

Chapter 2

Theoretical Models of the Development and Maintenance of Internet Addiction

Matthias Brand

Abstract In this contribution, theoretical considerations of the development and maintenance of specific types of Internet addiction are summarized. On the basis of previous research, several predisposing variables and vulnerability factors have been identified. These comprise psychopathological symptoms, such as depression and social anxiety, but also personality variables, such as impulsivity and self-esteem. Social cognitions, like perceived social support, stress vulnerability, and also genetic vulnerabilities are considered further potential predisposing variables. It is argued that predisposing variables act in concert with moderating and mediating variables in the development and maintenance of an Internet addiction. Dysfunctional coping style and Internet use expectancies are considered important in this context. In the course of reinforcement learning and conditioning processes, cue reactivity and craving is supposed to develop, which may interact with reduced executive functioning and inhibitory control. Future research should more explicitly investigate the interactions of certain variables, beyond addressing bivariate effects on a correlational or group-comparison level. The model suggested should be seen as a model in progress, which hopefully has the potential to inspire both future research and clinical practice.

2.1 Introduction: Why Are Theoretical Models of the Development and Maintenance of Internet Addiction Important?

The scientific investigation of excessive and pathological Internet use only emerged 20 years ago with the first description of a young patient's symptoms of Internet addiction by Young (1996). Nowadays, a relatively large body of literature exists

M. Brand (✉)

General Psychology: Cognition and Center for Behavioral Addiction Research (CeBAR) and Erwin L. Hahn Institute for Magnetic Resonance Imaging, University of Duisburg-Essen, Forsthausweg 2, 47057 Duisburg, Germany
e-mail: matthias.brand@uni-due.de

on the phenomenology and comorbidities as well as on the epidemiology for different countries of problematic or pathological Internet use (see recent review by Spada 2014). Internet gaming disorder, as one specific type of Internet addiction, has recently been included in section III of the DSM-5 (APA 2013). This emphasizes that more research on the phenomenon of Internet addiction is required in order to gather evidence regarding its clinical relevance and potential underlying mechanisms. Although different terms are used in the scientific literature when referring to overuse of the Internet, the most common of which is Internet addiction (e.g., Chou et al. 2005; Hansen 2002; Widyanto and Griffiths 2006; Young 1998, 2004; Young et al. 2011). In this chapter, consequently, the term Internet addiction is also used.

Internet addiction generally covers all applications which are provided by the Internet. Most previous studies, however, focus on Internet gaming disorder, although several authors have argued that other applications are also used addictively by individuals seeking treatment. Such applications include gambling, pornography, social networking, and shopping sites (Young et al. 1999; Griffiths 2012; Müller et al. in press; Brand et al. 2014b). Based on a representative German survey, addictive behavior on the Internet can refer at least to three types of behavior: gaming/gambling, use of social networking sites (SNS), and other applications (e.g., pornography) (Bischof et al. 2013). Therefore, it seems plausible that, wherever possible, Internet activity should be specified and different potential types of Internet addiction should be distinguished (Starcevic 2013; Montag et al. 2015; Brand et al. 2014b). This distinction is important because an awareness of the common and distinct processes behind these discrete phenomena potentially have a huge impact on clinical treatments.

Theoretical models and frameworks which describe mechanisms potentially underlying the development and maintenance of specific types of Internet addiction are very important. Such models should summarize previous research based on both individual studies and meta-analyses. They should also integrate results from other research areas where appropriate, e.g., in situations where less research on the variables of interest are available. For instance, when considering pathological Internet use as an addiction, concepts of the addiction processes known from substance dependency research and other behavioral addictions should be incorporated into a new theoretical framework. Theoretical models and frameworks can then inspire future research on mechanisms of development and maintenance of the disorder. Current and future studies can test the theoretical assumptions empirically, which will then result in revised versions of theoretical frameworks. This means that a theoretical model and framework is never final, but must be continuously improved and specified as it evolves in interaction with current research. These models have then a benefit for both clinical practice and science. Theoretical models and frameworks can help us to understand the etiology and classification of the phenomenon of interest. When the underlying mechanisms are understood, methods for prevention and treatment may be derived on the basis of systematic hypotheses. In other words, to develop successful prevention and treatment methods, it is essential to gain a better understanding of common and differential influences of vulnerability factors in

interaction with potential moderating and mediating variables. Moderator and mediator variables should be core components of a theoretical model for a psychological disorder, since moderating and mediating variables can often be treated better than certain vulnerability factors (Brand et al. 2014a).

2.2 Recent Models of the Development and Maintenance of Internet Addiction

Two new theoretical models of Internet addiction were published in 2014. The first was introduced by Brand et al. (2014b), and shortly afterwards, Dong and Potenza (2014) published a model which specifically focuses on Internet gaming disorder. These models will now be described. Afterwards, empirical studies on factors, which are considered of particular importance in the models, are reviewed and desirable future research directions are highlighted.

The model by Brand et al. (2014b) distinguishes between a generalized Internet addiction and specific types of Internet addiction. This differentiation was inspired by the distinction proposed by Davis (2001). In this context, generalized Internet addiction refers to a multidimensional overuse of the Internet, which is frequently accompanied by time-wasting and nondirected use of different Internet applications, such as YouTube, music sites, social network sites (SNS), information-searching sites, etc. Davis (2001) argued that social aspects of the Internet (e.g., social communication via SNS) are particularly, but not exclusively, heavily used in the context of a generalized Internet addiction (see also discussion in Lortie and Guitton 2013). In this case, one may argue that the individual is addicted *to* the Internet in general and not addicted to a particular application *on* the Internet (but see also discussion in Starcevic 2013). Davis argued that one main difference between generalized versus specific types of Internet addiction is that individuals who suffer from a generalized Internet addiction would not have developed a similar problematic behavior outside or without the Internet. In contrast, individuals suffering from a specific Internet addiction would have developed similar problematic behavior within another setting (e.g., would addictively watch offline pornography, shop offline, gamble offline, and so on). The specific types of Internet addiction refer to an addictive use of one particular application, such as games, gambling sites, pornography/cybersex, shopping sites, or social networking and communication sites. In other words, these individuals have a “first-choice use”, which may be comparable to the “first-choice drug” in substance-dependent individuals.

Although it is still a topic of debate whether a generalized Internet addiction exists in the clinical context, some studies with nonclinical samples demonstrated that generalized and specific Internet addictions differ in a meaningful manner (Montag et al. 2015; Pawlikowski et al. 2014). The model of generalized Internet addiction and the first empirical data were addressed in the study by Brand et al. (2014a). This model assumes certain personality factors (e.g., shyness, low

self-esteem), psychopathological symptoms (e.g., social anxiety, depression), and social cognitions (e.g., low perceived social support and loneliness) to be predisposing factors for the development of a generalized Internet addiction. As mediating variables, a dysfunctional coping style (e.g., disengagement and conflict avoidance) and Internet use expectancies (e.g., the expectancy that social networking sites and other Internet applications can be useful for avoiding problems in real life or for escaping from reality and for regulating negative mood) have been suggested. If the Internet (or various Internet applications) is then used as a type of dysfunctional coping with everyday life requirements (Kardefelt-Winther 2014), the dysfunctional coping style and the Internet use expectancies are reinforced. This model of generalized Internet addiction has been tested empirically with a non-clinical sample, and it was indeed shown that the effect of personality, psychopathological symptoms, and social aspects are fully mediated by a dysfunctional coping style and Internet use expectancies (Brand et al. 2014a).

