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Review article

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

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ABSTRACT

Within the last two decades, many studies have addressed the clinical phenomenon of Internet-use disorders, with a particular focus on Internet-gaming disorder. Based on previous theoretical considerations and empirical findings, we suggest an Interaction of Person-Affect-Cognition-Execution (I-PACE) model of specific Internet-use disorders. The I-PACE model is a theoretical framework for the processes underlying the development and maintenance of an addictive use of certain Internet applications or sites promoting gaming, gambling, pornography viewing, shopping, or communication. The model is composed as a process model. Specific Internet-use disorders are considered to be the consequence of interactions between predisposing factors, such as neurobiological and psychological constitutions, moderators, such as coping styles and Internet-related cognitive biases, and mediators, such as affective and cognitive responses to situational triggers in combination with reduced executive functioning. Conditioning processes may strengthen these associations within an addiction process. Although the hypotheses regarding the mechanisms underlying the development and maintenance of specific Internet-use disorders, summarized in the I-PACE model, must be further tested empirically, implications for treatment interventions are suggested.

Contents

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1. Introduction

The first description of a patient with symptoms of Internet addiction was published by Young (1996). Although the extent to which the Internet may be considered as a focus of an addiction or facilitates addictive behaviors (or whether excessive or problematic engagement in Internet-related behaviors should be considered within an addiction framework at all) remains debated (Petry and O'Brian, 2013), there have been significant changes in the availability and use of the Internet since 1996. Within the last two decades, research on Internet addiction has grown significantly. Many studies have assessed epidemiological factors of an addictive use of the Internet, its prevalence in different countries as well as its comorbidities and personality correlates (see recent reviews by Cash et al., 2012; Kuss and Lopez-Fernandez, 2016; Pezoa-Jares et al., 2012; Pontes et al., 2015; Spada, 2014; Suissa, 2015). In the fifth edition of the Diagnostic and Statistical Manual (DSM-5) (APA, 2013), Internet-gaming disorder – as one specific type of Internet addiction – has recently been included in section III emphasizing that it is most likely that this condition has clinical significance, but that more research is needed to ensure its clinical relevance and the exact phenomenology. Although the term Internet addiction is discussed controversially (Starcevic, 2013), it is arguably the most frequently used term in international publications (e.g., Brand et al., 2014a,b; Chou et al., 2005; Dong et al., 2013b; Douglas et al., 2008; Griffiths, 1999; Hansen, 2002; Kuss and Griffiths, 2011a; Kuss et al., 2014; Weinstein and Lejoyeux, 2010; Widyanto and Griffiths, 2006; Young, 1998, 2004; Young et al., 2011). However, given controversies regarding the usage of the term addiction and to be consistent with existing nomenclature in DSM-5 and proposed nomenclature in ICD-11, we will more frequently use the term Internet-use disorder(s) except when it is more precise to use the term Internet addiction (e.g., when referring to prior literature).

Although the DSM-5 focuses on Internet gaming, a meaningful number of authors indicate that treatment-seeking individuals may also use other Internet applications or sites addictively. Prominent examples include gambling, pornography, social networking, and shopping sites (Brand et al., 2014b; Griffiths, 2012; Kuss and Griffiths, 2011b; Müller et al., in press; Müller et al., 2016; Young et al., 1999). The Internet activity of individuals reporting features of addictive usage should therefore be specified, because individuals are not addicted to the medium itself per se, but to the content they are using (see comprehensive discussion in Starcevic, 2013). Empirical evidence also suggests differentiating between a more generalized Internet addiction and specific types of addictive Internet usage (e.g., Montag et al., 2015; Pawlikowski et al., 2014). Consistent with this notion, we argue to use the term specific Internet-use disorders, which implies that the content used should be specified, for example Internet-gaming disorder, Internet-gambling disorder, Internet-pornography-viewing disorder, etc. (Brand et al., 2014b). An awareness of the common and distinct processes behind these phenomena may have a significant impact on policies, prevention efforts, and clinical treatments.

For both research and clinical practice, theoretical models of the mechanisms underlying the development and maintenance of addictive behaviors are very important. For Internet addiction, two theoretical models have been published in 2014, one by Brand et al. (2014b), and another, which focuses on Internet gaming, by Dong and Potenza (2014). Since the publication of these two models, new research findings exist, which partly confirm certain theoretical assumptions of the models, but which also give rise to new ideas on the mechanisms involved in the addiction process. Consequently, we think that revising our model on specific Internet-use disorders (Brand et al., 2014b) is timely, given that theoretical models and frameworks should be modified based on new data emerging from research.

The aim of the current article is to suggest a revised version of our model on specific Internet-use disorders. The specific goals are as follows. First, we integrate current research on Internet-use disorders into the theoretical model. We also integrate findings and theoretical assumptions from other research areas, e.g., by referring to concepts known from substance-dependence research. This is consistent with the idea to classify Internet-use disorders and other behavioral addictions together with substance-use disorders as addictive behaviors (cf. Chamberlain et al., 2015; Derbyshire and Grant, 2015; Fauth-Bühler and Mann, 2015; Fauth-Bühler et al., 2016; Grant et al., 2006, 2010; Grant and Chamberlain, 2015; Kraus et al., 2016; Potenza, 2006; Robbins and Clark, 2015). Second, we aim at suggesting the revised model as a general model for specific types of Internet-use disorders, which can then be further specified in future studies with respect to the certain forms of Internet use (e.g., gaming, gambling, pornography, cybersex, social networking, buying/shopping, etc.). Third, we aim at expressing and illustrating the process of the development and maintenance of specific addictive behaviors. By doing this, we explicitly distinguish between predisposing factors, which make individuals vulnerable for developing specific Internet-use disorders, and variables that act as moderators and mediators within the addiction process. Moderator and mediator variables are important components of theoretical models for psychiatric/psychological disorders, because pharmacological and psychological interventions may address moderating and mediating variables effectively, while certain vulnerability factors (e.g., genetic vulnerability, personality) may be relatively stable (Brand et al., 2014a). Such theoretical models, or parts there of, may then be transferred into statistical models, which may be tested empirically in future studies. By understanding the mechanisms behind the phenomena, policy, prevention and treatment efforts may be developed and tested on the basis of systematic hypotheses.

We aim at suggesting such a theoretical framework for a process model, which hopefully inspires future research and clinical practice.

2. Summary of current models on the development and maintenance of Internet-use disorders

The model for Internet addiction by Brand et al. (2014b) consists of three parts: a model describing the functional/healthy use of the Internet, a model of generalized Internet addiction (see Davis, 2001), and a global model of specific types of Internet addiction. Here, we focus on the revision of the model on specific Internet-use disorders. The specific types refer to an addictive use of one certain genre of applications or sites, such as gaming, gambling, pornography/cybersex, shopping, social networking, or communication. This means we postulate that individuals have a "first-choice use", which is considered being comparable to the "first-choice drug" in substance-dependent individuals.

