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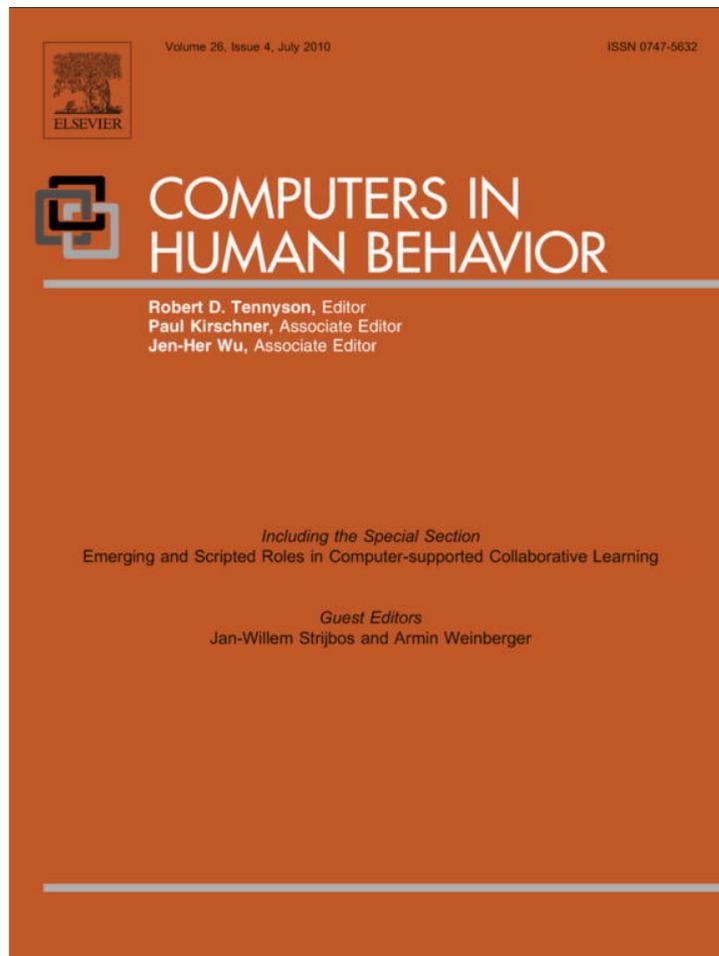
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Is compulsive internet use related to sensitivity to reward and punishment, and impulsivity?

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ABSTRACT

Aim of the present study was to examine whether the personality correlates sensitivity to reward and to punishment, and impulsivity predict compulsive internet use (CIU). Furthermore, the predictive value of these personality correlates was compared to the predictive value of factors relating to psychosocial well-being. The results showed that particularly rash spontaneous impulsivity predicts CIU and that this personality factor is more important than psychosocial wellbeing factors. Sensitivity to reward, which is supposed to play a role in craving processes associated with substance abuse and eating disorders, could not be related to CIU. The data suggest that internet users who are characterized by an impulsive personality feature, are less able to control their use of the internet, which makes them more vulnerable to develop CIU.

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1. Introduction

From a behaviorist point of view, the internet can be seen as a giant web of individually tailored Skinner boxes where the behavior of its users is reinforced through classical and operant conditioning mechanisms. Through positive intermittent reinforcement, the behavior is gradually shaped and the user becomes increasingly skilled to find stimuli on the internet that suits and pleases him or her most. The behavior resembles, in this regard, short-odds continuous gambling practices. These conditioning mechanisms have been described as an explanation for compulsive online sexual behavior (Putnam, 2000) and compulsive online gaming (Yee, 2001), but may be applicable more generally to compulsive online behavior, because practically all internet users can find rewarding stimuli on the internet. The crux of compulsive internet use (or internet addiction, as it is sometimes referred to; a pattern of internet use characterized by loss of control, preoccupation, conflict, withdrawal symptoms, and use of the internet as a coping strategy (Meerkerk, Van Den Eijnden, Vermulst, & Garretsen, 2009) – see for a discussion e.g. Holden (2001), Mitchell (2000) and Orford (2005)), may even, in part, be found in the vast variety of rapidly achievable and instantly rewarding stimuli that

can be found online conveniently, anonymously, abundantly, and at no or low cost. Moreover, because the internet can be used continuously, it can also be used to escape from or cope with daily problems (see also Orford (2005), Cooper, McLoughlin, and Campbell (2000), Young, Griffin Shelley, Cooper, O'Mara, and Buchanan (2000), and Meerkerk, van den Eijnden, Vermulst, and Garretsen (submitted for publication) for a more detailed description of the unique factors that make the internet highly entrapping). Although these rewarding stimuli are ubiquitous on the internet and the majority of the population in industrialized countries has access to the internet (for example, in 2008 86% of the Dutch households had internet access; www.cbs.nl), only a small minority of internet users appears to develop compulsive online behavior (Aboujaoude, Koran, Gamel, Large, & Serpe, 2006). Apparently, there are individual differences in the vulnerability to develop CIU.

