Cybersex addiction: Craving and cognitive processes.

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General Abstract

Cybersex addiction is discussed with growing interest, because some individuals report symptoms of dependency regarding their cybersex use resulting in personal distress of clinical significance. The aim of this dissertation is to investigate the role of the reinforcing nature of pornographic stimuli in cybersex addiction within four studies. In the first and the second study the theoretical background of substance dependency has been taken as basis for cybersex addiction and experimental paradigms used in research on substance dependencies were adapted to the field of cybersex addiction. These studies address the role of positive reinforcement, cue-reactivity, and predefining vulnerability in cybersex addiction. Regarding this, sensitivity for sexual excitation and a generally problematic use of sex were identified as specific factors of vulnerability and a general psychological-psychiatric symptom severity as unspecific factor of vulnerability for cybersex addiction. It was shown that these vulnerability factors together with self-reported craving predicted tendencies towards cybersex addiction. Moreover, the intensity of craving partially mediated the relationship of specific and unspecific vulnerability factors with tendencies towards cybersex addiction. However, indicators of a poor sex life in general were not associated to symptoms of cybersex addiction. The third and the forth study examined the effect of pornographic stimuli on cognitive processes. It was shown that working memory and decision-making performance was worse when pornographic pictures had to be processed simultaneously. From a cognitive point of view, these results might partly explain why some individuals continue cybersex activities although they experience negative consequences during or following their cybersex use. Altogether, the studies' findings are discussed according to the assumed underlying processes of conditioning to explain the repeated cybersex use in the light of growing, but neglected negative consequences. It is concluded that positive reinforcement due to sexual arousal can be considered as core mechanism in the development of cybersex addiction and interferes with cognitive processes important for goal-directed behaviors.

1. General Introduction

Since the World Wide Web became a public medium in 1993, it developed rapidly into a mass medium of different applications having impact on single individuals and whole societies. Nowadays, people can use the Internet for private, school, or work purposes and can cope with their needs and goals. While most of the individuals can use the Internet without experiencing any negative consequences, there are some individuals reporting subjective complaints in everyday life and symptoms of dependency resulting from their Internet use (for review see Chou, Condron, & Belland, 2005; Weinstein & Lejoyeux, 2010; Widyanto & Griffiths, 2006). While in some individuals these symptoms result from an excessive use of the Internet in general, others report problems associated with the use of specific Internet applications such as cybersex, gaming or communication (e.g. Block, 2008; Griffiths, 2000a; Young, Pistner, O'Mara, & Buchanan, 1999).

Although the phenomenology and the high clinical importance of Internet addiction has been described well within the last years (Block, 2008), there is an ongoing controversial debate about their classification. Accordingly, a problem associated Internet use has been termed differently, for example pathological (e.g. Davis, 2001; Niemz, Griffiths, & Banyard, 2005; Suler, 1999), unregulated (e.g. Larose, Lin, & Eastin, 2003), problematic (e.g. Caplan, 2002; Kim & Davis, 2009), compulsive (e.g. Meerkerk, van den Eijnden, & Garretsen, 2006; Schwartz & Southern, 2000), excessive (e.g. Griffiths, 2000a; Pawlikowski & Brand, 2011; Yang, Choe, Baity, Lee, & Cho, 2005), or addictive (e.g. Ko et al., 2010; Leung, 2004; Weinstein & Lejoyeux, 2010; Young, 2004). Some authors argue for classifying these kinds of behaviors as impulse control disorders or impulsive-compulsive spectrum disorders (for diagnostic criteria of and review on these disorders please see Dell'Osso, Altamura, Allen, Marazziti, & Hollander, 2006; McElroy, Phillips, & Keck, 1994), because they see several problems with the concept of behavioral addictions. Often raised arguments are that the diagnostic criteria for addiction have been established for drugs only, that an inclusion of

behavioral addictions would dilute the addiction concept, and doubts have been raised if the diagnostic criteria of tolerance and withdrawal can be fulfilled in these problematic behaviors (e.g. Pies, 2009; Shapira et al., 2003). But after recognizing the symptom patterns reported by persons concerned (e.g. Griffiths, 2000b; Young, 2004), it becomes clear that the classification of a problem associated Internet use as impulse control or as an impulsive-compulsive spectrum disorder is not adequate. The reported symptoms of affected persons include more than the criteria for the suggested classifications. Patients do not only report a disability to regulate their behavior, but indeed they indicate symptoms which are comparable to the diagnostic criteria for addiction: A great cognitive salience of the Internet, the persistent experience of negative consequences resulting from their Internet use, failed attempts to reduce time spent on the Internet, an increase of Internet use, and withdrawal when they have no possibility to be online. Furthermore, impulse control disorders and impulsive-compulsive spectrum disorders include hardly comparable disorders themselves. It is doubtable if a problem associated Internet use shares important similarities with respect to their phenomenology, etiology, as well as with respect to their mechanisms of development and maintenance with these disorders. Most authors argue that there is not enough data allowing for final conclusions regarding the nature of Internet addictions to be drawn and are cautious with a premature classification of a problem associated Internet use. Still, the concept of Internet addiction is the most favored in these days (e.g. Potenza, 2006; Weinstein & Lejoyeux, 2010). The consideration as Internet addiction is furthermore supported by research converging to the view that the phenomenology of substance and other behavioral addictions (e.g. sex addiction or pathological gambling) are similar with respect to biological and behavioral attributes (Garcia & Thibaut, 2010; Grant, Brewer, & Potenza, 2006; Potenza, 2008; Yellowlees & Marks, 2007). According to this, Internet addictions are not yet classified within the international classification systems of diseases (APA, 2000; WHO, 1993), but will be included within the appendix of addictive disorders in the DSM-V (Holden, 2010). The

inclusion within the appendix points out that a full achievement of the addiction status is not legitimate yet, because Internet addiction's behavioral and biological similarities to substance addictions have not been addressed sufficiently. Consequently, using the concept of addiction, it is necessary to address potential mechanisms of development and maintenance in generalized and specific Internet addictions to contribute to the discussion on this important topic.

The aim of this thesis is to approach potential mechanisms of development and maintenance of cybersex addiction in analogue samples in order to contribute to a better understanding of specific Internet addictions. Proposing that cybersex addiction can be considered as an addiction, the theoretical background of positive reinforcement and cue-reactivity as well as experimental paradigms, well known in substance dependency research, were adapted to investigate cybersex addiction within four studies. The first and the second study focus on the role of gratification received by sexually motivated online behaviors as well as factors of vulnerability for cybersex addiction. The third and fourth investigations examine the effect of sexual cues and sexual arousal on executive functioning, respectively working memory and decision making. Therefore, the general introduction will give a brief overview on substance addictions focusing on their neuropsychological mechanisms of development and maintenance. Then, Internet addiction in general and cybersex addiction specifically will be introduced. Moreover, a brief overview on executive functioning, particularly on working memory and decision making will be given. After taking the insights of the conducted studies into account, the general conclusion aims at embedding the findings of this thesis into a broader theoretical and empirical context. Moreover, a revised model of Internet addiction is presented within the general conclusion and suggestions for future studies will be given.

1.1 Substance addictions

Substance addiction summarizes the physiological and psychological dependency from several drugs, such as nicotine, cannabis, alcohol, or cocaine, etc., in which the drug use is accompanied by physical, psychological, social and in some cases also legal problems (for current overview see Sussman, Lisha, & Griffiths, 2011). Some core symptoms for diagnostics which are the same for all drug addictions are: The development of tolerance including an increase of substance intake as well as a lowered drug effect when taking the same dose, abstinence phenomenon, loss of control about one's drug consume, unsuccessful attempts to regulate or to stop the drug use, a high degree of cognitive salience and a great amount of time to buy, to consume, and to recover from drug intake, the experience of negative consequences in private and work issues as well as a continued drug intake in face of physical or psychological problems (APA, 2000). Against the background of the significance of these problems experienced from substance addicted individuals and the high prevalence of addictions (e.g. Compton, Thomas, Stinson, & Grant, 2007; Kraus et al., 2003; Sussman et al., 2011), investigating addictions' mechanisms of development and maintenance as well as their treatment has a high clinical relevance.

With respect to the development of addictions, the vulnerability encompasses multiple dimensions ranging from biological and environmental to cultural factors (for current review please see Swendsen & Le Moal, 2011). These factors include genetic vulnerabilities (Kendler, Jacobson, Prescott, & Neale, 2003; Li et al., 2011), environmental factors such as the experience of childhood maltreatment (De Bellis, 2002), psychiatric-psychological comorbidity (Hasin, Stinson, & Ogburn, 2007), personality facets such as impulsivity and negative emotionality (Allen, Moeller, Rhoades, & Cherek, 1998; Conway, Swendsen, Rounsaville, & Ries, 2002), or the functionalization of drugs as mechanism for emotion regulation and coping (Aldao, Nolen-Hoeksema, & Schweizer, 2010).

Even if the neurobiological processes of addiction are not understood completely yet, there is strong evidence for the involvement of different brain regions and neurotransmitter systems during drug intoxication as well as structural and functional changes following chronic drug use (for review see Koob & Volkow, 2010). Most notably, learning mechanisms, reinforcement, the development of cue-reactivity and craving are held as substantial key factors with respect to the development and maintenance of substance addictions (Everitt & Robbins, 2005; Hyman, Malenka, & Nestler, 2006). Because learning mechanisms are the crucial basic concept behind this, they will be outlined in more detail in the following.

Learning mechanisms can be separated into classical (also called pavlovian) and into operant (also called instrumental) conditioning. In classical conditioning, basically a neutral stimulus is paired once or repeatedly with another stimulus (US). It is characteristic for the US that it evokes a reflexive physiological reaction. By pairing these two stimuli together, the response evoked by the US becomes associated to the neutral stimulus, named conditioned stimulus (CS) then. As a result, the CS elicits the so called conditioned response (CR) even in the absence of the US, because the individual learned that the CS predicts the US (for current review see Martin-Soelch, Linthicum, & Ernst, 2007). It is called extinction, when the CR declines, because of repeated presentation of the CS without the occurrence of the US. Classical conditioning has been investigated extensively for example in the development of fear (for reviews see Kim & Jung, 2006; Maren, 2001). If the US is not a biological significant one leading to a physiological reflex, but is an emotional stimulus with positive or negative valence changing the emotional evaluation of the neutral stimulus, this is termed evaluation conditioning (De Houwer, Thomas, & Baeyens, 2001; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

In contrast, operant conditioning describes a change of behavior not caused by reflexive reactions elicited by a stimulus, but by the association of the individual's behavior

with its consequences. These consequences can be positive and negative as well as reinforcing or punishing. If the consequences are rewarding or appetitive, this is called positive reinforcement. If the consequences are the disappearance of aversive stimuli this is called negative reinforcement. Both, positive and negative reinforcement increase the probability that the reinforced behavior will be repeated. Positive punishment describes the experience of aversive stimuli following behavior and negative punishment is characterized by the removal of a rewarding, appetitive stimulus. Positive and negative punishments decrease the probability that a behavior will be repeated again. If the behavior is not followed by any or incongruent consequences, this is called extinction leading to a decline of the behavior (Martin-Soelch et al., 2007). Physiologically it has been shown that a subjective reward experience is generally related to the mesolimbic reward system, reacting with an increase of dopamine release to positive and negative reinforcement (Day & Carelli, 2007; Fields, Hjelmstad, Margolis, & Nicola, 2007; Wightman & Robinson, 2002; Wise, 2002). In drug intake, an increase of dopaminergic transmission in mesolimbic pathways is the neural correlate of the drug associated "high", which is perceived as subjectively pleasurable and is highly reinforcing (e.g. Goldstein et al., 2009; Volkow, Fowler, & Wang, 2002). Based upon these learning mechanisms, cue-reactivity arises within the development of addiction.

Cue-reactivity describes the result of repeated drug use, in which the effects of the drug's positive and negative reinforcement are conditioned with environmental factors (for review see Carter & Tiffany, 1999). Moreover, the perceived positive effects following drug intake increase the probability that drugs will be retaken. Following the principles of conditioning, conditioned environmental cues predict drug intake associated to the drug's physiological effect in addicted individuals. Consequently, it has been shown that already the presentation of conditioned drug associated stimuli leads to an increase of craving, i.e. the urge to consume the drug in order to receive the anticipated rewarding effects. This kind of craving induced due to cue-reactivity has also been termed reward craving. But with respect

to the desire for repeated drug use, the concept of craving distinguishes generally between reward and withdrawal relief craving. In contrast to reward craving, withdrawal relief craving is the desire for repeated drug intake to avoid negative emotional states as well as aversive physiological symptoms of withdrawal (for reviews see Anton, 1999; Drummond, 2001). Typical cue-reactivity paradigms used in addiction research comprise the presentation of neutral and addiction related cues (e.g. bottles of beer, inks, etc.) and the assessment of subjective craving for a drug, or diverse physiological (e.g. skin conductance, heart rate, neural) responses (cf. Tiffany & Wray, 2012). These paradigms have been investigated in diverse samples of addiction, e.g. with respect to alcohol (Chiang, Schuetz, & Soyka, 2002; Grüsser, Heinz, & Flor, 2000; Heinz et al., 2003; Heinz, Beck, Grüsser, Grace, & Wrase, 2009), nicotine (e.g. Janes et al., 2009), marijuana (e.g. Gray, LaRowe, & Upadhyaya, 2008), cocaine (e.g. Garavan, Pankiewicz, & Bloom, 2000; Goldstein et al., 2009), or heroin addiction (e.g. Wang et al., 2011; Yang et al., 2009). Studies converge to the view that addiction related cues lead to strong emotional arousal and craving in substance dependent individuals. Moreover, craving strength is strongly associated to relapse. On a neural level, addiction related cues lead to neural activations in brain areas associated to reward, motivation, memory, and executive control (for overview on craving's neural correlates see Hommer, 1999).

Moreover, repeated drug intake leads to alterations of reward related brain structures (e.g. ventral tegmental area), decreases in striatal dopamine release after drug intake and dopamine receptor occupancy which is associated to a lowered reinforcing effect of the drug, but for natural reinforcements as well (Kauer, 2004; Volkow et al., 1997; Volkow, Fowler, Wang, & Goldstein, 2002). These neural changes are accompanied with a subjective decrease of the drug's rewarding effects in addicted individuals, i.e. they continue drug taking even if it is decreasingly pleasurable and in consequence they need higher doses to achieve the expected effect. This observation deals with the difference between “wanting” and “liking”,

meaning that addicted individuals can have an appetitive motivation for the positive, hedonic value of the drug (liking), but can either have a need or desire (wanting) for the drug independent from the positive effects (e.g. Robinson & Berridge, 2001). While the development of tolerance deals with the circumstance that addicted individuals less "like" the drug and need higher doses to experience the designated positive effect, incentive-sensitization leads to changes of wanting, i.e. in attentional processing toward drug cues, motivational behaviour and incentive salience attribution (Berridge, Robinson, & Aldridge, 2009; Robinson & Berridge, 1993).

In conclusion, recurrent drug use leads to high valued expectations of a drug, impaired response inhibition, substantial craving, decreases of cognitive control circuits, and as a consequence to repeated drug intake and in some individuals even to addiction. These processes are mediated by changes in the mesolimbic pathways, decreased orbitofrontal activity during withdrawal and arising general dysfunctions of the prefrontal cortex (Goldstein & Volkow, 2002; Volkow et al., 2003). Based upon the background of positive reinforcement and processes of conditioning, it was demonstrated that cue-reactivity and resulting reward craving urges are the core mechanisms to explain repeated drug use and the development of addiction. Therefore, these concepts should be relevant in the development and maintenance of behavioral addictions as well. Following this assumption, an overview about Internet addiction will be given in the next sections and links to cue-reactivity and craving will be outlined.

1.2 Internet and cybersex addiction

1.2.1 Internet addiction

Internet addiction is considered to be a behavioral addiction which is characterized by symptoms of dependency regarding the Internet use associated with subjective complaints in everyday life (Chou et al., 2005; Young, 2004). But the consideration of Internet addiction as a distinct and unified entity neglects the possibility of important differences regarding the Internet activity of choice associated with an addictive usage pattern (for review see Weinstein & Lejoyeux, 2010). According to various authors, there are several Internet activities at risk, which may result in Internet addiction: cybersex, cyber-relationships, online gambling, surfing for information and online gaming (Block, 2008; Weinstein & Lejoyeux, 2010; Young et al., 1999). But cybersex is thought to have the highest potential for developing an specific Internet addiction (Meerkerk, van den Eijnden, & Garretsen, 2006).

One theoretical model dealing with problematic Internet use (PIU) is the cognitive-behavioral model developed by Davis (2001). The model focuses on the role of maladaptive cognitions associated with PIU as well as on an underlying psychopathology as a predisposing factor. Moreover, it distinguishes between a generalized (GPIU) and specific (SPIU) pathological Internet use (see Figure 1).

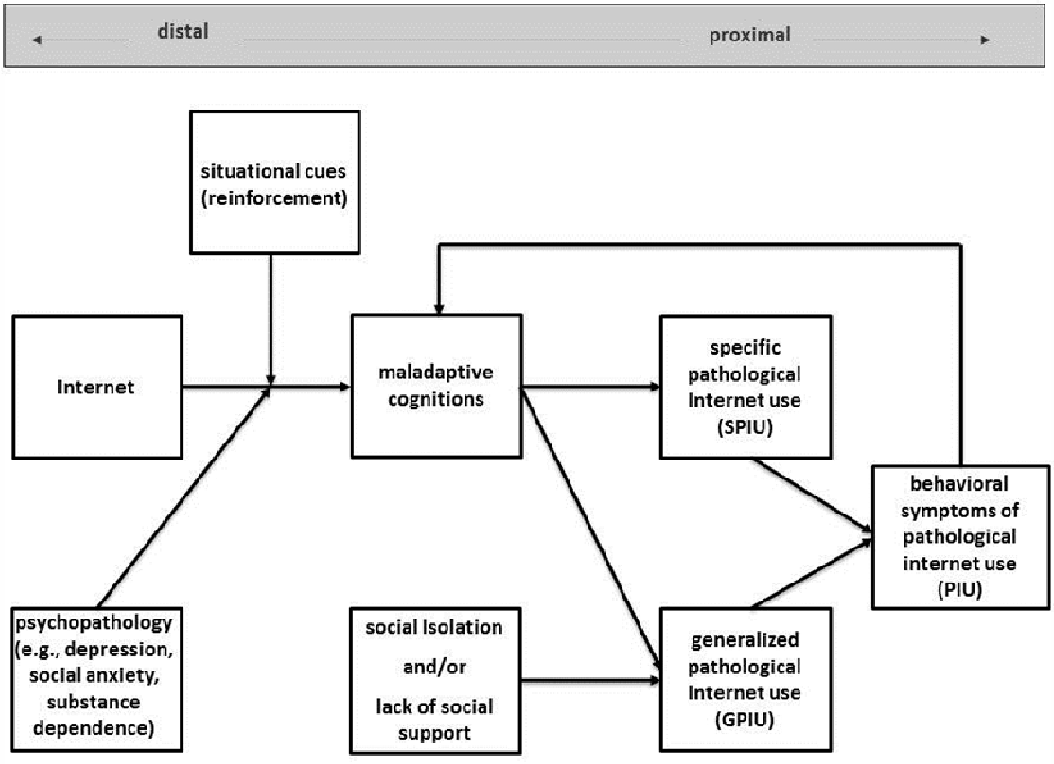

Figure 1

The cognitive-behavioral model of pathological Internet use (modified from Davis, 2001).

In general, a diathesis-stress framework is postulated assuming that a predisposing vulnerability and stressors are important factors in the development of PIU. As a predisposing factor, a pre-existing psychopathology such as depression, social anxiety, or substance dependence is introduced as a necessary cause of PIU. The stressor in the model is the Internet itself or a specific Internet application. The Internet facilitates the possibility of making positive experiences and should therefore lead to a recurrent Internet use to achieve similar effects. This is said to lead to a fostering of the maladaptive behavior in terms of operant conditioning. As a key factor within the development of PIU, maladaptive cognitions about oneself and the world as well as a ruminative cognitive style are introduced. Self-doubt,

low self-efficacy, and negative self-appraisal are supposed to make an individual more prone for receiving reinforcement by the use of the Internet.

