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Heritability of compulsive Internet use in adolescents

Jacqueline M. Vink, Toos C. E. M. van Beijsterveldt, Charlotte Huppertz, Meike Bartels & Dorret I. Boomsma

Department of Biological Psychology/Netherlands Twin Register, VU University, The Netherlands

ABSTRACT

Over the past decades, Internet use has grown substantially, and it now serves people as a supportive tool that is used regularly and—in large parts of the world—inevitably. Some people develop problematic Internet use, which may lead to addictive behavior and it is becoming important to explore the risk factors for compulsive Internet use. Data were analyzed on compulsive Internet use [with the Compulsive Internet Use Scale (CIUS)] from 5247 monozygotic (MZ) and dizygotic (DZ) adolescent twins registered with the Netherlands Twin Register. The participants form a sample that is informative for genetic analyses, allowing the investigation of the causes of individual differences in compulsive Internet use. The internal consistency of the instrument was high and the 1.6-year test–retest correlation in a subsample ($n = 902$) was 0.55. CIUS scores increased slightly with age. Remarkably, gender did not explain variation in CIUS scores, as mean scores on the CIUS were the same in boys and girls. However, the time spent on specific Internet activities differed: boys spent more time on gaming, whereas girls spent more time on social network sites and chatting. The heritability estimates were the same for boys and girls: 48 percent of the individual differences in CIUS score were influenced by genetic factors. The remaining variance (52 percent) was due to environmental influences that were not shared between family members. Because a life without Internet is almost impossible nowadays, it is important to further explore the determinants of compulsive Internet use, including genetic risk factors.

Keywords Addictive behavior, adolescents, compulsive Internet use, heritability, Internet addiction.

Correspondence to: Jacqueline Vink, Department of Biological Psychology, VU University, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands. E-mail: jm.vink@vu.nl

INTRODUCTION

The advent of computers and the Internet has led to a series of changes and developments that affect most individuals in large parts of the world. The number of Internet users has grown substantially. In a report about world Internet usage in 2012, the population in North America had the highest Internet use (78.6 percent of the population), followed by Australia (67.6 percent) and Europe (63.2 percent). In other parts of the world, the percentage of Internet users was considerably lower (Internet-World-Stats 2012), but this is changing rapidly. The prevalence of daily Internet use in the Netherlands is high compared with other European countries. According to statistics of Eurostat (the statistical office of the European Union collecting data on Internet use through European ICT surveys), the prevalence of daily Internet use was almost 80 percent in the Netherlands in 2011 (Eurostats 2011). The percentage of regular Internet users tended to be highest among 16–24 year olds (91 percent) and lowest among 55–74 year olds (40 percent) (van Deursen & van Dijk 2011). At all ages, differences between men and women were relatively small, but slightly more men than women used the Internet regularly (Seybert 2011). Generally, the Internet appears to serve people as a supportive tool, but there is also a group of individuals who develop problematic Internet use, which may lead to addictive behavior. Different terms for this behavior are used in the literature, varying from pathological Internet use, Internet addiction and Internet dependence to compulsive Internet use (Christakis 2010; Carli *et al.* 2013; Kuss *et al.* 2014).

Growing evidence suggests that behavioral addictions, including compulsive Internet use, resemble substance addictions in many domains, including natural history, phenomenology, tolerance, co-morbidity, neurobiological mechanisms and response to treatment (Grant *et al.* 2010). Key components of addiction include pre-occupation with the substance or behavior; repeated unsuccessful attempts to reduce use; mood disturbances related to reduction attempts; greater usage than anticipated or desired; jeopardizing employment, relationships or education; or lying about usage. All of these criteria can be observed with respect to Internet use (Christakis 2010; Kuss *et al.* 2013).

Twin studies have shown that the heritability of substance use and addiction is moderate to high (Li *et al.* 2003; Kendler *et al.* 2008; Verweij *et al.* 2010), so given that Internet addiction shows similarities to substance addiction, this trait might also be heritable. A Chinese twin study found that genetic factors explained 58 percent (girls) to 66 percent (boys) of the variance in problematic Internet use (Li *et al.* 2014).

