criteria for substance abuse and pathological gambling. The questionnaire addresses different aspects such as increased tolerance, negative effects arising from the problematic Internet use, reduction of activities, loss of control, avoidance, and desire to be online. Scores range from 0 to 40, with 34 or higher signaling problematic Internet use. The questionnaire has been shown to have an internal consistency of 0.77 in the Spanish sample (Beranuy et al., 2009).
- *Academic outcomes*: The average school mark was calculated on a scale from 0 to 10, as well as the number of subjects failed in the last year. Both data were reported by the students.
- *Variables related to cognitive performance*: A battery of neuropsychological instruments was used to measure perceptual acuity, attention span, verbal memory (immediate and delayed recall), verbal fluency, and abstract reasoning. The hits and errors of all tests were collected.
- *Perceptual acuity*: This was measured with the WAIS-III Symbol Search Subtest (Wechsler, 1995), in which participants have to identify the presence of certain symbols in a sequence of several elements. The test was applied for one minute.
- *Attention*: The Symbol Digit Modalities Test (SDMT) (Smith, 1982) was used. This test evaluates sustained attention and concentration, requiring complex visual scanning and visual tracking. It consists of indicating the numbers corresponding to each symbol (from one to nine) beneath it, in a list of randomly distributed symbols and following a certain order. Subjects had one minute and thirty seconds to complete the test.
- *Immediate and delayed verbal recall*: Immediate and delayed recall was assessed by using of a list of twelve standard words extracted from the Weschler Memory Scale (1945). A list of the words was read to the participants with an interval of two seconds between each word. They were then asked to write down those they remembered in two attempts, one immediately after hearing the list, and another five minutes later. Between the two attempts a distractor was introduced in the form of the SDMT.
- *Verbal fluency*: semantic fluency was assessed (Buriel, Casanova, Rodés, Fombuena & Böhm, 2004) with the spontaneous production of names of fruits and vegetables in one minute.
- *Abstract reasoning*: we used the DAT (Differential Aptitude Test) (Bennett, Seashore & Wesman, 2000), which consists of 32 items. The subjects were presented with a series of images ordered consecutively and logically and had to infer from the alternatives presented which would be the next one to follow in the sequence. A total of three minutes was provided to complete the test.

Procedure

After receiving the relevant permits from the Conselleria d'Educació of the Generalitat Valenciana (Education Department of the Regional Government of Valencia) and the heads of study of the schools, the questionnaires used in this cross-sectional descriptive study were administered in groups in the schools themselves during school hours. Student participation was subject to consent from parents or legal guardians, and was voluntary, anonymous and confidential. All neuropsychological and self-report tests were applied at the same time, in a single session of between 30-50 minutes. After being given a brief explanation of the aims of the study, the students responded to the instruments according to the instructions provided for the correct completion of the same. The study was approved by the Ethics and Research Commission of the Miguel Hernández University in Elche.

Data analysis

The data obtained were coded and analyzed using the statistical software IBM SPSS Statistics 20.0 for Windows. Descriptive analyses of means and frequencies were performed in order to detect and exclude those cases that did not meet the study's inclusion criteria, as well as to identify the sociodemographic profile of the participants (eg. sex), their use of the Internet (eg. days online) and academic performance (eg. average grade). Likewise, descriptive analyses were made to differentiate between those subjects with problematic Internet use (PIU) and those without (NPIU).

In order to study the frequency differences in non-continuous variables, the chi-square test was used, while for the analysis of mean differences in continuous variables a non-parametric (Mann-Whitney U) analysis was used for independent samples, since the variables did not fit the normal distribution. Effect size was found with the Rosenthal *r* (*r*) for comparisons between groups (Rosenthal, 1991), with the following value settings: 0.10 (small effect size), 0.30 (moderate effect size) and 0.50 (large effect size) (Ro-

senthal, 1991). The confidence level applied in these statistical tests was 95%. To minimize the type I error that can occur with multiple analyses, we used the Bonferroni correction for an alpha of 0.05 in groups of related variables.

Finally, for an in-depth analysis of the relationship between problematic Internet use and academic and cognitive performance, a hierarchical linear regression analysis was conducted. The variable problematic Internet use was used as a dummy control variable. Interaction terms were calculated using differential scores to control multicollinearity problems.

Results

First, we analyzed the sociodemographic differences between PIU and NPIU, applying the Bonferroni correction for the three sociodemographic variables analyzed, and obtaining an α of 0.0167 (0.05/3).