The literature on CIU suggests that individual differences in the vulnerability to develop CIU can, at least in part, be explained by factors indicating low psychosocial wellbeing such as depression, low self-esteem, and loneliness (Caplan, 2002; Davis, Flett, & Besser, 2002; Meerkerk et al., submitted for publication; Whang, Lee, & Chang, 2003; Yang & Tung, 2007; Young & Rodgers, 1998b). The causal nature of the relationship between low psychosocial wellbeing and CIU, however, still needs further clarification (Davis, 2001; Meerkerk et al., submitted for publication).

In addition, individual differences in the vulnerability to develop CIU might be related to more or less stable personality features.

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Research into the relationship between personality and CIU is still relatively sparse (see also Meerkerk et al. (submitted for publication)), although some studies including a Big Five personality questionnaire (Danforth, 2003; Engelberg & Sjöberg, 2004) or the 16-Factor Personality Questionnaire (Yang, Choe, Baity, Lee, & Cho, 2005; Young & Rodgers, 1998a) showed that emotionally less stable personalities seem to be more vulnerable to develop CIU. Few researchers studied the relationship between CIU and other more or less stable personality features such as impulsivity; a trait often related to addictive behavior (Dawe, Gullo, & Loxton, 2004; Dawe & Loxton, 2004). Armstrong, Phillips, and Saling (2000) studied the relationship between CIU and sensation seeking, as measured by disinhibition, a sub-trait of impulsivity and closely related to extraversion. Armstrong and colleagues hypothesized a positive relation between disinhibition and CIU but disinhibition appeared not a good predictor of CIU. Lavin, Marvin, McLarney, Nola, and Scott (1999) even found compulsive internet users to score significantly lower on sensation seeking, a construct that also can be linked to impulsivity, and Petrie and Gunn (1998) found self-declared internet addicts to be more introverted which also invalidates the assumed relation between CIU and (sub-traits) of impulsivity. Yen and colleagues, on the other hand, studying the relationship between ADHD and CIU, did find a positive association between CIU and impulsivity (Yen, Yen, Chen, Tang, & Ko, 2009). In part, these differences in results may be explained in the diverse conceptual denotations of impulsivity (Leshem & Glicksohn, 2007; Potenza, 2007). Nevertheless, despite these contradictory results, several researchers have conceptualized CIU as an impulse control disorder (Davis, 2004; Davis et al., 2002; Morahan Martin, 2005; Shapira et al., 2003; Treuer, Fabian, & Furedi, 2001; Yellowlees & Marks, 2007; Young, 1998).

An unreclaimed theoretical perspective that may explain individual differences in the vulnerability to develop and maintain CIU is Gray's neuropsychological Reinforcement Sensitivity Theory of personality (RST) (Gray, 1987; Gray, 1991). As far as we know, this perspective has not yet received any attention in the literature on CIU, although it provides an interesting and promising viewpoint. In brief, Gray's original RST postulated anxiety and impulsivity as the two basic and independent biologically-based dimensions in motivation and personality. These dimensions reflect the functioning of two brain systems that regulate approach and withdrawal/avoidance behavior in response to environmental stimuli. The behavioral inhibition system (BIS) reacts in response to stimuli of punishment or termination of reward, and evokes feelings of fear (negative affect) and withdrawal/avoidance behavior. The behavioral activation (or approach) system (BAS) reacts in response to stimuli of reward or termination of punishment and evokes positive affect and approach behavior. According to RST, differences in personality reflect differences in the sensitivity to punishment and reward (BIS and BAS, respectively) (Corr, 2004; Dawe & Loxton, 2004).

Originally, Gray hypothesized that both sensitivity to punishment and sensitivity to reward (Gray labeled the latter "impulsivity") are one-dimensional traits. With regard to sensitivity to punishment there is considerable agreement (Franken & Muris, 2006b) that this is indeed a one-dimensional trait, characterized by fear and anxiety, and conceptually near to neuroticism (Jorm et al., 1999). Sensitivity to reward or impulsivity, on the other hand, seems to be at least bi-dimensional. Subsequent authors have made a distinction between reward sensitivity and impulsivity (Dawe & Loxton, 2004; Dawe et al., 2004; Franken & Muris, 2006b; Smillie & Jackson, 2006). Impulsivity, according to these authors, is related to rash and spontaneous behavior without thinking of risks or future consequences, and includes constructs such as novelty seeking, sensation seeking, behavioral undercontrol and disinhibition. Sensitivity to reward or drive, on the other

hand, does not necessarily imply rash and spontaneous behavior but is a more deliberate and goal-directed approach behavior. In short, there is consensus that sensitivity to punishment is a one-dimensional construct (conceptually near to neuroticism), but that impulsivity is at least bi-dimensional, pertaining to reward sensitivity or drive on the one hand, and rash spontaneous impulsivity on the other.