While the debate is still ongoing as to whether the condition called 'Internet addiction' could be fully recognized as an established disorder, Internet gaming addiction has been proposed for inclusion in the DSM-V as a behavioral addiction. It is now listed in the appendix of the DSM-V instead, stipulating that more research is required before this diagnosis can be incorporated (Holden 2010). An important factor might be the lack of universal diagnostic criteria for Internet (gaming) addiction (Carli *et al.* 2013). A systematic review among studies published after 2000 with a minimum of 1000 participants concluded that no gold standard for the classification of Internet addiction exists as 21 different assessment instruments were identified in 68 epidemiological studies (Kuss *et al.* 2014). International estimates for the prevalence of Internet addiction vary widely, ranging from 1 to 27 percent (Christakis 2010; Kuss *et al.* 2014)—but because of the different definitions, these estimates must be interpreted with caution (Weinstein & Lejoyeux 2010).

In the Netherlands, the Compulsive Internet Use Scale (CIUS) has been validated (Meerkerk *et al.* 2009). This scale contains 14 items and covers 5 typical symptoms of compulsive Internet use: loss of control, pre-occupation, withdrawal symptoms, coping or mood modification, and conflict. The CIUS does not include an item on tolerance (Kuss *et al.* 2013). Tolerance denotes the requirement to increase the amount of engagement in the addictive behavior to produce an experience similar to initial behavior engagement. Over time, the individual needs to increase their time or the intensity of being online to feel the same pleasurable effects. Meerkerk *et al.* stated in a qualitative study that this component did not appear to be an integral characteristic of compulsive Internet use (Meerkerk *et al.* 2009), but Kuss *et al.* recommended to add an item assessing tolerance to the CIUS (Kuss *et al.* 2013). The CIUS shows good factorial stability across time and across different samples and high internal consistency (Meerkerk *et al.* 2009).

Data were collected using the CIUS in 5247 monozygotic (MZ) and dizygotic (DZ) adolescent twins registered with the Netherlands Twin Register (NTR). Because MZ and DZ twins differ in their genetic relatedness, they form a sample that is informative for genetic analyses, allowing the investigation of the extent to which individual differences in the vulnerability to compulsive Internet use are influenced by genetic factors. If individual differences for compulsive Internet use cluster within families (in other words, if family members resemble each other more than unrelated individuals), the twin design allows for a distinction between genetic factors and common environmental factors shared by family members in explaining the familial resemblance. This 'experiment of nature' (Martin, Boomsma & Machin 1997; Boomsma 2013) is based on the fact that MZ twins share (nearly) all their genetic material, whereas DZ twins share, on average, 50 percent of their segregating genes, while both types of twins share their family environment, including the prenatal environment. Including twin pairs of opposite sex offers the opportunity to test for qualitative (different genes in men and women) sex differences (Vink *et al.* 2012) in the genetic architecture of compulsive Internet use. This is the first study investigating the heritability of compulsive Internet use in a Caucasian sample.

MATERIALS AND METHODS

Subjects

Participants are part of the NTR, established around 1987 at the VU University in Amsterdam. Young twins are registered at the NTR at birth by their parents. In childhood, their parents (and teachers) complete surveys about the twins' behavior and development. Around age 14 and 16, the adolescent twins complete a self-report survey, after consent has been obtained from their parents. The data collection protocol was approved by the Medical Research Ethics Committee of the VU University Medical Centre. Recruitment and participation rates have been described recently (van Beijsterveldt *et al.* 2013). Since 2011, the Compulsive Internet Use Scale (CIUS) is included in the surveys that are sent to adolescent twins. CIUS data were available for 5278 twins. Subjects older than 18 years ($n = 7$ individuals) and twins with missing information on zygosity ($n = 34$ individuals) were excluded. In the final dataset, CIUS data were available for 5247 twins (60.1 percent female). The twins were born between 1993 and 1998. Mean age was 15.6 [standard deviation (SD) 1.33], and age ranged from 13 to 18. The sample included 689 monozygotic male (MZM) twins