The model of specific Internet addiction (gaming, gambling, cybersex use, buying and communicating) by Brand et al. (2014b), which is illustrated in Fig. 2.1, also included psychopathological symptoms (e.g., depression, social anxiety) and dysfunctional personality traits, as well as other variables (e.g., stress vulnerability) as predisposing factors. In addition, it was assumed that persons have specific preferences, e.g., a high tendency towards games or a high sexual excitability, which may explain why they choose a certain type of application in order to experience gratification. We have also argued that the predisposing variables do not directly influence the development of a specific Internet addiction but that they are linked to a dysfunctional coping style (e.g., avoidance of problems) and certain Internet use expectancies (e.g., the idea of reducing stress by using a specific application). Both coping style and expectancies are considered part of a person's core cognitions, which represent mediating variables. This is consistent with the model of generalized Internet addiction. However, the expectancies are considered to be specific, i.e., that an individual has the expectancy that consuming Internet pornography is the best (and only) way to find sexual gratification and to satisfy personal sexual desires. The model has recently been revised and specified and is now named I-PACE model (I-PACE stands for Interaction of Person-Affect-Cognition-Execution) (see Brand et al. 2016b).

The use of the first-choice application is seen to result in positive reinforcing effects and the experience of gratification, at least at the beginning of the addiction process (Piazza and Deroche-Gamonet 2013; Everitt and Robbins 2016). Gratification leads to positive (and partly negative) reinforcement of the dysfunctional coping style, the expectancies about the use of specific Internet applications, and also parts of the core characteristics, particularly the psychopathological symptoms and the specific preferences. It has been further argued that the learning mechanisms resulting from repeated experience of mainly gratification and therefore of positive (and partly negative) reinforcement in the context of Internet use make it difficult for individuals to exert inhibitory control over using the Internet application of choice. The main assumptions of the model by Brand et al. (2014b, 2016b) are summarized in Fig. 2.1.

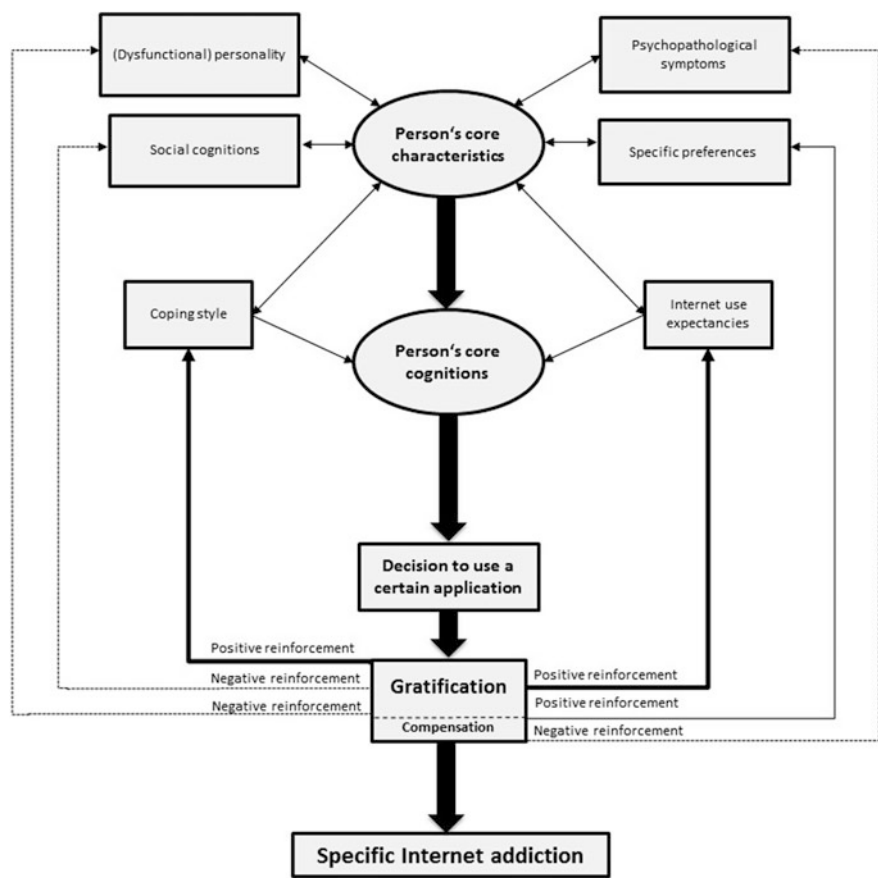


Fig. 2.1 The model (simplified) of the development and maintenance of a specific Internet addiction suggested by Brand et al. (2014b, 2016b). Specific Internet addiction refers to the addictive use of a certain Internet application, such as Internet gaming, gambling, pornography/cybersex, shopping, or communication, respectively. This figure only depicts the main components of the theoretical model. Details on potential vulnerability factors and cognitive processes are described in more detail in the text

The theoretical model proposed by Dong and Potenza (2014) focuses on Internet gaming disorder. It also includes several variables linked to a person’s attitudes and cognitive processes. Central to this model is motivation seeking (craving), which is assumed to directly influence the use of Internet games. Motivation seeking itself is considered to be influenced by a person’s decision-making style (preference for rewarding alternatives despite negative long-term consequences), executive control (inhibition and monitoring), stress relief (responses to previous or current stress), and reward sensation (reward sensitivity, cognitive bias towards the Internet). Dong and Potenza (2014) also refer to models of substance dependency, which are reward-centered, such as the incentive salience ideas and the distinction of “liking”

a drug from “wanting” a drug (Berridge 2007; Berridge et al. 2009; Robinson and Berridge 2001, 2008). They also integrated other components of addiction models, for example the interaction between the motivation for drug seeking and reductions of executive control (Goldstein and Volkow 2011), which then may interfere with advantageous decision-making in the context of weighing short-term versus long-term positive and negative consequences (Bechara 2005; Dong et al. 2013; Pawlikowski and Brand 2011). The authors also suggest that treatment interventions should specifically target the aforementioned factors, which are assumed to influence motivation seeking/craving.