As in Table 1 shows, no statistically significant differences were found between the two groups in terms of sex, mean age or school year.

We also performed a differential analysis of the two variables related to academic performance across PIU and NPIU (Table 2). Again, the Bonferroni correction was performed for these variables, obtaining α = 0.025 (0.05/2). Statistically significant differences were found both in relation to the mean grades (z = -4.52, p = .0001) and to the number of subjects failed in the previous course (z = -2.47, p = .01). In this way, the group with problematic Internet use obtained a lower average grade (6.47 ± 1.42) than the NPIU group (7.23 ± 1.58), as well as a greater number of failed subjects (PIU = 1.22 ± 2.11; NPIU = 0.86 ± 2.12), although the size of the effect was small in both cases (r = 0.20 and r = 0.11, respectively).

Table 1. *Sociodemographic differences between PIU and NPIU*

	PIU (19.7%; *n*=113)	NPIU (80.3%; *n*=462)	X^2/*z(p)*
%(*n*) *Boys*	59.3 (67)	57.6 (262)	0.11 (.74)
Mean age	14.79 ± 0.86	14.63 ± 0.78	- 1.53 (.12)
%(*n*) *3rd year*	51.8 (58)	56.6 (256)	0.85 (.35)

Note. *Significant for α=0.0167 (Bonferroni correction)

Table 2. *Differences in academic outcomes (means) between PIU and NPIU*

	PIU	NPIU	*z(p)*	*r*
Grade[a]	6.47 ± 1.42	7.23 ± 1.58	- 4.52 (.0001)*	.20
Failed subjects[b]	1.22 ± 2.11	0.86 ± 2.12	- 2.47 (.01) *	.11

Note. *Significant for α=0.025 (Bonferroni correction)
[a]N = 521; PIU = 101; NPIU = 420
[b]N = 545; PIU = 107; NPIU = 438

Finally, we analyzed the differences between PIU and NPIU with regard to cognitive performance (Table 3). Mean differences in the number of hits and errors in attention span tests, perception, memory (immediate and delayed recall), verbal fluency, and abstract reasoning were evaluated. The α was 0.0042 (0.05/12) after performing the Bonferroni correction on these twelve variables.

As shown in Table 3, we found statistically significant differences between the two groups in relation to the success rate on the perceptual acuity test (z = -2.89, p = .0039), with the PIU group obtaining a higher number of hits (19.18 ± 5.41) than the NPIU group (17.55 ± 5.8). Likewise, differences were found in the error rate of the abstract reasoning test (z = -3.15, p = .002), with a higher rate in the PIU group (5.84 ± 4.00) compared to those with NPIU (4.45 ± 3.20). In both cases, the effect size was small (r = 0.12 and r = 0.13, respectively). No statistically significant differences were found in the hit and error rates of the other neuropsychological tests applied.

Table 3. *Differences in academic outcomes (means) between PIU and NPIU.*

	PIU (*n*=113)	NUPI (*n*=462)	*z* (p)	*r*
Perception				
Hits	19.18 ± 5.41	17.55 ± 5.80	-2.89 (.0039)*	.12
Errors	0.65 ± 1.14	0.69 ± 1.51	-0.36 (.71)	
Immediate recall				
Hits	6.57 ± 1.94	6.46 ± 2.11	-0.34 (.73)	
Errors	0.50 ± 0.84	0.51 ± 0.5	-0.06 (.94)	
Delayed recall				
Hits	5.73 ± 1.85	5.80 ± 2.01	- 0.27 (.78)	
Errors	0.67 ± 1.25	0.67 ± 2.07	- 1.11 (.26)	
Verbal fluency				
Hits	12.73 ± 2.80	12.34 ± 3.31	- 0.92 (.35)	
Errors	0.12 ± 0.38	0.15 ± 0.80	- 0.42 (.66)	
Attention				
Hits	32.65 ± 9.47	32.84 ± 8.55	-0.49 (.61)	
Errors	1.42 ± 8.39	2.55 ± 12.26	- 0.12 (.89)	
Abstract reasoning				
Hits	6.85 ± 3.29	6.69 ± 3.43	-0.62 (.53)	
Errors	5.84 ±4.00	4.45 ± 3.20	-3.15 (.002)*	.13

Note. *Significant for α=0.0042 (Bonferroni correction)

Finally, to eliminate any confounding bias that cognitive performance might have on academic performance, hierarchical linear regression analyses were performed in which those cognitive performance variables were incorporated as predictors of academic performance in which statistically significant differences were found.