(272 complete pairs), 680 dizygotic male (DZM) twins (244 complete pairs), 1115 monozygotic female (MZF) twins (458 complete pairs), 1032 dizygotic female (DZF) twins (386 complete pairs) and 1731 dizygotic twins from opposite-sex pairs (DOS) (592 complete pairs). The sample is population based, with 27.3 percent of the mothers and 29.4 percent of the fathers of the twins having a lower education level; 42.9 percent of the mothers and 33.7 percent of the fathers a middle education level, and 28.8 and 36.9 percent having a higher education level. If we take the highest educational level within a family (both educational level of father and mother), then 16.2 percent of the families had a low educational level, 45.3 percent a middle educational level and 38.5 percent a high educational level. Of the 5247 subjects with complete data, 902 completed the CIUS twice (at age 14 and 16). When subjects participated twice, the first CIUS was selected for genetic analyses. Both data points were used to estimate the test–retest correlation.

Assessment of Internet use

Compulsive Internet use was measured with the CIUS, which has been developed and validated in the Netherlands (Meerkerk *et al.* 2009). The CIUS consists of 14 items, covering five typical symptoms of CIU: loss of control, pre-occupation, withdrawal symptoms, coping or mood modification, and conflict. Each item can be answered on a 5-point Likert scale, ranging from 'never' to 'very often' (Meerkerk *et al.* 2009). We will explore the internal consistency (with Cronbach's alpha) and stability over time. Although compulsive Internet use is not an all or nothing phenomenon, but may exist in a variety of severities, a cut-off point of > 28 is specified to dichotomize respondents into compulsive and non-compulsive Internet users (Meerkerk *et al.* 2009). The authors reasoned that for Internet use to be called compulsive, the behavior specified in the 14 items of the CIUS should play an important role in the life of the Internet user. This should be the case when the behavior occurs, on average, more than 'sometimes', which implicates a cut-off score of 14 items × 2 ('sometimes') > 28.

If one, two or three items were missing, the mean score of the other items was calculated and multiplied by 14. If more than three items were missing, the CIUS was changed to missing.

In addition, twins were asked how many hours they spent on the computer/Internet, watching YouTube, gaming, visiting social media sites/chatting/skyping, watching television/DVD/video on a typical day. Answer categories on these questions were 'never', less than 1 hour, 1–2 hours, 3–4 hours, 5–6 hours, 7–8 hours and more than 8 hours a day.

Statistical method

The influence of genetic factors on compulsive Internet use was estimated by genetic structural equation modeling of the data collected in MZ (genetically identical) and DZ twin pairs (Boomsma 2013). We estimated heritability based on covariances, but correlations in MZ and DZ pairs offered a first impression of the etiology of individual differences in CIUS. If both MZ and DZ correlations are larger than zero, there is significant familial resemblance. If the correlation in MZ twin pairs is larger than in DZ twin pairs, additive genetic factors (A) are expected to play a role. When the DZ correlation is more than half the MZ correlation, there is evidence for common environmental influences shared by family members (common environment, C), but when the DZ correlation is less than half the MZ correlation, there is evidence for non-additive genetic effects (genetic dominance, D) (Falconer & Mackay 1996). Dominance genetic effects are due to the interaction of alleles at a particular locus. DZ twins share 50 percent of their additive genetic variance and 25 percent of the dominant genetic variance. MZ twins share the totality of both the additive and the dominant genetic variances (Falconer & Mackay 1996). The differences in CIUS scores within MZ twin pairs must be due to unique environmental influences (E).

Twin correlations were estimated conditional on sex (see Vink *et al.* 2012) in a so-called saturated model, which included 10 parameters: the correlations between within MZ male pairs, DZ male pairs, MZ female pairs, DZ female pairs and DZ opposite-sex twin pairs, the mean CIUS score, a regression coefficient for fixed effects of age and sex (0 = female, 1 = male) on the CIUS score (i.e. CIUS score = intercept + ß1 × sex + ß2 × age), and the SDs for males and females. We tested whether the SDs were the same for male and female participants (model 2) and if there were significant effects of sex (model 3) and age (model 4) on the CIUS. Next, we tested if the correlations of male and female MZ twin pairs ($r_{MZM} = r_{MZF}$) and the correlations in dizygotic twin pairs could be constrained to be equal ($r_{DZM} = r_{DZF} = r_{DOS}$) (model 5).