In the model, PIU is differentiated into GPIU and SPIU. GPIU is described as a multidimensional, non-directed overuse of the Internet. In GPIU's etiology, a pre-existing psychopathology and the social context of the individual are emphasized as predefining factors. Missing social support and social isolation are said to result in spending much time without purpose on the Internet, for example in chat-rooms. In contrast, SPIU refers to the overuse of a specific Internet application (e.g. cybersex) resulting preliminarily from mechanisms of reinforcement and a specific pre-existing psychopathology. One postulated difference between GPIU and SPIU is the assumption that individuals suffering from GPIU would not have developed a similar problematic behavior without the Internet, whereas individuals suffering from SPIU would have developed a similar behavior within another setting. The example is presented that individuals who use conventional pornography excessively may become Internet sex addicts as well. Moreover, while comparable to GPIU, a pre-existing psychopathology and maladaptive cognitions are assumed to be relevant factors in the development of SPIU, the social context of an individual is not supposed to be a predefining factor.

Davis' (2001) cognitive-behavioral model has contributed to our understanding of Internet addiction and has inspired many studies addressing this topic. The strength of the model is that it distinguishes between GPIU and SPIU and that it assumes some common and differential factors of vulnerability as well as mechanisms of development for both. But despite the strength of this theoretical approach, there are some concerns regarding the conception of the model. Within its approach, it emphasizes the role of maladaptive cognitions in the development of PIU. But it has not been demonstrated yet that individuals suffering from GPIU or SPIU indeed have maladaptive cognitions about themselves or the

world. It has also not been shown that they have a ruminative cognitive style, or that maladaptive cognitions increase within the development of PIU. Regarding the aspect of reinforcement, the model posits that reinforcement is crucial for the development of both GPIU and SPIU. But postulating this, it neglects to distinguish between positive and negative reinforcement. It seems plausible that positive and negative reinforcement are differentially relevant within the development of GPIU and SPIU. Moreover, the assumptions with respect to individuals' vulnerability seem to be not sufficient. Indeed, several studies report an association of a general psychological-psychiatric symptom severity to GPIU and SPIU (e.g. Green, Carnes, Carnes, & Weinman, 2012; Kuss & Griffiths, 2011; Weinstein & Lejoyeux, 2010). But whether or not there might be specific predisposing factors for SPIU is not mentioned. Finally, an empirical confirmation of the whole model is missing.

With respect to the diagnostic of Internet addiction, several instruments have been developed (for diagnostic instruments of cybersex addiction please see chapter 1.2.2). Internationally, the Internet Addiction Test (Young, 1998) has been used most frequently to assess Internet addiction. The questionnaire was constructed using the diagnostic criteria for pathological gambling and asks for subjective complaints in everyday life resulting from Internet use by 20 items. Although the factorial structure of the Internet Addiction Test is under controversial debate (e.g. Chang & Law, 2008; Khazaal et al., 2008; Widyanto & McMurran, 2004), a German short-version of it has been developed recently (Pawlikowski, Altstötter-Gleich, & Brand, 2012). As revealed by explanatory and confirmatory factor analysis, it was shown that this short-version with 12 items has a two-factorial solution namely "loss of control and time management" and "craving and social problems". The internal consistency of both subscales and of the overall scale is high. Moreover, congruent, discriminant, and incremental validity has been demonstrated within the validation study (cf. Pawlikowski et al., 2012). Other diagnostic instruments aiming at assessing Internet addiction are for example the Compulsive Internet Use Scale (Meerkerk, Eijnden, Vermulst, &

Garretson, 2009), the Online Cognition Scale (Davis, Flett, & Besser, 2002), or the Generalized Pathological Internet Use Scale (Caplan, 2002). For an overview of these and some other questionnaires please see the review published by Beard (2005).

Using these instruments, psychological studies followed the aim of estimating the prevalence as well as addressing psychological correlates of Internet addiction. Depending on the used instrument and the used criterion for Internet addiction, the prevalence has been estimated to be between 1.5-8.2% internationally (for review see Weinstein & Lejoyeux, 2010). But these estimates have to be interpreted cautiously, since the diagnostic criteria for Internet addiction have not yet been defined and because the used diagnostic instruments differ with respect to their validity and their psychometric properties. In Germany, no representative studies have been conducted yet (Petersen, Weymann, Schelb, Thiel, & Thomasius, 2009), but it is assumed that about 3% of the general population are at risk for developing an Internet addiction (Wölfling, Bühler, Leménager, Mörsen, & Mann, 2009).

Studies addressing psychological correlates of Internet addiction focused primarily on personality traits and indicators of psychological well-being. One replicated result is that Internet addicted individuals report lower self-esteem (e.g. Armstrong, Phillips, & Saling, 2000; Kim & Davis, 2009; Niemz et al., 2005). Correspondingly, Internet addicted individuals indicate greater feelings of loneliness in everyday life and a socially motivated use of the Internet, for example to chat with others sharing some interests, for emotional support, or to meet new people (Morahan-Martin & Schumacher, 2000). Other personality factors linked to Internet addiction are introversion, low agreeableness, neuroticism, shyness, and social anxiety (Aa et al., 2009; Ebeling-Witte, Frank, & Lester, 2007; Hardie & Tee, 2007). Contributing to this, it was demonstrated that Internet addiction is associated to interpersonal difficulties, perceived stress in real-life, depressive mood, and to procrastination on the Internet (Thatcher, Wretschko, & Fridjhon, 2008; Whang, Lee, & Chang, 2003). Moreover, it

has been shown that Internet addiction is linked to poor self-regulation capacities (Billieux, 2012). Finally, several studies have assessed psychiatric comorbidities in Internet addiction (e.g. Bernardi & Pallanti, 2009; De Berardis et al., 2009; Ha et al., 2007). One recent review concludes that coexisting psychiatric disorders are frequently diagnosed in Internet addiction. Especially, substance dependencies, depression, hostility, social anxiety disorder, and attention deficit hyperactivity disorder have been found to be main comorbidities of Internet addiction (Ko, Yen, Yen, Chen, & Chen, 2012). Summarized, Internet addiction is linked to several characteristics of personality, which are principally in line with the pre-existing psychopathology and social deficits postulated in Davis' (2001) cognitive-behavioral model of PIU.

There are no studies addressing neural correlates of GPIU. Neural correlates have only been investigated in the SPIUs of online gaming or in pathological gambling. In the study of Ko et al. (2009) the neural response to pictures of the online game World of Warcraft of addicted and non-addicted World of Warcraft gamers have been compared. It has been shown that in addicts, addiction related cues lead to stronger activations in the right orbitofrontal cortex, in the right nucleus accumbens, bilaterally in the anterior cingulate, and in the medial frontal cortex as well as in the right dorsolateral prefrontal cortex, and in the right caudate nucleus. Moreover, the activation of these areas correlates with subjective gaming urge and a recall of game experiences. These results lead to the conclusion that there are neural differences elicited by addiction related cues in emotion, memory and motivation associated brain structures in online gaming addicted individuals compared to healthy comparisons. Ko et al. (2009) state that their results give reason to assume that online gaming addiction shares similar neurobiological mechanisms with substance addiction. Cue-reactivity and craving are considered to be relevant mechanisms within the development and maintenance of online gaming addiction. Another study conducted by Dong, Huang, and Du (2011) reports findings of neural correlates of online gaming addicted individuals during the performance of a

guessing task. In this task, participants choose one card from either one or the other card deck in 245 trials. Depending on the color of the card, they win or lose money. In Internet gaming addicts, an increased activation of the right orbitofrontal cortex in the gain trials and a decreased activation in the anterior cingulate cortex in the loss trials has been found. Authors conclude that in Internet gaming addicts the processing of reward and punishment is altered and that they show a greater sensitivity to reward and a greater insensitivity to punishment. It is assumed that Internet gaming addicts continue and repeat online gaming, although they experience negative consequences, because they might depend on short-term reinforcement, neglecting negative consequences in the long run. This interpretation is in line with studies on decision making in substance addiction (please see section 1.3.2). Similar results of an altered processing of addiction related cues as well as of reward and punishment have not been reported regarding GPIU. These results and interpretations are generally in line with those of cue-reactivity and craving explored in pathological gambling as behavioral addiction (e.g. Crockford, Goodyear, Edwards, Quickfall, & El-Guebaly, 2005; Goudriaan, de Ruiter, van den Brink, Oosterlaan, & Veltman, 2010; Ko et al., 2009; Potenza et al., 2003; Thalemann, Wölfling, & Grüsser, 2007; van Holst, van den Brink, Veltman, & Goudriaan, 2010).

Taken together, there is neither an agreement about the classification nor about the diagnostic criteria of Internet addiction. But the conducted studies make clear that Internet addiction is a serious mental health problem with high prevalence. This circumstance points out the importance of clarifying Internet addiction's classification and investigating the mechanisms of Internet addiction's development and maintenance. Specifically, in psychological research on GPIU, experimental studies focusing on cognitive and neural correlates are widely missing (for cognitive correlates of addiction please see section 1.3). After summarizing findings on GPIU in this section, the next section gives an overview about studies conducted on cybersex addiction as one example of SPIU.

1.2.2 Cybersex addiction

Cybersex comprises diverse sexually motivated behaviors on the Internet via several Internet applications. While some of them are more interactive, such as sexchats, self-displaying to or watching at others within sexual actions via webcam, others are more passive (i.e. watching pornography on the Internet). In the broader sense, cybersex includes not only watching material, but also making sexual contacts on the Internet, buying in online sex shops, directed information search about sexual issues, the usage of online sex services (e.g. strip or sex shows) or making Internet based contact to prostitutes (for review see Döring, 2009). Although no studies addressed the prevalence of unproblematic cybersex use in the general population, watching pornography on the Internet is assumed to be most widespread, at least among males (for review see Short, Black, Smith, Wetterneck, & Wells, 2012). Two concepts were introduced aiming at explaining some individuals' frequent utilization of cybersex: The "ACE model" (Young et al., 1999) and "Triple-A-Engine" (Cooper, 1998). The ACE model assumes that the easy accessibility, a perceived personal control and privacy in cybersex actions as well as excitement offered by cybersex explain a common use of cybersex. In addition, the Triple-A-Engine claims that besides the easy accessibility, anonymity and affordability are important characteristics of cybersex associated to its recurrent utilization.

Most individuals develop a healthy use of cybersex and perceive mostly positive effects of cybersex on their sex life and life in general and additionally receive no or rare negative consequences. For example they report that cybersex has led to greater sexual openness, an enrichment of their sex life, or an increase of life satisfaction in general (e.g. Hald & Malamuth, 2008). But there are individuals reporting subjective complaints in everyday life and symptoms of dependency resulting from cybersex (e.g. Cooper, Delmonico, Griffin-Shelley, & Mathy, 2004; Green et al., 2012; Young, 2008). Similar to studies addressing substance addictions, research describing the population of Internet sex addicted individuals converges to the view that cybersex addiction is associated to personal distress,

diverse negative consequences, high prevalence rate of comorbidities as well as to dysfunctional emotion regulation and coping (for review see Kuss & Griffiths, 2011).

Regarding the psychological assessment of cybersex addiction, the number of available instruments is very limited and these instruments are not yet validated. Delmonico and Miller (2003) introduced the Internet Sex Screening Test, which consists of 25 items in five subscales, which can be answered with “yes” or “no”. Because the factorial structure has not yet been clarified clearly and the instrument has not been used in a number of other studies, the validity of this measurement is doubtable. Moreover, using the item response format of “yes” and “no” neglects the possibility of assessing cybersex addictions’ symptom severity. Furthermore, no cut-off scores for the diagnosis of a healthy, problematic, and addictive usage pattern are presented. The same problems occur with the assessment of cybersex addiction using the revised Sexual Addiction Screening Test (Carnes, Green, & Carnes, 2010). Although this questionnaire addresses some important features of cybersex addiction, for example preoccupation, loss of control, or affect disturbance, a validation of this measurement is outstanding. Behind this background, the validity of the published diagnostic instruments of cybersex addiction cannot be considered as confirmed. One promising solution within this situation was presented by Brand, Laier, Schächtle, Schöler, and Altstötter-Gleich (2011). The authors modified Young's (1998) Internet Addiction Test for Internet sex sites. By this, they were able to assess all proposed criteria for cybersex addiction and, moreover, where able to measure the severity of these symptoms. Still, the prevalence of cybersex addiction has not been estimated or determined.

The number of studies on cybersex addiction is very limited, too. There are some qualitative, mainly case-studies presenting the results of interviews with cybersex addicted patients searching for professional help. The first case-studies have been provided by Orzack and Ross (2000) and by Stein, Black, Shapria, and Spitzer (2001), in which male individuals,

who have fulfilled diagnostic criteria of Internet, sex, and cybersex addiction are described. The result of both studies is that the presented cases have experienced the proposed symptoms of cybersex addiction. In a further qualitative study by Schneider (2000), 45 men and 10 women have been surveyed, who have reported negative consequences resulting from their cybersex use. The study addresses gender differences in cybersex addiction and reveals that men have reported watching and downloading particularly pornography and females have preferred interactive cybersex facets, for example sexually motivated chats. Comparable to the case studies, the majority of participants have reported former sexual addiction. Taken together, the main merit of these and other qualitative studies (for review please see Kuss & Griffiths, 2011b) is that they clearly point out that cybersex is associated to symptoms of dependency in at least some individuals and that it is worth investigating this mental health problem. Moreover, they have given the first impulse for the assumption that individuals who share a problematic sex life in general might be more prone for the development of cybersex addiction.

Comparable to qualitative approaches, quantitative studies have been conducted aiming at describing the population and the online behavior of cybersex addicted individuals. Contributing to the qualitative studies, Delmonico and Miller (2003) as well as Daneback et al. (2006) report that cybersex use is frequent in sexual addicted individuals and that sex addicted males and females spend more time on Internet sex sites. In an online study of Cooper, Scherer, Boies, and Gordon (1999), 9,177 individuals have participated and have been asked about their cybersex behaviors. Participants have been classified as low, moderate, or heavy cybersex users on the basis of time spent on Internet sex sites. Heavy cybersex users have indicated to spend more than 11 hours on the Internet for sexual purpose weekly, have been less often partnered or married, and have reported greater subjectively perceived interference of cybersex with their life. Cooper et al. (2004) proposes different types of cybersex users. Recreational users are said to be quite common, using cybersex to gain sexual

arousal, to relax, as a distraction, or for educational reasons. Besides this unproblematic use, some risk groups have been assumed following their surveys. Individuals reporting past difficulties with sex, individuals who use cybersex as coping mechanism in stress, individuals using cybersex as emotion regulation strategy within dysphoric mood as well as individuals using cybersex as compensatory for unfulfilled sexual fantasies in real-life are assumed to be at risk for developing cybersex addiction. The mentioned quantitative studies give important insight regarding the behavior and the motivation of cybersex participants and give first empirical evidence for factors which can be assumed as specific factors of vulnerability for the development of cybersex addiction. The main limitation of these studies is the missing valid diagnostic criterion for cybersex addiction. Time spend on Internet sex sites might be an indicator of cybersex addiction, but is not sufficient for diagnosis. Time issues leading to subjective complaints in everyday life due to cybersex use might be strongly dependent on personal life situations of the participants. Although some risk factors have been postulated for the development of cybersex addiction, an experimental verification of these assumptions is outstanding.

With respect to comorbidities of cybersex addiction, Schwartz and Southern (2000) report high rates of sexual abuse and psychiatric symptoms in male and female cybersex addicts. Most notably, affective, eating, and substance use disorders as well as sex addiction have been diagnosed. However, data about the actual cybersex consume has not been provided in the study of Schwartz and Southern (2000). Further evidence for a general psychological-psychiatric symptom severity is given by the study of Brand et al. (2011). They present correlations of tendencies towards cybersex addiction with psychological-psychiatric symptoms of obsessive-compulsivity, interpersonal sensitivity, depression, anxiety, phobic anxiety, paranoid ideation, psychoticism, and a general psychological-psychiatric symptom severity in an analogue sample.

Studies addressing neural correlates of cybersex addiction are missing. Since gaining and anticipating sexual arousal and gratification seem to be the main reasons for engaging in cybersex (Paul, 2009), it has been assumed that this may be a relevant key factor in the development of cybersex addiction (Meerkerk et al., 2006; Young, 2008). There are several neuroimaging studies investigating neural correlates of sexual arousal by presenting sexual pictures to participants. Stoléru et al. (1999) report on neural activations in the nucleus caudate, the insula, the anterior cingulate gyrus, and the inferior temporal gyrus elicited by sexual cues in heterosexual males. Redouté et al. (2000) and Arnow et al. (2002) can replicate these findings in heterosexual males and observe further activations in the claustrum, in the orbitofrontal cortex, in the hypothalamus as well as in sensor and motor cortices. Two studies addressing neural correlates of sexual arousal in hetero- and homosexual males show comparable neural activations of sexual cues according to sexual preference in the nucleus caudate, in the insula, in the thalamus, in the gyrus cingulate, in frontal lobes, in the hypothalamus as well as in the cerebellum (Hu et al., 2008; Paul et al., 2008). Similar results have been shown in the studies by Ponseti, Bosinski, Wolff, and Peller (2006) and by Kranz and Ishai (2006). Taken together, the results converge to the view that sexual cues elicit brain activations related to reward and that therefore sexual arousal taps into the neural systems of reinforcement (e.g. Wightman & Robinson, 2002; Wise, 2002). Moreover, there is evidence showing that sexual arousal can be conditioned in humans. Lalumiere and Quinsey (1998) report findings regarding pavlovian conditioning of sexual arousal in heterosexual males. In their study, a presentation of partially nude females (CS) has been combined with highly arousing videotapes displaying heterosexual interactions (US). Following repeated association of these stimuli, participants have reported greater sexual arousal, have shown longer viewing times as well as increased reactions in penile tumescence responses due to the presentation of the CS alone compared to a pretest. In another study by Hoffmann, Janssen, and Turner (2004), sexually relevant pictures (CS) have been presented subliminally and have been

followed by a highly arousal erotic film clip. Afterwards, male participants have shown greater sexual arousal, greater skin conductivity as well as greater penile tumescence responses. In a neuroimaging study by Klucken et al. (2009), pictures of geometric figures have been followed by sexual pictures and abstract pictures have been followed by neutral pictures. It is reported that past the conditioning males rated the geometric figures as more positive and more arousing and have shown greater neural activity in amygdala, the thalamus and in the brain stem compared to females. Against the background of these studies and the highly reinforcing effects of sexual arousal (for review see Georgiadis & Kringelbach, 2012), it makes theoretically absolutely sense to consider cue-reactivity and craving as potential mechanisms of development and maintenance in cybersex addiction as well. Processes of classical and operant conditioning might lead to an association of former neutral internal (e.g. emotions, stress) and external (e.g. computer, home environment, etc.) cues with gratification received by cybersex resulting in cue-reactivity and associated craving reactions. Experimental studies investigating this postulated mechanism are widely missing. Only one study indicates that subjective sexual arousal ratings for pornographic pictures covariies with a tendency towards cybersex addiction (Brand et al., 2011). This study provides the first link of cybersex addiction to cue-reactivity and needs to be addressed in more detail in further studies. Therefore, Study 1 and Study 2 in this thesis address the role of sexual arousal and craving as reactions to pornographic pictures as well as a specific predisposition in the development and maintenance of cybersex addiction.

In summary, a lot of psychological research investigating Internet addiction has been conducted in the last years. Early case-studies, theoretical assumptions and models have been followed by the development of diagnostic instruments and lead to a series of studies addressing psychological correlates of Internet addiction. While Internet addiction was considered to be a unitary entity for several years, today there is a growing acceptance for distinguishing between a GPIU and diverse SPIUs. Regarding cybersex addiction, the number

of published studies is still very limited regarding personality, cognitive, and neural correlates. Moreover, research on PIU lacks of addressing the role of general executive functioning and the impact of addiction related cues on cognitive functioning for GPIU and SPIU. Since investigating these associations improved the understanding of substance addictions, study 3 and 4 aim at approaching to this important field. Therefore, a general introduction to executive functioning and more detailed to working memory and decision making will be given in the following sections.

1.3 Executive functioning

The complex construct of executive functioning tries to describe the interaction of higher cognitive functions in order to facilitate goal-directed behaviors (for review see Alvarez & Emory, 2006). There is an ongoing debate about the operationalization and the core facets of executive functions, but still no unitary definition has been established. In general, executive functions include diverse cognitive processes and are addressed by different theories, e.g. by the concept of the supervisory attentional system (Norman & Shallice, 1986), the multi-component model (Baddeley & Logie, 1999; Baddeley, 2010), or the somatic marker hypothesis (Damasio, 1996) (for an overview of theories see Chan, Shum, Toulopoulou, & Chen, 2008). Taken together, goal-directed behaviors in everyday life rely on "cold" processes of logic and reasoning as well as on "hot" processes involving emotional arousal (Chan et al., 2008). With respect to the rather "cold" processes of executive functions, the core facets are the abilities to focus attention, to inhibit irrelevant information, to switch between relevant information, but moreover, to plan, monitor and code information in working memory (Miyake et al., 2000; Smith & Jonides, 1999).