In the first regression analysis (Table 4), stratified according to problematic or non-problematic Internet use, the existence of a positive and statistically significant association between the hit rate in the perceptual acuity test and average school grade ($p < .05$) was found in the NPIU group, as well as between the error rate in abstract reasoning and the number of failed subjects ($p < .01$). Likewise, a statistically significant negative association between the error rate in abstract reasoning and the average school grade ($p < .01$), and between the hit rate in perception and the number of failed subjects ($p < .05$) were observed. However, in the PIU group, the only statistically significant standardized coefficient was the errors in abstract reasoning variable, which again was negatively associated with average grades ($p < .05$).

Given the results obtained, a new regression model was run with the complete sample incorporating the interactions of each predictor with the problematic Internet use variable, which was also included as a predictor. As shown in Table 5, PIU as well as the perception hit rate and error rate in abstract reasoning are statistically significant predictors of the average grade, with PIU being the variable which explains the highest percentage of variance. Regarding the number of failed subjects, perceptual acuity and errors in abstract reasoning are the only statistically significant predictors, with each of these variables contributing only a small amount. Furthermore, in the interaction analysis, no evidence has been found that problematic Internet use moderates the association between cognitive performance and academic outcomes ($p > .05$).

Table 4. *Regression analysis of academic outcomes (mean grade and failed subjects) in relation to cognitive performance*

	Mean grade			Failed subjects		
Variables	**B (SE)**	**β**	**sr² (%)**	**B (SE)**	**β**	**sr² (%)**
NPIU						
Hits perception	.03 (.01)	.11*	1.17%	-.04 (.02)	-.11*	1.14%
Errors abstract reasoning	-.07 (-.03)	-.13**	1.72%	.11 (.03)	.16**	2.56%
PIU						
Hits perception	.04 (.03)	.15	2.31%	-.05 (.04)	-.15	2.19%
Errors abstract reasoning	-.08 (.04)	-.22*	4.54%	.07 (.05)	.13	1.64%

Note. B= non-standardized coefficient , SE= standard error, β=standardized coefficient, sr=semipartial
*p<.05,**p<.01

Discussion

The aim of this study was to analyze the relationship between the problematic use of the Internet and academic and cognitive performance of a sample of secondary school students. The results obtained showed worse academic outcomes of subjects with PIU, as well as statistically significant differences in the tests of perception and abstract reasoning between subjects with and without problematic Internet use.

First, students were divided into two groups according to their use of the Internet, with a 19.7% ($n = 113$) prevalence of PIU found in the sample assessed. While this figure is within the range found in international investigations (Aboujaoude, 2010; Kamal & Mosallem, 2013; Wang et al.,

Table 5. *Linear hierarchical regression for the analysis of the link between academic outcomes, cognitive performance and problematic Internet use*

Variables	**B (SE)**	**β**	**sr² (%)**	**B (SE)**	**β**	**sr² (%)**
Step 1						
Hits perception	.03 (.01)	.12**	1.30%	-.04 (.02)	-.12**	1.30%
Errors abstract reasoning	-.07 (-.02)	-.15**	2.05%	.10 (.03)	.15**	2.25%
PIU	-.70 (.18)	-.17**	2.89%	.25 (.23)	.05	0.20%
Step 2						
Hits perception	.03 (.01)	.11**	0.96%	-.04 (.02)	-.11**	0.94%
Errors abstract reasoning	-.07 (.02)	-.14**	1.39%	.11 (.03)	.17**	2.10%
PIU	-.70 (.18)	-.17**	2.76%	.29 (.24)	.05	0.27%
Perception*PIU	.01 (.03)	.01	0.01%	-.01 (.04)	-.02	0.02%
Abstract reasoning *PIU	-.02 (.05)	-.02	0.02%	-.04 (.06)	-.04	0.09%

Note. B= non-standardized coefficient , SE= standard error, β=standardized coefficient, sr=semipartial
*p<.05,**p<.01

2011), it is notable for being higher than that observed in other studies with the Spanish population (Carbonell et al., 2012). This discrepancy may be related to the increase in Internet access in recent years (Gómez, Rial, Braña & Varela, 2014), as well as to the different types of measures and diagnostic criteria used to evaluate PIU.