This model of specific Internet-use disorders includes psychopathological features (e.g., depression, social anxiety) and dysfunctional personality traits as well as other variables (e.g., stress vulnerability) as factors representing predispositions. Beyond those more global vulnerability factors, we have proposed that persons have specific characteristics, which make them more vulnerable to use certain types of applications or sites addictively. For example, a strong predilection towards gaming or high sexual excitability in general may in part explain why people excessively use specific applications/sites (i.e., relating to gaming or pornography-viewing, respectively) to experience gratification and pleasure. In terms of a mediation effect, we have also proposed that the predisposing variables may not have a direct impact on the development of a specific Internet-use disorder, but that they are associated with certain Internet-use expectancies and dysfunctional coping styles. Internet-use expectancies and coping have been considered personal core cognitions and may represent important moderating or mediating variables. As the final part of the model, the use of the first-choice application/site results in experience of gratification and positive reinforcement (Everitt and Robbins, 2016; Piazza and Deroche-Gamonet, 2013). Gratification leads to positive (and partly negative) reinforcement of the dysfunctional coping style, the expectancies about the use of specific Internet applications/sites, and some core characteristics, particularly psychopathological features and the specific preferences. We have argued further that these learning mechanisms may make it increasingly difficult for individuals to exert executive and inhibitory control over their Internet-use behavior.

The theoretical model of Internet-gaming disorder by Dong and Potenza (2014) also includes personal attitudes and cognitive processes. Central to this model is the link between decision-making style in terms of searching for immediate reward despite long-term negative consequences, and motivation-seeking (craving) in terms of a drive to experience pleasure and/or to reduce stress. The third domain involves executive control (inhibition and monitoring) over motivation-seeking, which is hypothesized to be reduced in individuals with Internet-gaming disorder. This assumption is consistent with theories and empirical findings of executive functioning in substance-dependent individuals (Goldstein and Volkow, 2011). In their model, Dong and Potenza (2014) refer to theories on substance addictions, which are reward-centered. One example is the incentive salience theory and the distinction of "liking" from "wanting" a drug (Berridge, 2007; Berridge et al., 2009; Robinson and Berridge, 2001, 2008). Dong and Potenza (2014) also included suggestions for treatment interventions, which could target specific cognitive and motivational factors.

Both models, which share several main components, are theoretically plausible, and studies to date have empirically tested parts of them. Previous studies with Internet-gaming disorder and other types of Internet-use disorders could show that certain vulnerability factors, motivation-seeking and craving, cognitive processes and decision-making, are worth considering. On the basis of these two theoretical models and integrating findings from recent studies on Internet-use disorders as well as other research areas, we suggest a revised theoretical process model for specific Internet-use disorders, which is aimed to reflect the addiction process in the development and maintenance of specific Internet-use disorders. This model should be understood as a theoretical framework for Internet-use disorders, although several parts of the model need to be tested empirically in future studies, in particular in investigations comparing different types of Internet-use disorders.

3. The Interaction of Person-Affect-Cognition-Execution (I-PACE) model of specific Internet-use disorders

The I-PACE model includes the following main components: Predisposing variables, affective and cognitive responses to internal or external stimuli, executive and inhibitory control, decision-making behavior resulting in the use of certain Internet applications/sites, and consequences of using the Internet applications/sites of choice. The model is illustrated in Fig. 1.

3.1. Predisposing variables representing core characteristics of the person: the P-component of the model

3.1.1. Biopsychological constitution

Predisposing variables contribute to a person's core characteristics, which may be relatively stable over time. The earliest predisposing factors are genetic factors and other biological determinants of human behavior, such as ontogenetic aspects and early childhood experiences and their resulting biological consequences and effects on learning experiences. With respect to a potential genetic contribution to Internet-use disorders, studies suggest that up to 48% of individual differences in Internet-use-disorder features may be accounted for by genetic factors, although the degrees of heritability estimates vary across investigations (Deryakulu and Ursavas, 2014; Li et al., 2014; Vink et al., 2015). One example for genetic variations that have been linked to Internet-use disorders are related to dopamine systems (in particular polymorphisms *COMT* Val158Met and *ANKK1/DRD2* Taq Ia), as reported by Han et al. (2007). This finding resonates with findings linking candidate polymorphisms to other behavioral addictions, such as pathological gambling (Goudriaan et al., 2004; Potenza, 2013). The serotonin-transporter-linked polymorphic region (5-HTTLPR) of the gene encoding the serotonin transporter (*SLC6A3*) has also been linked to Internet-use disorders (Y.S. Lee et al., 2008). With respect to the cholinergic system as a third potential neurochemical system involved in Internet-use disorders, Montag et al. (2012) reported a link between a genetic variation of the *CHRNA4* gene (linked to the cholinergic nicotine/acetylcholine receptor) and Internet-use-disorder features. However, these studies have typically involved relatively small, incompletely characterized samples and analyses targeted to specific candidate polymorphisms. In summary, although several initial studies give preliminary evidence for potential genetic contributions to Internet-use disorders, further research is needed (including from genome-wide association studies). It is also likely that individuals with different types of Internet-use disorders represent a heterogeneous group with respect to their genetic profiles. Most studies on genetics have included persons with Internet-gaming disorder or did not differentiate among different types of usage (Weinstein and Lejoyeux,