Because executive functioning is a multidimensional construct, there are several paradigms aiming at assessing its single components (for overviews on common instruments

please see Alvarez & Emory, 2006; Chan et al., 2008; Jurado & Rosselli, 2007). Prominent tasks are the "Wisconsin Card Sorting Test" (Heaton, Chelune, Talley, Kray, & Curtis, 1993), the "Stroop Color Word Interference Test" (MacLeod, 1992), "Go/No-go-Tasks" (e.g. Gomez, Ratcliff, & Perea, 2007), or the "Trail Making Test" (e.g. Tombaugh, 2004). Working memory-performance is frequently measured with modifications of the n-back task (e.g. Jaeggi, Buschkuehl, Perrig, & Meier, 2010).

Accordingly to the multidimensionality of executive functions, the neural correlates of executive functions are mainly found in the frontal cortex, but are varying correspondingly to the single facets (Stuss & Alexander, 2000). Using the current conception of executive functioning it was shown, that there are differential neural correlates of the single processes (for reviews see Jurado & Rosselli, 2007; Royall et al., 2002): While the dorsolateral prefrontal cortex is the core correlate of planning, goal-selection, set-shifting, working memory, and self-monitoring, the lateral orbitofrontal cortex is associated to inhibition and emotional processing, and the anterior cingulate cortex is related to monitoring. However, updating was shown to be linked to activity of the parietal lobe and the left middle and inferior frontal gyrus (Collette et al., 2005).

Executive functions in addictions have been investigated in several studies. For example, it was shown that alcohol, cocaine, amphetamine, cannabis and heroine addicted individuals show deficits in attention, set-shifting, and working memory (e.g. Errico, King, Lovallo, & Parsons, 2002; Indlekofer et al., 2009; Kübler, Murphy, & Garavan, 2005; Ornstein et al., 2000). In a very elaborate study published by Verdejo-García, Bechara, Recknor, and Pérez-García (2006), alcohol, cocaine, and methamphetamine addicted individuals have been compared with healthy controls in several behavioral, cognitive, and emotional tasks. With respect to executive functioning it is reported that the group of substance addicted individuals has shown worse performance in tasks measuring working

memory, inhibition, and mental flexibility. These cognitive deficits in substance addicted individuals are explained by dysfunctional neural circuits in the prefrontal cortex resulting from substance use (for reviews please see Goldstein & Volkow, 2011; Verdejo-García, López-Torrecillas, Giménez, & Pérez-García, 2004). Studies assessing classical neuropsychological test batteries in Internet addicted individuals have not been published yet. Support for the assumption that executive functioning might be impaired in Internet addictions as well comes from studies on pathological gambling as another behavioral addiction. It was shown that pathological gamblers have deficits in inhibition, set-shifting, working memory and planning (Forbush et al., 2008; Fuentes, Tavares, Artes, & Gorenstein, 2006; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005). For results regarding decision making in Internet addiction, please see section 1.3.2.

Because executive processes often work on the content of working memory (Smith & Jonides, 1999), a more detailed Introduction on this will be given in the following section. After that an overview about decision making will be given, because it was shown that working memory is important for advantageous decision making (Hinson, Jameson, & Whitney, 2002; Jameson, Hinson, & Whitney, 2004).

1.3.1 Working memory

In general, executive functions manipulate the content of working memory in order to facilitate goal-directed behaviors. Several working memory models have been developed (for overview see Miyake & Shah, 1999), which generally have in common that for all kinds of cognitive processes, some information needs to be maintained by processes of active storage or directed attention in what has also been termed short-term memory. While working memory's capacity is limited (Cowan, 2010), it is necessary for the development of speech, understanding, learning, reasoning, problem solving as well as for decision making (Bechara,

Damasio, Tranel, & Anderson, 1998; D'Esposito, 2007; Pecchinenda, Dretsch, & Chapman, 2006; Smith & Jonides, 1999). The most influential model of working memory is the multiple-component model (Baddeley, 1994; 2000; 2010; Baddeley & Logie, 1999). It distinguishes between a phonological loop, a visuospatial sketchpad, a central executive and an episodic buffer, which are separate but interacting components to store and manipulate information temporarily (see Figure 2).

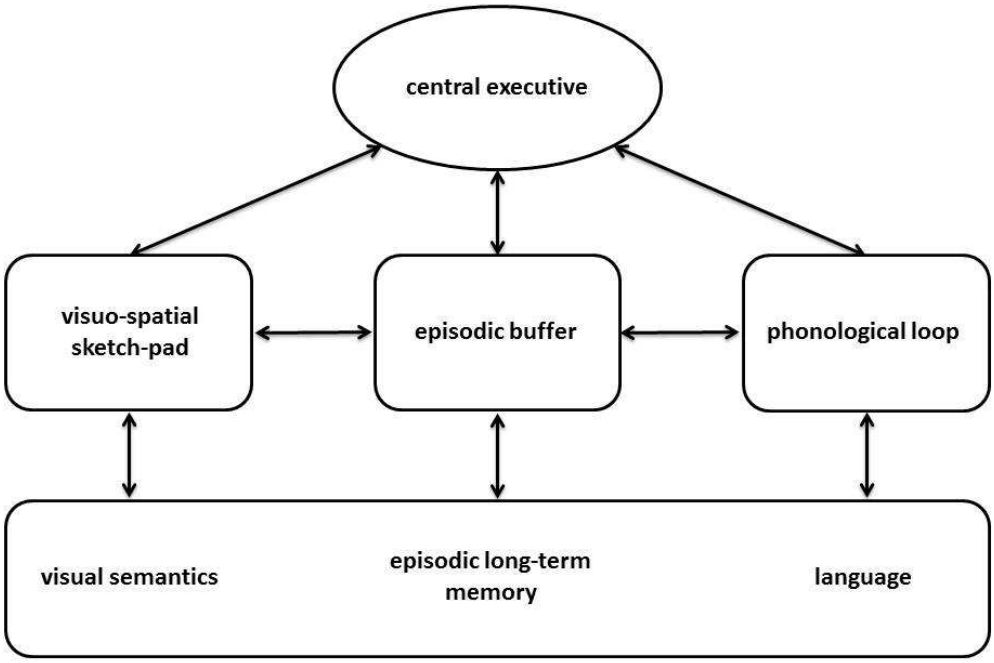

Figure 2

The multicomponent model (modyfied from Baddeley, 2010). Visual or verbal information can be maintained separately, combined or linked to long-term memory contents to be used for mental operations carried out by the central executive.

Neuroimaging and brain lesion studies support the proposed structure of the model. It has been shown that there are distinct and interacting brain structures building up prefrontal-

parietal working memory circuits even for different kinds of stimuli (Cabeza & Nyberg, 2000; Chein, Ravizza, & Fiez, 2003; D'Esposito, Postle, & Rypma, 2000; Hautzel, Mottaghy, Schmidt, & Zemb, 2002; Müller & Knight, 2006; Smith & Jonides, 1997). Callicott et al. (1999) have demonstrated that the amount of neural activity, particularly in the dorsolateral prefrontal cortex, indeed depends upon the amount of memory load induced through a working memory task. Moreover, there is evidence that sub-cortical structures such as the basal ganglia (Cools, Gibbs, Miyakawa, Jagust, & D'Esposito, 2008; Voytek & Knight, 2010), the hippocampus (Mitchell, Johnson, Raye, & D'Esposito, 2000) and the cerebellum (Hautzel, Mottaghy, Specht, Müller, & Krause, 2009) play a supportive role in executive and working memory functions. It was also shown that amygdala's activity, classically considered to be part of the emotion processing limbic system, is correlated with working memory-performance (Schaefer et al., 2006), which is explained by an early enhancement of attention in information processing.

Taken together, working memory is an important facet of executive functioning, relevant for cognitive processes and for everyday functioning in individuals' life. Although it has been shown that emotional stimuli of positive or negative valence interfere with working memory because they bind attention (e.g. Erk, Kleczar, & Walter, 2007), no studies have addressed the effect of sexual stimuli on working memory. This seems important, because it might partly explain the negative consequences occurring during or after engaging in cybersex, as reported by at least some individuals (Griffiths, 2001). Moreover, addressing this research question might contribute to the understanding of cybersex addictions' mechanisms of development and maintenance. It was shown that addiction related cues are processed differently: They bind attention more strongly and lead to greater interference with cognition (Field, Munafò, & Franken, 2009; Field & Cox, 2008), they lead to craving, and are associated to relapse (Carter & Tiffany, 1999; Tiffany & Wray, 2012). Study 3 in this thesis

addresses the effect of sexual stimuli on working memory and discusses the relevance of the observed interfering effects of sexual arousal for cybersex addiction.

1.3.2 Decision making

Decision-making research aims at explaining why individuals make rather advantageous or disadvantageous decisions under certain circumstances. To address the underlying mechanisms a convention was established, which distinguishes between two decision situations on the basis of the explicitness of the probability as well as the amount of possible decision consequences. If the amount of reward or punishment and their probabilities are not explicit, decisions are made under the condition of ambiguity. If the decision situation is more explicit, meaning that potential reward and punishment as well as their probabilities are known or calculable, decisions are done under the conditions of risk (Bechara, Damasio, Tranel, & Damasio, 1997; Brand, Labudda, & Markowitsch, 2006).

With respect to decisions under ambiguity, the somatic marker hypothesis proposes that individuals' decisions are influenced by earlier emotional experiences of similar decision situations (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, Tranel, & Damasio, 2000; Dunn, Dalgleish, & Lawrence, 2006). According to this, studies have pointed out the relevance of functional emotion related brain structures with respect to advantageous decision making in daily life and laboratory setting using the Iowa Gambling Task (IGT, Bechara, Damasio, & Damasio, 2000, 2003; Bechara, Damasio, Damasio, & Lee, 1999; Bechara et al., 1994; Denburg et al., 2007; Dolan, 2002; Naqvi, Shiv, & Bechara, 2006). In contrast, the role of emotional feedback has a secondary role in decision making under risk. Although emotional biases have also an impact on these decisions, it has been shown that rule based feedback learning, executive functioning, strategy application, probability handling, and logical thinking is more relevant for decisions under risky conditions (Brand, 2008; Brand,

Heinze, Labudda, & Markowitsch, 2008; Brand, Laier, Pawlikowski, & Markowitsch, 2009; Brand, Recknor, Grabenhorst, & Bechara, 2007; Cokely & Kelley, 2009; Schiebener, Zamarian, Delazer, & Brand, 2011). Correspondingly, the dorsolateral prefrontal cortex has been demonstrated to be a main neural correlate of risky decision making (Labudda et al., 2008), which is in turn known to be associated with attention, inhibition, working memory and executive functioning (D'Esposito, Postle, & Rypma, 2000; Smith & Jonides, 1997; 1999). Two models of decision making are illustrated in Figure 3.

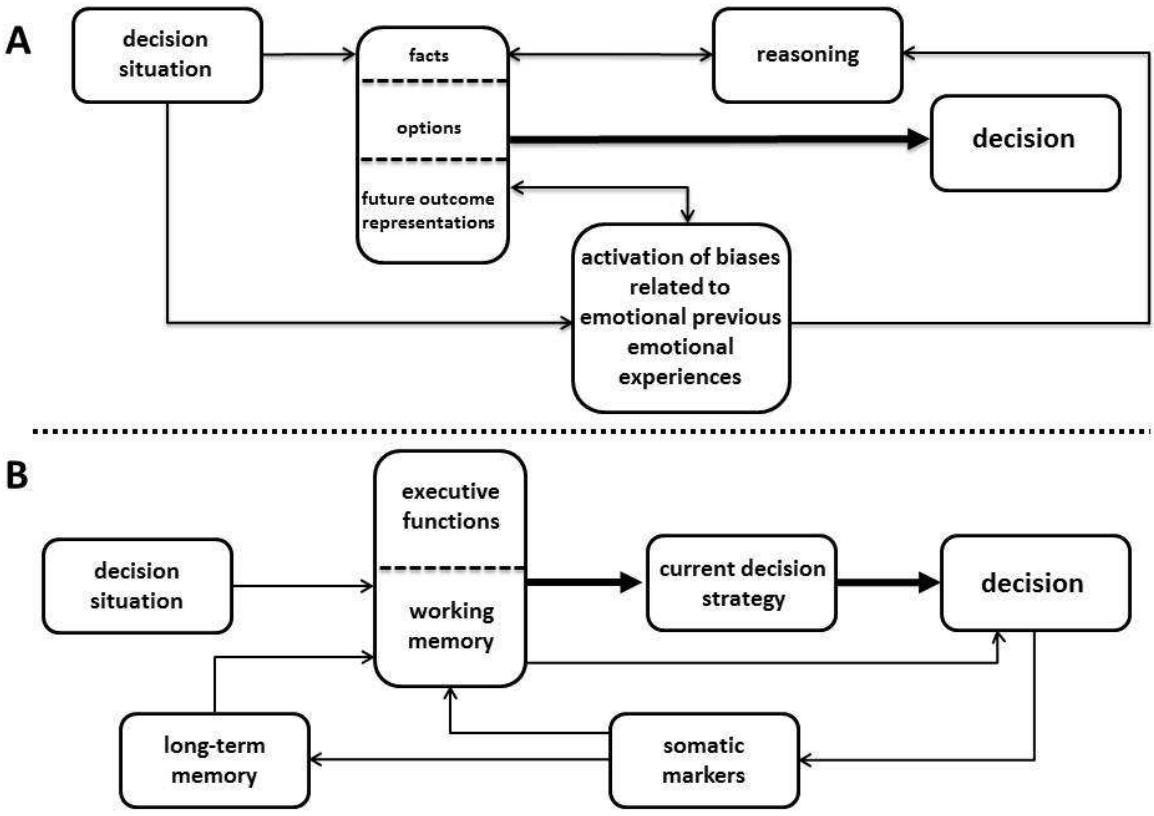

Figure 3

Illustration of decision making under ambiguity (A, modified from Bechara et al., 1997) and decision making under risk (B, modified from Brand, Labudda, & Markowitsch, 2006).

Further evidence contributing to the view that decision under ambiguity and risk are mediated by different systems comes from studies with secondary-tasks, showing that decisions under risk, but not under ambiguity are interfered by secondary-tasks which have demands on executive functioning (Starcke, Pawlikowski, Altstötter-Gleich, Wolf, & Brand, 2011; Turnbull, Evans, Bunce, Carzolio, & O'Connor, 2005). Summarized and assigned on a more cognitive level, decisions under ambiguity are done rather by an intuitive system, while decisions under risk are more directed by reasoning (Kahneman, 2003). With respect to decision making under ambiguity, the stimulating nature and the emotional processing of pornographic pictures could interfere with the emotional feedback learning (most notably of negative consequences) necessary for the development of advantageous decision making in the long run.

With respect to addiction, it has been demonstrated that decision-making performance under ambiguity as well as under risk is impaired in substance consuming individuals (e.g. Bechara & Martin, 2004; Bechara & Damasio, 2002; Bechara, Dolan, & Hindes, 2002; Bolla et al., 2003; Brand et al., 2005, 2009; Brand, Roth-Bauer, Driessen, & Markowitsch, 2008). Regarding Internet addiction, two studies assessed the IGT in Internet addicted students. One of these two study revealed worse (Sun et al., 2009) and the second better (Ko et al., 2010) decision-making performance in the IGT. The first result is in line with literature reporting that individuals with pathological gambling or excessive usage of online games rather decide disadvantageously under ambiguity and risk (Brand, Kalbe, et al., 2005; Goudriaan, Oosterlaan, Beurs, & Brink, 2005; Pawlikowski & Brand, 2011). Against this background, the finding of better decision-making performance in Internet addicted individuals (Ko et al., 2010) is not as expected. On a speculative level, the authors try to explain this result in the way that students might rely more on explicit information neglecting emotion-based information in a decision-making situation. One problem of both studies addressing decision making in Internet addiction is that the used diagnostic instruments for Internet addiction did

not distinguish between an addicted use of the Internet in general or of specific Internet applications. Because of that, the generalization of these results is limited.

Taken together, advantageous decision making can rely on the functional integration of emotional feedback and/or on components of executive functioning. But both might be interfered by sexual arousal leading to rather disadvantageous decision making associated with negative consequences. Study 4 in this thesis addresses the role of sexual arousal on decision making under ambiguity and aims at explaining why some individuals decide disadvantageously during cybersex. Moreover, the study discusses the relevance of the interfering role of sexual arousal with decision making for cybersex addicted individuals.

1.4 Summary of the general Introduction

After reviewing the literature on Internet addiction it has become clear that Internet addiction is a serious mental health problem associated with subjective complaints in everyday life and symptoms of dependency. The main achievements in the last years consist of the development of theoretical models regarding Internet addiction as well as diagnostic instruments. Moreover, there is growing agreement that it has to be distinguished between GPIU and SPIU. Regarding GPIU, mainly its phenomenology and diverse personality correlates have been addressed. Concerning SPIU, mainly online gaming has been investigated, while the number of studies addressing cybersex addiction is very limited. Research on cybersex addiction lacks of experimental studies exploring the role of cue-reactivity as well as of executive functioning. To approach this research gap, four studies will be presented in the following addressing mainly the role of the stimulating and reinforcing nature of Internet pornographic stimuli in the development of cybersex addiction as well as their effect on working memory and decision making. Each study will be discussed separately at first and a general conclusion of the study's results will be given finally.

2. Study 1: Gratification and not a compensation of unsatisfied real-life sex explains cybersex addiction.

2.1 Abstract

Some individuals report personal distress and subjective complaints in everyday life resulting from cybersex use. The issue of cybersex addiction is under scientific debate, while experimental investigations addressing mechanisms of development and maintenance are missing. The aim of this study was to investigate the gratification and compensation hypothesis of cybersex addiction in a cross-sectional within-group experimental design. 171 participants were screened for symptoms of cybersex addiction using the short version of the Internet Addiction Test modified for Internetsex sites. In an experimental paradigm, participants rated 100 pornographic pictures of ten categories with respect to subjective sexual arousal. Viewing times as implicit measurement of attraction to the presented stimuli were recorded. Furthermore, individuals were asked about their cybersex use as well as their sexual real-life contacts. Sexual arousal rating and viewing times for pornographic pictures, craving, the variety of interest in Internet pornographic content as well as the frequency of Internet pornography use accompanied by masturbation predicted a tendency towards cybersex addiction ($R^2 = .29$, $p < .001$). In contrast, the number of sexual real-life contacts as well as the satisfaction with the frequency and the quality of real-life sexual contacts did not predict cybersex addiction. As shown by moderated regression analysis, individuals reporting high satisfaction with the quality of their real-life sexual contacts and high craving reactions show the highest severity of cybersex addiction. Results emphasize the role of positive reinforcement gained by cybersex and need to be discussed with respect to cue-reactivity in the development of cybersex addiction.

2.2 Introduction

The Internet offers lots of applications which may be used for private, social or work purposes. While most people use the Internet without experiencing any problems, some individuals develop an Internet usage pattern accompanied by the experience of negative consequences and subjective complaints in everyday life (Byun et al., 2009; Chou et al., 2005). While this phenomenon has been named differently (Block, 2008; Caplan, 2005; Davis, 2001; Larose, Lin, & Eastin, 2003) cybersex is thought to be one of the most compromising Internet applications for the development of an Internet addiction (Meerkerk et al., 2006; Young et al., 1999). Even though there is still not enough data allowing conclusions regarding the nature of Internet addictions to be drawn, addiction seems to be the most appropriate term since the phenomenology of substance and behavioral addictions have been shown to be similar with respect to behavioral and biological mechanisms (Grant et al., 2006; Potenza, 2008). Regardless of the outstanding classification as a distinct addiction or a form of a general hypersexual behavior, several authors describe individuals suffering from symptoms similar to those displayed within addiction and impulsive-compulsive spectrum disorders emerging from their cybersex use (Griffiths, 2001; Young, 2008). Given the high prevalence of comorbidity in cybersex addiction, this topic has high clinical relevance, but experimental studies addressing potential mechanisms of development and maintenance of cybersex addiction are sparse (Brand et al., 2011; Kuss & Griffiths, 2011). The gratification and the compensation hypothesis have been postulated to explain how cybersex addiction may develop or increase (Kuss & Griffiths, 2011; Young, 2008). However, the question whether gratification, compensation, or both can be considered as predictive factors for the severity of cybersex addiction has not yet been investigated experimentally.