With reference to the hypotheses set out at the beginning of this study, it was suggested firstly that students with PIU would experience worse academic outcomes in terms of lower average grades and a greater number of failed subjects than the adolescents with NPIU. This hypothesis has been confirmed in its entirety for the sample assessed, the results being consistent with the findings of previous studies, in which a positive relationship between PIU and scholastic failure has been observed (Huang et al., 2009; Tsitsika et al., 2011; Stavropoulos et al., 2013).

Regarding the second hypothesis, it was thought that, in comparison with adolescents with NPIU, students with PIU would show worse cognitive performance in all the neuropsychological tests applied, measured in terms of higher rates of error and lower hit rates. This hypothesis has only been partially confirmed for the abstract reasoning test, where the PIU group scored a higher number of errors. This higher error rate, coupled with a similar hit rate to the NPIU group, would indicate a higher total response rate among adolescents with problematic use. A high response rate has been described as an indicator of greater impulsivity (Lozano & Pérez, 2012) and is frequently observed in studies with a substance-addicted population (De Wit, 2009). This result is furthermore consistent with previous evidence linking PIU to difficulties in impulse control and in the regulation of response inhibition circuits, with subjects experiencing this problem failing in the inhibition of unwanted actions and presenting worse impulse control than those without PIU (Dong et al., 2012, Dong, Zhou & Zhao, 2010, Li et al., 2014). In any case, these results merely indicate trends which should be analyzed in depth in future research.

With regard to the perceptual acuity test, it is interesting to note that the results illustrated a tendency running counter to the predicted hypothesis. Thus, it was found that the adolescents presenting PIU obtained higher hit rates in the perception test than the NPIU group. This improved perceptual performance in subjects with PIU could be due to greater exposure to and training with visual stimuli resulting from a more extensive use of the Internet and computers, as some previous studies have suggested (Castel, Pratt & Drummond, 2005; Green & Bavelier, 2003, 2007). However, it should be noted that the evidence relating to this aspect is still controversial (Murphy & Spencer, 2009; Park et al., 2011).

With the aim of minimizing biases in the results, and based on previous studies that link academic outcomes and cognitive performance (Stelzer & Cervigni, 2011), the association between both variables was assessed. Although significant associations were found between them, specifically in the case of average school grade, it is important to note that it was PIU that explained the greatest percentage of variance. Further studies are nevertheless needed to analyze these relationships in more depth.

Having presented these findings, however, it is necessary to point out that the results of this research should be treated with caution, since it is an exploratory study suffering from a series of limitations that need to be taken into account for future research.

Firstly, this is a descriptive, cross-sectional study and the results have therefore been analyzed and interpreted only in terms of the trends displayed by the variables of interest. Moreover, the small effect sizes yielded by the relationships found mean that the results shown should be interpreted with extreme caution.

Secondly, in relation to the measuring instruments used, it is worth emphasizing the limitations inherent in self-reports (eg. social desirability). It would be interesting here to be able to include sincerity scales that would make it possible to assess the validity of the responses of adolescents.

Similarly, with regard to the neuropsychological assessments, it is important to remember that performance in such tests could be influenced by other extraneous variables, such as, for example, previous training of subjects through the frequent playing of video games, or participation in psycho-pedagogical improvement programs, which commonly use some of the tasks applied in this study. In relation to these instruments it would also be advisable to redefine or improve their characteristics in order to establish specific tests that reliably assess cognitive abilities in this area, as has been achieved in the field of other addictive problems (Szczebak & Glisky, 2011).

Although extensive control of extraneous variables that might contaminate outcomes (eg. substance use) was carried out, future studies should consider the possible influence of other factors on cognitive performance, such as variables interfering at the time of the test (eg. anxiety state). It would likewise be of interest to include other comparison groups in the assessment of cognitive variables, such as non-students or adolescents with other addictive disorders or problems (eg. alcohol abuse). Furthermore, it would be advisable to consider longitudinal designs with broader samples that allow the analysis of how performance and PIU of adolescents develops, the assessment of the cognitive performance of subjects before they start using the Internet for the first time, as well as the analysis of relationships with variables such as impulsivity, time online or type of Internet use.

Despite these limitations, it is important to note that the results of this study provide new data in a field of research of growing interest but in which conclusive evidence has yet to be established. Also, unlike other studies in the area

of PIU which have focused on neuroimaging techniques, this paper presents comparative data from performance in neuropsychological tests, providing results on specific cognitive functions. In this way, the trends observed in this study may lead to the start of future lines of research that will allow us to deepen our knowledge of the consequences of PIU on cognitive abilities, as well as their implications in the neuropsychological development of subjects who initiate problematic use early on.