The two models share main concepts and ideas, namely that predisposing factors are not sufficient to explain Internet addiction, but rather interact with the individual’s concrete response when confronted with addiction-related stimuli. The two models also integrate ideas from research on substance dependence, with a focus on cognitive processes in conjunction with motivation seeking. Both models are theoretically plausible, but require further empirical testing. For the model by Brand et al. (2014b, 2016b), there is some initial empirical evidence for certain variables, for example for cybersex addiction (Laier and Brand 2014) and an addictive use of SNS (Wegmann et al. 2015). For the main components of both models, previous studies with either Internet gaming disorder or other types of Internet addiction also demonstrate that certain factors such as vulnerability factors, motivation seeking and craving, cognitive processes and decision-making are worth considering. Key findings for these variables are summarized in the following sections.

2.3 Previous and Current Research as the Basis for the Model’s Assumptions

A relatively broad body of literature exists on the correlations between subjective complaints in everyday life resulting from Internet use and diverse psychopathological symptoms and personality characteristics. It was shown that Internet addiction in general is linked to depression and anxiety disorders as well as to attention deficit hyperactivity disorder (ADHD) symptoms (see meta-analysis by Ho et al. 2014). A recent study even showed that ADHD symptoms are a better predictor for Internet addiction than depressive tendencies (Sariyska et al. 2015). Distinct personality factors are also correlated with symptoms of Internet addiction (see meta-analysis by Koo and Kwon 2014). These personality factors are shyness, neuroticism, impulsivity, low conscientiousness, a tendency to procrastinate, low self-esteem, and low self-directedness (Ebeling-Witte et al. 2007; Hardie and Tee 2007; Kim and Davis 2009; Niemz et al. 2005; Thatcher et al. 2008; Floros et al. 2014; Koo and Kwon 2014; Wang et al. 2015; Sariyska et al. 2014). There is also a relatively broad literature on social aspects, particularly for generalized Internet addiction and for specific Internet addictions in which social interactions are crucial, for example gaming and SNS. It has been shown that lack of social support or

perceived social isolation (Caplan 2007; Morahan-Martin and Schumacher 2003) and even loneliness in the educational setting in adolescents (Pontes et al. 2014) seem to be related to an addictive use of the Internet in general. Stress vulnerability and experienced stress in daily life, and the subsequent use of the Internet as a tool for coping with problematic or stressful life events, have also been considered important factors contributing to the development of Internet addiction (Whang et al. 2003; Tang et al. 2014). Tendencies towards impulsive coping strategies (e.g., doing the first thing that comes to the mind when facing negative mood) when confronted with daily stress have also been linked to Internet addiction (Tonioni et al. 2014), and some authors even conceptualize Internet addiction as a type of dysfunctional coping with everyday life (Kardefelt-Winther 2014).

It has been suggested that the specific types of Internet addiction share some main psychopathological and personality correlates (Brand et al. 2014b, 2016b). In particular, depressive symptoms, social anxiety, impulsivity, low conscientiousness, stress vulnerability, and social distrust have been proposed. In addition, it has also been argued that specific types of Internet addiction are linked to diverse personality variables. For example, extraversion and openness to experience are considered important in the use of interactive social media (Correa et al. 2010) but not necessarily for using Internet pornography or shopping sites. Sexual excitability should play the main role in the addictive use of Internet pornography and cybersex (Lu et al. 2014; Laier and Brand 2014). Future research is needed to investigate common and differential correlates of Internet addiction with respect to personality and psychopathological symptoms across different types of specific Internet addiction. For more information on the link between personality and Internet addiction please see Chap. 9 in the present book.

Another potential contributing factor that should be considered in the future is genetics. In the original model by Brand et al. (2014b) and also in the model by Dong and Potenza (2014), genetic vulnerabilities were not explicitly included as predisposing factors (but they have now been included in the I-PACE model within the category of biopsychological constitution, Brand et al. 2016b). In the last few years, a number of studies have been published which indicate varying degrees of heritability estimates (Deryakulu and Ursavas 2014; Li et al. 2014; Vink et al. 2015), showing that up to 48% of individual differences in Internet addiction symptoms can be accounted for by genetic factors (see also Chap. 8). Han et al. (2007) reported that genetic variations of dopaminergic polymorphisms (COMT Val158Met and ANKK1/DRD2 Taq Ia) may be linked to Internet addiction. With respect to serotonin, Lee et al. (2008) reported that the serotonin-transporter-linked polymorphic region (5-HTTLPR) might be involved in Internet addiction. Third, Montag et al. (2012) found that a genetic variation of the CHRNA4 gene, which is linked to the cholinergic nicotine/acetylcholine receptor, is also associated with Internet addiction symptoms. These studies give preliminary evidence for a potential genetic contribution to the development of Internet addiction (see Chap. 9). Genetic vulnerability factors seem, therefore, worth including as predisposing factors in theoretical models of Internet addiction. Clearly, there are no genes being exclusively linked to Internet addiction leading to a false term such as “Internet addiction gene”. As outlined in

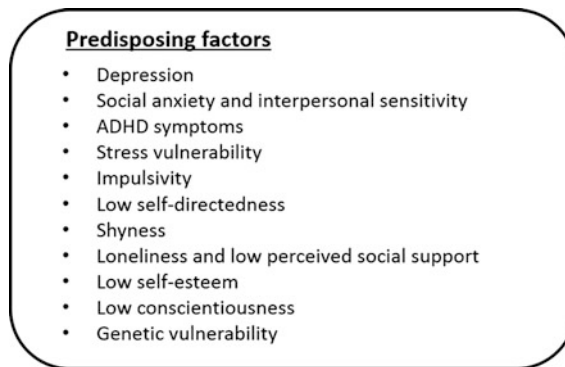


Fig. 2.2 A summary of potential predisposing factors and vulnerability variables, which are thought to influence the development of a specific Internet addiction. Beyond these global variables, specific attitudes and desires may explain why a certain Internet addiction can be developed. For example, a generally high sexual excitation (and other specific predisposing variables) may explain why individuals develop an Internet pornography addiction but not an Internet gaming disorder. The summary only includes those factors seen to be involved in all types of specific Internet addiction. Citations for these predisposing factors are mentioned in the text above

Chap. 9, genetic effects being associated with Internet addiction exert their effects via personality traits or a general vulnerability of addictions.

A summary of potential predisposing factors of Internet addiction can be found in Fig. 2.2.

2.4 Neurocognitive Mechanisms Potentially Underlying Internet Addiction

An open question is why some individuals use certain Internet applications addictively. What are core mechanisms which shape the decision to use an application again and again resulting in a loss of control over the Internet use? One key concept is cue reactivity and craving (note that also the term motivation seeking has been used for craving, e.g. in the model by Dong and Potenza 2014).