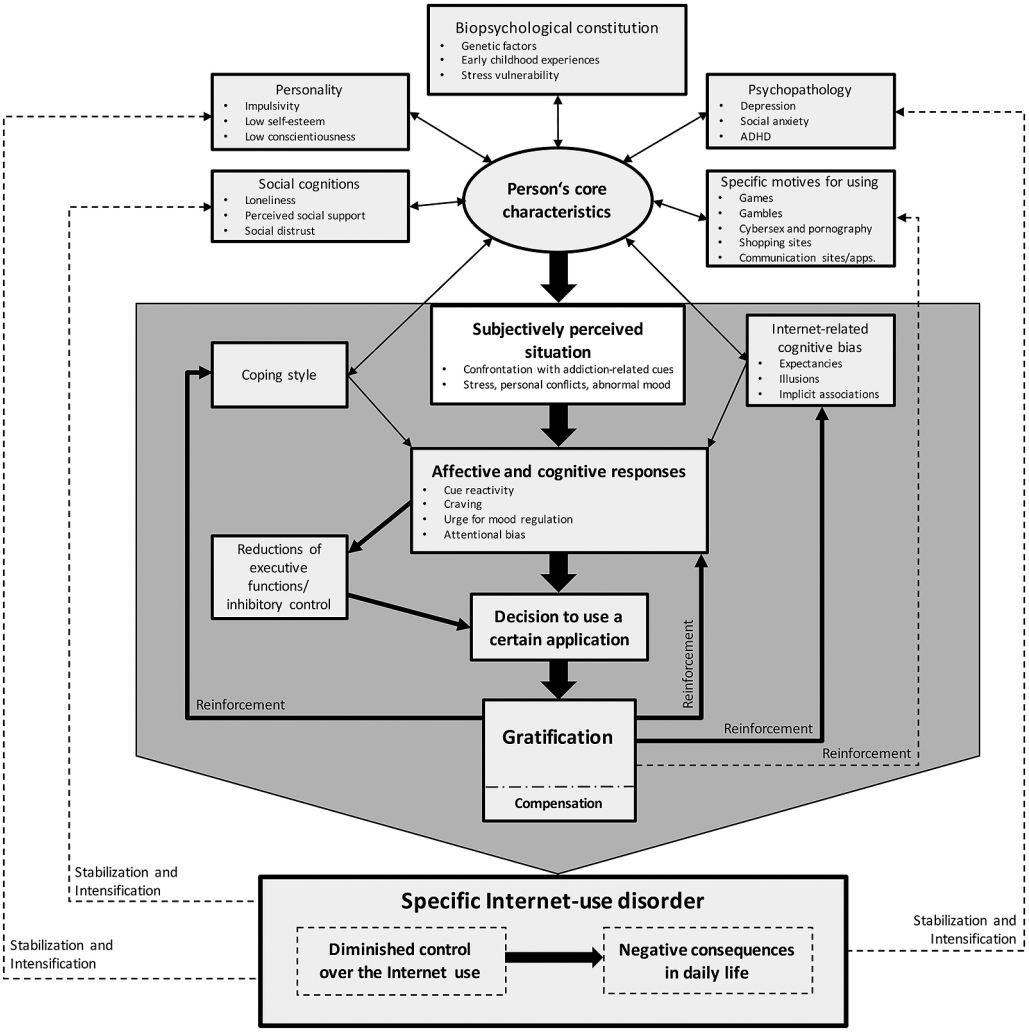

Fig. 1. The model on the development and maintenance of a specific Internet-use disorder. Bold arrows represent the main pathways of the addiction process.

2015). Future studies should explicitly ask for the "first-choice" use and compare the genetic profiles among different forms of Internet-use disorders (for example, those related to gaming, gambling, pornography viewing, buying, and social networking).

Further biopsychological factors, which may make individuals vulnerable to develop a mental disorder in general or an addictive behavior in particular, are negative early childhood experiences, such as early trauma, emotional or physical abuse, and social isolation. Consistent with this notion, some studies have found correlations between negative early life events and Internet-use disorders (Dalbudak et al., 2014; Hsieh et al., 2016). Negative life events in early childhood have also been linked to an insecure attachment style, which has also been found related with Internet-use disorders (e.g., Odaci and Çikrikçi, 2014; Schimmenti et al., 2014) including problematic Internet pornography use (Kor et al., 2014). One biological correlate of insecure attachment style is lower levels of oxytocin, which have also been associated with developing addictive behaviors (Baskerville and Douglas, 2010; Sarnyai and Kovács, 2014). Consistent with this notion, stressful experiences in early childhood make individuals more vulnerable to react intensively to stress in adolescents and adulthood (Elsey et al., 2015) and to develop mental disorders (Chen and Baram, 2016) and addictive behaviors (Briand and Blendy, 2010). In this context, early childhood experiences in combination with parental styles, familial atmospheres and parents' own Internet and media use may also have an important impact on children's and adolescents' Internet use and the development of an Internet-use disorder (Lam and Wong, 2015; Zhang et al., 2016).

3.1.2. Psychopathological features, personality, and social cognitions

Beyond these vulnerability factors, which develop relatively early or are even prenatally determined, a broad body of literature exists on the correlations and comorbidities of diverse psychopathological features and features of Internet-use disorders. Depression and (social) anxiety disorders as well as attention-deficit/hyperactivity disorder (ADHD) have been considered as three main co-morbid conditions of Internet-use disorders (see meta-analyses by Ho et al., 2014; Prizant-Passal et al., 2016). With respect to personality factors, the most consistent links have been found between Internet-use-disorder features and high impulsivity, low self-esteem, low conscientiousness, high shyness, high neuroticism, a tendency to procrastinate, and low self-directedness (Ebeling-Witte et al., 2007; Floros et al., 2014; Hardie and Tee, 2007; Kim and Davis, 2009; Koo and Kwon, 2014; Müller et al., 2014; Niemz et al., 2005; Sariyska et al., 2014; Thatcher et al., 2008; Wang et al., 2015a; Weinstein et al., 2015). Social cognitions have been primarily linked to the excessive use of Internet applications/sites which include communication features (for example, social-networking sites and online role-playing games). A perceived lack of social support, feelings of isolation, and loneliness have been considered important in this context (Caplan, 2007;

Morahan-Martin and Schumacher, 2003; Odacı and Kalkan, 2010; Pontes et al., 2014). Again, it is likely that individuals with different types of Internet-use disorders have specific personality profiles. There may be some commonalities across the different groups. For example, higher ADHD rates and higher impulsivity have been observed in recent meta-analyses (see citations above). However, it is also likely that different types of Internet-use disorders are linked to specific personality traits. One example is the above-mentioned link between social cognitions and using communication applications excessively. Future studies should explicitly address the personality profiles among different forms of Internet-use disorders to explore common and unique correlates of dysfunctional use of certain Internet applications, as it has been done with respect to other fields (e.g., with respect to substance-use disorders).

3.1.3. Using motives

The aforementioned predisposing factors may represent potential risk factors for the development of addictive use of the Internet without considering the specific applications/sites of choice. Although most studies mentioned investigated Internet gaming or did not define the certain use of choice precisely, some disjunctive predispositions may explain individual motives or preferences for using specific applications or sites excessively. Social aspects are particularly relevant for using online communication applications/sites (Kuss and Griffiths, 2011b). Extraversion and openness to experience (Correa et al., 2010) as well as narcissism (Ryan and Xenos, 2011) are also considered important in this context. Sexual excitability, on the other hand, should play a more central role in problematic use of Internet pornography and cybersex (Laier and Brand, 2014; Lu et al., 2014). Specific motives may predispose individuals to choose specific forms of Internet use, such as sites for Internet pornography and cybersex (Paul and Shim, 2008; Reid et al., 2011), gaming (Billieux et al., 2013; Demetrovics et al., 2011; King and Delfabbro, 2014; Kuss et al., 2012; Ryan et al., 2006; Yee, 2006), or shopping (Kukar-Kinney et al., 2009). Further subdivisions may also make sense, for example separating the motives for using pornography versus using sex-dating applications or differentiating between shopping sites and sites for online auctions. However, the empirical evidence for such specific predispositions is rare. We argue that certain preferences and motives are relevant for the selection of the first-choice applications/sites. Future research should consider different first-choice applications/sites when investigating using motives in the context of Internet-use disorders.

3.2. Affective and cognitive responses to external or internal stimuli: the A- and C-components of the model

After reviewing general and specific factors of vulnerability for developing a specific Internet-use disorder, a question remains why some individuals may use certain Internet applications/sites addictively. In other words, what are the mechanisms underlying the decision to use an application/site and which result in a diminished control over Internet use in certain situations?