Cybersex comprises a variety of sexually motivated behaviors carried out on the Internet. This includes watching pornographic pictures and videos, taking part in sexually motivated chats or in sex via webcam, but also the online searching for offline sex partners

(Döring, 2009). Though more and more studies address aspects of sexually motivated behavior on the Internet, an exact definition of cybersex, actual consumer behavior as well as the effects of cybersex usage is not yet clearly described. Watching pornography is considered to be the most common and widespread cybersex application (Short et al., 2012). Some studies indicate that cybersex is indulged in by a great variety of individuals, e.g. adolescents (Brown & L'Engle, 2008), students (Goodson, McCormick, & Evans, 2001; Shaughnessy, Byers, & Walsh, 2011) and adults of all ages (Cooper et al., 1999; Daneback, Cooper, & Månsson, 2005). Motivation for cybersex arises for different reasons: While users may satisfy their curiosity, stimulate fantasy, gather information or manage mood by cybersex (Cooper et al., 1999; Goodson et al., 2001; Paul & Shim, 2008), gaining sexual arousal seems to be the strongest predictor of cybersex usage (Paul, 2009). Moreover, a frequent utilization of cybersex is thought to be encouraged by Internet pornography's easy, mostly free or affordable accessibility, while users assume a high degree of both anonymity and control (Cooper et al., 2000; Griffiths, 2000; Young et al., 1999).

Most individuals perceive a positive impact of cybersex, e.g. the experience of sexual arousal (Paul, 2009; Shaughnessy et al., 2011) improvement of their sex life, acquisition of sexual knowledge, a change in attitudes towards sex and life in general (Hald & Malamuth, 2008) as well as an enrichment of real-life sexual contacts due to a greater sexual openness (Grov, Gillespie, Royce, & Lever, 2011). While a discussion of a negative impact of pornography usage in general on opposite gender role-models (Barak, Fisher, Belfry, & Lashambe, 1999), sexual socialization (Stulhofer, Busko, & Landripet, 2010), partnerships (Whitty & Quigley, 2008) and sexual aggression (Kingston, Fedoroff, Firestone, Curry, & Bradford, 2008) has also found its introduction into (Internet) pornography literature, there are several cybersex specific risks and possible negative consequences discussed, which cybersex participants may experience during or following the use of cybersex. Individuals report problems in controlling their cybersex use, missing sleep, forgetting appointments,

disregarding responsibilities, family, partnership or friends (Cooper et al., 2004; Griffiths, 2001; Young, 2008). It was reported that there are individuals suffering from cybersex addiction (Kuss & Griffiths, 2011b), which is linked to personal distress due to an inability to control one's cybersex use, the persistent experience of negative consequences in individuals' life, and unsuccessful efforts to reduce the behavior**.**

With respect to the development of cybersex addiction some approaches try to explain the addictive process through analogy to substance addictions. In Davis' (2001) cognitive-behavioral model it is described that cybersex addiction might develop due to a pre-existing psychopathology, but the role of immediate reinforcement gained by Internet pornography use is also emphasized. Complementary to this, Young (2008) claims that the reinforcing effects of cybersex – in terms of anticipation of gratification – might foster its use as a coping mechanism and emotion regulation. Following this rationale, the discovery of and experimentation with cybersex escalates in some users, resulting in an addictive usage pattern. The role of these learning mechanisms and reward craving has been shown to be crucial for the development and maintenance of substance addictions (Carter & Tiffany, 1999; Everitt & Robbins, 2005), as well as for other behavioral addictions (Crockford et al., 2005; Goudriaan et al., 2010; Ko et al., 2009; Potenza et al., 2003; Sodano & Wulfert, 2009; Thalemann et al., 2007; Wulfert et al., 2009). We consider cue-reactivity and reward craving to be crucial processes in the development of cybersex addiction as well, since sexual arousal taps into neural systems of reinforcement (Arnow et al., 2002; Bancroft, 2005; Holstege et al., 2003; Paul et al., 2008; Redouté et al., 2000; Stolèru et al., 1999).

Based upon the claims that the anticipation and the experience of sexual arousal is the key element of engaging in cybersex excessively (Young, 2008) one would assume that the development of cybersex addiction is encouraged by gratification. However, this assumption has only been investigated in one study demonstrating associations of sexual arousal ratings

of pornographic pictures with cybersex addiction (Brand et al., 2011). Based upon these assumptions, missing or unsatisfying sexual real-life contacts should also be considered as risk factors for the development of cybersex addiction (Kuss & Griffiths, 2011). Encouraged by Internet pornography's easy availability, individuals might engage in cybersex to compensate poor real-life sex and use cybersex as a substitute of sexual real-life contacts. In fact, some users report engaging in cybersex primary to fulfill sexual fantasies missed in real-life sexual intercourse (Cooper et al., 2004). Investigating these research questions might lead to a better understanding of the phenomenon of cybersex addiction with respect to the role of learning mechanisms (Carter & Tiffany, 1999) for the development of cybersex addiction.

Following the theoretical assumptions, gratification and compensation hypotheses imply differential predictors of the severity of cybersex addiction. According to the gratification hypothesis, indicators of attraction to or sexual arousal due to pornographic pictures should explain this severity. In contrast, following the compensation hypothesis, the quantity, the variability, and the satisfaction with real-life sexual contacts should be the relevant predictors. Moreover, following the aforementioned potential combination of gratification and compensation, indicators of gratification should moderate or mediate, respectively, the relationship between indicators of compensation and a tendency towards cybersex addiction.

2.3 Methods

2.3.1 Participants

In this study, 171 heterosexual men (M_{age} = 24.56 *SD* = 5.22) participated. They were recruited by advertisements in public or on campus of the University of Duisburg-Essen. We explicitly addressed male, heterosexual participants of legal age. We indicated that study

participation would include a confrontation with explicit pornography of legal sexual practices. All participants gave written informed consent prior to the investigation, confirmed their heterosexual preference via questionnaire and were paid at an hourly rate for participation (10€/hr.). Mean years of education was M = 12.53 (SD = 1.08). All participants indicated that they had any form cybersex at least once in their life. Mean age at first cybersex use was M = 15.86 (SD = 4.48). All questionnaires and the experimental paradigm were administered in a computer-based laboratory setting. The study was approved by the local ethics committee.

2.3.2 Internetsex Addiction Test

Subjective complaints in everyday life due to cybersex and severity of cybersex addiction were assessed with a modified version of the German short-version Internet Addiction Test (s-IAT, Pawlikowski, Altstötter-Gleich, & Brand, 2012). The original Internet Addiction Test assesses symptoms of Internet addiction with twenty items (Young, 1998). In the s-IAT, twelve items have to be answered on a five-point scale from 1 (= never) to 5 (= very often) resulting in sum scores ranging from 12 to 60. The authors report a two-factorial solution of the s-IAT as revealed by exploratory and confirmed by confirmatory factor analysis. All items have a high load on one and a low load on the other factor. The reliability of the two factors "loss of control and time management" (Cronbach's α = .876) and "craving and social problems" (Cronbach's α = .836) as well as of the overall scale (Cronbach's α = .897) is high. Moreover, to address the convergent and divergent validity of the scale, the method of destructive testing (Anderson & Anderson, 1996) was used. Both factors and the overall score of the s-IAT correlate with a general psychiatric symptom severity, impulsivity, and personality facets. Furthermore, a strong relationship to the Compulsive Internet Use Scale (Meerkerk, van den Eijnden, Vermulst, & Garretson, 2009) is reported (r = .897, p < .001).

For both factors of the s-IAT divergent and incremental validity was revealed when correlated with or regressed on the specific facets of the validation constructs (Pawlikowski et al., 2012). Because both factors were moderately correlated (r = .57, p < .01), authors suggest that the overall score as well as two sub scores can be used in future studies. Moreover the authors state that all items are suited for modification for diverse specific Internet applications. In this study, the s-IAT was modified for Internet sex sites (s-IATsex). Comparable to the modification in the study of Brand et al. (2011), terms like "online" or "Internet" were replaced by the terms "online sexual activity" or "Internet sex sites". An example item is "How often do you find that you stay on Internet sex sites longer than you intended?". In our sample, internal consistency of the s-IATsex was high (Cronbach's α = .841).

2.3.4 Indicators of the gratification hypothesis

To assess subjective sexual arousal experienced during watching pornographic material, the study's experimental paradigm comprised a randomized presentation of 100 standardized explicit pornographic pictures (ten categories having ten pictures each). To control for the influence of specific sexual interests, only Caucasian people of an approximate age of 25 to 35 years and no fetish relevant information were shown. Pictures displayed heterosexual sex (vaginal, anal and oral sex, with two oral categories: one with the man the cunnilingus and one with the woman doing the fellatio actively), homosexual sex (anal and oral sex between two men, tribadism and oral sex between two women) as well as single masturbating men and women, all in an indoor scenery. Each picture had to be rated on a five-point scale with respect to subjective arousal (1 = sexually not arousing to 5 = sexually very arousing). Additionally, viewing times (VT) as an unobtrusive measurement of sexual attraction to the presented stimulus were recorded (Imhoff et al., 2010). Of particular interest were the sexual arousal ratings and the VT of "heterosexual pornography" (vaginal, oral and anal sex between

a man and a woman, tribadism and oral sex between two women and masturbating women). Before and after the experimental paradigm, participants were asked to indicate their urge to masturbate from 0 (= no urge to masturbate) to 100 (= very great urge to masturbate). As an indicator of reward craving strengths, the urge to masturbate at t1 was subtracted from the urge to masturbate at t2, resulting in a delta score (craving Δ). To assess attraction to various forms of pornographic content, participants were shown a list of 29 sexual practices or fetishes (vaginal intercourse, group sex, role play, different fetishes for clothes, etc.) and asked, in which of those they were interested in, scale from 0 (= not interesting) to 3 (= very interesting). Using this information, we calculated a score indicating the variability of the individual's interest in Internet pornographic content. This Internet pornography variability score was computed as a cumulative value of those of the 29 items which were answered with 2 (= rather interesting) or 3 (= very interesting). Furthermore, participants were asked how often they watch pornographic pictures or videos on the Internet using a scale from 1 (= never) to 5 (= very often) as well as how often they masturbate when watching pornography on the Internet (1 = never to 5 = very often).

2.3.5 Indicators of the compensation hypothesis

Participants were surveyed with respect to their real-life sexual contacts. We assessed an approximation of the number of sexual contacts in the last six months. To specify the variability of sexual real-life contacts, we presented 22 sexual practices (vaginal intercourse, group sex, clothes fetishes, etc.) and asked the participants how often they had practiced these in the last six months. Using this information, we calculated a score indicating the variability of an individual's real-life sexual contacts. This variability score was computed as a cumulative value of practiced sexual practices in the last six months (no matter how often it was performed out and how satisfied individuals were with the sexual contact) and could

range from 0 to 22. Moreover, if there was at least one sexual contact within the last six months, participants were asked to indicate how satisfied they were with the frequency (1 = not satisfied to 5 = very satisfied) and the quality (1 = not satisfied to 5 = very satisfied) of their sexual contacts in the last six months.

2.3.6 Statistical analyses

All analyses have been carried out with SPSS 20.0 (IBM, 2011). *T*-tests for dependent samples and repeated measures ANOVAs were used to compare sexual arousal ratings as well as VT with regard to the pornographic picture categories. To investigate the relationship between indicators of the gratification and the compensation hypothesis as well as with the s-IATsex Pearson's correlation was used. To predict the s-IATsex, hierarchical and moderated regression analyses were carried out. Two-tailed tests were performed for all analyses, p was set to .05.

2.4 Results

The results of the experimental paradigm are shown in Table 1. Moreover, an illustration of the results is given in Figure 4 to demonstrate the relationship of ratings with viewing times graphically. Repeated measures ANOVA revealed a significant effect of the within-subject factor "pornographic picture category" with respect to sexual arousal ratings, Wilks' Lambda = .06, $F(9, 162) = 259.23$, $p < .01$, $\eta^2 = .94$. According to the preference of a heterosexual male, we calculated the mean sexual arousal for "heterosexual pornography" (including heterosexual sex, sex between females, and single masturbating women) and "homosexual pornography" (including sex between men or single masturbating men). As indicated by *t*-test for dependent groups, "heterosexual pornography" (M_1) was rated as more sexually arousing

than "homosexual pornography" (M_2), M_1 = 3.37, SD = .70, M_2 = 1.11, SD = .33, $t(170)$ = 41.34, $p < .01$, d = 4.48) with a large effect (Cohen, 1992). A second repeated measures ANOVA revealed a significant effect of the within-subject factor "pornographic picture category" when the dependent variable were VT, Wilks' Lambda = .23, $F(9, 162) = 60.37$, $p < .01$, $\eta^2 = .77$. As indicated by t-test for dependent groups, "heterosexual pornography" (M_1) was watched longer than "homosexual pornography" (M_2), M_1 = 4.05, SD = 1.42, M_2 = 2.18, SD = 1.06, $t(170) = 20.12$, $p < .01$, $d = 2.17$) with a large effect (Cohen, 1992).

Table 1

Result of the experimental pornographic picture presentation. Ten pornographic picture categories were rated with respect to sexual arousal while viewing times were recorded.

N = 171	**sexual arousal rating**[1]		**viewing times**[2]	
	M	***SD***	***M***	***SD***
male female vaginal sex	3.59	.76	4.30	1.70
male female anal sex	3.23	.93	4.54	1.97
male female oral sex (fm)	3.34	.88	3.81	1.52
male female oral sex (mf)	3.14	.75	4.19	1.58
female female tribadism	3.39	.87	3.97	1.51
female female oral sex	3.54	.81	3.78	1.71
male male anal sex	1.14	.46	2.49	1.29
male male oral sex	1.11	.35	1.99	1.13
female masturbation	3.38	.77	3.73	1.44
male masturbation	1.07	.22	2.04	1.00

[1] scale from 1 (= sexually not arousing) to (5 = sexually very arousing)

[2] in seconds

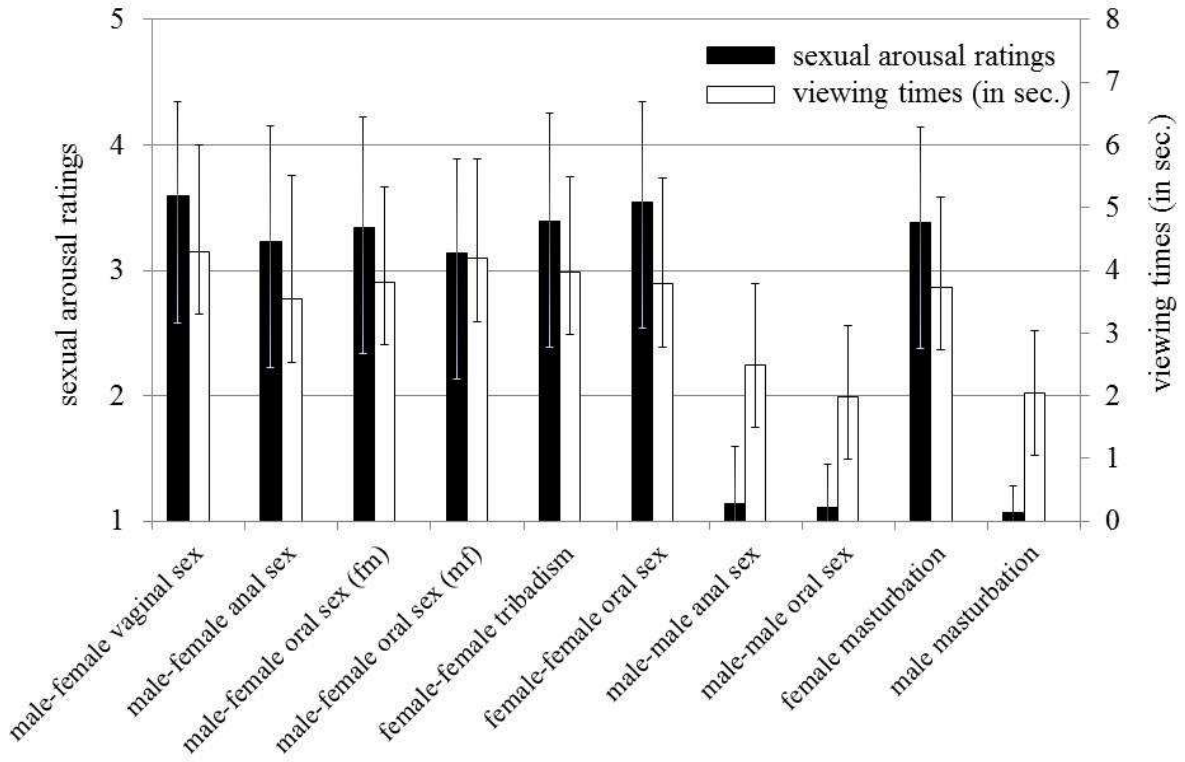

Figure 4

Result of the experimental pornographic picture presentation. Sexual arousal rating to the ten pornographic picture categories is represented by black bars and left axis. VT measure is represented by white bars and right axis. Error bars represent standard deviations.

As indicated by *t*-test for dependent groups, the experimental paradigm lead to a significant increase in the urge to masturbate with a large effect (M_{t1} = 6.58, *SD* = 10.94 , M_{t2} = 22.19, *SD* = 26.43, *t* = -8.54, $p < .05$, *d* = .87) (Cohen, 1992). A description of gratification and compensation hypothesis' indicators is shown in Table 2.

Table 2

Description of variables concerning cybersex consuming behavior, indicators of gratification as well as indicators of compensation.

N = 171	***M***	***SD***
s-IATsex	19.27	6.22
indicators of gratification		
sexual arousal rating (heterosexual pictures)[1]	3.37	.70
viewing times (heterosexual pictures)	4.05	1.42
urge to masturbate (craving) Δ	14.02	25.98
Internet pornography variability score[2]	3.51	2.45
pornographic picture usage[3]	1.21	1.09
pornographic video usage[3]	2.81	1.04
masturbation frequency during cybersex[3]	3.04	1.08
indicators of compensation		
frequency of sexual contacts (6 months)	25.42	33.25
real-life sexual contacts variability score (6 months)[4]	5.32	3.16
satisfaction (frequency, 6 months)[5]	1.46	1.12
satisfaction (quality, 6 months)[5]	1.98	1.06

[1] scale from 1 (= sexually not arousing) to 5 (= sexually very arousing)

[2] range from 0 - 29

[3] scale from 1 (= never) to 5 (= very often)

[4] range from 0 - 22

[5] scale from 1 (= not satisfied) to 5 (= very satisfied)

2.4.1 Gratification hypotheses

The s-IATsex was correlated with variables indicating attraction to or sexual arousal due to pornographic pictures (see Table 3). The s-IATsex correlates consistently with indicators of gratification. The observed effect sizes were small to moderate (Cohen, 1992).

To analyze the influence of the indicators of the gratification hypothesis on the s-IATsex a hierarchical regression analysis was conducted. In its first step, the pornographic picture rating together with the VT measurement explained 5.00% of the s-IATsex ($F(2,168) = 4.39$, $p < .05$). In the second step, craving Δ lead to a significant increase of s-IATsex' variance explanation (changes in $R^2 = .04$, changes in $F(1, 167) = 7.03$, $p < .01$). The variability score for Internet pornography (third step) also lead to a significant increase of variance explanation (changes in $R^2 = .07$, changes in $F(1, 166) = 14.04$, $p < .001$). Adding the frequency of Internet pornographic picture and video use and the masturbation frequency when watching Internet pornography (fourth step), increased the variance explanation of the s-IATsex significantly (changes in $R^2 = .13$, changes in $F(3, 163) = 10.34$, $p < .001$). The whole model was significant and explained 29% of the s-IATsex ($R^2 = .29$, $F(7, 163) = 9.68$, $p < .001$). For further values of this regression analysis see Table 4.

Table 3

Correlations of subjective complaints in everyday life due to cybersex usage as measured by the s-IATsex with indicators of attraction to or sexual arousal due to pornographic pictures.

N = 171	s-IATsex	sexual arousal rating (heterosexual pictures)	viewing times (heterosexual pictures)	craving Δ	Internet pornography variability score	pornographic picture use	pornographic video use
sexual arousal rating (heterosexual pictures)	**.16***						
viewing times (heterosexual pictures)	**.15***	-.06					
craving Δ	**.23****	**.24****	-.02				
Internet pornography variability score	**.32****	.13	.03	**.19***			
pornographic picture use	**.27****	.08	.02	.12	**.20****		
pornographic video use	**.43****	**.36****	.03	**.40****	**.30****	.08	
cybersex masturbation	**.42****	**.30****	.12	**.36****	**.31****	.13	**.67****

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

** = $p \leq .01$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

Table 4

Hierarchical regression analyses with indicators of the gratification hypothesis predicting the s-IATsex score as dependent variable.