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Conflict of interests

The authors of this paper declare that they have no conflicts of interest.

References

Aboujaoude, E. (2010). Problematic Internet use: an overview. *World Psychiatry, 9*, 85–90. doi: 10.1002/j.2051-5545.2010.tb00278.x.

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders. Fifth edition.* Washington, DC: American Psychiatric Publishing.

Bauernhofer, K., Papousek, I., Fink, A., Unterrainer, H. F. & Weiss, E. M. (2015). Biological basis of problematic internet use (PIN) and therapeutic implications. *Neuropsychiatrie: Klinik, Diagnostik, Therapie Und Rehabilitation: Organ Der Gesellschaft Österreichischer Nervenärzte Und Psychiater, 29*, 157–162. doi:10.1007/s40211-015-0164-8.

Bennett, G. K., Seashore, H. G. & Wesman, A.G. (2000). *Test de Aptitudes Diferenciales (DAT-5). Manual.* Madrid: TEA Ediciones.

Beranuy, M., Chamarro, A., Graner, C. & Carbonell, X. (2009). Metodología: Validación de dos escalas breves para evaluar la adicción a Internet y el abuso de móvil. *Psicothema, 21*, 480–485.

Bertran, E. & Chamarro, A. (2016). Video gamers of League of Legends: The role of passion in abusive use and in performance. *Adicciones, 28*, 28-34. doi:10.20882/adicciones.787.

Brand, M., Young, K. S. & Laier, C. (2014). Prefrontal control and internet addiction: a theoretical model and review of neuropsychological and neuroimaging findings. *Frontiers in Human Neuroscience, 8*, 375. doi:10.3389/fnhum.2014.00375.

Buriel, Y., Casanova, J. P., Rodés, E., Fombuena, N. G. & Böhm, P. (2004). Fluencia verbal. Estudio normativo piloto en una muestra española de adultos jóvenes (20 a 49 años). *Neurología: Publicación oficial de la Sociedad Española de Neurología, 19*, 153-159.

Carballo, J.L., García, G., Jáuregui, V., Marín, M. & Pérez-Jover, V. (2011). Análisis longitudinal de diferencias en habilidades cognitivas entre estudiantes de bachillerato consumidores de alcohol de la provincia de Alicante. *Health and Addictions, 11*, 163-178.

Carballo, J.L., Marín, M., Jáuregui, V., Sánchez, G., Espada, J.P., Orgilés, M. & Piqueras, J.A. (2013). Consumo excesivo de alcohol y rendimiento cognitivo en estudiantes de secundaria de la provincia de Alicante. *Health and Addictions, 13*, 157-163.

Carbonell., X., (2014). La adicción a los videojuegos en el DSM-5. *Adicciones, 26*, 91-95. doi:10.20882/adicciones.10.

Carbonell, X., Fúster, H., Chamarro, A. & Oberst, U. (2012). Adicción a Internet y móvil: Una revisión de estudios empíricos españoles. *Papeles del Psicólogo, 33*, 82–89.

Castel, A. D., Pratt, J. & Drummond, E. (2005). The effects of action video game experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychologica, 119*, 217-230. doi:10.1016/j.actpsy.2005.02.004.

De Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: a review of underlying processes. *Addiction Biology, 14*, 22-31.

D'Hondt, F., Billieux, J. & Maurage, P. (2015). Electrophysiological correlates of problematic Internet use: Critical review and perspectives for future research. *Neuroscience and Biobehavioral Reviews, 59*, 64–82. doi:10.1016/j.neubiorev.2015.10.005.

Dong, G., Devito, E. E., Du, X. & Cui, Z. (2012). Impaired inhibitory control in "internet addiction disorder": a functional magnetic resonance imaging study. *Psychiatry Research, 203*, 153–158. doi:10.1016/j.pscychresns.2012.02.001.

Dong, G., Lin, X., Zhou, H. & Lu, Q. (2014). Cognitive flexibility in internet addicts: fMRI evidence from difficult-to-easy and easy-to-difficult switching situations. *Addictive Behaviors, 39*, 677–683. doi:10.1016/j.addbeh.2013.11.028.