Guided by the results from the saturated model, especially the pattern of twin correlations, a decomposition of the total variance into an ADE model was chosen. An ADE model includes three of the components described above: additive genetic factors (A), genetic dominance (D) and unique environmental factors (E), (Falconer & Mackay 1996). Given that for compulsive Internet use the DZ correlations are less than twice the MZ correlations, the shared environment was not included in the model.

All data were included in the analyses (i.e. from complete and incomplete twin pairs), and raw-data maximum likelihood estimating as implemented in Mx (Neale *et al.* 2006) was used to fit the saturated and the genetic models to the data. Testing of submodels was carried out by likelihood-ratio test, by subtracting the negative log-likelihood (−2LL) for the more restricted model from the −2LL of the more general model. This yields a statistic that is distributed as a chi-square with degrees of freedom equal to the difference in the number of parameters in the two models. If the chi-square test yields a *P*-value higher than the *P*-value threshold of 0.05, the constrained model is kept as the most parsimonious.

RESULTS

The CIUS score in our total sample of twins aged between 12 and 18 ranged between 0 and 51, with a mean of 10.45 (SD 8.76). The prevalence of the individual items can be found in Supporting Information Table S1. The Cronbach's alpha was 0.91, which indicated a high level of internal consistency. For the subsample of 902 twins who completed the CIUS twice, the correlation between the two timepoints was 0.55 (mean time difference between the two surveys was 1.6 years). In our sample, 4 percent of the adolescents has a CIUS score above 28 and can therefore be considered as compulsive Internet users. The mean CIUS score was 10.54 (SD 8.76) at an age of 16 years and varied from 9.34 at age 12 to 11.41 for 18 year olds ($ß_2 = 0.30$, so an increase of 0.30 point per year). We did not observe significant sex differences in CIUS score. CIUS score significantly increased with age.

Although the mean CIUS was the same for boys and girls, the activities boys and girls were involved in differed. Figure 1 shows that boys spend more time on gaming compared with girls, especially the compulsive Internet users. The time spend on YouTube is comparable for boys and girls with a CIUS below 29 (Fig. 2). Girls with a high CIUS tend to spend more time on YouTube than boys with a high CIUS. All girls seem to spend more time on social network sites or chatting compared with boys (Fig. 3). Girls with a high CIUS tend to spend more time on the computer than boys with a high CIUS (Fig. 4). For time spend on watching television, the differences between compulsive Internet users and non-compulsive Internet users seem rather small in boys. The girls with CIUS scores above 28 seem to spend more time in front of the television than girls with a CIUS below 29 (Fig. 5).

The correlations among the MZ twin pairs and the correlations among the DZ twin pairs did not significantly differ as a function of sex. The MZ correlation of 0.49 is quite high and substantially larger than the DZ correlation of 0.21 (Table 1). This pattern of correlations indicated that there were no shared environmental influences, and an ADE model was fitted to the data, including genetic non-additivity (D). The D-component could be dropped without a significant deterioration of the model