Main effects of the single predictors in the whole model	***β***	***T***	***p***
“sexual arousal rating (heterosexual pictures)"	-.01	-0.21	.83
“viewing times (heterosexual pictures)”	.11	1.65	.10
"craving Δ”	.02	0.30	.77
“Internet pornography variability score”	.15	2.07	.04
“pornographic picture use”	.19	2.80	.01
“pornographic video use”	.24	2.61	.01
“cybersex masturbation”	.17	1.88	.06

2.4.2 Compensation hypothesis

The s-IATsex was correlated only with the variability of real-life sex, not with any of the other variables concerning the number of and satisfaction with real-life sexual contacts (Table 5).

Table 5

Correlations of the s-IATsex with variables concerning the number and the variability of as well as satisfaction with real-life sexual contacts.

N = 171	s-IATsex	frequency of sexual contacts (6 months)	real-life sex variability score	satisfaction (frequency)
frequency of sexual contacts (6 months)	.02			
real-life sex variability score	**.23****	**.29****		
satisfaction with sexual contacts (frequency)	-.07	**.55****	**.42****	
satisfaction with sexual contacts (quality)	.05	**.42****	**.53****	**.61***

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

** = $p \leq .01$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

To investigate potential moderating effects of the satisfaction dimensions, four hierarchical, moderated regression analyses with the s-IATsex as dependent variable were conducted. Therefore, all variables were centralized (Cohen, Cohen, West, & Aiken, 2003). In the first model, the variability score for real-life sexual contacts served as the first predictor and explained 5.10% of the variance in the s-IATsex ($F(1, 169) = 9.09$, $p < .05$). Adding satisfaction with the frequency of sexual contacts (second step) lead to a significant increase in variance explanation (changes in $R^2 = .03$, changes in $F(1, 168) = 6.32$, $p < .05$). The interaction of both (third step) did not explain variance significantly (changes in $R^2 = .01$, changes in $F(1, 167) = 1.45$, $p = .23$). The overall explanation of the s-IATsex by all predictors remained significant ($R^2 = .09$, $F(3, 167) = 5.73$, $p < .01$). In a second regression model, the variability score for real-life sexual contacts explained again 5.10% of the variance of the s-IATsex. Entering satisfaction with the quality of sexual contacts (second step)

(changes in R^2 = .01, changes in $F(1, 168) = 1.23$, $p = .27$) and the interaction of both (third step) (changes in $R^2 < .01$, changes in $F(1, 167) = .06$, $p = .80$) did not lead a significant increase in variance explanation. The overall explanation of the s-IATsex remained significant ($R^2 = .06$, $F(3, 167) = 3.45$, $p < .05$). In the third regression model, the number of sexual contacts, the satisfaction with frequency of sexual contacts and their interaction did not lead a significant variance explanation ($R^2 = .01$, $F(3, 167) = .62$, $p = .61$). In the fourth regression model, the number of sexual contacts, the satisfaction with the quality of sexual contacts and their interaction did not lead a significant variance explanation ($R^2 = .004$, $F(3, 167) = .25$, $p = .86$).

2.4.3 Combined hypothesis

To combine indicators of both hypotheses, two moderated regression analyses with the s-IATsex as dependent variable were conducted. All variables were centralized (Cohen et al., 2003). Correlations between all indicators are shown in Table 6.

Table 6

Correlations of the indicators of the gratification hypothesis with the indicators of the compensation hypotheses.

N = 171	number of sexual contacts (6 months)	real-life sex variability score	satisfaction (frequency)	satisfaction (quality)
sexual arousal rating (heterosexual pictures)	.04	.08	-.01	-.05
viewing times (heterosexual pictures)	.04	-.03	-.01	.08
craving Δ	-.03	.11	-.11	.02
Internet pornography variability score	-.02	**.40****	-.01	.12
pornographic picture use	-.02	.11	-.04	.02
pornographic video use	-.14	**.21****	**-.16***	.05
cybersex masturbation	-.05	.15	**-.15***	-.01

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

** = $p \leq .01$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

In both models, craving Δ as first predictor explained 5.20% of the s-IATsex ($F(1, 169) = 9.26$, $p < .01$). Adding the satisfaction with the frequency of sexual real-life contacts (second step) ($p = .51$) as well as their interaction (third step) ($p = .74$) did not increase variance explanation significantly. The whole model remained significant ($R^2 = .05$, $F(3, 167) = 3.24$, $p < .05$). Adding the satisfaction with the quality of sexual contacts (second step), variance explanation did not increase significantly ($p = .57$). The interaction of craving Δ and the satisfaction with the quality of sexual contacts lead to a significant increase of s-IATsex explanation (changes in $R^2 = .02$, changes in $F(1, 167) = 4.58$, $p < .05$). The whole model was significant ($R^2 = .07$, $F(3, 167) = 4.78$, $p < .01$). Given the significant interaction effect, we analyzed simple slopes in order to address the moderating effect in more detail. The slope of

regression line representing “low satisfaction with the quality of sexual contacts” (one standard derivation below the mean) was not significantly different from zero ($t = 0.47$, $p = .64$), regardless whether or not the craving Δ was low or high. The slope of regression line representing “high satisfaction with the quality of sexual contacts” was significantly different from zero ($t = 4.06$, $p < .01$), representing a higher s-IATsex when satisfaction was high and a lower s-IATsex score when satisfaction was low, respectively (see Figure 5). Since the number of sexual contacts, the satisfaction with frequency of sexual contacts as well as the satisfaction with the quality of sexual contacts do not correlate with the s-IATsex, there is no reason to assume a mediation effect of the indicators of gratification on the relationship between the indicators of the compensation hypothesis with the s-IATsex (Preacher & Hayes, 2004).

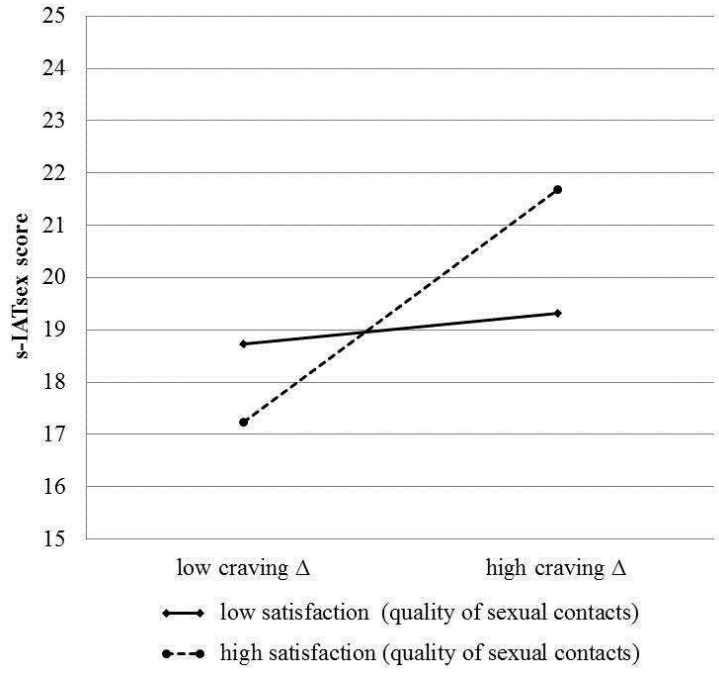

Figure 5

Demonstration of hierarchical regression analysis’ results with the s-IATsex as dependent variable showing a moderation by satisfaction with the quality of sexual real-life contacts. Participants reporting ‘low satisfaction’ show no difference in the s-IATsex. Individuals reporting a ‘high satisfaction’ have a higher s-IATsex score, if they report high craving.

2.5 Discussion

The aim of the present study was to investigate experimentally the gratification and compensation hypothesis with respect to the severity of cybersex addiction by using indicators of both hypotheses to predict subjective complaints in everyday life due to cybersex usage in heterosexual males. We found correlations of a tendency towards and severity of cybersex addiction with indicators of attraction to or sexual arousal due to pornographic stimuli as well as with the variability of performed out sexual practices in sexual real-life contacts. These indicators were able to predict the severity of cybersex addiction indicated by the users. Concerning craving reactions, a moderation effect of the satisfaction with the quality of sexual real-life contacts was found. However, the number of sexual real-life contacts in combination with the satisfaction with sexual intercourses did not show an effect on the tendency towards cybersex addiction. In summary, our results support the gratification hypothesis (Brand et al., 2011; Kuss & Griffiths, 2011b; Young, 2008). This needs to be discussed with respect to the role of reinforcement and learning mechanisms in the development of cybersex addiction.

The study's main result is that sexual arousal ratings and VT for pornographic pictures, an indicator of craving (urge to masturbate), the variability of interest in Internet pornographic contents, and the frequency of cybersex usage accompanied with masturbation together predict a tendency towards or the severity of cybersex addiction, respectively. Moreover, individuals who were gratified by their sexual real-life contacts and showed craving reactions for pornographic stimuli reported a higher severity of cybersex addiction. This highlights the importance of receiving reinforcement by cybersex for the development and maintenance of cybersex addiction, which is in line with the theoretical background of the development of substance addictions (for review see Koob & Volkow, 2010). Most notably, receiving reinforcement and consequentially conditioned learning as well as the development of cue-reactivity are known to be key factors for the development and maintenance of

substance addictions (Berridge et al., 2009; Everitt & Robbins, 2005; Hyman et al., 2006). Physiologically, the effect of reinforcement is related to the mesolimbic reward system. This system reacts on positive and negative reinforcement (Wightman & Robinson, 2002), also through natural reinforcers as food or sex (Kelley & Berridge, 2002; Wise, 2002), with an increase of dopamine release. Moreover, neuroimaging studies point out the involvement of neural structures related to the reward system in sexual arousal (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000; Stolèru et al., 1999) and orgasm (Holstege et al., 2003). Since our measurements represent attraction to and sexual arousal due to pornographic pictures on a subjective, implicit and behavioral level and predict a tendency towards cybersex addiction, it seems plausible to assume mechanisms of reinforcement and conditioned learning to be relevant for the development and maintenance of cybersex addiction. This has been postulated previously on a theoretical level, but no experimental evidence supported this assumption so far (Brand et al., 2011; Young, 2008). There is evidence showing conditioned sexual arousal in animals (Pfaus, Kippin, & Centeno, 2001), humans (Hoffmann et al., 2004; Klucken et al., 2009; Lalumiere & Quinsey, 1998) and also in individuals with deviant sexual behavior (Akins, 2004). The theoretical backgrounds converges to the view that sexual arousal as an unconditioned stimulus can become associated with an initially neutral stimulus which then mediates future sexual behavior. Based upon these findings, classical and operant learning mechanisms should lead to an association of internal (e.g. emotions, stress) or external (e.g. computer, home environment, etc.) stimuli with sexual arousal and the reinforcing behavior of cybersex resulting in cue-reactivity, craving reactions, and repeated behavior elicited by conditioned stimuli (Carter & Tiffany, 1999). In fact, cue-reactivity was shown to be an important mechanism of addiction maintenance in several behavioral and substance addictions (Braus et al., 2001; Garavan, Pankiewicz, & Bloom, 2000; Goudriaan et al., 2010; Gray et al., 2008; Grüsser et al., 2004; Ko et al., 2009; Parker & Gilbert, 2008; Thalemann et al., 2007; Yang et al., 2009).

The compensation hypothesis was not supported by our data. The number of sexual contacts and the satisfaction with frequency or quality of sexual contacts was not associated with a tendency towards cybersex addiction. Moreover, results are clearly contrariwise to the predictions of the compensation hypothesis, as individuals reporting a high satisfaction with the quality of sexual real-life contacts and high craving reactions showed higher severity of cybersex addiction. Following this, missing or unsatisfying sexual real-life contacts do not seem to be risk factors for the development of cybersex addiction. Since gaining sexual arousal seems to be the main motivator for cybersex use (Paul, 2009), a poor sex life still may explain the engagement in cybersex to use it to satisfy one's sexual needs. We found some effects supporting this hypothesis: Satisfaction with the frequency of sexual real-life contacts was associated negatively with Internet pornography video usage and masturbation frequency when engaging in cybersex. In general, this supports the assumption that cybersex users can actively use cybersex in a healthy and constructive way to satisfy their sexual needs (Döring, 2009), leading to perceived positive effects of cybersex use on individuals life (Grov et al., 2011; Hald & Malamuth, 2008; Shaughnessy et al., 2011). However, the variability of individuals' sexual real-life contacts and the satisfaction with the frequency of these sexual contacts predicted tendencies towards cybersex addiction. This result is, however, in contrast to the compensation hypothesis, which assumes a poor sex-life to predict a tendency towards cybersex addiction. Our contradictory results could reflect a relation of real-life and online sexual behavior: People who share a lot of variance in their sexual real-life contacts and who are satisfied with this behavior seem to use the Internet for sexual purposes as well - also known as "rich get richer" effect in research on the relationship between using social network sites and life satisfaction (Kraut et al., 1998). This is supported by the correlation between the variability of individuals' sexual real-life contacts with the variability of individuals' interest in Internet pornography. Still, it remains unclear why people should engage in cybersex accompanied by subjective complaints in everyday life when the number of sexual real-life

contacts has no relevance, and individuals share a satisfying variance of sexual contacts. One explanation might be that individuals sharing a satisfying variance of sexual contacts might have a higher interest in sex per se, leading to an addictive usage pattern of cybersex in consequence of the gratification received by cybersex. Therefore, it seems important to investigate the interdependency of sexual interest, sexual real-life contacts, and cybersex use with respect to the development of cybersex addiction (Kafka, 2010a).

Limitations and future studies

The insights of this study rely on the investigation of freely recruited males. As we try to announce a clinical research question by investigating a predefined clinical sample, it seems important to notice that the severity of cybersex addiction in our sample showed a reasonable amount of variance, with some individuals fulfilling diagnostic criteria for behavioral addictions (Albrecht, Kirschner, & Grüsser, 2007). Nevertheless, effects need to be replicated in a sample of diagnosed cybersex addicted patients. Moreover, neural correlates of gratification and cue-reactivity need to be investigated in patients with cybersex addiction. For a better understanding of the etiology of cybersex addiction, future studies need to ascertain the role of incentive-sensitization within the addiction process, since the wanting rather than the liking aspect is known to be associated to maintenance and relapse in substance addiction (Robinson & Berridge, 2003, 2008). Finally, since the population of cybersex addicts includes heterosexual and homosexual males and females (Griffiths, 2000; Grov et al., 2008; Kuss & Griffiths, 2011), mechanisms of development and maintenance need to be investigated with respect to gender and sexual orientation. Our data suggest that gratification is indeed a key element of cybersex addiction, which may inspire future research to get deeper insights into the development and maintenance of cybersex addiction and which

may help to improve therapeutic processes in treating subjects who experience negative consequences in their life due to an excessive use of cybersex.

3. Study 2: Craving partially mediates the relationship between the vulnerability to cybersex addiction and tendencies towards cybersex addiction.

3.1 Abstract

Cybersex addiction is associated with symptoms of dependency regarding cybersex use resulting in personal distress of clinical significance (Kuss & Griffiths, 2011b). Theoretical assumptions and empirical evidence give reason to assume that some individuals might be more vulnerable for cybersex addiction, while positive reinforcement and cue-reactivity are considered to be core mechanisms within the development and maintenance of cybersex addiction. In this study, 125 heterosexual males (M = 24.85, SD = 3.54) were surveyed with respect to tendencies towards cybersex addiction using the short-version of the Internet Addiction Test (Pawlikowski et al., 2012) modified for Internet sex sites, their sensitivity to sexual excitation, problematic use of sex in general, and general psychological-psychiatric symptom severity. Moreover, participants rated 100 pornographic pictures and indicated craving in terms of an increase of sexual arousal following the pornographic picture presentation. Using mediation analysis, it was shown that craving partially mediated the relationship between the latent dimensions "vulnerability" and "tendencies towards cybersex addiction" (R^2 = .70, p < .01). The results emphasize the role of predefining factors of vulnerability to cybersex addiction. They give also further evidence for the assumption that positive reinforcement received by cybersex and cue-reactivity are the main mechanisms in the development of cybersex addiction.

3.2 Introduction

The Internet itself is a mass medium, which can be used for different purposes. Most individuals are able to use the Internet in a functional and unproblematic way to cope with their needs and goals. But since several years, it became apparent that some individuals develop an addictive usage pattern of the Internet in general or of specific Internet applications, for example cybersex addiction (Kuss & Griffiths, 2011b; Widyanto & Griffiths, 2006; Young, 2000). These Internet addictions are associated with subjective complaints in everyday life, symptoms of dependency, and personal distress (for reviews see Chou et al., 2005; Weinstein & Lejoyeux, 2010). Because of its highly reinforcing effects, cybersex is assumed to be the Internet application with the highest risk for developing a specific Internet addiction (e.g. Griffiths, 2001; Meerkerk et al., 2006; Young, 2008). There is an ongoing debate about why some individuals develop a cybersex addiction and others do not. To contribute to this research question, the aim of this study is to explore the relationship between factors of individuals' vulnerability to cybersex addiction with subjective complaints in everyday life due to cybersex use. Moreover, since the development of cue-reactivity is held as one of the key mechanisms underlying the development of cybersex addiction (Brand et al., 2011), the study aims at exploring the role of cue-reactivity in the relation between vulnerability for and experienced symptoms of cybersex addiction.

In clinical psychology, there is non-controversial agreement that psychological-psychiatric disorders are not caused by unitary factors, but develop due to an interaction of biological, environmental, and personal factors. The main insight of these so called diathesis-stress models (e.g. Ingram & Luxton, 2005) is that negative or stressful life-events do not effect individuals in the same way. While some develop mental health problems, negative life-events do not or only temporarily lead to psychological disturbances in other individuals. Therefore, one challenge of clinical psychology is to identify biological, environmental, and personal predisposing factors for single psychological disorders as well as their interactions.

With respect to substance addiction, interactions of genetic variations, predisposing personality characteristics (e.g. impulsivity, risk-taking, or stress vulnerability) and neural changes due to substance use have been shown to be associated to various stages of addiction (Everitt et al., 2008; Kreek, Nielsen, Butelman, & LaForge, 2005; Sinha, 2008). Although a specific predisposition to specific pathological Internet use, such as cybersex addiction, has been postulated in Davis' (2001) cognitive-behavioral model of pathological Internet use, no studies have investigated directly the role of vulnerability in terms of several predisposing factors contributing to the development and maintenance of addicted Internet behavior.

In his review, Kafka (2010a) concludes that a sensitivity to sexual excitation and a general severity of psychological-psychiatric symptoms are strongly associated to hypersexual behaviors. Moreover, he reckons that individuals with hypersexual behavior independently from the Internet might be more prone for an excessive use of cybersex. Contributing to this, a study of Delmonico and Miller (2003) shows that problematic, excessive sexual behavior off- and online are strongly related. From a psychological point of view, sexual arousal is mainly characterized by subjective arousal as well as by central, peripheral, and behavioral responses (Janssen, 2011), while individuals differ physiologically in their sensitivity to sexual excitation and sexual inhibition (Janssen, Goodrich, Petrocelli, & Bancroft, 2009). Indeed, it was shown that individuals scoring higher on sensitivity for sexual excitation and that individuals with a greater sexual interest within negative mood are more likely to engage in addictive sexual behavior (Bancroft, Graham, Janssen, & Sanders, 2009; Bancroft & Vukadinovic, 2004). Moreover, it has been shown that sex and cybersex addiction are associated to a general psychological-psychiatric symptom severity (Brand et al., 2011; Kafka, 2010a; Kuss & Griffiths, 2011b; Raviv, 1993). Taken together, sensitivity to sexual excitation, a tendency towards problematic use of sex in general, and a pre-existing psychopathology might be considered as predefining factors for individual’s vulnerability to cybersex addiction.

The concept of cue-reactivity and craving has developed from research on substance addiction. Craving is described as a strong urge to recurrently consume a drug in order to experience the anticipated reinforcing effects (reward craving) or to avoid aversive symptoms during withdrawal (withdrawal relief craving) (e.g. Anton, 1999; Drummond, 2001). Based on mechanisms of reinforcement, processes of conditioning, and neuronal adaptions, cue-reactivity describes the process that addiction related cues become sensitized and associated to drug's reinforcing effects. This results in changes in the perception, the processing, and the mental representation of addiction related cues to that effect that the processing of these cues result in reward craving (Berridge et al., 2009; Robinson & Berridge, 1993). Therefore, cue-reactivity and reward craving are substantial mechanisms of development, maintenance of addiction and is furthermore associated to relapse (Carter & Tiffany, 1999; Tiffany & Wray, 2012).