Situational factors are perceived subjectively, and the subjective perception results in affective and cognitive responses linked to the level of perceived stress (Dickerson and Kemeny, 2004; Koolhaas et al., 2011). Perceived stress resulting from personal conflicts or abnormal mood (e.g., depressive or anxious state, euphoria) may influence cognitive processes, for example, by focusing the attention to short-term rewards and risky decision-making (Starcke and Brand, 2012; in press). Subjective stress responses to situational factors may influence whether or not individuals decide to use the Internet potentially to cope with the associated cognitions and affects (Tavolacci et al., 2013). We propose that both internal and external stimuli may be conditioned within an addiction process (Kalivas and Volkow, 2005; Volkow et al., 2012) and may then trigger affective and cognitive processes resulting in the decision to use the Internet application/site of choice. Consistent with this notion, individuals with Internet-gaming disorder may react with changes in mood and other withdrawal symptoms when being confronted with Internet-related cues, and addiction-related cues may be associated with the anticipated gratification or the reduction of withdrawal symptoms (Kaptsis et al., 2016; Osborne et al., 2016; Romano et al., 2013).

3.2.1. Coping

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 potentially contributing to the development of Internet-use disorders (Tang et al., 2014; Whang et al., 2003). In particular, tendencies towards impulsive coping strategies when being confronted with daily stress have been considered problematic in this context (Tonioni et al., 2014). Some authors conceptualize Internet-use disorders as dysfunctional coping with everyday life (Kardefelt-Winther, 2014). We propose that individuals who have a greater vulnerability to stress (as predisposing factors) in combination with dysfunctional/impulsive coping strategies may be more inclined to react with an urge for mood regulation when being confronted with a stressful situation. This interaction could then result in a higher probability of using the Internet application/site of choice, if the individual has the (implicit or explicit) expectancy or illusion that using the Internet is stress-relieving or has other Internet-related cognitive biases.

3.2.2. Internet-related cognitive biases

Several cognitive factors, such as general dysfunctional attitudes, are related to features of Internet-use disorders (Noh and Kim, 2016) in combination with Internet-related expectancies or even illusions (i.e., false beliefs about the effects of using certain applications/sites (Taymur et al., 2016)), as well as implicit associations. In the proposed model, these examples of explicit and implicit cognitions about Internet use and their potential effects on individuals are summarized under the term Internet-related cognitive biases. Features of Internet addiction may co-vary positively with both positive expectancies (e.g., to experience pleasure) and avoidance expectancies (e.g., to escape from reality) on a bivariate level (Brand et al., 2014a; Lee et al., 2014; Turel et al., 2011; Xu et al., 2012). Moreover, positive metacognitions about Internet use have been shown to mediate the relationship between emotional dysregulation and Internet addiction (Casale et al., 2016) as well as the relationship between psychopathological symptoms (depression, social anxiety) and the addictive use of social-networking sites (Wegmann et al., 2015). These expectancies have some overlap with motives for using the Internet (see above). A difference is seen in the stability and concreteness of effects. Motives are considered to be relatively stable and predispose the general approach behavior towards certain applications. The concrete expectancies refer to the ideas and thoughts on the concrete effects that using a specific application or site will most likely have in a certain situation. Such expectancies may be explicit or implicit, and one underlying cognitive process may be that using an application frequently and experiencing positive results (e.g., pleasure or escaping from reality) will result in positive (implicit) associations, which may make it more likely to use this application again (reinforcement). Implicit associations have a reliable predictive value in the context of substance addictions (see meta-analysis by Rooke et al., 2008). Such implicit associations have been demonstrated for Internet gaming (Yen et al., 2011), Internet pornography (Snagowski et al., 2015), and gambling (e.g., Brevers et al., 2013) using a modified version of the Implicit Association Test (Greenwald et al., 1998). On the

basis of these studies on several facets of explicit and implicit cognitions, we propose that Internet-related cognitive biases, which comprise explicit expectancies and illusions and implicit associations, may have an accelerating effect on cue-reactivity and craving, if an individual is confronted with Internet-related cues and other situational variables (e.g., negative or very positive moods, stress).

3.2.3. Cue-reactivity and craving

One main process behind the diminished behavioral control is craving, which was also defined as motivation-seeking in the model by Dong and Potenza (2014). Craving originally referred to a difficult-to-resist urge to consume a substance. Craving can be triggered by cue-reactivity, which is the result of the confrontation with conditioned addiction-related stimuli (Breiner et al., 1999; Carter and Tiffany, 1999). Cue-reactivity is developed on the basis of (associative) learning mechanisms, in particular conditioning processes (Carter and Tiffany, 1999; Loeber and Duka, 2009; Tiffany et al., 2000), which provide the main physiological, emotional, and motivational basis for craving (Robinson and Berridge, 1993, 2000). The concepts of cue-reactivity and craving have been transferred from research on substance addictions to that on behavioral addictions, for example with respect to gambling disorder (e.g., Potenza, 2008; Potenza et al., 2003; Wölfling et al., 2011). Several fMRI studies have investigated brain correlates of cue-reactivity and craving in individuals with gambling disorder (Crockford et al., 2005; Goudriaan et al., 2010; Kober et al., 2016; Miedl et al., 2014; Potenza et al., 2003; Wulfert et al., 2009). These studies typically observe an involvement of the ventral striatum (and partially further structures of the expanded limbic system) in the experience of craving when being confronted with addiction-related cues. More recently, neural correlates of cue-reactivity and craving, also consistently focusing on the ventral striatum, were demonstrated in subjects with Internet-gaming disorder (Ahn et al., 2015; Ko et al., 2009; Liu et al., 2016; Thalemann et al., 2007), hypersexual behavior (Klucken et al., 2016; Voon et al., 2014), and Internet-pornography-use problems (Brand et al., 2016). The findings fit well with previous behavioral investigations of the important role of craving and the anticipation of sexual gratification in individuals with cybersex problems (Brand et al., 2011; Laier et al., 2013), and demonstrate the involvement of the ventral striatum in the process of cue-reactivity and craving in behavioral addictions.

3.2.4. Urge for mood regulation

When being confronted with abnormal mood, withdrawal symptoms, or craving, an urge to regulate the experienced mood may develop. The process of emotion regulation is an important consideration across multiple psychopathological conditions including addictions (Aldao et al., 2010; Gross and Jazaieri, 2014; Thorberg and Lyvers, 2006). It has been reported that addictive behaviors may be used in a dysfunctional fashion to cope with experienced aversive affective responses to internal or external cues; e.g., with respect to smoking, alcohol drinking, and use of Internet pornography and performance of online gaming or social networking (Holahan et al., 2001; Hormes et al., 2014; Kuss, 2013; Laier and Brand, 2014; Li et al., 2012; Shapiro et al., 2002). Abstinent individuals in recovery from drug addictions may be at elevated risk for relapse in situations in which they are confronted with internal or external cues associated with former drug intake (Welberg, 2013). We propose that the urge for mood regulation is an important factor within the development of Internet-use disorders because it may influence the decision to use certain Internet applications/sites in the early stages of an addiction process. Furthermore, a role may become more important later within the addictive process since perception of experienced problems should lead to greater aversive moods, while coping skills decline in favor of dysfunctional coping by using the Internet applications/sites of choice.