Various forms of addictive behavior have been related to impulsivity and reward sensitivity measures, notably alcohol and drug abuse (see for an overview Dawe et al. (2004)) and eating disorders (Loxton & Dawe, 2001). Dawe and Loxton (2004) argue that the two impulsivity-related components reward sensitivity or drive, and rash spontaneous impulsiveness should be considered in both the explanation of the development and the maintenance of addictive behavior. They hypothesize that "reward sensitivity/drive plays a role in cued-cravings and motivation to use drugs, but that rash spontaneous impulsiveness influences actual drug-taking behavior and the inability to discontinue use in light of negative consequences." (p. 347). The conjunction of heightened reward sensitivity and rash spontaneous impulsivity leads in this model to drug abuse and dependence (Dawe et al., 2004). Similarly, neurobiological studies reveal that an anomaly in the reward pathways of the brain can be related to addictive, compulsive or impulsive disorders comprising alcoholism, substance abuse, smoking, compulsive overeating and obesity, attention-deficit disorder, Tourette's syndrome and pathological gambling (Blum, Cull, Braverman, & Comings, 1996). In short, it is hypothesized that a deficiency in the limbic system of the brain, which is supposed to accommodate the reward system, makes the individual less able to experience reward from normal everyday activities, making the individual anhedonic and therefore more sensitive to the rewarding effects of drugs and other artificial highly rewarding stimuli (Volkow, Fowler, & Wang, 2002).

The model described above leads to several assumptions when applied to internet behavior and CIU. First, the internet offers an enormous variety of sometimes highly rewarding stimuli that can be obtained by simply clicking a button. Therefore, we expect that, compared to people low in sensitivity to reward, high sensitive individuals will engage more in reward-seeking behavior on the internet. Consequently, we expect a positive association between CIU and reward sensitivity (hypothesis 1). In addition, once online, it is easy to repetitively find rewarding stimuli and internet users can administer themselves endless arrays of individually-tailored rewarding stimuli. Because one of the most characteristic problems of people suffering from CIU is spending more time online than intended (i.e. they are unable to control the use of the internet), we also expect a positive association between CIU and impulsivity (hypothesis 2). Several studies have shown an association between CIU and the personality factor emotional stability or neuroticism (Danforth, 2003; Meerkerk et al., submitted for publication; Yang et al., 2005) and between CIU and factors indicating low psychosocial wellbeing (Caplan, 2002; Davis et al., 2002; Meerkerk et al., submitted for publication; Whang et al., 2003; Yang & Tung, 2007; Young & Rodgers, 1998b). Because psychosocial wellbeing is conceptually linked to neuroticism and emotional stability, and because sensitivity to punishment is related to neuroticism and emotional stability, we expect a positive association between sensitivity to punishment and CIU (hypothesis 3). Finally, the hypothesized associations may be moderated by the specific function for which the internet is used. Although the term CIU suggests an overuse of the internet in general, there is growing agreement that internet addicts are actually dependent on some rewarding aspects or functions of behavior associated with internet use (Davis, 2001; Meerkerk, van den Eijnden, & Garretsen, 2006; Yellowlees & Marks, 2007). That is, the addictive potential of the different applications varies. Studies addressing the

addictive potential of various applications revealed that online gaming (especially MMORPG (Lee et al., 2007)), online erotica, and online chatting (Meerkerk et al., 2006; Orford, 2005) belong to the most addictive applications. Secondly, the level of psychosocial wellbeing may moderate the hypothesized associations between levels of CIU and reward and punishment sensitivity and impulsivity. Therefore, the moderating effects of the three main risky internet functions (gaming, chatting and searching online erotica), and the moderating effects of the four variables related to psychosocial wellbeing that significantly predict CIU (see Section 2), will be examined.

In summary, the present study examines whether the constructs of sensitivity to punishment and to reward, and impulsivity can contribute to the explanation of individual differences in the vulnerability to develop CIU. It is hypothesized that high levels of reward and punishment sensitivity and high levels of rash spontaneous impulsivity are associated with CIU. Moreover, since earlier studies reported variables related to psychosocial wellbeing to be important predictors of CIU, it is tested whether sensitivity to punishment and reward, and impulsivity contribute more to the prediction of CIU than factors related to psychosocial wellbeing.