This cue-reactivity concept has been transferred into research addressing diverse behavioral addictions within the last years. For example it has been shown that in gaming or gambling addicted individuals the presentation of specific addiction related cues leads to strong gaming/gambling urges (e.g. Sodano & Wulfert, 2009; Thalemann et al., 2007; Wulfert et al., 2009) and to activations of brain structures related to craving and addiction (e.g. Goudriaan et al., 2010; Ko et al., 2009). These findings converge to the view that reward craving is an important mechanism in the development and maintenance of gaming or gambling addiction. Moreover, some authors conclude that these findings strengthen the assumption that problematic gaming/gambling can be considered as behavioral addiction (e.g. Grant et al., 2006). With respect to Internet addiction, Davis (2001) postulates in his cognitive behavioral model of pathological Internet use that receiving reinforcement is the main mechanism underlying the development and maintenance of a specific pathological Internet use (for detailed description of Davis' model please see section 1.2.1). Contributing to this, Young (2008) hypothesizes that the anticipation and experience of sexual arousal is one key

factor in the development of cybersex addiction. But experimental studies addressing the role of craving in cybersex addiction are rare. In two experimental studies, pornographic cues have been presented to participants and indicators of sexual arousal were assessed. Results show that a sexual arousal rating of pornographic cues as well as an increase of craving following the pornographic picture presentation predict tendencies towards cybersex addiction (Brand et al., 2011; cf. Study 1). The authors conclude that cue-reactivity and resulting reward craving should be the main mechanisms behind the development and maintenance of cybersex addiction. To contribute to these findings and to give a deeper insight into the etiology of cybersex addiction, the role of craving needs to be addressed with respect to a vulnerability to cybersex addiction.

Summarized, the theoretical and empirical background of substance and behavioral addictions give reason to assume that the phenomenon of cybersex addiction may be associated to specific (sensitivity for sexual excitation, problematic use of sex in general) and unspecific (general psychological-psychiatric symptom severity) factors of vulnerability. Moreover, studies' findings converge to the view that cue-reactivity and reward craving can be understood as key mechanism of development and maintenance within the development of addiction. If individuals are predefined for receiving positive reinforcement by sexual arousal, they should be more prone to engage repeatedly in cybersex. In turn, a predefinition for receiving positive reinforcement by sexual arousal in combination with recurrent cybersex use should lead to cue-reactivity and reward craving elicited by addiction related cues. Transferred into a statistical model, reward craving should mediate the relationship between a vulnerability to and tendencies towards cybersex addiction. However, the role and the relationship of and between vulnerability and craving have not yet been addressed with respect to cybersex addiction. Following the argumentation, two hypotheses need to be addressed empirically (the hypothesized model of cybersex addiction is illustrated in Figure 6):

Hypothesis 1: Vulnerability to cybersex addiction and craving reactions elicited by addiction related cues correlate positively with tendencies towards cybersex addiction.

Hypothesis 2: Craving mediates the relationship between vulnerability and tendencies towards cybersex addiction.

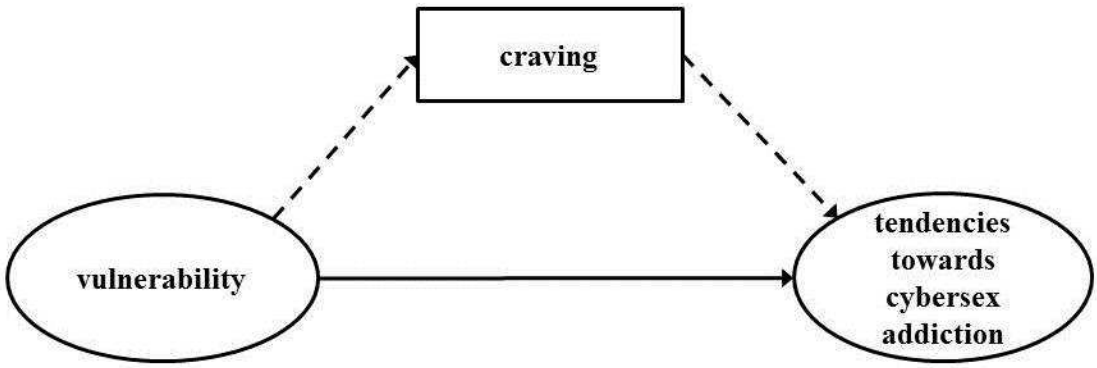

Figure 6

Illustration of the hypothesized mediation effect. Tendencies towards cybersex addiction are assumed to be predicted by person's vulnerability as well as by craving. Craving mediates the relationship between person's vulnerability and tendencies towards cybersex addiction. Latent variables are shown in circle, manifest variables are presented in rectangles. The direct effect is shown continued; the indirect effect is shown dashed.

3.3 Methods

3.3.1 Participants

In this study, 125 heterosexual males (M = 24.85, SD = 3.54) males were investigated at the University of Duisburg-Essen in a laboratory setting. We explicitly advertised for males of legal age and indicated that participating would include viewing explicit pornographic pictures of legal sexual practices. All participants gave written informed consent prior to the investigation, confirmed their heterosexual orientation via questionnaire and were paid at an hourly rate for participation (10€/hr.). The experimental paradigm and questionnaires were administered computer-based. The study was approved by the local ethics committee.

3.3.2 Questionnaires

Several questionnaires were administered to the participants. A tendency towards cybersex addiction was assessed with a short-version of the Internet Addiction Test (s-IAT, Pawlikowski et al., 2012). The s-IAT was modified for Internetsex sites (s-IATsex, for further description see Brand et al., 2011). Twelve items have to be answered on a five-point scale from 1 (= never) to 5 (= very often) resulting in overall sum scores ranging from 12 to 60. The s-IATsex comprises two subscales “loss of control/time management” (s-IATsex-1) and “craving/social problems” (s-IATsex-2). Internal consistency of the whole scale (Cronbach’s α = .87) as well as the s-IATsex-1 (Cronbach’s α = .88) and the s-IATsex-2 (Cronbach’s α = .68) was good (for a more detailed description of the s-IATsex please see section 2.3.2, p. 19).

To measure sensitivity to sexual excitation, a short form of the sexual excitation scale (SES) was used (Carpenter, Janssen, Graham, Vorst, & Wicherts, 2010). In comparison to the original scale, the response format was recoded. Six items have to be answered on a four-

point scale from 1 (= strongly disagree) to 4 (= strongly agree) resulting in a mean value representing high sensitivity to sexual excitation in high scores (Cronbach's α = .77).

As an indicator of a problematic use of sex in general, the Hypersexual Behavioral Inventory was applied (HBI, Reid, Garos, & Carpenter, 2011). Nineteen items had to be answered from 1 (= never) to 5 (= very often) resulting in a total mean score (Cronbach's α = .93) as well as mean scores of the three subscales "Control" (Cronbach's α = .86), "Coping" (Cronbach's α = .89), and "Consequences" (Cronbach's α = .80)

To assess subjective complaints in everyday life due to psychological and physical symptoms the Brief Symptom Inventory (BSI) was administered (Boulet & Boss, 1991). On a scale from 0 (= not at all) to 4 (= extremely), participants were asked to indicate how strongly they suffered from 53 psychological or physical symptoms within the last seven days. Of specific interest was the Global Severity Index (GSI) as a measurement of general psychological disturbance.

With respect to the proposed mediation model (see above, Figure 6), manifest variables were used to modulate latent dimensions. The SES, HBI and the GSI represented the latent dimension "vulnerability" when regressed on tendencies towards cybersex addiction. The latent dimension "tendencies towards cybersex addiction" was represented by the two factors of the s-IATsex: s-IATsex-1 (loss of control/time management) and s-IATsex-2 (craving/social problems).

3.3.3 Experimental paradigm: Pornographic picture rating

To induce sexual arousal, participants viewed and rated 100 explicit pornographic pictures of ten categories, which were presented in a randomized order. The picture categories included heterosexual sex between one man and one woman (vaginal intercourse, anal sex, and two

oral sex categories), homosexual sex (tribadism and oral sex between two females, anal and oral sex between two males) as well as single masturbating men or females. Pictures were controlled for specific sexual interest (for a further description of the experimental paradigm cf. Study 1, p. 30-31). Each picture had to be rated on a five-point scale with respect to subjective arousal (1 = sexually not arousing to 5 = sexually very arousing). Before (t1) and after (t2) the experimental paradigm, participants were asked to indicate their sexual arousal from 0 (= not sexually aroused) to 100 (= very sexually aroused). As an indicator of individual reactivity to pornographic pictures, sexual arousal at t1 was subtracted from sexual arousal at t2, resulting in a delta score (craving Δ).

3.3.4 Statistical analysis

Statistical analyses have been carried out with two programs. *T*-Tests for dependent samples and bivariate correlations have been calculated with SPSS 20.0 (IBM, 2011). Structural equation modeling and mediation analysis was conducted with MPlus 6.0 (Muthén & Muthén, 2011). Bootstrapping was used (number of estimations = 5000). Two-tailed tests were performed for all analyses, p was set to .05.

3.4 Results

A description of variables concerning questionnaires and the experimental paradigm are shown in Table 7. As indicated by *t*-test for dependent groups, sexual arousal at t2 (M = 33.67, SD = 25.99) was higher compared to t1 (M = 9.65, SD = 17.10), $t(123) = 9.84$, $p < .001$, $d = 1.25$. Pornographic pictures displaying pictures of male heterosexual interest (M = 2.97, SD = .88) were rated as more sexually arousing than pictures showing sex between men or masturbating males (M = 1.15, SD = .41), $t(119) = 20.27$, $p < .001$, $d = 2.62$. According to

Cohen (1992), both observed effects are strong. Correlations of the manifest variables are shown in Table 8.

Table 7

Descriptive values of questionnaires and the experimental paradigm.

***N* = 125**	***M***	***SD***
Questionnaires		
s-IATsex	18.48	6.54
SES[1]	2.67	.49
HBI	3.42	.61
BSI (GSI)	.47	.45
Experimental paradigm		
craving Δ	23.82	27.16

[1] SEM was recoded

Table 8

Correlations of the manifest variables used within the mediation model.

	s-IATsex-1	s-IATsex-2	SES	HBI	BSI (GSI)
s-IATsex-2	**.65****				
SES	**.36****	**.40****			
HBI	**.49****	**.55****	**.40****		
BSI (GSI)	**.26****	**.34****	**.22***	**.46****	
craving Δ	**.37****	**.49****	**.36****	**.25****	.09

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

** = $p \leq .01$ (correlation is significantly different from zero with alpha = 1%, two-tailed)

When the data was entered into the mediation model, there was no missing data. Maximum likelihood parameter estimation was chosen, because the data were distributed normally (Kline, 2005). First, it was analyzed whether the manifest variables fit the latent dimensions. Second, the criteria for mediation analyses suggested by Baron and Kenny (1986) were fulfilled. According to Hu and Bentler (1999) as well as to Schumacker and Lomax (2010) the model-fit criteria were checked to ensure that the theoretical models fit with the data.

The proposed model fitted well on the data (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006; Schumacker & Lomax, 2010). The result of the Chi-Square-Test was $\chi^2 = 10.69$, $df = 7$, $p = .15$, $\chi^2/df = 1.53$. The RMSEA was .06; the CFI was .98; and the SRMR was .05. Accordingly, no post-hoc modifications were conducted. Standardized regression coefficients are illustrated in Figure 7. Direct, indirect and total effects are reported in the following and are shown in Table 9. Given that both the direct and the indirect effect

are significant and that the direct effect is weaker when controlling for the indirect effect, the relationship between person's characteristics and tendencies towards cybersex addiction is partially mediated by craving.

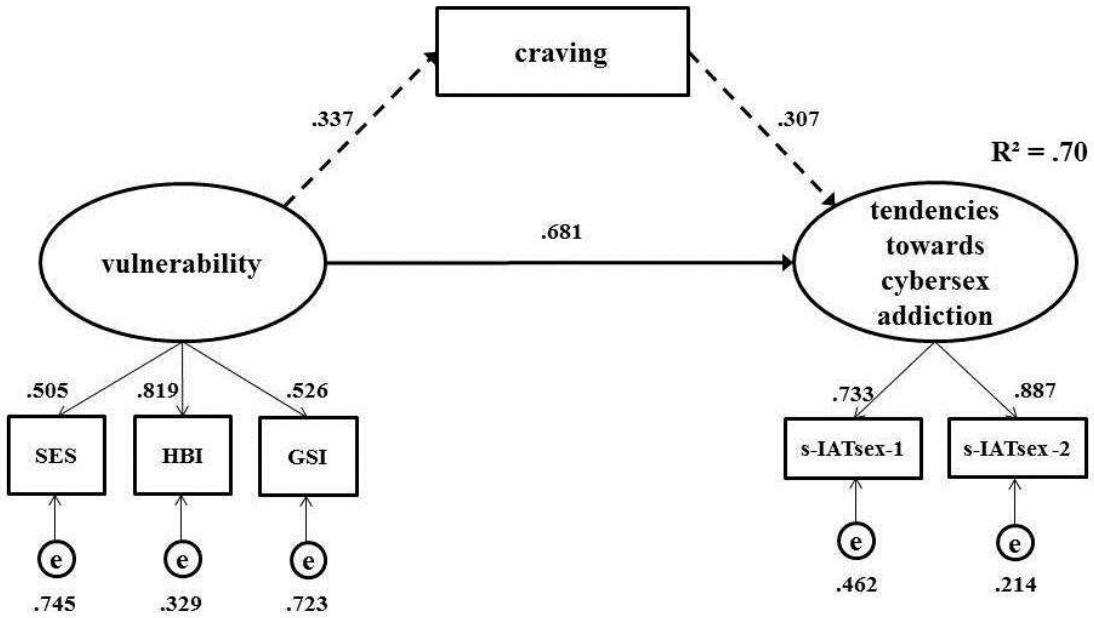

Figure 7

Results for the structural equation model. Chi-Square-Test χ^2 = 10.69, p = 0.15; RMSEA = .06; CFI = .98; degrees of freedom = 7. e = error. Significant effects are in boldface.

Table 9

Direct, indirect, and total effects in the mediation analysis.

Effects	***β***	***SE***	***p***
total effect	.78	.10	< .001
direct effect	.68	.12	< .001
indirect effect	.10	.04	< .01

3.5 Discussion

The aim of this study was to explore facets of vulnerability to cybersex addiction as well as the role of reward craving in the relationship of vulnerability to cybersex addiction and tendencies towards cybersex addiction. The main results of this study are: Firstly, specific vulnerability (in terms of sensitivity for sexual excitation and a problematic use of sex in general) and unspecific (general psychological-psychiatric symptom severity) as well as an indicator of reward craving predicted tendencies towards cybersex addiction. Secondly, reward craving partially mediated the relationship between vulnerability factors with tendencies towards cybersex addiction. The study's findings are discussed with respect to mechanisms of development of cybersex addiction.

The assumption of a specific predisposition for a specific pathological Internet use, such as cybersex addiction, has been formulated within Davis' (2001) cognitive-behavioral model. It has been hypothesized that the development of cybersex addiction is caused by a pre-existing, specific psychopathology, e.g. a problematic use of sex in general and unspecific psychopathology, such as symptoms of depression or other psychological disturbances. Therefore, an individual with the tendency to use sex problematically in general should be

more prone for using cybersex problematically as well, because cybersex is assumed to be an immediate stimulus-response condition with highly reinforcing effects. Indeed, sensitivity for sexual excitation, a problematic use of sex in general, and a general psychological-psychiatric symptom severity predicted tendencies towards cybersex addiction. This supports and complements the assumptions regarding the specific predisposition for cybersex addiction formulated within the cognitive-behavioral model (Davis, 2001). Sensitivity to sexual excitation refers to the degree in which individuals react with subjective and physiological sexual arousal as reaction to sexual cues (Bancroft et al., 2009; Bancroft & Vukadinovic, 2004). Therefore, individuals with a high sensitivity to sexual arousal should be more prone for receiving positive reinforcement by sexual behaviors in real-life or on the Internet and should be more at risk for developing cybersex addiction. The result that a general psychological-psychiatric symptom severity covariies with symptoms of cybersex addiction is in line with studies reporting high rates of comorbidities and pre-existing psychopathology in substance (Conway et al., 2002; Hasin et al., 2007), Internet (Weinstein & Lejoyeux, 2010; Whang et al., 2003; Yang, Choe, Baity, Lee, & Cho, 2005), and sex addiction (Garcia & Thibaut, 2010; Kafka, 2010a; Raviv, 1993) and replicates the findings with respect to cybersex addiction (Brand et al., 2011). Therefore, general psychological-psychiatric symptom severity can be considered as an unspecific, predefining factor of vulnerability for the development of cybersex addiction.

The finding that reward craving mediates partially the relationship between vulnerability and tendencies towards cybersex addiction gives further reason to assume that positive reinforcement and cue-reactivity are core mechanisms in the development and maintenance of cybersex addiction. It has been pointed out theoretically, that anticipating and receiving sexual arousal in terms of positive reinforcement should be the core mechanism behind the development of cybersex addiction (Davis, 2001; Young, 2008). First empirical evidence supporting this assumption has been given by the study Brand et al. (2011), in which

sexual arousal ratings of pornographic pictures have predicted tendencies towards cybersex addiction. Moreover, sexual arousal is perceived as highly reinforcing and is physiologically closely related to reward (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000; Wise, 2002). Indeed, it was shown that sexual arousal as unconditioned stimulus can be conditioned in humans mediating future sexual behavior (Hoffmann et al., 2004; Klucken et al., 2009; Lalumiere & Quinsey, 1998). In this study, the increase of sexual arousal following pornographic picture presentation was used as indicator of craving. Regarding the conception of craving (e.g. Anton, 1999; Drummond, 2001), this measurement can be interpreted as indicator of reward craving occurring due to cue-reactivity, i.e. that addiction related cues lead to craving in the anticipation of positive reinforcement. Behind the background of associative learning in addiction (Berridge et al., 2009; Robinson & Berridge, 1993), the positive reinforcement received by cybersex may be associated to internal (e.g. negative emotions, stress) or external stimuli (e.g. computer, home environment) resulting in cue-reactivity and craving urges elicited by addiction related cues leading to recurrent and addictive cybersex use. Taken the insights of this study into account, particularly highly vulnerable individuals should be more prone for receiving positive reinforcement by cybersex use and in conclusion more at risk for developing cybersex addiction.

Behind the theoretical assumptions of the cognitive-behavioral model of pathological Internet use (Davis, 2001), a full mediation between vulnerability to and tendencies towards cybersex addiction has been expected. Therefore, the partial mediation supposes that previous theoretical assumptions need to be extended. Research on craving in substance addiction revealed that not only reward craving, but also withdrawal relief craving is crucial within the development and especially in the maintenance of substance dependency (e.g. Heinz et al., 2003). Potentially both, positive reinforcement in terms of sexual arousal and negative reinforcement in terms of avoiding negative experiences in conditioned withdrawal might be

considered as mechanisms contributing to the development and maintenance of cybersex addiction.

Limitations and future studies

There are some limitations and suggestions for improvement regarding this study. First, the measurement of reward craving could be improved. Although the pornographic picture presentation increased the subjective sexual arousal, one could use pornographic cues individually matched to participants' sexual interests to induce craving as well as a multimodal measurement of craving. There are several possibilities to measure sexual arousal (see Janssen, Prause, & Geer, 2007; Kalmus & Beech, 2005). Using for example other physiological parameters (e.g. skin conductance reactions or penile tumescence) would allow modeling craving as latent dimension within a mediation model. Contributing to this, neural correlates of sexual arousal might give further insight into the processing of pornographic stimuli in cybersex addiction. Second, the results of this study rely on the free recruitment of heterosexual males. The questionnaires, the pornographic picture rating as well as the measurement of reward craving assessed highly sensitive information potentially biased by uncontrollable and unknown confoundation. Nevertheless, the reported results, particularly the mediation effect, strengthen the assumption that positive reinforcement, learning mechanisms, and resulting craving are core mechanisms in the development of cybersex addiction.