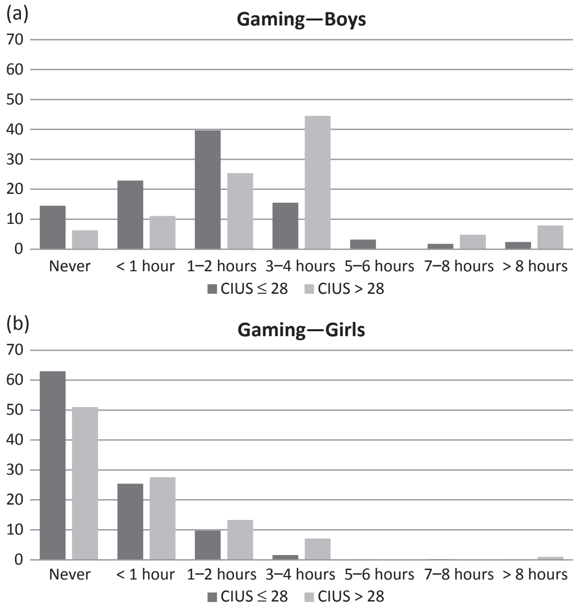

Figure 1 (a) Time (hours/day) spent on gaming, split in boys with a Compulsive Internet Use Scale (CIUS) ≤ 28 (n = 1744) and boys with a CIUS > 28 (n = 63). (b) Time (hours/day) spent on gaming, split in girls with a CIUS ≤ 28 (n = 2601) and girls with a CIUS > 28 (n = 98)

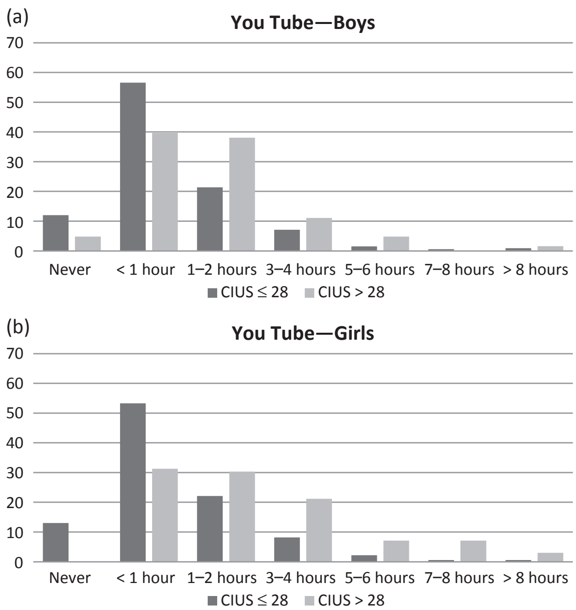

Figure 2 (a) Time (hours/day) spent on YouTube, split in boys with a Compulsive Internet Use Scale (CIUS) ≤ 28 (n = 1733) and boys with a CIUS > 28 (n = 62). (b) Time (hours/day) spent on YouTube, split in girls with a CIUS ≤ 28 (n = 2594) and girls with a CIUS > 28 (n = 100)

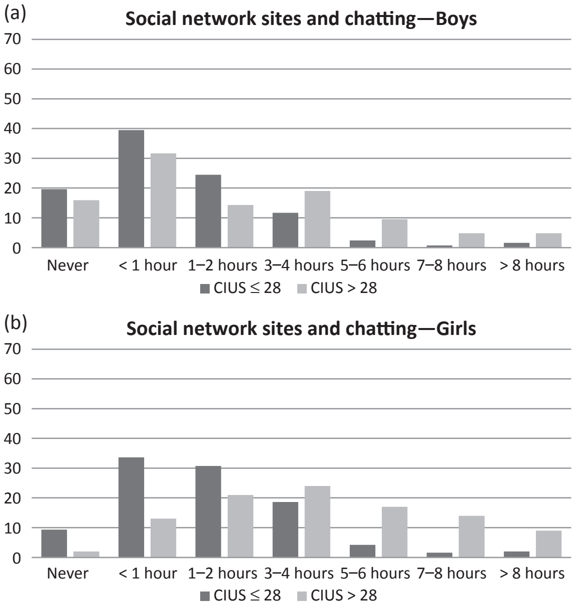

Figure 3 (a) Time (hours/day) spent on social network sites, chatting and skyping, split for boys with a Compulsive Internet Use Scale (CIUS) ≤ 28 ($n = 1731$) and boys with a CIUS > 28 ($n = 63$). (b) Time (hours/day) spent on social network sites, chatting and skyping, split for girls with a CIUS ≤ 28 ($n = 2592$) and girls with a CIUS > 28 ($n = 100$)