2. Methods

2.1. Procedure

Data for the study were gathered by means of an online survey, carried out among a sample of 'heavy users'. We made use of an existing online panel, which contains over 100,000 voluntary subscribers, who receive (on average once a month) an invitation to participate in a survey. As a reward, the respondents participate in a sweepstake offering them an opportunity for earning money and financially support charitable organizations. The respondents for the present study were respondents of the second wave of an other longitudinal study, supplemented with respondents who were invited to join in the study for the first time. Respondents were selected who (a) were at least 18 years old, (b) had internet access at home for at least 1 year, and (c) spent on average at least 16 h/week on the internet for private purposes (information about the time online was known from previous surveys). Respondents had to have internet access at home for at least 1 year to exclude novice users, whose online behavior might be dominated by 'beginner's fascination'. The 16 h/week criterion was used to ensure that the sample contained enough compulsive internet users for useful statistical analyses, reasoning that the prevalence of CIU is higher among internet users who spent much time online. Participants received an email which invited them to surf to a website where the questionnaire could be completed in a little over 10 min. Non-responders received reminders after two and four weeks.

2.2. Instruments

Besides the instruments to assess CIU, sensitivity to punishment and reward, and impulsivity (which are discussed below) the online questionnaire contained demographic variables (age, gender, and education) and items related to internet usage. Respondents were asked to specify the amount of time (average number of hours per online day and average number of days online per week) spent online in general. Based on these quantity/frequency figures, the average number of hours per week online was calculated. In addition, respondents were asked to specify the amount of time in hours per week spent on 12 specific internet functions, namely: email, searching information, surfing, gaming, chatting, reading or participating in a forum, online shopping, gambling on the

internet, downloading music, videos or software, searching erotica, Usenet, and dating.

The Compulsive Internet Use Scale (CIUS) was used to measure CIU. The CIUS consists of 14 items on a 5-point Likert scale ("never" to "very often") and scores between 0 and 56. The CIUS has a high internal consistency (Cronbach's alpha in the current sample = .890). The scale taps on loss of control, preoccupation, withdrawal symptoms, coping, and conflict with regard to the use of the internet. Sample items are 'How often do you find it difficult to stop using the internet when you are online?' and 'How often do you feel restless, frustrated or irritated when you cannot use the internet?' (for more details see Meerkerk et al. (2009)). Although CIU is not an all or nothing phenomenon, but may exist in a variety of severities, a cut-off point has to be specified to dichotomize respondents into compulsive and non-compulsive internet users. We 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 \times 2 ("sometimes") $>$ 28.

We used a validated Dutch version of the BIS/BAS scales (Franken, Muris, & Rassin, 2005) to assess reward and punishment sensitivity. The BIS/BAS consists of 20 items (+4 filler items) (4-point Likert scale, "totally agree" to "totally disagree") and contains the Behavioral Inhibition Scale (BIS, 7 items) and the Behavioral Approach System Scale (BAS, 13 items). The latter scale can be subdivided in three subscales: fun seeking (BAS-fun, 4 items), reward responsiveness (BAS-reward, 5 items), and drive (BAS-drive, 4 items). Sample items are: 'If I think something unpleasant is going to happen, I usually get pretty "worked up"' (BIS), 'When I get something I want, I feel excited and energized' (BAS-reward), 'When I want something, I usually go all out to get it' (BAS-drive), and, 'I crave excitement and new sensations' (BAS-fun). Cronbach's alpha in the current sample of the BIS scale was .79, of the BAS-fun scale .57, of the BAS-reward scale .65, and of the BAS-drive scale .70.

A revised version (Franken et al., 2005) of a Dutch translation (Claes, Vertommen, & Braspenning, 2000) of the Dickman Impulsivity Inventory (DII) (Dickman, 1990) assessed impulsivity. The DII consists of 23 dichotomous ("yes" "no") items and contains the subscale functional impulsivity (11 items, Cronbach's alpha in the current sample = .82) and the subscale dysfunctional impulsivity (12 items, Cronbach's alpha = .81). Sample items are: 'I feel uncomfortable when I have to make a quick decision' (DII functional impulsivity, reversed item) and 'I often say and do things without considering the consequences' (DII dysfunctional impulsivity).

Psychosocial wellbeing was assessed by four scales: the UCLA Loneliness Scale (Russell, Peplau, & Cutrona, 1980), the Satisfaction with Life Scale (Pavot & Diener, 1993), the Kandel and Davies Depressive Mood Scale (1982), Kandel and Davies Depressive Mood Scale (1986), and the Rosenberg Self-Esteem Scale (1989). The scales were highly intercorrelated (between .54 and .68, $p < .01$, see Table 2) and had, in the current sample, high internal consistencies; Cronbach's alpha for loneliness was .88, for life satisfaction .89, for depressive mood .86, and for self-esteem .90. Sample items are: 'I feel left out' (loneliness), 'I am satisfied with my life' (life satisfaction), 'Felt unhappy, sad, or depressed' (depressive moods), and 'I wish I could have more respect for myself' (self-esteem, reversed item).