Craving, which was originally defined within substance dependence research, describes a hardly resistible urge to consume a substance. Craving can be triggered by the confrontation with drug-related cues resulting in so-called cue reactivity (Breiner et al. 1999; Carter and Tiffany 1999). Cue reactivity is considered to be a consequence of (associative) learning mechanisms, in particular conditioning processes (Carter and Tiffany 1999; Tiffany et al. 2000; Loeber and Duka 2009), and it provides the physiological, emotional, and motivational basis for craving (Robinson

and Berridge 1993, 2000). The concept of cue reactivity and craving has already been applied to behavioral addictions, for example gambling disorder (e.g., Wölfling et al. 2011). Some recent fMRI studies have investigated neural correlates of cue reactivity and craving in individuals with gambling disorder (Wulfert et al. 2009; Crockford et al. 2005; Potenza et al. 2003) and also in subjects with Internet gaming disorder (Thalemann et al. 2007; Ko et al. 2009). On a behavioral level, initial evidence for cue reactivity and craving and their impact on symptom severity has also emerged for Internet pornography addiction (Brand et al. 2011; Laier et al. 2013) and pathological buying (Trotzke et al. 2014). Transferring these concepts to the model of Internet addiction by Brand et al. (2014b), the ellipsis representing a person's core cognitions could be complemented by including "cognitive and affective responses to Internet-related cues". These components have been included explicitly in the recently published I-PACE model (Brand et al. 2016b). The predisposing factors together with Internet use expectancies should influence the intensity of cue reactivity and craving and other specific cognitive and affective processes. In addition, and more importantly, the use of certain Internet applications and the gratification received thereby should also lead to an increase of cue reactivity and craving as responses to certain stimuli, as a result of conditioning processes. Future studies are needed to test these hypotheses.

Another aspect that is not explicitly included in our initial model (Brand et al. 2014b) is the potential impact of reduced executive functioning and reduced inhibitory control, the role of which has been described in detail in the aforementioned text. Executive functions, particularly decision-making abilities, are central components of the model of Internet gaming disorder proposed by Dong and Potenza (2014). Executive functions, inhibitory control, and decision-making have already been studied in the context of Internet addiction in general and Internet gaming disorder in particular (e.g., Dong et al. 2013; Pawlikowski and Brand 2011; Sun et al. 2009). Results regarding inhibitory control in Internet-addicted individuals are mixed (Sun et al. 2009; Dong et al. 2010, 2011, 2013). However, it must be noted that all the studies on inhibitory control utilize neutral versions of the Go/No-Go task or the Stroop paradigm. Results may be clearer if stimuli explicitly depicting Internet-related content were used, since it may be assumed that subjects with a specific Internet addiction have difficulty in inhibiting responses to stimuli representing their first-choice-use, as has been shown in binge drinkers (Czapla et al. 2015) and substance-dependent individuals (e.g., Pike et al. 2013). Zhou et al. (2012) used a shifting task with Internet gaming-related cues and reported that reductions in response inhibition and mental flexibility can occur when addicted individuals are confronted with such addiction-specific cues. Another example of using addiction-related cues to investigate executive reductions and deficits in decision-making in Internet-addicted individuals is the study by Laier et al. (2014), although they used a nonclinical sample only. For the experimental paradigm, they modified the Iowa Gambling Task to include pornographic and neutral pictures on the advantageous and disadvantageous card decks (and vice versa for the other

group of subjects). The results demonstrate that those individuals who performed the task with pornographic pictures on the disadvantageous card decks continued choosing the cards from these decks even though they incurred high-monetary losses. This effect was particularly strong in those participants who reported a relatively high subjective craving experience in response to the presentation of pornographic stimuli in an additional paradigm used in the study.

Previous findings on reduced executive functioning and inhibitory control as well as on cue reactivity and craving are—at least preliminarily—consistent with results obtained from neuroimaging investigations (Kuss and Griffiths 2012). Recent studies, mostly addressing Internet gaming disorder, revealed both gray and white matter abnormalities in prefrontal brain areas and additional brain regions, such as limbic structures (e.g., Hong et al. 2013a, b; Zhou et al. 2011). Functional brain changes are also reported on the prefrontal cortex, in particular the orbito-frontal cortex, and limbic structures (Dong et al. 2012, 2013, 2014). There is also initial evidence for changes in the dopaminergic system (Kim et al. 2011), which might be related to reinforcement processing (Jović and Đinđić 2011) and which could therefore be a correlate of cue reactivity and craving in individuals with Internet addiction.

In summary, reductions in executive functions, inhibitory control, and decision-making emerge in individuals with Internet addiction or in those subjects who are at risk for developing an addictive use of certain applications. Most likely, this is particularly the case when they are confronted with addiction-related stimuli. One interpretation of these findings is that cue reactivity and craving may reduce inhibitory control and executive functions. The reduction of executive/inhibitory control has been well described in patients with substance dependence (Goldstein and Volkow 2011). The new I-PACE model of Internet addiction (Brand et al. 2016b) has therefore explicitly included the interaction between cognitive and affective responses to addiction-related cues and reductions in executive functions and inhibitory control. It has been suggested that this interaction results in diminished decision-making with a preference for short-term rewarding options, which leads to using the Internet application again and again. The suggested specification of the model's component "person's core cognitions" is illustrated in Fig. 2.3. Future studies should address these potential mechanisms using cognitive tasks, which include addiction-related stimuli. Given that cue reactivity and craving when being confronted with Internet-related cues are also present in patients with Internet addiction, which is neutrally represented by a stronger ventral striatum activity (Thalemann et al. 2007; Ko et al. 2009; Liu et al. 2016; Ahn et al. 2015; Brand et al. 2016a), one may argue that maintaining the addictive behavior is the consequence of a reduced top-down behavioral control in combination with an increased bottom-up process of addiction-related stimuli.

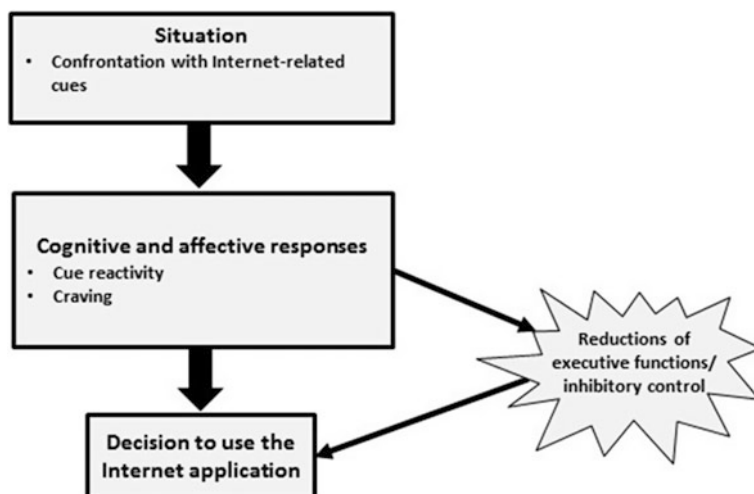


Fig. 2.3 The hypothesized interaction between cognitive and affective responses to specific Internet-related cues and reductions of executive functions and inhibitory control resulting in decisions to use a certain application as a result of craving when being confronted with certain stimuli