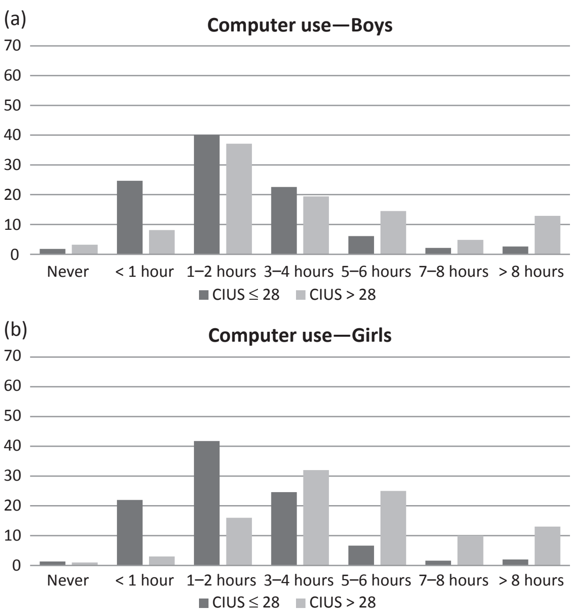

Figure 4 (a) Time (hours/day) spent on computer/Internet, split for boys with a Compulsive Internet Use Scale (CIUS) ≤ 28 ($n = 1744$) and boys with a CIUS > 28 ($n = 63$). (b) Time (hours/day) spent computer/Internet, split for girls with a CIUS ≤ 28 ($n = 2601$) and girls with a CIUS > 28 ($n = 98$)

($P = 0.180$). The heritability of individual differences in CIUS score was 48 percent, whereas the remaining variance (52 percent) was due to unique environmental influences (Table 2).

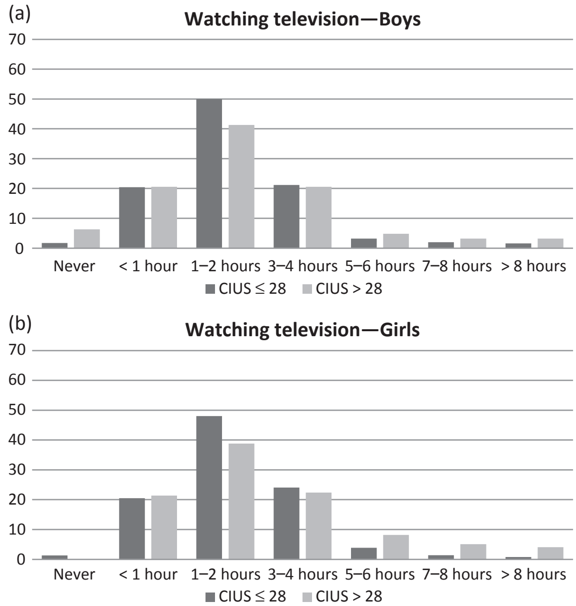

Figure 5 (a) Time (hours/day) spent on watching television/DVD/video, split for boys with a CIUS ≤ 28 ($n = 1743$) and boys with a CIUS > 28 ($n = 63$). (b) Time (hours/day) spent on watching television/DVD/video, split for girls with a CIUS ≤ 28 ($n = 2598$) and girls with a CIUS > 28 ($n = 98$)

DISCUSSION

This is the first study exploring the heritability of compulsive Internet use in a Caucasian sample. Data were available from a large population-based adolescent twin sample from the NTR. Individual differences in compulsive Internet use were due to genetic factors (48 percent) and unique environmental factors (52 percent). No contribution of shared environmental influences (such as socio-economic background of the family, parenting style or neighborhood characteristics) was observed.

Although the mean CIUS was the same for boys and girls, the activities they were involved in differed. Boys spent more time on gaming compared with girls. This is in line with a Taiwanese study reporting that subjects who played online games were predominantly male. Gender differences were also found in the severity of online gaming addiction and motives for playing (Ko *et al*. 2005). Girls are more likely to have an online profile on a social network site (Pujazon-Zazik & Park 2010), which is in our study reflected by girls spending more time on social network sites and/or chatting.