2.3. Participants

The sample contained 304 respondents aged 19–78 years ($M = 40.4$, $SD = 12.3$). Most of them (75.3%, $n = 229$) were

participants of the second wave of the longitudinal study, the rest (24.7%, $n = 75$) were supplemental and new to the study. The participants who took part in the longitudinal study were stratified on age, gender and education level to make the sample representative for the Dutch internet users meeting the inclusion criteria on these variables. A non-response analyses revealed only minor differences between responders and non-responders (see Meerkerk et al. (2006) for details). However, no information is available about the non-response among the supplemental respondents. Generally spoken it should be concluded that the representativeness of the sample is not guaranteed.

Males and females were equally well represented with 49.3% ($n = 150$) and 50.7% ($n = 154$), respectively. A total of 15% had lower (preparatory) vocational training, 42% junior or senior general secondary educational training, and 42% (preparatory) college or (preparatory) university educational training. Respondents spent on average 24.9 h/week ($SD = 13.2$) on the internet for private purposes, mostly on e-mail, searching information, and surfing.

2.4. Statistical analyses

First, simple Pearson correlation coefficients were calculated between internet use, the four variables representing psychosocial wellbeing (loneliness, satisfaction with life, depressive mood, and self-esteem), and the variables representing personality (BIS/BAS and impulsivity). Next, the predictive value of the independent variables was determined by means of linear regression analyses with CIU as dependent variable. All independent variables were forced into the model simultaneously. Because of the sometimes high intercorrelations between the independent variables and the exploratory nature of the current study, some of the analyses were repeated using stepwise methods to reveal the best predictor. First, a regression equation was built with the sensitivity to reward and punishment scales; second, a regression equation was built with the impulsivity scales; and third a regression equation was built with the four variables relating to psychosocial wellbeing. Next, the significant terms of the previous analyses were entered simultaneously in a regression equation. Finally, to examine the moderating effects of specific internet functions and of the four variables representing psychosocial wellbeing on the relationship between CIU and sensitivity to reward and punishment and impulsivity, a regression equation was built including the interaction terms with time spent on gaming, chatting and searching online erotica, and with the four variables representing psychosocial wellbeing.

In all equations the variables age, gender, and educational level were entered in the first step of the equation to control for demographic variables. Interactions were defined as the prod-

uct of two independent variables. To avoid multicollinearity problems, the independent variables were centered ($value_{centered} = value_{original} - mean$) before computing the interaction terms in equations with interaction effects involved.

3. Results

3.1. Descriptive statistics

Table 1 shows the descriptive statistics of all variables involved. More females than males appear to meet the criterion for compulsive internet use and compulsive internet users appear to be found less often among respondents with a higher education level, however, both differences are not significant. As could be expected compulsive internet users were more hours per week online validating the assumption that the prevalence of CIU is higher among internet users who spent much time online. Furthermore, in line with previous studies, compulsive internet users were lonelier, less satisfied with life, experienced more depressive moods and had a lower self-esteem. Finally, compulsive internet users were more sensitive to punishment (BIS), had a heightened rash spontaneous impulsivity (as measured by the subscale dysfunctional impulsivity) and scored lower on functional impulsivity.

3.2. Correlation analyses

Pearson correlation analyses (Table 2) revealed clear correlations between the dependent variable CIU and the independent variables sensitivity to punishment (BIS) and both impulsivity scales. Reward sensitivity (BAS) appeared to correlate less strong to CIU; BAS-reward and BAS-fun were weakly correlated and BAS-drive was not correlated to CIU. The correlations among the independent variables were as expected from previous studies. Specifically, functional and dysfunctional impulsivity were uncorrelated, as were sensitivity to reward and sensitivity to punishment, except BIS and BAS-reward, which showed a moderate positive correlation. Furthermore, sensitivity to punishment (BIS) showed a clear negative correlation with functional impulsivity and a positive correlation with dysfunctional impulsivity. BAS-drive was mainly correlated with functional impulsivity and BAS-fun mainly with dysfunctional impulsivity. The three BAS-subscales showed high intercorrelations. Finally, the scales relating to psychosocial wellbeing (especially depressive moods and self-esteem) correlated clearly with sensitivity to punishment (BIS) and both impulsivity scales (particularly functional impulsivity), and much lower to sensitivity to reward (BAS).

Table 1
Descriptive statistics for demographic variables and the variables relating to internet use, psychosocial wellbeing, and personality.