2.5 Conclusion

The theoretical models introduced by Brand et al. (2014b, 2016b) and by Dong and Potenza (2014) are a first step to describe potential mechanisms underlying the development and maintenance of Internet addiction or Internet gaming disorder, respectively. Most of the variables included in the models have been selected from previous studies with both treatment-seeking patients and nonclinical samples. These previous studies addressed, at least in most cases, group comparisons of patients with Internet addiction and healthy control subjects or bivariate correlations between certain variables, such as psychopathological symptoms or personality facets, and symptom severity of Internet addiction in general or specific types of Internet addiction, respectively. This means that research on interactions in terms of potential moderating and mediating effects for the relationship between predisposing factors and symptoms of Internet addiction is still very limited. The theoretical I-PACE model by Brand et al. (2016b) illustrates such potential interactions. For instance, dysfunctional copying style and Internet use expectancies are considered mediators for the link between a person's core characteristics/predisposing factors and the severity of Internet addiction. In addition, the development of cue reactivity and craving on the basis of reinforcement learning mechanisms in interaction with reduced executive functioning and inhibitory control could be further important processes underlying the development and maintenance of a specific Internet addiction. This model must be seen as a model in progress. Future studies may explicitly address the hypothesized relationships and interaction effects

for several types of specific Internet addiction. Such studies can show similarities and differences across several types of Internet addiction and can also show which of the model's main assumptions seem valid. If the proposed cognitive processes would indeed play a major role in the course of the addictive behavior, this may also inspire the improvement of the specificity of intervention methods. In cognitive behavioral therapy for Internet addiction (Young 2013), working with the client on his/her cognitions about the Internet use is already a component of the intervention, but this could be tailored to specific expectancies and illusions about the Internet use. Strengthening cognitive control over the Internet use in combination with reducing cue reactivity could also be worth considering in Internet addiction therapy.

References

- Ahn HM, Chung HJ, Kim SH (2015) Altered brain reactivity to game cues after gaming experience. *CyberPsychol Behav Soc Netw* 18:474–479. doi:[10.1089/cyber.2015.0185](https://doi.org/10.1089/cyber.2015.0185)
- APA (2013) Diagnostic and statistical manual of mental disorders, 5th edn. APA, Washington DC
- Bechara A (2005) Decision making, impulse control and loss of willpower to resist drugs: A neurocognitive perspective. *Nat Neurosci* 8:1458–1463. doi:[10.1038/nm1584](https://doi.org/10.1038/nm1584)
- Berridge KC (2007) The debate over dopamine's role in reward: the case for incentive salience. *Psychopharmacology* 191:391–431
- Berridge KC, Robinson TE, Aldridge JW (2009) Dissecting components of reward: 'liking', 'wanting', and learning. *Curr Opin Pharmacol* 9:65–73. doi:[10.1016/j.coph.2008.12.014](https://doi.org/10.1016/j.coph.2008.12.014)
- Bischof G, Bischof A, Meyer C, John U, Rumpf H-J (2013) Prävalenz der Internetabhängigkeit—Diagnostik und Risikoprofile (PINTA-DIARI) [Internet]. http://drogenbeauftragte.de/fileadmin/dateien-dba/DrogenundSucht/Computerspiele_Internetsucht/Downloads/PINTA-DIARI-2013-Kompaktbericht.pdf
- Brand M, Laier C, Pawlikowski M, Schächtle U, Schöler T, Altstötter-Gleich C (2011) Watching pornographic pictures on the Internet: Role of sexual arousal ratings and psychological-psychiatric symptoms for using Internet sex sites excessively. *CyberPsychol Behav Soc Netw* 14:371–377. doi:[10.1089/cyber.2010.0222](https://doi.org/10.1089/cyber.2010.0222)
- Brand M, Laier C, Young KS (2014a) Internet addiction: coping styles, expectancies, and treatment implications. *Front Psychol* 5:1256. doi:[10.3389/fpsyg.2014.01256](https://doi.org/10.3389/fpsyg.2014.01256)
- Brand M, Young KS, Laier C (2014b) Prefrontal control and Internet addiction: a theoretical model and review of neuropsychological and neuroimaging findings. *Front Human Neurosci* 8:375. doi:[10.3389/fnhum.2014.00375](https://doi.org/10.3389/fnhum.2014.00375)
- Brand M, Snagowski J, Laier C, Maderwald S (2016a) Ventral striatum activity when watching preferred pornographic pictures is correlated with symptoms of Internet pornography addiction. *NeuroImage* 129:224–232. doi:[10.1016/j.neuroimage.2016.01.033](https://doi.org/10.1016/j.neuroimage.2016.01.033)
- Brand M, Young KS, Laier C, Wölfling K, Potenza MN (2016b) Integrating psychological and neurobiological considerations regarding the development and maintenance of specific Internet-use disorders: An Interaction of Person-Affect-Cognition-Execution (I-PACE) model. *Neuroscience & Biobehavioral Reviews* 71:252–266. doi:[10.1016/j.neubiorev.2016.08.033](https://doi.org/10.1016/j.neubiorev.2016.08.033)
- Breiner MJ, Stritzke WGK, Lang AR (1999) Approaching avoidance. A step essential to the understanding of craving. *Alcohol Research & Therapy* 23:197–206
- Caplan SE (2007) Relations among loneliness, social anxiety, and problematic Internet use. *CyberPsychol Behav* 10:234–242. doi:[10.1089/cpb.2006.9963](https://doi.org/10.1089/cpb.2006.9963)