Dong, G., Zhou, H. & Zhao, X. (2010). Impulse inhibition in people with Internet addiction disorder: electrophysiological evidence from a Go/NoGo study. *Neuroscience Letters, 485*, 138–142. doi:10.1016/j.neulet.2010.09.002.

Dong, G., Zhou, H. & Zhao, X. (2011). Male Internet addicts show impaired executive control ability: evidence from a color-word Stroop task. *Neuroscience Letters, 499*, 114–118. doi:10.1016/j.neulet.2011.05.047.

Geil, C. R., Hayes, D. M., McClain, J. A., Liput, D. J., Marshall, S. A., Chen, K. Y. & Nixon, K. (2014). Alcohol and adult hippocampal neurogenesis: Promiscuous drug, wanton effects. *Progress in Neuro-Psychopharmacol-*

ogy & Biological Psychiatry, 54, 103-113. doi:10.1016/j.pnpbp.2014.05.003.

Gómez, P., Rial, A., Braña, T. & Varela, J. (2014). Evaluation and early detection of problematic Internet use in adolescents. *Psicothema, 26*, 21–26.

Green, C. S. & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*, 534-537. doi:10.1038/nature01647.

Green, C. S. & Bavelier, D. (2007). Action-video-game experience alters the spatial resolution of vision. *Psychological Science, 18*, 88-94. doi:10.1111/j.1467-9280.2007.01853.x.

Herrera, M. F. Pacheco, M. P., Palomar, J., & Zavala, D. (2010). La adicción a Facebook relacionada con la baja autoestima, la depresión y la falta de habilidades sociales. *Psicología Iberoamericana, 18*, 6–18.

Huang, R. L., Lu, Z., Liu, J. J., You, Y. M., Pan, Z. Q., Wei, Z., … Wang, Z. Z. (2009). Features and Predictors of Problematic Internet Use in Chinese College Students. *Behaviour & Information Technology, 28*, 485-490.

Instituto Nacional de Estadística (INE) (2015). *Encuesta sobre equipamiento y uso de tecnologías de la información y comunicación en los hogares*. Madrid: Instituto Nacional de Estadística.

Jelenchick, L. A. & Christakis, D. A. (2014). Problematic Internet Use During Adolescence and Young Adulthood. *Adolescent Medicine: State of the Art Reviews, 25*, 605–620.

Kamal, N. N. & Mosallem, F. A. E. H. (2013). Determinants of problematic internet use among el-minia high school students, Egypt. *International Journal of Preventive Medicine, 4*, 1429-1437.

Li, B., Friston, K. J., Liu, J., Liu, Y., Zhang, G., Cao, F., … Hu, D. (2014). Impaired frontal-basal ganglia connectivity in adolescents with internet addiction. *Scientific Reports, 4*, 5027. doi:10.1038/srep05027.

Li, W., O'Brien, J.E., Snyder, S.M. & Howard, M.O. (2016). Diagnostic Criteria for Problematic Internet Use among U.S. University Students: A Mixed-Methods Evaluation. *PLoS ONE, 11*, e0145981. doi:10.1371/journal.pone.0145981.

Lozano, J.H. & Pérez, M.A. (2012). Impulsivity, Intelligence and Discriminating Reinforcement Contingencies in a Fixed-Ratio 3 Schedule. *The Spanish Journal of Psychology, 15*, 922-929. doi:10.5209/rev_SJOP.2012.v15.n3.39384.

Ministerio de Sanidad, Servicios sociales e Igualdad (2013). *Encuesta estatal sobre uso de drogas en Educación Secundaria. ESTUDES 2012-2013*. Madrid: Delegación del Gobierno para el Plan Nacional sobre Drogas. Retrieved at http://www.pnsd.msc.es/Categoria2/observa/pdf/PresentESTUDES2012_2013.pdf.

Murphy, K. & Spencer, A. (2009). Playing video games does not make for better visual attention skills. *Journal of Articles in Support of the Null Hypothesis, 6*, 1–20.

National Institute on Alcohol Abuse and Alcoholism (2004). Council Approves Definition of Binge Drinking. *NIAAA Newsletter, Winter 3*, 1-4.

Nie, J., Zhang, W. & Liu, Y. (2017). Exploring depression, self-esteem and verbal fluency with different degrees of internet addiction among Chinese college students. *Comprehensive Psychiatry, 72*, 114-120. doi:10.1016/j.comppsych.2016.10.006.