3.2.5. Attentional biases

Attentional biases and their relationships with craving responses have been studied in substance addictions (e.g., Christiansen et al., 2015; Field and Cox, 2008; Field et al., 2009). Implicit cognitions, in particular approach and avoidance tendencies, have been related to craving responses in substance-dependent individuals (e.g., Wiers and Stacy, 2006). The idea that attentional biases may guide addictive behaviors fits well with recent dual-mode theories of addictive behaviors (e.g., Bechara, 2005; Evans and Coventry, 2006; Stacy and Wiers, 2010). These approaches share main views on the nature of addiction, which is that addictive behaviors may result from the interaction of two types of processes. The first type is an impulsive or relatively automatic processing mode, and the second type is a relatively controlled and reflective processing mode. This general approach of viewing addictive behaviors as the outcome of an impulsive and a deliberate cognitive processing mode is consistent with current decision-making theories (e.g., Schiebener and Brand, 2015) and cognitive psychology models of dual-processing in reasoning and thinking (Evans, 2003; Kahneman, 2003; Stanovich and West, 2000).

Evidence for attentional bias has been observed in problem-gamblers (Ciccarelli et al., 2016). Attentional bias in individuals with Internet-gaming problems was demonstrated recently (Jeromin et al., 2016), with attentional bias measured using two instruments which have been widely used in studies of substance addictions: the Addiction Stroop Task and Visual-Probe Task (Field and Cox, 2008). Individuals with Internet-gaming problems as compared to those without reacted more slowly to computer-related words as compared to neutral words during Addiction-Stroop performance, which can be regarded as an attentional bias towards the addiction-related stimuli. The results fit with those from studies of Internet use and video-game playing, which also used an Addiction Stroop Task (Metcalf and Pammer, 2011; van Holst et al., 2012), although in the study by van Holst et al. (2012) reaction times for addiction-related cues and neutral words were not different. With respect to the Visual-Probe findings, no differences in reaction times were found in either studies (Jeromin et al., 2016; van Holst et al., 2012), but participants made more errors for targets in the condition with computer-related words, indicating a potential interference between attentional bias and correctly identifying the target position. Even clearer findings were observed in patients with hypersexual behavior compared to healthy volunteers during performance of a Visual-Probe Task; individuals with hypersexual behaviors showed greater attentional bias to explicit sexual stimuli relative to neutral pictures (Mechelmans et al., 2014).

Another line of research within the field of affective-attentional processes in addicted individuals is the relationship between craving and the tendency to approach or avoid addiction-related stimuli (Breiner et al., 1999). Studies suggest a multi-dimensional model for alcohol addiction that focuses on an evaluative space in the situation when being confronted with addiction-related stimuli. Positive or negative expectancies towards the effects of drug intake may influence the tendency to approach or to avoid drug-related cues. Positive expectancies should result in approach tendencies while negative expectancies should result in avoidance tendencies. The approach/avoidance framework is also in line with the aforementioned dual-process models of addictive behaviors. One task that has been frequently used in alcohol-use research to measure approach and avoidance tendencies is the Approach-Avoidance Task, which was originally developed by Rinck and Becker (2007) to investigate individuals with anxiety disorder (spider phobia). The task includes a physical movement via joystick

and participants have to pull stimuli presented on a computer screen towards themselves (approach condition) or push them away (avoidance condition) from themselves as fast as possible. Multiple studies indicate that addicted subjects react faster when they have to approach the drug-related stimuli as compared to non-addicted individuals or compared to the avoidance condition (Cousijn et al., 2012; Cousijn et al., 2011; Wiers et al., 2013). Using the Approach-Avoidance Task, Snagowski and Brand (2015) found that individuals with problematic Internet-pornography use (in an analogue sample) can be linked to both approach and avoidance tendencies, as they found a quadratic relationship in their sample of pornography users. Although these results should be considered cautiously, since they need to be replicated and transferred to other types of Internet-use disorders, it seems worth considering such approach and avoidance tendencies as potential mechanisms underlying addictive use of certain Internet applications/sites.

In summary, predisposing factors together with dysfunctional coping styles, Internet-use expectancies, illusions, and implicit associations may influence the intensities of cue-reactivity and craving and other specific cognitive and affective processes, such as attentional biases and approach tendencies towards addiction-related stimuli. Consistent with some of the findings on potential interactions, although studies addressing explicitly interaction effects between variables are still scarce, we propose that the predisposing variables act in concert with coping styles and Internet-related biases resulting in specific patterns of affective and cognitive responses in specific situations. The affective and cognitive responses, as results of interaction effects, include cue-reactivities, cravings, urges for mood regulation, and attentional biases. We consider these as being important processes that impact decisions to use certain applications/sites. However, we also propose that mediating variables may exist between affective and cognitive responses and the decision to use the Internet, and these mediating factors may reside in the domains of inhibitory control and executive functioning.

3.3. *Executive functions, inhibitory control, and the decision to use certain applications/sites: the E-component of the model*

The potential impact of reduced executive functioning and reduced inhibitory control were central ingredients of the model on Internet-gaming disorder by Dong and Potenza (2014) and also of the model by Brand et al. (2014b), although this was not included explicitly in the figure, but described in the text (Brand et al., 2014b). The idea that executive functions contribute importantly to the development and maintenance of specific Internet-use disorders is based on neuropsychological and neuroscientific research and theories of substance addictions (Bechara, 2005; Goldstein et al., 2009; Goldstein and Volkow, 2002, 2011; Kalivas and Volkow, 2005; Koob and Volkow, 2010; Volkow and Fowler, 2000; Volkow et al., 2002, 2012). These models propose that reduced function of the prefrontal cortex is linked to impaired response inhibition and salience attribution (IRISA-model) in individuals with addictions. A main characteristic of this model is the increased salience to drug-related stimuli and – simultaneously – decreased sensitivity to natural, non-substance-related reinforcers. As a consequence of this interaction, diminished control over the addictive behavior and reduced inhibition of disadvantageous decision-making occur (cf. Goldstein and Volkow, 2011). We argue that the diminished control over decision-making in the context of addictions can be transferred to behavioral addictions and specific Internet-use disorders.

Executive functions, inhibitory control, and decision-making have been studied in the context of Internet-use disorders, with a focus on Internet-gaming disorder in particular (e.g., Dong et al., 2013a; Pawlikowski and Brand, 2011; Sun et al., 2009). Findings regarding inhibitory control in individuals with Internet-use disorders are mixed, although the majority of studies found at least mild executive reductions in individuals with Internet-use disorders (Dong et al., 2013a, 2010, 2011; Sun et al., 2009; van Holst et al., 2012). The same appears true for decision-making, as some studies have found no general differences between subjects with and without Internet-use disorders during decision-making under ambiguous conditions, as measured with the Iowa Gambling Task (Yao et al., 2015), while others have found affected individuals performing inferiorly to healthy volunteers (Sun et al., 2009). More consistently, significant decision-making reductions were found in tasks assessing decisions under risk conditions (Dong and Potenza, 2016; Pawlikowski and Brand, 2011; Seok et al., 2015; Yao et al., 2015). When comparing individuals with either Internet-use or alcohol-use disorders, both groups had comparable levels of performance in executive-function tasks, and both groups scored significantly lower in comparison to healthy volunteers (Zhou et al., 2014).