The heritability estimates for compulsive Internet use (the proportion of variance explained by genetic factors) were the same for boys and girls. We did not find quantitative of qualitative sex differences, indicating that the relative contribution of genetic factors on compulsive

Table 1 Model fit parameters from a full model (model 1) which included 10 parameters: intercept, standard deviation for males and females, a regression coefficient for age and sex (0 = female, 1 = male) on CIUS score, and the correlations between: monozygotic male (MZM) twin pairs, dizygotic male (DZM) twin pairs, monozygotic female (MZF) twin pairs, dizygotic female (DZF) twin pairs, dizygotic opposite sex (DOS) twin pairs.

	−2LL	*d.f.*	*versus*	*Δd.f.*	χ^2	P
1. Saturated model	37 408.512	5237				
2. as 1, standard deviation males = females	37 410.574	5238	1	1	2.062	
3. as 2, and no sex effect on mean	37 411.992	5239	2	1	1.417	0.234
4. as 3, and no age effect on mean	37 421.349	5240	3	1	10.774	0.005
5. as 3, and r (MZM) = r (MZF), r (DZM) = r (DZF) = r (DOS)	**37 421.644**	**5243**	**3**	**3**	**0.652**	**0.884**

Best model is printed in bold. −2LL = −2 log likelihood; d.f. = degrees of freedom; versus = model is tested versus more general model; χ^2 = difference in −2LL (by subtracting the −2LL for the more restricted model from the −2LL of the more general model); *P* = *P*-value for χ^2 (if the test yields a *P*-value higher than the *P*-value threshold of 0.05, the constrained model is kept as the most parsimonious one).

Table 2 Parameter estimates from twin model. Full model = parameter estimates in the fully saturated model (model 1), and best model = estimates in the most parsimonious model (model 5). ADE model.

	Full model	*Best Model*
Saturated model		
r (MZM) (95 percent CI)	0.45 (0.36–0.55)	0.49 (0.44–0.54)
r (MZF)(95 percent CI)	0.51 (0.44–0.56)	
r (DZM)(95 percent CI)	0.20 (0.07–0.31)	0.21 (0.15–0.26)
r (DZF) (95 percent CI)	0.21 (0.12–0.30)	
r (DOS) (95 percent CI)	0.21 (0.13–0.28)	
$ß_1$ (effect of sex on CIUS)	0.31	–
$ß_2$ (effect of age on CIUS)	0.30	0.30
CIUS[a] males age 16	10.76	10.54[a]
CIUS[a] females at age 16	10.45	
Standard deviation males	8.61	8.76
Standard deviation females	8.86	
Genetic model (ADE) model		
Proportion of variance explained by Additive genetic factors (95 percent CI)	0.33 (0.32–0.50)	0.48 (0.43–0.52)
Proportion of variance explained by Dominant genetic factors (95 percent CI)	0.16 (0.16–0.16)	–
Proportion of variance explained by Environmental factors (95 percent CI)	0.51 (0.46–0.56)	0.52 (0.48–0.57)

[a]CIUS score = intercept + $ß_1$ × sex + $ß_2$ × age. CI = confidence interval; CIUS = Compulsive Internet Use Scale; DOS = dizygotic twins from opposite-sex pairs; DZF = dizygotic female; DZM = dizygotic male; MZF = monozygotic female; MZM = monozygotic male.

Internet use is equal in boys and girls (quantitative) and that the same set of genetic factors is involved (qualitative). A Chinese study did report quantitative sex differences with a higher heritability for boys (66 percent) compared with girls (58 percent) (Li *et al.* 2014). One possible explanation that is mentioned by the authors is that social norms restricted girls' genetic propensities to expression (Li *et al.* 2014). Because we did not observe heritability differences between boys and girls in our sample, this might be due to cultural differences between the Netherlands and China.

As growing evidence suggests that behavioral addictions including compulsive Internet use resemble substance addictions in many domains and often co-occur (Grant *et al.* 2010; Lee *et al.* 2013), we expected heritability estimates for compulsive Internet use to be comparable to the heritability of substance addiction. Our results (moderate heritability and no sex differences) are in line with heritability studies of addictive behavior based on substance use in Dutch samples (Vink, Willemsen & Boomsma 2005; Distel *et al.* 2011; Geels *et al.* 2012). A next step should be to investigate the amount of genetic overlap between substance addiction and compulsive Internet use based on twin-family data.