Parada, M., Corral, M., Mota, N., Crego, A., Rodriguez Holguin, S. & Cadaveira, F. (2012). Executive functioning and alcohol binge drinking in university students. *Addictive Behaviors, 37*, 167-172.

Park, M. H., Park, E. J., Choi, J., Chai, S., Lee, J. H., Lee, C. & Kim, D. J. (2011). Preliminary study of Internet addiction and cognitive function in adolescents based on IQ tests. *Psychiatry Research, 190*, 275-81. doi:10.1016/j.psychres.2011.08.006.

Rial, A., Gómez, P., Isorna, M., Araujo, M. & Varela, J. (2015). EUPI-a: Escala de Uso Problemático de Internet en adolescentes. Desarrollo y validación psicométrica. *Adicciones, 27*, 47. doi:10.20882/adicciones.193.

Rosenthal, R. (1991). *Meta-analytic procedures for social research (2nd ed.)*. Newbury Park, CA: Sage.

Rücker, J., Akre, C., Berchtold, A. & Suris, J. C. (2015). Problematic Internet use is associated with substance use in young adolescents. *Acta Paediatrica, 104*, 504–507. doi:10.1111/apa.12971.

Secades-Villa, R., Calafat, A., Fernández-Hermida, J. R., Juan, M., Duch, M., Skärstand, E., ... Talic, S. (2014). Tiempo de uso de Internet y efectos psicosociales adversos en adolescentes europeos. *Adicciones, 26*, 247–253. doi: 10.20882/adicciones.6.

Shrivastava, A., Johnston, M. & Tsuang, M. (2011). Cannabis use and cognitive dysfunction. *Indian Journal of Psychiatry, 53*, 187-191. doi:10.4103/0019-5545.86796.

Smith, A. (1982). *Symbol Digit Modalities Test (SDMT). Manual (revisado)*. Los Angeles: Western Psychological Services.

Starcevic, V. (2010). Problematic Internet use: a distinct disorder, a manifestation of an underlying psychopathology, or a troublesome behaviour? *World Psychiatry, 9*, 92–93.

Stavropoulos, V., Alexandraki, K. & Motti-Stefanidi, F. (2013). Recognizing internet addiction: prevalence and relationship to academic achievement in adolescents enrolled in urban and rural Greek high schools. *Journal of Adolescence, 36*, 565-576. doi:10.1016/j.adolescence.2013.03.008.

Stelzer, F. & Cervigni, M. A. (2011). Desempeño académico y funciones ejecutivas en infancia y adolescencia. Una revision de la literatura. *Revista de Investigación en Educación, 9*, 148-156.

Szczebak, M. & Glisky, M. (2011). The Repeatable Battery for the Assessment of Neuropsychological Status

(RBANS) in Assessing Cognitive Deficits in Chronic Heavy Alcohol Consumers. *Archives of Clinical Neuropsychology, 26*, 494-494.

Tsitsika, A., Critselis, E., Louizou, A., Janikian, M., Freskou, A., Marangou, E., … Kafetzis, D. A. (2011). Determinants of Internet Addiction among Adolescents: A Case-Control Study. *The Scientific World Journal*, *11*, 866-874. doi:10.1100/tsw.2011.85

Wang, H., Zhou, X., Lu, C., Wu, J., Deng, X. & Hong, L. (2011). Problematic Internet Use in High School Students in Guangdong Province, China. *PLoS ONE*, *6*, e19660. doi:10.1371/journal.pone.0019660.

Weschler, D. (1945). A standardized memory scale for clinical use. *Journal of Psychology, 19,* 87-95.

Wechsler, D. (1995). *Escala de Inteligencia de Wechsler para Adultos (WAIS).* Madrid: Tea Ediciones, S.A.

Yuan, K., Yu, D., Cai, C., Feng, D., Li, Y., Bi, Y., … Tian, J. (2016). Frontostriatal circuits, resting state functional connectivity and cognitive control in Internet gaming disorder. *Addiction Biology*. Avance de publicación on-line. doi:10.1111/adb.12348.

Zhang, J. T., Ma, S. S., Yip, S. W., Wang, L. J., Chen, C., Yan, C. G., … Fang, X. Y. (2015). Decreased functional connectivity between ventral tegmental area and nucleus accumbens in Internet gaming disorder: evidence from resting state functional magnetic resonance imaging. *Behavioral and Brain Functions: BBF*, *11*, 37. doi:10.1186/s12993-015-0082-8.