- Carter BL, Tiffany ST (1999) Meta-analysis of cue-reactivity in addiction research. *Addiction* 94:327–340
- Chou C, Condon L, Belland JC (2005) A review of the research on Internet addiction. *Educ Psychol Rev* 17:363–387. doi:[10.1007/s10648-005-8138-1](https://doi.org/10.1007/s10648-005-8138-1)
- Correa T, Hinsley AW, de Zuniga HG (2010) Who interacts on the Web? The intersection of users' personality and social media use. *Comput Hum Behav* 26:247–253
- Crockford DN, Goodyear B, Edwards J, Quickfall J, el-Guebaly N (2005) Cue-induced brain activity in pathological gamblers. *Biol Psychiatry* 58:787–795
- Czapla M, Simon J, Friederich H-C, Herpertz SC, Zimmermann P, Loeber S (2015) Is binge drinking in young adults associated with an alcohol-specific impairment of response inhibition? *Eur Addict Res* 21:105–113
- Davis RA (2001) A cognitive-behavioral model of pathological Internet use. *Comput Hum Behav* 17:187–195. doi:[10.1016/S0747-5632\(00\)00041-8](https://doi.org/10.1016/S0747-5632(00)00041-8)
- Deryakulu D, Ursavas ÖF (2014) Genetic and environmental influences on problematic Internet use: a twin study. *Comput Hum Behav* 39:331–338. doi:[10.1016/j.chb.2014.07.038](https://doi.org/10.1016/j.chb.2014.07.038)
- Dong G, Devito EE, Du X, Cui Z (2012) Impaired inhibitory control in “internet addiction disorder”: a functional magnetic resonance imaging study. *Psychiatry Res* 203:153–158. doi:[10.1016/j.psychres.2012.02.001](https://doi.org/10.1016/j.psychres.2012.02.001)
- Dong G, Hu Y, Lin X, Lu Q (2013) What makes Internet addicts continue playing online even when faced by severe negative consequences? Possible explanations from an fMRI study. *Biol Psychol* 94:282–289. doi:[10.1016/j.biopsycho.2013.07.009](https://doi.org/10.1016/j.biopsycho.2013.07.009)
- 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. *Addict Behav* 39:677–683. doi:[10.1016/j.addbeh.2013.11.028](https://doi.org/10.1016/j.addbeh.2013.11.028)
- Dong G, Lu Q, Zhou H, Zhao X (2010) Impulse inhibition in people with Internet addiction disorder: electrophysiological evidence from a Go/NoGo study. *Neurosci Lett* 485:138–142
- Dong G, Potenza MN (2014) A cognitive-behavioral model of Internet gaming disorder: theoretical underpinnings and clinical implications. *J Psychiatr Res* 58:7–11. doi:[10.1016/j.jpsychires.2014.07.005](https://doi.org/10.1016/j.jpsychires.2014.07.005)
- Dong G, Zhou H, Zhao X (2011) Male Internet addicts show impaired executive control ability: Evidence from a color-word Stroop task. *Neurosci Lett* 499:114–118. doi:[10.1016/j.neulet.2011.05.047](https://doi.org/10.1016/j.neulet.2011.05.047)
- Ebeling-Witte S, Frank ML, Lester D (2007) Shyness, internet use, and personality. *CyberPsychol Behav* 10:713–716. doi:[10.1089/cpb.2007.9964](https://doi.org/10.1089/cpb.2007.9964)
- Everitt BJ, Robbins TW (2016) Drug addiction: updating actions to habits to compulsions ten years on. *Ann Rev Psychol* 67:23–50. doi:[10.1146/annurev-psych-122414-033457](https://doi.org/10.1146/annurev-psych-122414-033457)
- Floros G, Siomos K, Stogiannidou A, Giouzepas I, Garyfallos G (2014) The relationship between personality, defense styles, internet addiction disorder, and psychopathology in college students. *CyberPsychol Behav Soc Netw* 17:672–676
- Goldstein RZ, Volkow ND (2011) Dysfunction of the prefrontal cortex in addiction: neuroimaging findings and clinical implications. *Nat Rev Neurosci* 12:652–669
- Griffiths MD (2012) Internet sex addiction: a review of empirical research. *Addict Res Theory* 20:111–124. doi:[10.3109/16066359.2011.588351](https://doi.org/10.3109/16066359.2011.588351)
- Han DH, Lee YS, Yang KC, Kim EY, Lyoo IK, Renshaw PF (2007) Dopamine genes and reward dependence in adolescents with excessive Internet video game play. *J Addict Med* 1:133–138
- Hansen S (2002) Excessive Internet usage or ‘Internet Addiction’? The implications of diagnostic categories for student users. *J Comput Assist Learn* 18:235–236. doi:[10.1046/j.1365-2729.2002.t01-2-00230.x](https://doi.org/10.1046/j.1365-2729.2002.t01-2-00230.x)
- Hardie E, Tee MY (2007) Excessive Internet use: the role of personality, loneliness, and social support networks in Internet Addiction. *Aust J Emerg Technol Soc* 5:34–47
- Ho RC, Zhang MWB, Tsang TY, Toh AH, Pan F, Lu Y, Cheng C, Yip PS, Lam LT, Lai C-M, Watanabe H, Mak K-K (2014) The association between internet addiction and psychiatric co-morbidity: a meta-analysis. *BMC Psychiatry* 14:183. doi:[10.1186/1471-244X-14-183](https://doi.org/10.1186/1471-244X-14-183)