Most studies to date of inhibitory control using the Go/No-Go Task have employed versions with neutral stimuli (i.e., without addiction-related stimuli) and observed no reductions in behavioral performance (Ding et al., 2014), although results are mixed across the existing studies (see meta-analysis by Smith et al., 2014). As with studies on attentional biases, studies may be more informative and findings may be more consistent if addiction-related stimuli were used. We hypothesize that subjects with specific Internet-use disorders may have difficulties in inhibiting responses to stimuli, which represent 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). In this context, Zhou et al. (2012) used a shifting task with cues representative for Internet games and found reductions in response inhibition and mental flexibility. In a cue-specific version of the Go/No-Go Task, cue-related reductions of inhibitory control in individuals with Internet-gaming disorder were reported (Yao et al., 2015). Another example is the study by Nie et al. (2016) showing impaired response inhibition and working memory in adolescents with Internet-use disorder in the Stop Signal Task and 2-back Task including Internet-related words as cues. Consistent with this finding, Laier et al. (2014) used a modified Iowa Gambling Task with pornographic and neutral pictures on the advantageous and disadvantageous card decks (and vice versa in the other group of subjects). In a sample of male pornography users, those individuals who performed the task with pornographic pictures on the disadvantageous card decks continued choosing cards from these decks despite receiving high losses. This effect was accelerated in participants who reported high subjective craving after the presentation of pornographic pictures in an additional experimental task.

The findings on reduced executive functioning and inhibitory control, perhaps as a consequence of cue-reactivity and craving, are consistent with results obtained from neuroimaging studies (cf. Kuss and Griffiths, 2012; Meng et al., 2015; Sepede et al., 2016). Structural differences in individuals with and without Internet-gaming disorder have been reported in both gray and white matter in prefrontal brain areas and additional brain regions, such as limbic structures (e.g., Hong et al., 2013a,b; Wang et al., 2015b; Zhou et al., 2011). Functional brain correlates of Internet-gaming disorder are also reported in the prefrontal cortex and limbic structures (Dong et al., 2012, 2013a, 2014). Changes in dopaminergic systems have also been proposed (Kim et al., 2011), which may relate to reinforcement processing (Jović and Đinđić, 2011). Studies are also beginning to bring together findings from neuropsychological investigations and neuroimaging assessments in individuals with Internet-gaming disorder or problematic gaming behavior, which show that deficits in executive functions and inhibitory control

are related to functional changes in fronto-striatal circuits (Luijten et al., 2015; Seok et al., 2015; Yuan et al., 2016).

Taken together, reductions in executive functions, inhibitory control, and decision-making are present in individuals with Internet-use disorders or in individuals who appear at elevated risk for developing addictive patterns of Internet use, particularly in situations when they are confronted with Internet-addiction-related cues. The neural correlates of Internet-gaming disorder and other Internet-use disorders (e.g., Brand et al., 2016) may reflect a maladaptive interaction of cue-reactivity/craving and reduced prefrontal/executive functioning, as suggested for substance addictions (Goldstein and Volkow, 2011; Koob and Volkow, 2010; Volkow and Fowler, 2000; Volkow et al., 2002). We propose that a dysfunctional interaction between poor executive control and situationally accelerated reward-seeking, as a result of cue-reactivity and craving, may promote disadvantageous decision-making. The decision to use certain Internet applications/sites to reduce craving and to increase mood is regarded as being characterized by seeking a short-term attractive behavior that results in the experience of gratification despite negative long-term consequences. This hypothesized type of dysfunctional interaction between executive control and reward-seeking has been emphasized recently by the fMRI study of Dong et al. (2015). They used resting-state fMRI and showed decreased functional connectivity in the so-called executive-control network (including lateral prefrontal and parietal regions) in individuals with Internet-gaming disorder compared to healthy volunteers. In addition, the individuals with Internet-gaming disorder showed increased functional connectivity in reward-associated networks (including ventral striatum and orbitofrontal cortex). Dong and colleagues propose that the imbalance between executive control and reward networks represent a mechanism seen in individuals with Internet-gaming disorder, with reductions in executive control leading to a diminished inhibition of motivation-seeking and craving, resulting in excessive Internet gaming. We agree with this interpretation, as reflected in our model in the path from affective and cognitive responses over reductions in executive function and inhibitory control to disadvantageous decision-making. Future studies may investigate decision-making, executive functions, and inhibitory control with and without addiction-related stimuli and compare performances across different types of Internet-use disorders. Such studies could provide a more complete picture of how specific cognitive processes may be involved in the development and maintenance of specific Internet-use disorders.

3.4. *Consequences resulting from using the Internet applications/sites of choice*

The decision to use certain applications/sites and the behavior of using them may lead to short-term positive experiences and gratification, at least in the early stages of the addiction process. In addition, and perhaps even more importantly, the use of certain Internet applications/sites and the gratification received should also lead to an increase in cue-reactivity and craving as responses to certain stimuli, as a result of both Pavlovian- and instrumental-conditioning processes. The importance of conditioning in the development of addictive behaviors has been suggested theoretically, for example within the incentive sensitization theory (Berridge et al., 2009; Robinson and Berridge, 1993, 2001, 2008), and has been demonstrated empirically in substance addictions (Duka et al., 2011; Hogarth et al., 2010, 2006; Loeber and Duka, 2009), for example using the Pavlovian Instrumental Transfer Task (Hogarth et al., 2007). Recent data suggest that similar conditioning processes are also involved in developing cue-reactivity and craving in the context of Internet-pornography-use disorder (Klucken et al., 2016; Snagowski et al., in press). Although for other types

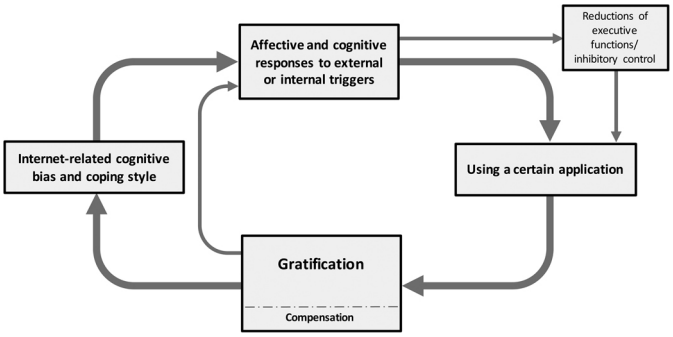

Fig. 2. The reinforcement circle representing a temporal dynamic of the affective and cognitive contributions to the process of development and maintenance of a specific Internet-use disorder. Bold arrows represent the main pathways of the addiction process from the very beginning. The smaller arrows indicate the additional interactions that develop within the addiction process.

of Internet-use disorders empirical evidence for conditioning processes is still missing, we propose that experiencing gratification due to using the Internet applications/sites of choice leads to positive reinforcement, which is the basis for developing stabilizing cue-reactivity and craving. Consistent with this notion, we also propose that based on reinforcement learning, the dysfunctional coping styles and the Internet-related cognitive biases are positively and partly negatively reinforced and therefore strengthened. All of these reinforcement mechanisms may make it more likely that individuals use the applications/sites of choice repeatedly. The mechanisms may also make it more likely that the applications/sites of choice are used in many situations, akin to what is seen in substance addictions. Due to conditioning processes in substance addictions, a generalization of situational features triggering cue-reactivity and craving is developed and the addictive behavior becomes habitual and/or compulsive (cf. Everitt, 2014; Everitt and Robbins, 2005, 2016). The suggested reinforcement cycle, which represents the temporal dynamic within the middle/grey part of the model (Fig. 1), is presented in Fig. 2.