Future studies could investigate the most obvious implications drawn by the study's results: First, using non-clinical samples, cue-reactivity and craving need to be addressed more directly to verify the consideration of them as core mechanism in the development and maintenance of cybersex addiction. Therefore, it needs to be investigated, if sexual arousal experienced by cybersex indeed becomes associated with individuals' internal and external

cues heightening the probability of recurrent cybersex use. Secondly, although the variance of tendencies towards cybersex addiction was quite high within this study, future studies need to verify the demonstrated result in clinical samples of cybersex addicted patients to rule out any doubts respective the relevance of the proposed mechanisms in cybersex addiction.

4. Study 3: Pornographic picture processing interferes with working memory-performance.[1]

4.1 Abstract

Some individuals report problems during and after Internetsex engagement, such as missing sleep, forgetting appointments, etc., which are associated with negative consequences in individuals' life. One mechanism potentially leading to these kinds of problems is that sexual arousal during Internetsex might interfere with working memory (WM) capacity, resulting in a neglect of relevant environmental information and therefore disadvantageous decision making. In this study, 28 healthy individuals performed four experimental manipulations of a pictorial 4-back working memory task with neutral, negative, positive, or pornographic stimuli. Participants also rated 100 pornographic pictures with respect to sexual arousal and indicated masturbation urges previous and following pornographic picture presentation. Results reveal worse WM-performance in the pornographic picture condition of the 4-back task compared with the three remaining picture conditions. Furthermore, hierarchical regression analysis indicates an explanation of variance of the sensitivity in the pornographic picture condition by the subjective rating of the pornographic pictures as well as by a moderation effect of masturbation urges. Results contribute to the view that indicators of sexual arousal due to pornographic picture processing interfere with WM-performance. Findings are discussed with respect to Internetsex addiction since WM interference by addiction-related cues is well known from substance dependencies.

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[1] This study was in press: Laier, C., Schulte, F. P., & Brand, M. (2012). Pornographic picture processing interferes with working memory-performance. *Journal of Sex Research, EPub*. doi: 10.1080/00224499.2012.716873

4.2 Introduction

Engagement in Internetsex applications, such as pornography consumption on the Internet, is mainly free of charge, the content is easy accessible and is thought to gratify its users (Döring, 2009). Therefore, Internetsex is indulged in by many people of almost all ages (Daneback et al., 2005). Although most individuals report mainly self-perceived positive effects of Internetsex on their life (Hald & Malamuth, 2008), some individuals report subjective problems during and after Internetsex engagement associated with negative consequences in their life, e.g., missing sleep, forgetting appointments, disregarding partnership, job responsibilities, etc. (Cooper, Delmonico, Griffin-Shelley, & Mathy, 2004; Griffiths, 2001; Young, 2008). One potential mechanism leading to these problems could be that the sexual arousal while watching Internet pornography might interfere with working memory (WM) capabilities, leading to a neglect of relevant environmental information, interference with memory demands and disadvantageous decision making. While WM-performance is known to be prone to interference (Perlstein & Elbert, 2002; Unsworth, Spillers, & Brewer, 2009), the influence of the processing of pornographic pictures has not been investigated experimentally so far.

WM is considered to be an important facet of executive functioning, necessary for e.g. understanding, reasoning, problem solving, learning and development of speech as well as for more complex cognitive domains like decision making (Bechara, Damasio, Tranel, & Anderson, 1998; D'Esposito, 2007; Pecchinenda, Dretsch, & Chapman, 2006; Smith & Jonides, 1999). Additionally, WM is related to fluid intelligence and executive attention, while its capacity is limited (Cowan, 2010; Engle, 2002; Unsworth et al., 2009). Although different WM models have been developed (for overview see Miyake & Shah, 1999), WM cannot be considered as a unitary system (D'Esposito, 2007). However, all approaches assume that some form of information is maintained within the cognitive system by processes of directed attention or active storage in what has also termed short-term memory. Several

paradigms and modifications have been developed to measure WM capacity, e.g. WM span tasks, in which basically some information has to be remembered while sentences are read, calculations are done or symbols are counted (Conway et al., 2005). The most common paradigm to investigate WM processes of monitoring, updating and manipulation is the n-back task, in which participants see a series of stimuli and have to indicate concurrently if the currently presented stimulus is the same as the stimulus n trials before (Jaeggi et al., 2010). The most influential model of WM is the multiple-component model (Baddeley, 1994; 2000; 2010; Baddeley & Logie, 1999), which is strongly supported by neuroimaging and brain lesion studies (Cabeza & Nyberg, 2000; Callicott et al., 1999; Chein, Ravizza, & Fiez, 2003; D'Esposito, Postle, & Rypma, 2000; Hautzel, Mottaghy, Schmidt, & Zemb, 2002; Müller & Knight, 2006; Smith & Jonides, 1997). Studies suggest that there are distinct but interacting brain structures building up prefrontal-parietal WM circuits to store and manipulate information temporarily. Moreover, sub-cortical structures play a supporting role in executive and WM functions (Cools et al., 2008; Hautzel et al., 2009; Mitchell et al., 2000; Voytek & Knight, 2010). For example, it was shown that the activity of the amygdala, a brain area classically considered to be part of the emotion processing limbic system, is correlated with WM-performance (Schaefer et al., 2006). The authors suggest that limbic structures are able to modulate higher cognitive functions through an early enhancement of attention in information processing. This is in line with reports of an enhancing effect of emotional stimuli on memory performance (for review see Hamann, 2001; Phelps, 2006) which is explained by a modulating effect of the amygdala on sensory systems (Davis & Whalen, 2001; Kensinger & Corkin, 2004; Vuilleumier, 2005). In summary, these observations support the idea of connected brain regions in cortical and sub-cortical networks (Carpenter et al., 2000), which in turn should be susceptible to modulation WM-performance in different ways (i.e. enhancing or decreasing capacity of WM).

One way to induce emotional reactions in an experimental design is to present pictures of emotional content. The presentation of such stimuli leads to emotion specific reactions, while arousal is higher when positive, negative or sexual pictures are perceived compared to neutral stimuli (Bradley, Cuthbert, & Lang, 1996; Smith, Löw, Bradley, & Lang, 2006). The influence of stimuli's valence and arousal on WM-performance has been highlighted in only a small number of studies. In those, emotional pictures were included in the experimental designs in two ways: Emotional pictures were either target stimuli, which had to be remembered and recognized or were presented as distractors in WM tasks using neutral target stimuli. For example, Kensinger and Corkin (2003) used a WM task with interfering negative versus neutral stimuli. They reported no differences in task accuracy but recorded longer reaction times for fearful than neutral faces. Erk, Kleczar and Walter (2007), however, observed no behavioral effect of interfering emotional stimuli on verbal WM-performance in a low cognitive load condition, but registered an increased performance when positive and negative stimuli were used in comparison to neutral ones in a high cognitive load condition. Gotoh (2008) complements these results by showing slower reaction times and higher switching costs in a WM task with negative and positive compared to neutral stimuli. These results are also supported by neuroimaging studies (Dolcos & McCarthy, 2006; Perlstein & Elbert, 2002), which suggest differential, emotion dependent neural processes in WM. Taken together, previous studies give the impression that positive and negative stimuli lead to a capturing of attention interfering with WM-performance. The effect of pornographic pictures on WM and its underlying neural processes, however, have not yet been addressed.

In general, studies focusing on the impact of sexual stimuli on cognitive domains are sparse. Some studies indicate attention capturing effects of pornographic stimuli, which are associated with a decline in cognitive functioning, for example with decreased performance in dot detection tasks (Prause, Janssen, & Hetrick, 2008), rapid target perception tasks (Most, Smith, Cooter, Levy, & Zald, 2007) and choice reaction time with concurrently enhanced

memory for sexual stimuli in an incidental learning task (Wright & Adams, 1999). This explanation of attention capturing by associated interference effects are supported by results of neuroimaging studies. Compared to neutral, negative or positive pictures or videos, sexual stimuli lead to increased activations of the claustrum, paralimbic structures (including the anterior cingulate cortex, the orbitofrontal cortex and the insula), the striatum and the hypothalamus as well as temporal and occipital regions (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000; Stoléru et al., 1999). Therefore, the assumption of an interfering effect of pornographic picture processing on cognition elicited by a greater arousal of emotion-related structures is in line with Schimmack's (2005) observation that the degree of a stimulus' interference is rather dependent on arousal strength than on valence per se. If pornographic picture processing leads to interference of cognitive functioning, this might be a relevant factor linked to problems reported by individuals watching pornographic materials on the Internet excessively (such as forgetting appointments, neglecting responsibilities, etc.).

The aim of the present study was to investigate the influence of pornographic picture processing on WM-performance. In particular, we compared the influence of emotionally neutral, positive, negative and pornographic pictures. WM-performance was conducted through four pictorial 4-back tasks (Owen, McMillan, Laird, & Bullmore, 2005) with positive, negative, neutral or pornographic stimuli as within-subjects factor. Within these task conditions, information needs to be updated to categorize ambiguous stimuli as several varying targets within several varying distractors, which can be analyzed within the framework of signal detection theory (SDT, for overview see Abdi, 2007). Against the theoretical background we have assumed the following hypotheses: First, WM-performance for emotional stimuli is worse compared to WM-performance for neutral stimuli. Second, WM-performance for pornographic stimuli is worse compared to WM-performance for stimuli with positive or negative valence. Third, worse WM-performance for pornographic pictures is explained by indicators of sexual arousal.

4.3 Materials and Methods

In general, all participants were first surveyed with respect to general demographic data. This was followed by a sexual arousal rating of randomized pornographic pictures and a further assessment of questionnaire data. After approximately 30 minutes, four randomized pictorial 4-back task conditions were conducted at the end of the experimental investigation.

4.3.1 Participants

We examined 28 heterosexual, male participants (M_{age} = 26.21 years, *SD* = 5.95). Participants were recruited by advertisements in public or on the campus of the University of Duisburg-Essen and were paid 10€ per hour for participation. We explicitly advertised for male, heterosexual participants with a minimum age of 18 years and indicated that during participation there would be a confrontation with explicit pornographic stimuli of legal sexual practices. Mean duration of education in the sample was *M* = 12.77 years (*SD* = .81) years. All participants gave written informed consent prior to the investigation and confirmed their heterosexual orientation via questionnaire.

4.3.2 Procedure and Instruments

Working memory task

To assess the participants' WM-performance, we used an n-back paradigm, using pictures as stimuli (Owen et al., 2005) in a within-subject design. In the basic n-back design, participants are presented different cues consecutively and have to decide if the currently seen stimulus is the same as n stimuli before. In the current study, participants performed a 4-back paradigm in four different experimental picture conditions. The four conditions were performed in randomized order across the subjects. Single conditions comprized ten exclusively positive,

negative, neutral or pornographic pictures. The non-sexual pictures were obtained from the International Affective Picture System, which had been rated before using a scale from 1 (= not pleasant) to 9 (= very pleasant) regarding their valence and a scale from 1 (= not arousing) to 9 (= very arousing) regarding their arousal (IAPS, Lang, Bradley, & Cuthbert, 2008). The neutral pictures used in this study showed unmoved faces, people at work, walking in a street or during shopping and were rated by men as rather neutral (M = 5.91, SD = .43) and rather not arousing (M = 3.24, SD = .72). Negative pictures used in this study showed a mugging, a person with a weapon, harassment or war scenes and were rated by men as rather not pleasant (M = 3.27, SD = .60) and rather arousing (M = 5.63 , SD = .59). Positive pictures showed laughing people, a bride, sport awards or smiling grandparents and were rated by men as rather pleasant (M = 6.83, SD = .75) and rather arousing (M = 4.67, SD = .87) (Lang et al., 2008). Pornographic pictures showed heterosexual vaginal intercourse between one man and one woman (for further descriptions please see below). To equate for stimuli's complexity between the picture conditions, all pictures had to fulfill several criteria. The pictures in all conditions showed humans performing some sort of activity. With respect to the pornographic pictures, sexual intercourse was performed in different sexual positions. Furthermore, we included only discriminative backgrounds across all four categories. Participants were instructed using the following computerised and standardized instruction: "In a moment, there will show up several pictures consecutively in a random order. Please use the keys "j" and "n" to indicate if the actual shown picture is equal to the picture shown four trials before. Here, the "j" stands for "yes" (the picture you see is equal to the picture shown four trials before) and the "n" for "no" (no match between the currently seen picture and the picture shown four trials before). Please try to solve this task as quickly as possible, but without making any mistakes." Furthermore, an illustration of the task's challenge was shown. Comparably to Schoofs, Preuss, and Wolf (2008), stimuli were each shown for 500ms, followed by an interstimulus interval of 2500ms. Each condition consisted of 25 trials. In each condition,

seven pictures (28%) were targets (correct answer: "yes") and eighteen (72%) were distractors (correct answer: "no"). We calculated the relative frequency of responses and skips, the proportion of hits, false alarms as well as reaction times in each of the four experimental task conditions. Furthermore, we calculated *d'* for the four task conditions as a difference of the standardized means of hits and the standardized means of false alarms. This variable can be understood as sensitivity within the task conditions while higher individual scores reflect a higher ability to distinguish between targets and distractors and better task performance, respectively (Stanislaw & Todorow, 1999).

Sexual arousal ratings

Participants were asked to watch and rate 100 pornographic pictures in randomized order. Pictures were rated on a five point scale with respect to subjective arousal (1 = not sexually arousing, 5 = highly sexual arousing). Pornographic pictures were collected from free accessible Internetsex sites and depicted heterosexual sex (vaginal intercourse, anal sex and two oral sex categories: one with the man and one with the woman conducting the active part), homosexual sex (anal and oral sex between two men, vaginal-vaginal tribadism and oral sex between two women) and single masturbating men and women. Altogether, we presented 10 categories of pictures (as mentioned above) each consisting of 10 different pictures. The 100 pictures were presented in randomized order. The images did not contain any fetish relevant material, but genitals (or parts of them) were shown explicitly. Of particular interest was the mean rating of the heterosexual vaginal intercourse, because comparable pictures showing heterosexual vaginal intercourse were used within the experimental manipulation of the 4-back task with pornographic pictures. The internal consistency of the picture rating of this category was very good (Cronbach's α = .92). Moreover, we calculated the mean subjective arousal score for pictures displaying "heterosexual pictures" including vaginal

intercourse, oral and anal sex between a man and a woman, oral sex or tribadism between two women or single masturbating women (Cronbach's α = .98) and for "homosexual pictures" displaying anal and oral sex between two men or single masturbating men (Cronbach's α = .95) as general indicators of sexual arousal due to pornographic stimuli. Before (t1) and following (t2) the pornographic picture rating as well as before performing the WM task (t3), participants had to rate their current sexual arousal on a visual analogue scale ranging from 0 (= "not sexually aroused") to 100 (= "very sexually aroused") as well as their need to masturbate, also ranging from 0 to 100 (0 = "no need to masturbate", 100 = "very great need to masturbate").

4.4 Results

4.4.1 Working memory task

The mean 4-back task performance scores (performance data and reaction times) for the four experimental WM task conditions were calculated. At first, the relative number of detected responses and skips was analyzed before computing the relative frequency of hits and false alarms as well as *d*' within the detected responses. A detailed description of task performance is shown in Table 10.

Table 10

Description of working memory-performance in the four experimental task conditions with neutral, negative, positive or pornographic stimuli.

	neutral		**negative**		**positive**		**pornographic**	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
overall responses[1]								
correct responses	.80	.12	.80	.11	.77	.11	.67	.11
false responses	.17	.09	.15	.08	.20	.10	.28	.07
skips	.03	.07	.05	.08	.03	.07	.05	.07
hits[1]	.73	.16	.79	.19	.67	.22	.62	.17
false alarms[1]	.14	.11	.12	.11	.16	.12	.26	.11
d'	2.20	1.46	2.78	1.43	1.89	1.25	1.09	.61
reaction time[2]	1139.00	296.44	1266.42	324.02	1160.43	331.95	1290.58	354.17

[1] relative frequency

[2] in milliseconds

With respect to the hits as dependent variable a repeated measures ANOVA revealed a significant effect of the within-subject factor, Wilks' Lambda = .51, $F(3, 24) = 7.54$, $p < .01$, $\eta^2 = .48$. Post-hoc pairwise Bonferroni-corrected comparisons indicated that the number of hits in the pornographic picture condition was significantly less than in the neutral, negative and positive (all $p < .05$) task condition. The number of hits was not significantly different across the neutral, negative and positive conditions (all $p > .05$). Concerning the false alarms as dependent variable a repeated measures ANOVA revealed a significant effect of the within-subject factor, Wilks' Lambda = .33, $F(3, 24) = 16.34$, $p < .01$, $\eta^2 = .67$. Post-hoc

pairwise Bonferroni-corrected comparisons indicated that the number of false alarms in the pornographic picture condition was significantly higher than in the neutral, negative and positive (all $p < .05$) task condition. The number of false alarms was not significantly different across the neutral, negative and positive conditions (all $p > .05$). Regarding *d*' as dependent variable a repeated measures ANOVA revealed a significant effect of the within-subject factor, Wilks' Lambda = .25, $F(3, 24) = 23.63$, $p < .001$, $\eta^2 = .75$. Post-hoc pairwise Bonferroni-corrected comparisons indicated that the sensitivity in the pornographic picture condition was significantly lower than in the neutral, negative and positive (all $p < .05$) task condition. The sensitivity was not significantly different across the neutral, negative and positive conditions (all $p > .05$). With regard to performance data, task performance in the pornographic picture condition is worse compared to all other conditions of the WM task. With respect to the overall reaction times (irrespective of correct or false responses), repeated measures ANOVA revealed a significant effect of the within-subject factor, Wilks' Lambda = .45, $F(3, 24) = 9.81$, $p < .05$, $\eta^2 = .55$. When looking at the post-hoc Bonferroni-corrected pairwise comparisons, reaction times in the neutral and in the positive picture condition were significantly slower than in the pornographic picture condition (both $p < .05$), while there was no difference between the pornographic and negative picture condition ($p > .05$).

4.4.2 Indicators of sexual arousal

Descriptive values for the sexual arousal ratings of the 100 pornographic pictures, sexual arousal and the need to masturbate before (t1) and following (t2) the pornographic picture presentation as well as before performing the 4-back task (t3) are shown in Table 11.

Table 11

Description of the indicators of sexual arousal.

	M	*SD*
picture rating[1]		
vaginal sex	3.49	.88
heterosexual material	3.20	.77
homosexual material	1.14	.33
sexual arousal[2]		
t1	10.36	15.52
t2	29.89	23.85
t3	18.43	23.35
need to masturbate[3]		
t1	9.14	13.20
t2	28.86	33.55
t3	14.36	23.64

[1] scale from 1 (= not arousing) to 5 (= very arousing)

[2] scale from 0 (= not sexually aroused) to 100 (= very sexually aroused)

[3] scale from 0 (= no need to masturbate) to 100 (= very great need to masturbate)

Heterosexual pictures were rated as more sexual arousing than homosexual pictures ($t(27) = 13.98$, $p < .01$, $d = 2.91$). Repeated measures ANOVA with sexual arousal as dependent variable showed a significant effect of test interval (Wilks' Lambda = .49, $F(2, 26) = 13.68$, $p < .01$, $\eta^2 = .51$). Single comparisons showed no difference between sexual arousal at t1 and t3 ($p = .27$), but between t1 and t2 as well as between t2 and t3 (both $p < .01$), indicating a higher sexual arousal at t2. In line with this, a repeated measures ANOVA with the need to

masturbate as dependent variable revealed a significant effect of test interval (Wilks' Lambda = .69, $F(2, 26) = 5.83$, $p < .01$, $\eta^2 = .31$). Single comparisons showed no difference in the need to masturbate at t1 and t3 ($p = .54$), but between t1 and t2 as well as t2 and t3 (both $p < .01$) indicating a higher need to masturbate at t2.

In order to explain the performance in the pornographic picture condition of the 4-back task, performance data acquired in the pornographic picture condition was correlated with the sexual arousal ratings of the pornographic pictures as well as with the indication of current subjective sexual arousal and the need to masturbate after picture presentation (at t2). Correlations are shown in Table 12. The reaction time in the pornographic picture condition did not correlate significantly with the indicators of sexual arousal (all $p > .05$).