- Hong S-B, Kim J-W, Choi E-J, Kim H-H, Suh J-E, Kim C-D, Klauser P, Whittle S, Yücel M, Pantelis C, Yi S-H (2013a) Reduced orbitofrontal cortical thickness in male adolescents with internet addiction. *Behav Brain Funct* 9:11. doi:[10.1186/1744-9081-9-11](https://doi.org/10.1186/1744-9081-9-11)
- Hong S-B, Zalesky A, Cocchi L, Fornito A, Choi E-J, Kim H-H, Suh JE, Kim CD, Kim JW, Yi S-H (2013b) Decreased functional brain connectivity in adolescents with internet addiction. *PLoS ONE* 8:e57831. doi:[10.1371/journal.pone.0057831](https://doi.org/10.1371/journal.pone.0057831)
- Jović J, Đinđić N (2011) Influence of dopaminergic system on Internet addiction. *Acta Medica Medianae* 50:60–66. doi:[10.5633/amm.2011.0112](https://doi.org/10.5633/amm.2011.0112)
- Kardefelt-Winther D (2014) A conceptual and methodological critique of internet addiction research: towards a model of compensatory internet use. *Comput Hum Behav* 31:351–354. doi:[10.1016/j.chb.2013.10.059](https://doi.org/10.1016/j.chb.2013.10.059)
- Kim HK, Davis KE (2009) Toward a comprehensive theory of problematic Internet use: evaluating the role of self-esteem, anxiety, flow, and the self-rated importance of Internet activities. *Comput Hum Behav* 25:490–500. doi:[10.1016/j.chb.2008.11.001](https://doi.org/10.1016/j.chb.2008.11.001)
- Kim SH, Baik S-H, Park CS, Kim SJ, Choi SW, Kim SE (2011) Reduced striatal dopamine D2 receptors in people with Internet addiction. *NeuroReport* 22:407–411. doi:[10.1097/WNR.0b013e328346e16e](https://doi.org/10.1097/WNR.0b013e328346e16e)
- Ko C-H, Liu GC, Hsiao S, Yen JY, Yang MJ, Lin WC, Yen CF, Chen CS (2009) Brain activities associated with gaming urge of online gaming addiction. *J Psychiatr Res* 43:739–747. doi:[10.1016/j.jpsychores.2008.09.012](https://doi.org/10.1016/j.jpsychores.2008.09.012)
- Koo HJ, Kwon JH (2014) Risk and protective factors of Internet addiction: a meta-analysis of empirical studies in Korea. *Yonsei Med J* 55:1691–1711
- Kuss DJ, Griffiths MD (2012) Internet and gaming addiction: A systematic literature review of neuroimaging studies. *Brain Sci* 2:347–374. doi:[10.3390/brainsci2030347](https://doi.org/10.3390/brainsci2030347)
- Laier C, Brand M (2014) Empirical evidence and theoretical considerations on factors contributing to cybersex addiction from a cognitive-behavioral view. *Sex Addict Compulsivity* 21:305–321. doi:[10.1080/10720162.2014.970722](https://doi.org/10.1080/10720162.2014.970722)
- Laier C, Pawlikowski M, Brand M (2014) Sexual picture processing interferes with decision-making under ambiguity. *Arch Sex Behav* 43:473–482. doi:[10.1007/s10508-013-0119-8](https://doi.org/10.1007/s10508-013-0119-8)
- Laier C, Pawlikowski M, Pekal J, Schulte FP, Brand M (2013) Cybersex addiction: experienced sexual arousal when watching pornography and not real-life sexual contacts makes the difference. *J Behav Addict* 2:100–107. doi:[10.1556/JBA.2.2013.002](https://doi.org/10.1556/JBA.2.2013.002)
- Lee YS, Han DH, Yang KC, Daniels MA, Na C, Kee BS, Renshaw PF (2008) Depression like characteristics of 5HTTLPR polymorphism and temperament in excessive internet users. *J Affect Disord* 109:165–169
- Li M, Chen J, Li N, Li X (2014) A twin study of problematic internet use: its heritability and genetic association with effortful control. *Twin Res Human Genet* 17:279–287
- Liu L, Yip SW, Zhang J-T, Wang L-J, Shen Z-J, Liu B, Ma S-S, Yao YW, Fang XY (2016) Activation of the ventral and dorsal striatum during cue reactivity in internet gaming disorder. *Addict Biol* doi:[10.1111/adb.12338](https://doi.org/10.1111/adb.12338)
- Loeber S, Duka T (2009) Acute alcohol impairs conditioning of a behavioural reward-seeking response and inhibitory control processes—Implications for addictive disorders. *Addiction* 104:2013–2022. doi:[10.1111/j.1360-0443.2009.02718.x](https://doi.org/10.1111/j.1360-0443.2009.02718.x)
- Lortie CL, Guitton MJ (2013) Internet addiction assessment tools: dimensional structure and methodological status. *Addiction* 108:1207–1216. doi:[10.1111/add.12202](https://doi.org/10.1111/add.12202)
- Lu H, Ma L, Lee T, Hou H, Liao H (2014) The link of sexual sensation seeking to acceptance of cybersex, multiple sexual partners, and one-night stands among Taiwanese college students. *J Nurs Res* 22:208–215
- Montag C, Bey K, Sha P, Li M, Chen YF, Liu WY, Zhu YK, Li CB, Markett S, Keiper J, Reuter M (2015) Is it meaningful to distinguish between generalized and specific Internet addiction? Evidence from a cross-cultural study from Germany, Sweden, Taiwan and China. *Asia-Pacific Psychiatry* 7:20–26. doi:[10.1111/appy.12122](https://doi.org/10.1111/appy.12122)

- Montag C, Kirsch P, Sauer C, Markett S, Reuter M (2012) The role of the CHRNA4 gene in internet addiction: a case-control study. *J Addict Med* 6:191–195. doi:[10.1097/ADM.0b013e31825ba7e7](https://doi.org/10.1097/ADM.0b013e31825ba7e7)
- Morahan-Martin J, Schumacher P (2003) Loneliness and social uses of the internet. *Comput Hum Behav* 19:659–671. doi:[10.1016/S0747-5632\(03\)00040-2](https://doi.org/10.1016/S0747-5632(03)00040-2)
- Müller A, Brand M, Mitchell JE, de Zwaan M (in press) Pathological online shopping. In: Potenza M (ed) *Online addiction*. Oxford University Press, Oxford
- Niemz K, Griffiths MD, Banyard P (2005) Prevalence of pathological Internet use among university students and correlations with self-esteem, the General Health Questionnaire (GHQ), and disinhibition. *CyberPsychol Behav* 8:562–570. doi:[10.1089/cpb.2005.8.562](https://doi.org/10.1089/cpb.2005.8.562)
- Pawlikowski M, Brand M (2011) Excessive Internet gaming and decision making: do excessive World of Warcraft-players have problems in decision making under risky conditions? *Psychiatry Res* 188:428–433. doi:[10.1016/j.psychres.2011.05.017](https://doi.org/10.1016/j.psychres.2011.05.017)
- Pawlikowski M, Nader IW, Burger C, Biermann I, Stieger S, Brand M (2014) Pathological Internet use—it is a multidimensional and not a unidimensional construct. *Addict Res Theory* 22:166–175. doi:[10.3109/16066359.2013.793313](https://doi.org/10.3109/16066359.2013.793313)
- Piazza PV, Deroche-Gamonet V (2013) A multistep general theory of transition to addiction. *Psychopharmacology* 229:387–413. doi:[10.1007/s00213-013-3224-4](https://doi.org/10.1007/s00213-013-3224-4)
- Pike E, Stoops WW, Fillmore MT, Rush CR (2013) Drug-related stimuli impair inhibitory control in cocaine abusers. *Drug Alcohol Depend* 133:768–771. doi:[10.1016/j.drugalcdep.2013.08.004](https://doi.org/10.1016/j.drugalcdep.2013.08.004)
- Pontes HM, Griffiths MD, Patrão IM (2014) Internet addiction and loneliness among children and adolescents in the education setting: an empirical pilot study. *Aloma* 32 (91–98)
- Potenza MN, Steinberg MA, Skudlarski P, Fulbright RK, Lacadie CM, Wilber MK, Rounsaville BJ, Gore JC, Wexler BE (2003) Gambling urges in pathological gambling. A functional magnetic resonance imaging study. *Arch Gen Psychiatry* 60:828–836
- Robinson TE, Berridge KC (1993) The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Res Brain Res Rev* 18:247–291
- Robinson TE, Berridge KC (2000) The psychology and neurobiology of addiction: an incentive-sensitization view. *Addiction* 95:91–117
- Robinson TE, Berridge KC (2001) Incentive-sensitization and addiction. *Addiction* 96:103–114
- Robinson TE, Berridge KC (2008) The incentive sensitization theory of addiction: some current issues. *Philos Trans R Soc B* 363:3137–3146. doi:[10.1098/rstb.2008.0093](https://doi.org/10.1098/rstb.2008.0093)
- Sariyska R, Reuter M, Bey K, Sha P, Li M, Chen YF, Liu WY, Zhu YK, Li C, Suárez-Rivillas A, Feldmann M, Hellmann M, Keiper J, Markett S, Young KS, Montag C (2014) Self-esteem, personality and Internet addiction: a cross-cultural comparison study. *Personality Individ Differ* 61–62:28–33
- Sariyska R, Reuter M, Lachmann B, Montag C (2015) Attention deficit/hyperactivity disorder is a better predictor for problematic Internet use than depression: Evidence from Germany. *J Addict Res Therapy* 6:209. doi:[10.4172/2155-6105.1000209](https://doi.org/10.4172/2155-6105.1000209)
- Spada MM (2014) An overview of problematic Internet use. *Addict Behav* 39:3–6. doi:[10.1016/j.addbeh.2013.09.007](https://doi.org/10.1016/j.addbeh.2013.09.007)
- Starcevic V (2013) Is Internet addiction a useful concept? *Aust N Z J Psychiatry* 47:16–19. doi:[10.1177/0004867412461693](https://doi.org/10.1177/0004867412461693)
- Sun D-L, Chen ZJ, Ma N, Zhang X-C, Fu X-M, Zhang DR (2009) Decision-making and prepotent response inhibition functions in excessive Internet users. *CNS Spectr* 14:75–81
- Tang J, Yu Y, Du Y, Ma Y, Zhang D, Wang J (2014) Prevalence of internet addiction and its association with stressful life events and psychological symptoms among adolescent internet users. *Addict Behav* 39:744–747. doi:[10.1016/j.addbeh.2013.12.010](https://doi.org/10.1016/j.addbeh.2013.12.010)
- Thalemann R, Wölfling K, Grüsser SM (2007) Specific cue reactivity on computer game-related cues in excessive gamers. *Behav Neurosci* 121:614–618. doi:[10.1037/0735-7044.121.3.614](https://doi.org/10.1037/0735-7044.121.3.614)
- Thatcher A, Wretschko G, Fridjhon P (2008) Online flow experiences, problematic Internet use and Internet procrastination. *Comput Hum Behav* 24:2236–2254. doi:[10.1016/j.chb.2007.10.008](https://doi.org/10.1016/j.chb.2007.10.008)
- Tiffany ST, Carter BL, Singleton EG (2000) Challenges in the manipulation, assessment and interpretation of craving relevant variables. *Addiction* 95:177–187