Variable	Compulsive internet users ($n = 14$)	Non-compulsive internet users ($n = 290$)	All ($n = 304$)	Significance
Gender (% male)	28.6	50.3	49.3	.170
Age	41.4 (s.d. 7.0)	40.3 (s.d. 12.5)	40.4 (s.d. 12.3)	.758
Education (% higher education)	14.3	43.8	42.4	.092
CIUS	35.3 (s.d. 5.3)	10.4 (s.d. 6.9)	11.5 (s.d. 8.6)	.000
Internet h/week	33.5 (s.d. 11.4)	24.4 (s.d. 13.1)	24.9 (s.d. 13.2)	.012
Loneliness	24.6 (s.d. 8.5)	18.2 (s.d. 5.9)	18.5 (s.d. 6.2)	.000
Life satisfaction	15.6 (s.d. 7.5)	23.3 (s.d. 6.8)	23.0 (s.d. 7.0)	.000
Depressive moods	20.2 (s.d. 4.8)	15.5 (s.d. 4.4)	15.7 (s.d. 4.6)	.000
Self-esteem	25.6 (s.d. 5.3)	32.2 (s.d. 6.1)	31.9 (s.d. 6.2)	.000
BIS	22.9 (s.d. 4.1)	19.0 (s.d. 3.9)	19.2 (s.d. 4.0)	.000
BAS reward	16.8 (s.d. 2.0)	16.4 (s.d. 2.2)	16.5 (s.d. 2.2)	.563
BAS-drive	11.3 (s.d. 2.9)	10.7 (s.d. 2.4)	10.8 (s.d. 2.5)	.399
BAS fun	12.4 (s.d. 2.9)	11.5 (s.d. 2.2)	11.5 (s.d. 2.2)	.124
BAS total	40.5 (s.d. 6.6)	38.7 (s.d. 5.4)	38.7 (s.d. 5.4)	.215
Functional impulsivity	4.4 (s.d. 2.8)	7.8 (s.d. 2.8)	7.7 (s.d. 2.9)	.000
Dysfunctional impulsivity	6.1 (s.d. 3.9)	3.0 (s.d. 2.8)	3.1 (s.d. 2.9)	.000

Table 2
Correlations between internet use variables, psychosocialfunctional wellbeing, and personality variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 CIUS	1												
2 Internet h/week	.289**	1											
3 Loneliness	.241**	.047	1										
4 Life Satisfaction	-.259**	-.129*	-.537**	1									
5 Depressive moods	.295**	.089	.550**	-.560**	1								
6 Self-esteem	-.313**	-.108	-.617**	.559**	-.675**	1							
7 BIS	.269**	.044	.321**	-.268**	.548**	-.549**	1						
8 BAS reward	.117*	.004	-.227**	.089	.022	.069	.203**	1					
9 BAS-drive	.101	-.030	-.172**	.118*	-.087	.116*	-.112	.447**	1				
10 BAS fun	.176**	.061	-.028	-.084	.062	-.049	.058	.431**	.464**	1			
11 BAS total	.164**	.013	-.179**	.054	-.005	.060	.055	.776**	.818**	.790**	1		
12 Funct. impulsivity	-.252**	-.048	-.425**	.295**	-.432**	.506**	-.398**	.075	.245**	.167**	.208**	1	
13 Dysfunct. Impulsivity	.308**	.071	.147*	-.153**	.238**	-.286**	.242**	.100	.151**	.374**	.261**	-.057	1

N = 304.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

3.3. Predictive value of the sensitivity to reward and punishment scales

The first regression equation explored the predictive value of the sensitivity to reward and punishment scales (BIS/BAS). The demographic variables appeared not to predict CIU (Table 3, equation 0). The results (Table 3, equation 1a) showed a clear

Table 3
Predictors of compulsive internet use (regression analyses).

Variable	β	t	Adj. R ²
Equation 0: controls			
Gender	.05	.87	.00
Age	-.08	-1.36	
Education	-.04	-.76	
Equation 1a: sensitivity to reward and punishment (BIS/BAS)			
BIS	.25	4.10 ^a	.06
BAS-reward	-.05	-.69	
BAS-drive	.07	1.05	
BAS-fun	.10	1.57	
Equation 1b: sensitivity to reward and punishment (BIS/BAS)			
BIS	.23	3.97 ^a	.06
BAS-fun	.12	2.05 ^c	
Equation 2: impulsivity			
Functional impulsivity	-.26	-4.66 ^a	.13
Dysfunctional impulsivity	.26	4.78 ^a	
Equation 3a: psychosocial wellbeing			
Loneliness	.10	1.26	.08
Life satisfaction	-.01	-.15	
Depressive moods	.08	.93	
Self-esteem	-.17	-1.97 ^c	
Equation 3b: psychosocial wellbeing			
Self-esteem	-.29	-5.14 ^a	.08
Equation 4a: sensitivity to reward and punishment (BIS/BAS), impulsivity and psychosocial wellbeing			
BIS	.04	.67	.15
BAS-fun	.10	1.65	
Functional impulsivity	-.20	-2.99 ^b	
Dysfunctional impulsivity	.19	3.18 ^b	
Self-esteem	-.12	-1.66 ^c	
Equation 4b: final equation			
Functional impulsivity	-.19	-2.94 ^b	.14
Dysfunctional impulsivity	.23	4.09 ^a	
Self-esteem	-.14	-2.09 ^c	

^a p < .001.