The addiction process in general has been proposed to involve transitions from more voluntary and impulsive drug consumption to a more habitual or compulsive pattern of use, and that within this process, the positive and recreational feelings linked to drug intake may become less important compared to experiencing the direct drug effects (Everitt and Robbins, 2016; Piazza and Deroche-Gamonet, 2013). We propose that in the early stages of the process of specific Internet-use disorders, gratification is a main, but not exclusive, driving force that leads to changes in affective and cognitive responses to Internet-addiction-related stimuli. As the addiction process progresses, the level of experienced gratification decreases. Concurrently, the level of compensating effects increases in the course of the addiction. As control over the use of specific Internet applications/sites diminishes, there may be an increase in negative consequences, which may include social isolation and loneliness, conflicts with parents or peers, feelings of being misunderstood, feelings of emptiness, and other negative emotions and experiences. These feelings and losses of social contacts or other problems may be further exacerbated by repeatedly using the Internet applications/sites of choice, with gratification becoming less important, and compensation becoming more important. The hypothesized shift from gratification to compensation in the addiction process is summarized in Fig. 3.

4. Clinical implications

Given the recognized clinical significance of Internet-use disorders, clinicians and researchers have been developing specific

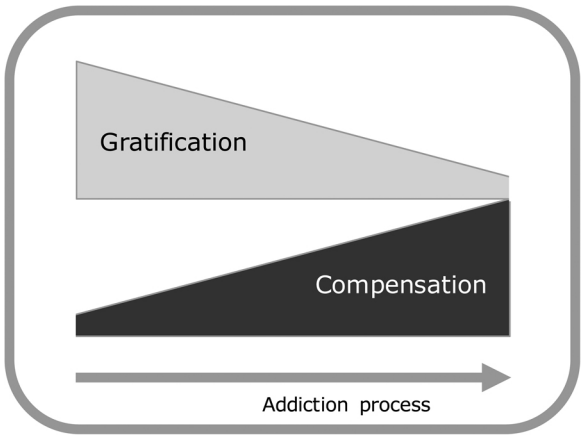

Fig. 3. The hypothesized shift from gratification to compensation in the addiction process.

treatments for individuals with Internet-use problems (Young, 2009), although only Internet-gaming disorder has been included in 2013 as a research diagnosis in section III in the DSM-5. Both pharmacological and psychological treatments have been suggested, similar to what is recommended for gambling disorder and other behavioral addictions (e.g., Grant et al., 2013; Yau and Potenza, 2015), and initial studies suggest varying degrees of efficacy (Cash et al., 2012; Santos et al., 2016; Winkler et al., 2013; Young, 2013). Cognitive-behavioral therapy for Internet addiction (CBT-IA) was introduced by Young (2011), which is reported currently as the method of choice (Cash et al., 2012; Winkler et al., 2013). However, large-scale randomized controlled trials are needed to evaluate further the efficacies of interventions and additional studies are needed to determine their translational feasibilities into non-research settings. Additionally, given that no medication has an indication for Internet-use disorders, additional research is needed in pharmacotherapy development.

The theoretical framework proposed may be used to promote future clinical interventions. Given that some predisposing factors may not be malleable (e.g., genetics, early childhood experiences) and others may be difficult to change (e.g., psychopathological vulnerability factors, personality), we propose that treatments should primarily address moderating and mediating variables, which may be theoretically modified by pharmacotherapy or psychotherapy. In this context, it is also important to note that even some of the predispositions, such as genetic constitution and stress vulnerability, interact with other moderating and mediating variables. For example, stress vulnerability may moderate the relationship between executive functions and decision-making (Starcke and Brand, in press), and may therefore have an impact on therapy success. Those predisposing factors should be examined in treatment contexts, to better observe potential interactions between personal factors within the treatment process. Variables that may be addressed directly in CBT include coping styles, Internet-related expectancies, attentional biases, cue-reactivities and cravings, as well as executive functions and inhibitory control.

In CBT-IA, an individual's Internet behavior is analyzed and monitored with respect to its situational, emotional, and cognitive contexts. In addition, the subsequent reinforcing effects of Internet use are considered. This process helps to generate understanding of the cognitive assumptions and distortions relating to Internet use and situational triggers. This first phase of CBT-IA considers several variables included in the theoretical model, in particular coping with situations in daily life that are high-risk situations for using the Internet excessively, expectancies and illusions about Internet use and reinforcing effects of Internet use. Afterwards, using methods of cognitive restructuring and reframing, the Internet-related cognitive biases may be targeted.

Given that both explicit and implicit cognitions, as well as an individual's conditionability, may interact with each other (Bernardin et al., 2014; Forrest et al., 2016; Wiers et al., 2015b), not only the explicit (verbalized) expectancies but also implicit cognitions should be addressed by treatments. Lee and Lee (2015) suggested that basic tenets of implicit and explicit cognitions, consistent with roles of approach/avoidance tendencies, could be implemented into therapy as a part of a patient's psychoeducation. Studies of substance addictions suggest that dysfunctional effects of implicit cognitions can potentially be retrained, for example, to increase the probability that experiencing craving might result in avoidance rather than approach tendencies (Eberl et al., 2013a, 2013b; Wiers et al., 2011). One way to transfer the concept of retraining to the treatment of Internet-use disorders could be to adapt existing training programs in which patients learn to avoid Internet-related stimuli (e.g., by pushing them away with a joystick, as this is a common training method). However, it should be noted that systematic studies would need to be conducted in order to identify the optimal number of training sessions (Eberl et al., 2013b), and also to evaluate their efficacy. Further methods could consider implicit associations, as has been done for alcohol-use disorders (Houben et al., 2010; Wiers et al., 2015a). However, evidence for the effectiveness of such methods is limited.

Attentional biases may also be decreased in attentional retraining programs (e.g., Christiansen et al., 2015; Schoenmakers et al., 2010). Closely related to this, it was suggested that an individual's ability to inhibit specific actions can be modified through training (e.g., Bowley et al., 2013; Houben and Jansen, 2011; Houben et al., 2011), for example, by using modified versions of the Go/No-Go Task. An adoption of these techniques may be beneficial for increasing inhibitory control and executive functioning and may be included into the treatment of Internet-use disorders, if future studies demonstrated them leading to treatment success. Conditioning processes, which represent main processes underlying Internet-use disorders, may be addressed by methods of cue-exposure therapy (Park et al., 2015). While cue-exposure therapy may not extinguish existing associations, the intensity of experienced craving may be reduced (Pericot-Valverde et al., 2015), which is consistent with current neuroimaging findings on the reduction of cue-reactivity due to cue-exposure therapy in abstinent alcohol-dependent individuals (Vollstädt-Klein et al., 2011), although its effectiveness is discussed controversially (Everitt and Robbins, 2016).