- Tonioni F, Mazza M, Autullo G, Cappelluti R, Catalano V, Marano G, Fiumana V, Moschetti C, Alimonti F, Luciani M, Lai C (2014) Is Internet addiction a psychopathological condition distinct from pathological gambling? *Addict Behav* 39:1052–1056. doi:[10.1016/j.addbeh.2014.02.016](https://doi.org/10.1016/j.addbeh.2014.02.016)
- Trotzke P, Starcke K, Pedersen A, Brand M (2014) Cue-induced craving in pathological buying: empirical evidence and clinical implications. *Psychosom Med* 76:694–700. doi:[10.1097/PSY.0000000000000126](https://doi.org/10.1097/PSY.0000000000000126)
- Vink JM, Beijsterveldt TC, Huppertz C, Bartels M, Boomsma DI (2015) Heritability of compulsive Internet use in adolescents. *Addiction biology*: Epub ahead of print. doi:[10.1111/adb.12218](https://doi.org/10.1111/adb.12218)
- Wang CW, Ho RT, Chan CL, Tse S (2015) Exploring personality characteristics of Chinese adolescents with internet-related addictive behaviors: Trait differences for gaming addiction and social networking addiction. *Addict Behav* 42:32–35
- Wegmann E, Stodt B, Brand M (2015) Addictive use of social networking sites can be explained by the interaction of Internet use expectancies, Internet literacy, and psychopathological symptoms. *J Behav Addict* 4:155–162. doi:[10.1556/2006.4.2015.021](https://doi.org/10.1556/2006.4.2015.021)
- Whang LSM, Lee S, Chang G (2003) Internet over-users' psychological profiles: a behavior sampling analysis on Internet addiction. *CyberPsychol Behav* 6:143–150. doi:[10.1089/109493103321640338](https://doi.org/10.1089/109493103321640338)
- Widyanto L, Griffiths MD (2006) 'Internet addiction': a critical review. *Int J Mental Health Addict* 4:31–51. doi:[10.1007/s11469-006-9009-9](https://doi.org/10.1007/s11469-006-9009-9)
- Wölfling K, Mörsen CP, Duvén E, Albrecht U, Grüsser SM, Flor H (2011) To gamble or not to gamble: at risk for craving and relapse – learned motivated attention in pathological gambling. *Biol Psychol* 87:275–281. doi:[10.1016/j.biopsycho.2011.03.010](https://doi.org/10.1016/j.biopsycho.2011.03.010)
- Wulfert E, Maxson J, Jardin B (2009) Cue-specific reactivity in experienced gamblers. *Psychol Addict Behav* 23:731–773. doi:[10.1037/a0017134](https://doi.org/10.1037/a0017134)
- Young KS (1996) Addictive use of the Internet: a case that breaks the stereotype. *Psychol Rep* 79:899–902. doi:[10.2466/pr0.1996.79.3.899](https://doi.org/10.2466/pr0.1996.79.3.899)
- Young KS (1998) Internet addiction: the emergence of a new clinical disorder. *CyberPsychol Behav* 3:237–244. doi:[10.1089/cpb.1998.1.237](https://doi.org/10.1089/cpb.1998.1.237)
- Young KS (2004) Internet addiction: a new clinical phenomenon and its consequences. *Am Behav Sci* 48:402–415
- Young KS (2013) Treatment outcomes using CBT-IA with Internet-addicted patients. *J Behav Addict* 2:209–215. doi:[10.1556/JBA.2.2013.4.3](https://doi.org/10.1556/JBA.2.2013.4.3)
- Young KS, Pistner M, O'Mara J, Buchanan J (1999) Cyber disorders: the mental health concern for the new millennium. *CyberPsychol Behav* 2:475–479. doi:[10.1089/cpb.1999.2.475](https://doi.org/10.1089/cpb.1999.2.475)
- Young KS, Yue XD, Ying L (2011) Prevalence estimates and etiologic models of internet addiction. In: Young KS, Abreu CN (eds) *Internet addiction*. Wiley, Hoboken, N.J., pp 3–18
- Zhou Y, Lin F-C, Du Y-S, Qin L-D, Zhao Z-M, Xu J-R, Lei H (2011) Gray matter abnormalities in Internet addiction: a voxel-based morphometry study. *Eur J Radiol* 79:92–95. doi:[10.1016/j.ejrad.2009.10.025](https://doi.org/10.1016/j.ejrad.2009.10.025)
- Zhou Z, Yuan G, Yao J (2012) Cognitive biases toward Internet game-related pictures and executive deficits in individuals with an Internet game addiction. *PLoS ONE* 7:e48961. doi:[10.1371/journal.pone.0048961](https://doi.org/10.1371/journal.pone.0048961)

Internet Addiction

Neuroscientific Approaches and Therapeutical

Implications Including Smartphone Addiction

Montag, C.; Reuter, M. (Eds.)

2017, XI, 392 p. 45 illus., 22 illus. in color., Hardcover

ISBN: 978-3-319-46275-2