^b p < .01.

^c p < .05.

relationship between sensitivity to punishment (BIS) and CIU ($\beta = .25$), but no significant results for the sensitivity to reward (BAS) subscales. Because of the high intercorrelations between the three BAS subscales, the analysis was repeated using stepwise methods. The results of this analysis (Table 3, equation 1b) revealed that, besides sensitivity to punishment (BIS), also BAS-fun predicted CIU ($\beta_{\text{BAS-fun}} = .12$). However, the contribution of the sensitivity to reward and punishment scales (BIS/BAS) to the explanation of CIU was limited (adj. $R^2 = .06$).

3.4. Predictive value of impulsivity scales

The second regression equation explored the predictive value of the two impulsivity scales (functional and dysfunctional impulsivity). The results (Table 3, equation 2) showed that both scales clearly contributed to the explanation of CIU ($\beta_{\text{functional impuls.}} = -.26$, $\beta_{\text{dysfunctional impuls.}} = .26$, adj. $R^2 = .13$).

3.5. Predictive value of the psychosocial wellbeing scales

The four psychosocial wellbeing scales (loneliness, life satisfaction, depressive moods and self-esteem) were entered in the third regression equation. The results (Table 3, equation 3a) showed that all the psychosocial wellbeing variables contributed to the explanation of CIU (adj. $R^2 = .08$), but that only self-esteem reached significance ($\beta = -.17$). Because of the high intercorrelations between the psychosocial wellbeing scales, the analysis was repeated using stepwise methods to determine the most important predictor. The results (Table 3, equation 3b) confirmed that self-esteem was the best predictor of CIU ($\beta = -.29$).

3.6. Predictive value of the significant results entered simultaneously

Next, the significant results of the previous analyses (BIS and BAS-fun, functional and dysfunctional impulsivity, and self-esteem) were entered simultaneously in a regression equation. The results (Table 3, equation 4a) revealed relationships between CIU and both impulsivity scales and self-esteem. Sensitivity to punishment (BIS) and sensitivity to reward (BAS-fun) did not reach significance. The analysis was again repeated using stepwise methods revealing the final regression equation (Table 3, equation 4b). Equation 4b makes clear that CIU is predicted by dysfunctional impulsivity ($\beta = .23$), functional impulsivity ($\beta = -.19$), and self-esteem ($\beta = -.14$). Note that the combination of the impulsivity scales and Self-Esteem hardly increased the explained variance in CIU, in comparison to the equation with only both impulsivity scales ($R^2 = .14$ and

$R^2 = .13$, respectively). However, the three variables did seem to contribute uniquely to the explanation of variance in CIU.

3.7. Predictive value of the interaction terms

In a final analysis, interaction terms between both impulsivity scales and Self-Esteem, and between both impulsivity scales and time spent on the internet functions chatting, gaming, and erotica were calculated and entered in two regression analyses. The results (data not shown) did not reveal a significant contribution of one of the interaction terms.

4. Discussion

Aim of the current study was to explore whether the constructs sensitivity to reward and to punishment, and impulsivity explain individual differences in the vulnerability to develop CIU, and to compare the predictive value of these constructs to the predictive value of factors related to psychosocial wellbeing.

Functional and dysfunctional impulsivity, as measured by the DII (Dickman, 1990), appeared to have a substantial predictive value and confirmed our second hypothesis that individuals with heightened rash spontaneous impulsivity (as measured by the subscale dysfunctional impulsivity) have a higher chance to use the internet compulsively, as compared to individuals scoring lower on rash spontaneous impulsivity. The relationship between rash spontaneous impulsivity and CIU appeared not to be influenced by specific internet functions, nor by psychosocial wellbeing.

In contrast, sensitivity to reward (BAS) did not clearly predict CIU, although a minor effect of the BAS subscale fun seeking was found. BAS fun seeking has been reported to be correlated to measures of substance use and abuse (Franken & Muris, 2006a; Jorm et al., 1999; Loxton & Dawe, 2001); however, the predictive value of BAS fun seeking appeared limited within the current study. Apparently, CIU is not robustly related to reward sensitivity and our first hypothesis is therefore not confirmed. These findings, however, are in line with the findings of Armstrong et al. (2000) and Lavin et al. (1999) who found that compulsive internet users scored lower on sensation seeking.

The third hypothesis that high sensitivity to punishment (BIS) predicts CIU was confirmed in the present study. This result is not surprising given the results of previous studies indicating a relationship between the personality dimension emotional stability and low psychosocial wellbeing on the one hand and CIU on the other (Caplan, 2002; Danforth, 2003; Davis et al., 2002; Meerkerk et al., submitted for publication; Whang et al., 2003; Yang & Tung, 2007; Yang et al., 2005; Young & Rodgers, 1998b). Both emotional stability and psychosocial wellbeing are linked to neuroticism, which is conceptually similar to sensitivity to punishment (Jorm et al., 1999).