If there is overlap in genetic factors, the currently known substance addiction genes might be good candidate genes for compulsive Internet use. A few studies already investigated genes associated with substance use as candidate genes for Internet use. In a group of Korean excessive Internet video game players ($n = 79$ adolescent males) and matched controls ($n = 75$ adolescent males), the excessive video game players had an increased prevalence of DRD2 Tag1A1 and COMT risk alleles. The DRD2 Taq 1A1 allele was specifically associated with reward dependence in the excessive game players (Han *et al.* 2007). A Korean study in males ($n = 91$ cases and 75 controls) showed that excessive Internet users had higher frequencies of the short allelic variant of the serotonin transporter gene (*SS-5HTTLPR*) compared with the controls (Lee *et al.* 2008). In 132 German participants with problematic Internet use and 132 matched controls, it was shown that a polymorphism (rs1044396) in the neuronal acetylcholine receptor subunit alpha-4 (*CHRNA4*) gene occurred significantly more often in the case group. This effect was driven by female participants (Montag *et al.* 2012).

The candidate genes in the studies described above (*DRD2*, *COMT*, *5HTTLPR*, *CHRNA4*) were associated with substance use and substance addiction in previous studies (Breitling *et al.* 2009; Foll *et al.* 2009; Tammimäki & Männistö 2010; Han *et al.* 2011; Yang *et al.* 2013), suggesting that behavioral addiction like compulsive Internet use might be influenced by (partly) the same risk genes as addiction to substances. However, significant associations that are derived from small candidate gene studies need to be replicated and usually such studies are underpowered and suffer from non-replication and inconsistent direction of effects (Duncan & Keller 2011; Flint & Munafò 2013). Future studies should focus on finding relevant genes not only by carrying out candidate gene studies but also by doing genome-wide association (GWA) studies. GWA studies are not based on specific hypotheses and can therefore reveal novel genes.

In line with a Chinese study (Li *et al.* 2014), we did not observe an influence of family environment on compulsive Internet use, as might be expected if such factors would influence all children in the family in a similar manner. This does not need be the case, however. An increasing body of behavioral genetic research suggests that a substantive part of individual differences in the way adolescents evaluate family functioning can be accounted for by genetic factors (e.g. Neiderhiser *et al.* 1998; Jacobson & Rowe 1999; Herndon *et al.* 2005; Van der Aa *et al.* 2010). Some previous studies in adolescents from East-Asia suggested that factors such as low family monitoring, high family conflict and lower family function all contributed to Internet addiction (Yen *et al.* 2007; Park, Kim & Cho 2008). However, the amount of Internet use is changing rapidly. The East-Asia studies were published in 2007/2008 (so data were collected before 2007), whereas the Dutch data were collected between 2011 and 2013. The fact that we did not observe any influence of family environment on compulsive Internet use in the Netherlands might be due to the fact that Internet is nowadays widely available. It is no longer restricted to a shared family computer at home, but most adolescents have their own computers, mobile phones or tablets, and free Internet is widely available throughout public places.

The significance of the Internet has changed over the last decades from being a work-related tool for certain groups to something that most people use for many activities on a daily basis: from bank transactions, to email-contact, social media, making reservations, looking for information, etc. The Internet has both positive and negative effects. Many people have more social contacts due to the use of Internet (without geographical limitations), but there is a decline in face-to-face contacts. A recent study showed that those who tended to use more media (especially Internet and television) also tended to be more depressed (Block *et al.* 2014). It is therefore important to further investigate individual risk factors for compulsive Internet use. Policy makers and counselors interested in reducing compulsive Internet use should be aware that shared family environment is probably not important, and liability to compulsive Internet use is largely driven by genetic factors.

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Authors Contribution

CH and TCEMB were responsible for data collection. MB and DIB supervised the data collection. TCEMB prepared the dataset and assisted with analyses. JMV carried out the analyses and drafted the manuscript. DIB assisted with writing and interpretation of findings. All authors critically reviewed content and approved final version of the manuscript.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Frequency distribution for CIUS items split for boys and girls