In summary, we propose that it is important to consider assessing individuals' cognitive functions, including attentional biases, implicit and explicit cognitions, executive functions and inhibitory control capacities, in the context of clinical treatment. We also propose that including neuropsychological training with a focus on Internet-specific control processes may increase the likelihood of positive outcomes relating to CBT in the context of Internet-use disorders.

5. Critical comments and future directions

Although the field of research on Internet-use disorders has grown rapidly over the last two decades and many studies on the phenomena exist, there still exist sizable gaps of knowledge, particularly with respect to treatment interventions. Multiple aspects of existing studies limit our current knowledge. First, most empirical studies concentrate on Internet-gaming disorder or do not differentiate among different types of Internet usage. Second, many previous studies have addressed single variables, such as personality or genetic correlates and cognitive functions, relatively isolated

from each other and for one form of Internet-use disorders only. Third, most studies have a cross-sectional design, limiting insight into the development and maintenance of Internet-use disorders. There are some longitudinal studies (e.g., Strittmatter et al., 2016; Zhang et al., 2016), but these are few and limited (e.g., with respect to the time of assessment). Fourth, most studies concentrate on adolescents and young adults and do not include questions regarding early development of the disorders, such as parental and family features. Fifth, gender aspects have not been addressed systematically in meta-analyses because most studies concentrating on Internet-gaming disorder (and also those focusing on Internet-pornography viewing) include mainly or solely male participants.

Given this lack of systematic research, the model suggested cannot be viewed as final. Although we have tried to include results from current research from different areas, not all aspects included in the model are empirically tested for all types of Internet-use disorders. In addition, results are mixed for some aspects, for example personality or decision-making, as we have discussed in the respective sections. However, we believe that the model suggested has the potential to influence future research by providing an explicitly framework for testing of hypotheses with respect to interactions of specific features including personal characteristics and cognitive and affective processes.

In future studies, interactions between core personal, and cognitive and affective features should be considered more systematically. In more detail, a better understanding of the interactions of personality and other trait variables, and cognitive and affective variables, which may develop within an addiction process, such as cue-reactivity, craving, attentional bias, and executive functions, is needed. Investigating the interactions of these variables instead of studying these variables separately seems to be very important in order to contribute to a better understanding of the nature and dynamics of Internet-use disorders. Although Internet-gaming disorder is the type of Internet-use disorder that is arguably most prominent in clinical practice and the published research literature, it is also important to consider other potential types of Internet-use disorders and compare profiles and underlying mechanisms among the different types. For example, Internet-gaming, Internet-gambling, Internet-pornography-use behaviors and disorders, amongst others, warrant consideration and attention. The lack of knowledge in these areas may have been a limiting factor with respect to considering Internet-use disorders in DSM-5, and may hinder efforts relating to how Internet-use disorders are considered in other classification systems like ICD-11.

From the current state of research, we suggest to include Internet-use disorders in the upcoming ICD-11. It is important to note that beyond Internet-gaming disorder, other types of applications are also used problematically. One approach could involve the introduction of a general term of Internet-use disorder, which could then be specified considering the first-choice application that is used (for example Internet-gaming disorder, Internet-gambling disorder, Internet-pornography-use disorder, Internet-communication disorder, and Internet-shopping disorder). The general term Internet-use disorder may also cover mixed forms of problematic or addictive use of more than one application (for example, a mixed type of Internet-gaming and Internet-gambling disorder). Based on the data we present in this synthetic review, we hypothesize that, although the evidence is still inconsistent in detail and future studies are needed, different types of Internet-use disorders likely share some core aspects and the I-PACE model incorporates these similarities in a structured framework for direct and systematic examination.

6. Conclusion

The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for specific Internet-use disorders is aimed at providing a theoretical framework, which distinguishes between predisposing factors and moderating and mediating variables. Coping styles and Internet-related cognitive biases are mainly conceptualized as moderating variables that may influence associations between predisposing factors and aspects of Internet-use disorders. Coping styles and cognitive biases may also act as mediating variables, which are influenced by, for example, psychopathologies and personality/temperamental characteristics. We further hypothesize the existence of moderated mediation effects between predisposing factors and the moderators/mediators coping styles and Internet-related cognitive biases. Affective and cognitive responses (e.g., cue-reactivities and cravings, attentional biases) to certain situational stimuli are referred to as mediating variables. These reactions should be influenced by the predispositions, but even more strongly by coping styles and Internet-related cognitive biases, and they are considered to develop within the addiction process as a result of conditioning processes in terms of positive and negative reinforcement. These affective and cognitive responses to situational stimuli may reduce inhibitory control and executive functioning, which then contribute to the decision to use the Internet applications/sites of choice. This process is hypothesized as a partial mediation, meaning that also direct effects from affective and cognitive responses to decisions to use certain applications/sites are strong by themselves, but that these effects are partially mediated by reductions in inhibitory control as a result of the responses to the situational features. In summary, the suggested I-PACE model is aimed at summarizing the mechanisms underlying the development and maintenance of specific Internet-use disorders in terms of a process model indicating the temporal dynamics of the addiction process. The ventral striatum and prefrontal brain areas are considered important neural contributors to the interaction of cue-reactivity and craving with reduced executive functions and diminished decision-making skills in individuals with specific Internet-use disorders. Although the components and processes within the I-PACE model are derived from previous theoretical and empirical studies, the hypothesized mechanisms should be investigated systematically in future studies. The model's assumptions should be specified in more detail for the specific types of Internet-use disorders, for example Internet-gaming, Internet-gambling, Internet-pornography-use, Internet-shopping, and Internet-communication disorders. We hope that the I-PACE model of specific Internet-use disorders inspires future research and clinical practice and is helpful for formulating clear research hypotheses within a rapidly developing and important scientific field.

Declarations of interests

The authors report that they have no financial conflicts of interest with respect to the content of this manuscript. Dr. Potenza has received financial support or compensation for the following: Dr. Potenza has consulted for and advised Boehringer Ingelheim, Ironwood, Lundbeck, INSYS, Shire, RiverMend Health, Opiant/Lakelight Therapeutics and Jazz Pharrmaceuticals; has received research support from the NIH, Veteran's Administration, Mohegan Sun Casino, the National Center for Responsible Gaming, and Pfizer, Forest Laboratories, Ortho-McNeil, Psyadon, Oy-Control/Biotie and Glaxo-

SmithKline pharmaceuticals; has participated in surveys, mailings or telephone consultations related to drug addiction, impulse control disorders or other health topics; has consulted for law offices and the federal public defender's office in issues related to impulse control disorders; provides clinical care in the Connecticut Department of Mental Health and Addiction Services Problem Gambling Services Program; has performed grant reviews for the NIH and other agencies; has edited journals and journal sections; has given academic lectures in grand rounds, CME events and other clinical or scientific venues; and has generated books or book chapters for publishers of mental health texts. The other authors report no biomedical financial interests or other conflicts of interest.

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