In addition, the current study again confirmed the relationship between psychosocial wellbeing and CIU found in previous studies. More specifically, individuals with low self-esteem have a higher chance to show signs of CIU as compared to individuals with high self-esteem. However, the predictive value of psychosocial wellbeing was smaller than in a previous study by our research group (Meerkerk et al., submitted for publication). In that study more than 20% of variance in CIU was explained by psychosocial wellbeing factors, while in the current study only 8% was explained. Moreover, impulsivity appeared to be more important for the prediction of CIU than psychosocial wellbeing.

Overall, dysfunctional and functional impulsivity appeared to be good predictors of CIU. To interpret these results, we first take a closer look at the concepts of dysfunctional and functional impulsivity. According to Smillie and Jackson (2006), functional impul-

sivity is conceptually similar to sensitivity to reward. Reward sensitivity, in their view, is characterized not only by a heightened sensitivity to rewarding stimuli, but also by a diminished behavioral inhibition. This implies a negative correlation between functional impulsivity and the behavioral inhibition correlates (BIS), which is indeed found in the present study, and is in concordance with the findings of, for example, Franken and Muris (Franken & Muris, 2006b), who found functional impulsivity to be the opposite of BIS. This reasoning also explains why the previously found effect of the sensitivity to punishment (BIS) measure was excluded when the functional impulsivity measure was also included in the equation. In short, functional impulsivity may reflect heightened reward sensitivity in combination with lowered sensitivity to punishment. Dysfunctional impulsivity, on the other hand, represents impulsivity in its common conceptualization; that is, rash spontaneous impulsive behavior disregarding consequences, and can largely be distinguished from measures of reward sensitivity (Franken & Muris, 2006b; Smillie & Jackson, 2006).

Dawe and Loxton (2004) proposed a model to explain the vulnerability to binge eating disorders including rash spontaneous impulsivity and reward sensitivity. Heightened reward sensitivity is supposed to play a role in the initiation of binge cravings, and rash spontaneous impulsivity contributes to the actual disinhibited behavior and loss of control during a binge episode. The results of the present study only partially confirm this explanation for CIU. The results show a positive relationship between rash spontaneous impulsivity and CIU, reflecting the difficulty many compulsive internet users have to control their use of the internet. On the other hand, the results did not show a positive relationship between reward sensitivity and CIU. However, we did not explicitly investigate CIU-related cravings, which prohibit speculations about the relationship between reward sensitivity and CIU-related cravings. Nevertheless, since impulsivity may be regarded as a relatively stable personality trait, the results suggest that heightened impulsivity reflects a vulnerability to develop CIU.

A limitation of the present study is that, although the impulsivity measures appeared to be the best predictor of CIU, the variance explained by the impulsivity measures is moderate (about 13%). Another limitation is that we had no measure of internet-related craving. This would have allowed us to examine the suggestion that reward sensitivity would be related to internet-related craving (Dawe & Loxton, 2004). A further limitation of the study may be found in the relatively low reliability of the sensitivity to punishment and reward scales, which had rather low Cronbach's alphas in the present sample. Finally, although the sample contains a diverse population of internet users, representativeness may be restricted which might limit the generalizability of the results.

In sum, the present study showed that the concept of rash spontaneous impulsivity adds to the explanation and understanding of CIU. It seems that individuals with heightened impulsivity are more vulnerable to develop CIU; i.e., they are less able to resist the impulse to continue clicking the next button, even when aware of negative consequences. The sensitivity to reward component, which causes cue-elicited craving in substance abusers, does not seem to play an important role with regard to CIU. This may explain why the complaints of compulsive internet users are dominated by complaints about loss of control; i.e., using the internet longer than intended. It may be that CIU can best be conceptualized as an impulse control disorder next to a compulsion; i.e., compulsive-impulsive (C-I) internet usage disorder (Dell'Osso, Altamura, Allen, Marazziti, & Hollander, 2006). This conclusion is in line with the findings of other researchers who concluded that diminished impulse control is a typical feature of CIU (Davis et al., 2002) and that subjects suffering from CIU typically meet the DSM-IV criteria (APA, 1994) for an impulse control disorder (ICD) not otherwise specified (NOS) (Beard & Wolf, 2001; Dell'Osso

et al., 2006; Morahan Martin, 2005; Shapira, Goldsmith, Keck, Khosla, & McElroy, 2000; Shapira et al., 2003; Treuer et al., 2001; Yellowlees & Marks, 2007; Yoo et al., 2004). However, further longitudinal research is needed to explore the role of impulsivity and sensitivity to punishment and reward in predicting the development of CIU. Such research, unraveling causes and consequences of CIU, may add to our current knowledge of mechanisms underlying the development of CIU as well as to the development of specific prevention and treatment procedures.

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