Table 12

Bivariate correlations of the performance data in the pornographic picture condition of the 4-back task with indicators of sexual arousal.

	hits	**false alarms**	**skips**	***d'***
picture rating				
vaginal sex	.24	**.47***	.14	-.07
heterosexual material	.26	.18	-.04	.11
sexual arousal (t2)	.09	.21	**.45***	.08
need to masturbate (t2)	.32	**.45***	.05	.19

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

In order to better understand potential predictors of task performance in the pornographic condition of the 4-back task, we conducted a hierarchical moderated regression analysis with *d'* as dependent variable. The sexual arousal rating of the heterosexual vaginal intercourse served as the first independent variable, because pictures in the pornographic picture condition of the 4-back task showed exclusively pictures of heterosexual vaginal intercourse. The need to masturbate at t2 served as second independent variable in the regression model and the interaction of the sexual arousal rating of pornographic pictures displaying vaginal heterosexual intercourse and the urge to masturbate at t2 was the third variable of the regression model (all variables centralized, Cohen et al., 2003). In the first step, the sexual arousal rating explained 1.00% of *d'* in the pornographic picture condition of the 4-back task, but failed to reach significance ($F(1, 26) = 1.34$, $p = .72$). In the second step, the urge to masturbate at t2 did not lead to a significant increase of variance explanation (changes in $R^2 = .06$, changes in $F(2, 25) = 1.48$, $p = .23$). In the third step, adding the interaction of both predictors resulted in a significant increase of variance explanation (changes in $R^2 = .20$, changes in $F(3, 24) = 6.68$, $p < .05$) of *d'* in the pornographic picture condition in the 4-back task indicating a moderation effect of the need to masturbate. Altogether, the overall explanation of *d'* in the pornographic picture condition of the 4-back task through the three predictors (block 1 + block 2 + block 3) was significant ($R^2 = .27$, $F(3, 24) = 2.89$, $p \leq .05$). For further values please see Table 13.

Table 13

Hierarchical regression analysis with d' in the pornographic picture condition as dependent variable.

		β	***T***	***P***
Main effects	"picture rating"	-.42	-1.96	.06
	"need to masturbate"	.58	2.53	.02
	"picture rating" x "need to masturbate"	-.55	-2.58	.01

Given the significant interaction effect, we analyzed the simple slopes in order to examine the moderating effect of the need to masturbate in more detail. The slope of regression line representing "low need to masturbate" (one standard derivation below the mean) was not significantly different from zero (t = .88, p = .39), whether or not the pornographic pictures showing vaginal sexual intercourse between men and women were rated as low or highly sexual arousing. The slope of regression line representing "high need to masturbate" (one standard derivation above the mean) was significantly different from zero (t = 2.70, $p \leq .01$), representing a higher sensitivity if the pornographic pictures were rated as low sexual arousing and lower sensitivity if pornographic pictures were rated as highly sexual arousing. This indicates that WM-performance within the pornographic picture condition interference is not primarily predictable by the general sexual attraction to pornographic pictures (as measured by the sexual arousal rating), because the sexual arousal rating showed no effect on WM-performance in the 4-back task with pornographic pictures. In fact, resulting needs to masturbate after pornographic picture presentation moderates the association between the sexual arousal rating and the performance in the 4-back task with pornographic pictures

leading to greater interference if pictures were rated as highly sexually arousing and the need to masturbate was high (see Figure 8).

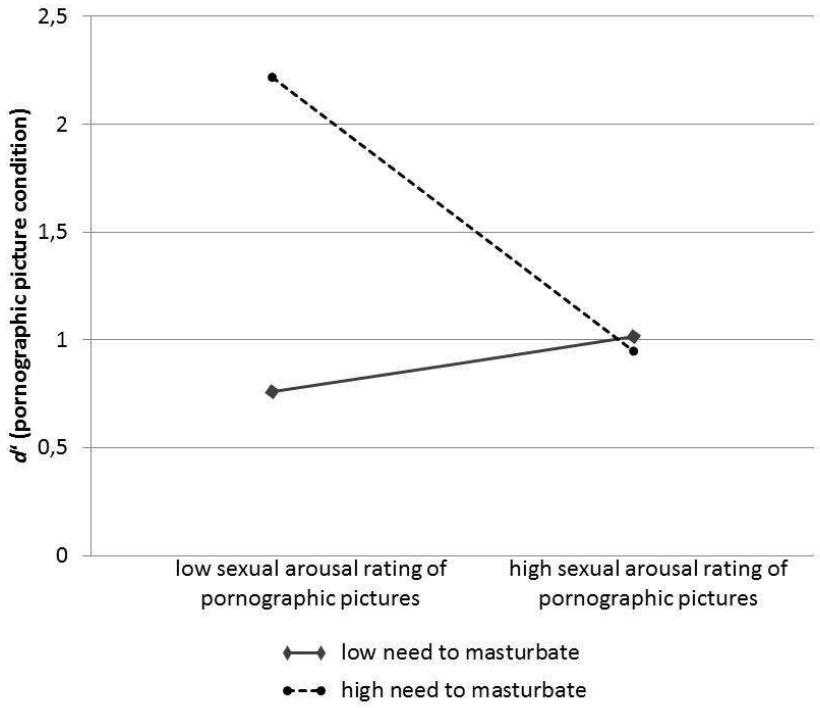

Figure 8

Demonstration of hierarchical regression analysis' result with *d'* in the pornographic picture condition in the 4-back task as dependent variable showing a moderation by masturbation needs. Participants reporting a 'low need to masturbate' show no difference in working memory-performance whether or not pornographic pictures were rated as sexually arousing. Individuals reporting a 'high need to masturbate' show a worse WM-performance, if pornographic pictures are rated as highly sexually arousing.

4.5 Discussion

The aim of the present study was to investigate WM-performance for pornographic pictures in comparison with neutral, negative and positive stimuli in a within-group design using a pictorial 4-back task in heterosexual men. The main result of the study is worse WM-

performance for pornographic pictures compared to neutral, negative and positive stimuli. This is represented by less hits, more false alarms as well as a lower sensitivity in the pornographic picture condition compared to all other conditions. With respect to the false alarms and skips within the pornographic picture condition, we found significant correlations concerning indicators of sexual arousal, such as sexual arousal ratings of pornographic pictures and the need to masturbate following pornographic picture presentation. Furthermore, a moderating effect of the need to masturbate following pornographic picture presentation on the sensitivity on the pornographic 4-back task was found. The results provide first evidence for the interfering role of sexual arousal on WM processes for pornographic pictures – at least in heterosexual men – and contribute to the overall pattern drawn by previous studies showing interfering effects of sexual stimuli on executive processes (Most et al., 2007; Prause et al., 2008; Wright & Adams, 1999). The findings might also be relevant for problems experienced by Internetsex participants as well in Internetsex addicted individuals.

The study's main result of worse WM-performance for pornographic stimuli is in line with other studies addressing sexual stimuli's impact on cognition. It was already shown that the presentation of sexual stimuli interfered with performance in choice reaction time (Wright & Adams, 1999), dot detection (Prause et al., 2008) and rapid target perception tasks (Most et al., 2007). As shown in previous studies, positive and negative stimuli lead to an early enhancement of attention towards the emotional stimulus (Hamann, 2001; Phelps, 2006; Vuilleumier, 2005). Since pornographic picture processing is linked to brain structures associated with emotion, arousal and attention (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000), it seems plausible to interpret the observed results concerning pornographic pictures against the theoretical background of emotional attention capturing. According to this, the pornographic pictures used in the WM task seem to have captured the participants' attention more strongly than the positive and negative pictures (indicated e.g. by increased reaction times. As indicated by the worse WM-performance, pornographic pictures lead to a

greater distraction from task demands than neutral, negative and positive pictures. Given these findings, two aspects need to be explained in more detail: the stronger interfering effect of pornographic pictures compared to negative and positive stimuli, and the absence of a differences in the used WM task between neutral and positive or negative stimuli.

With respect to the neural processing of negative and positive pictures, a distinct activity pattern of the prefrontal cortex, but not of limbic structures was shown (Ball et al., 2009; Dolcos, LaBar, & Cabeza, 2004; Kensinger & Schacter, 2006). As mentioned above, pornographic pictures lead to brain activations in attention and emotion associated brain regions (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000), but also of structures associated with the mesolimbic reward system (Wightman & Robinson, 2002; Wise, 2002). Since performance of the n-back task mainly relies on prefrontal areas (Owen et al., 2005), this suggests an interpretation of the obtained results in the WM task in the light of strong arousal-based attention capturing known from emotional stimuli (Vuilleumier, 2005). Following this rationale, the stronger interfering effect of pornographic pictures in the WM task (compared to positive and negative stimuli) might be explained by their greater incentive salience. Moreover, pornographic pictures lead to sexual arousal and eventually to masturbation needs. Sexual arousal comprizes both a subjective arousal component and sexual desire (for review see Janssen, 2011). In line with this argumentation, our data suggest that the pornographic pictures used elicited both components. Beyond the simple result that the pictures were rated as subjectively sexually arousing, individuals also reported an increase of current sexual arousal following pornographic picture presentation as well as an increase of the need to masturbate. These two indicators of sexual arousal correlated with WM-performance in the pornographic picture condition. In addition, as seen in the moderated regression, high needs to masturbate after pornographic picture presentation lead to greater interference with WM-performance for pornographic stimuli than low masturbation needs if pornographic pictures were rated as sexually arousing. Thus, the strong incentive value of

pornographic pictures as well as an increase in sexual motivation due to pornographic picture presentation seems to lead to a WM-interference in terms of a distraction from task demands. One could ask why the WM-performance was actually not better than observed when the need to masturbate was low. One speculative explanation is that if pornographic pictures are principally not interesting for an individual, WM-performance might be declined by avoiding a deeper processing of the pictures. This tendency in subjects for whom pornographic pictures are not sexually interesting (those who have very low masturbation needs, see moderated regression) may also result in distraction from the task and therefore relative worse WM-performance in the pornographic picture condition. Still, the association between the indicators of sexual arousal and WM-performance within the pornographic picture condition strengthens the theoretical interpretation of sexual arousal based interference of cognitive functioning.

Contrary to our assumptions and to the results of previous studies (Dolcos & McCarthy, 2006; Erk et al., 2007; Gotoh, 2008; Kensinger & Corkin, 2003), we observed no differences between the neutral, negative and positive picture conditions in the WM task. Since under all picture conditions people in different situations were shown, confounding effects by stimuli's content across conditions seem implausible. One explanation for the different findings compared to the studies mentioned above could be the experimental paradigms used: In delayed-response and item recognition tasks, participants see series of stimulus probes and have to decide if a shown stimulus has been included in the probe, while between seeing and deciding a form of distraction (there through emotional pictures) is conducted. The procedure applied by Gotoh (2008) comprizes a task switching between item recognition and item calculation aiming at representing WM-interference through decreased accuracy in conditions with emotional recognition stimuli. By this, those tasks require storage in WM during an induction of interference (Conway et al., 2005), a bias for the rehearsal process (Baddeley & Logie, 1999) emphasised in Baddeley's multi-component model

(Baddeley, 1994, 2010). A n-back task, as used in our study, requires monitoring, updating and manipulation of presented stimuli (Owen et al., 2005). Thus, the task interfering effect of attention capturing by emotional stimuli in form of distraction from WM (as in previous studies) might be stronger than the task interfering effect by attention capturing through emotional stimuli within a task that actually requires WM for the shown stimuli (as in this study). Contrary to pornographic pictures, the valence of the non-pornographic emotional pictures we used does not indicate an attention capturing effect compared to when neutral pictures are presented. Pictorial stimuli in all conditions seem to provide a lot of helpful information for memorizing and the successful handling of the WM task. Within the pornographic picture condition, the indicators of sexual arousal are able to explain WM-performance. Pornographic picture processing is associated to sexual arousal, which leads to interference of WM processes.

The results of attention capturing and cognitive interference through pornographic stimuli can also be discussed with respect to problems reported by individuals using Internetsex applications, such as an excessive Internet pornography consumption. Some individuals report problems occurring during or after pornography consumption on the Internet such as neglecting, forgetting or missing responsibilities, appointments, sleep, etc. leading to negative consequences in those individual's life (Brand et al., 2011; Kuss & Griffiths, 2011; Young, 2008). For Internetsex participants reporting this form of problematic behavior and its consequences, sexual arousal and its impact on cognitive processes might explain parts of these negative effects. The results of this study imply strong interference of WM by needs to masturbate arising from pornographic pictures. This might explain why Internetsex participants' executive functioning might be reduced during the engagement in Internetsex, since WM is a necessary and important factor of goal directed behaviors (Alvarez & Emory, 2006; Jurado & Rosselli, 2007). Moreover, it has been shown that for the development of advantageous decision making WM capacity is required (Hinson et al., 2002).

Since indicators of sexual arousal and the need to masturbate were the important variables to explain decreased WM-performance in the pornographic picture condition, facets of sexual arousal and associated changes in cognitive functions (e.g. focussing of attention) seem to be crucial to understand problems associated with Internetsex. On a speculative level, one might argue that if subjects' attention to sexual stimuli and subsequent sexual arousal interfered with executive functioning and decision making, then they might be less able to monitor and control their own Internetsex use. Contributing to this, it has been shown that the amount of subjective sexual arousal while watching pornographic material is a main predictor to explain everyday complaints due to Internetsex (Brand et al., 2011). The current findings may give some first hints for cognitive mechanisms potentially contributing to the link between the sensitivity for sexual arousal in the context of Internetsex and a loss of control over the use of Internetsex sites and occurring problems in daily life.

With respect to addictive disorders, a relationship between attentional bias for substance-related cues and craving reactions is known in substance dependent individuals (Field, Munafò, & Franken, 2009), which seem to be even relevant factors for the development and the maintenance of addiction arising by processes of conditioning (Robinson & Berridge, 2001). For example, problem drinkers show larger bias to alcohol-related cues and greater cognitive interference (Field et al., 2011; Gladwin & Wiers, 2012; Sharma, Albery, & Cook, 2001). In populations of dependent individuals, addiction-related cues do not only have an emotional connotation but also incentive-motivational properties leading to stronger attention capturing, higher craving and an increased probability of relapse. Since similar mechanisms of development and maintenance are suggested for excessive sexual behaviors on the Internet (Kuss & Griffiths, 2011; Young, 2008), the urge to masturbate observed in this study could be regarded as craving facet in the light of Carter and Tiffany's (1999) cue-reactivity model with respect to Internetsex addicted individuals. Following this line of argumentation, the confrontation with pornographic materials should lead to craving

reactions, such as strong masturbation needs, which should interfere with cognitive processes, such as WM, monitoring processes and decision making during browsing for Internetsex. Indeed, the results of this study reveal first evidence for the link between some form of craving (reflected in the need to masturbate and sexual arousal), attention capturing and declines in cognitive processing.

Limitations and future directions

All participants started the experiment with the assessment of general demographic data followed by the pornographic picture presentation, while the experimental paradigm was performed at the end of the investigation. Therefore, one may speculate if the effects found are influenced by participants' priming towards pornographic pictures. However, we do not believe that the observed effects are caused by priming for several reasons. On the one hand, pictures used in the picture rating and in the experimental paradigm were different and since pictures of all picture conditions showed humans, priming should have had an effect on WM-performance in all experimental conditions. In addition, priming usually results in better performance for the stimuli for which priming has been occurred. This was not the case in our study, since performance in the 4-back task with pornographic pictures was worse compared to the other conditions. Moreover, sexual arousal and the need to masturbate before the 4-back task were not different compared to the beginning of the investigation and less than following the pornographic picture rating, which shows that the effect of the pornographic picture presentation was not stable due the whole duration of the investigation. One further limitation of the study is that the observed effects might be influenced by a less varied content within the pornographic picture condition compared to the other picture conditions. Even though several attempts were made to equate stimuli's complexity between and within picture conditions (see methods section) we cannot exclude completely the possibility that the effects

were influenced by the level of heterogeneity across the picture conditions. However, the reported effects are principally in line with studies showing negative effects of sexual stimuli on cognitive functioning emphasizing the validity of our results. However, to rule out any remaining doubts about priming effects and picture content variance, future studies could use randomized sequencing as well as a different set of stimuli.

Furthermore, the number of correct responses in the 4-back task was unexpectedly high in all four experimental conditions. To produce more variance, following studies have, at least, two options. At first, task difficulty could be increased, e.g. by varying the complexity of pictures in all picture conditions. On the other side, sexual arousal induction could be stronger by using a longer presentation of the pornographic picture or for personal preferences individualized pornographic pictures. Finally, to improve the understanding of the impact of sexual arousals on cognition, different measurements of sexual arousal (Kalmus & Beech, 2005) could be assessed before, after and even during different experimental paradigms focusing on memory or executive processes.

In our study, the influence of pornographic pictures on WM-performance was only tested in men. Other studies report different reactions due to pornographic picture presentation between men and women (Chivers, Rieger, Latty, & Bailey, 2004; Peterson, Janssen, & Laan, 2010; Rellini, McCall, Randall, & Meston, 2005), therefore – on a speculative level - a differential effect of sexual stimuli on cognitive processes might be expected. Such investigations would contribute to gender differences with respect to interference susceptibility through sexual arousing stimuli.

5. Study 4: Sexual picture processing interferes with decision making under ambiguity.[2]

5. 1 Abstract

Many people watch pornography on the Internet in order to receive sexual arousal and gratification. When browsing e.g. for sexual pictures, individuals have to make several decisions, all possibly leading to positive or negative consequences. Decision-making research has shown that decisions under ambiguity are influenced by consequences received following earlier decisions. Sexual arousal might interfere with the decision-making process and should therefore lead to disadvantageous decision making in the long run. In the current study, 82 heterosexual, male participants watched sexual pictures, rated them with respect to sexual arousal and were asked to indicate their current level of sexual arousal before and following the sexual picture presentation. Afterwards, subjects performed one of two modified versions of the Iowa Gambling Task (IGT) in which sexual pictures were displayed on the advantageous and neutral pictures on the disadvantageous card decks or vice versa (n=41/n=41). Results demonstrate an increase of sexual arousal following the sexual picture presentation. Decision-making performance was worse when sexual pictures were associated with disadvantageous card decks compared to performance when the sexual pictures were linked to the advantageous decks. Subjective sexual arousal moderated the relationship between task condition and decision-making performance. This study emphasizes that sexual arousal interferes with decision making which may explain why some individuals experience negative consequences in the context of cybersex use.

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[2] This study is under consideration for publication: Laier, C., Pawlikowski, M., & Brand, M. (under review). Sexual picture processing interferes with decision making under ambiguity. *Archives of Sexual Behavior*.

5.2 Introduction

The Internet offers the opportunity to engage in cybersex easily. Cybersex comprises different sexually motivated behaviors. Some of them are interactive, e.g. chatting with sexual connotation, self-displaying to or watching at others within sexual actions via webcam. Other activities represent a rather passive facet of cybersex, e.g. watching sexual pictures or videos on the Internet (Döring, 2009). Some authors claim that anonymity, affordability, accessibility and a certain degree of control about the situation lead to frequent use of cybersex (Cooper, McLoughlin, & Campbell, 2000; Cooper, Delmonico, Griffin-Shelley, & Mathy, 2004; Griffiths, 2001; Young, Pistner, O'Mara, & Buchanan, 1999). Most cybersex users report mainly positive consequences received during or after indulging in cybersex such as experiencing sexual arousal (Paul, 2009; Shaughnessy et al., 2011), gathering sexual knowledge, changes in attitudes towards sex and life in general (Hald & Malamuth, 2008), greater sexual openness, or an enrichment of real-life sexual contacts (Grov et al., 2011). On the other hand, some individuals report from several negative consequences, resulting from an overuse of cybersex, such as missing sleep, spending money, social problems with partners, friend or family members and an interference with private or work responsibilities (Griffiths, 2001).

From decision-making perspective, cybersex users have to make several decisions, while some of them are associated with potential positive and some with potential negative consequences for the user. The decisions which have to be made in the context of cybersex activities have either explicit character (e.g. spending money), or the possible consequences of the decisions are less clear and implicit (e.g. sharing private information, displaying oneself to foreigners via webcam or on photography, spending an amount of time for cybersex, neglecting other activities, etc.) (Döring, 2009). The question remains, why some cybersex users are not able to control their behavior and continue e.g. watching pornography although they experience negative consequences during or following their cybersex behavior.

Understanding this might even have some relevance for understanding the loss of control experiences by cybersex addicted individuals (Kuss & Griffiths, 2011b).

In decision-making literature, decisions are differentiated with respect to the explicitness of rules for positive and negative consequences. If rules are explicit and the decider can deal with probabilities, decisions are called “decisions under risk”. In contrast, if no information about possible consequences and their probabilities is available and the decider has to learn implicitly which alternatives are good and which are bad, decisions are made under “ambiguity” (Bechara, Damasio, Tranel, & Damasio, 1997; Brand, Labudda, & Markowitsch, 2006). The somatic marker hypothesis aims at explaining how decisions under ambiguity are made. Generally, it is assumed that individuals' decisions are guided by earlier emotional experiences of similar decision situations (Bechara et al., 2000; Bechara et al., 1994; Dunn et al., 2006), for instance, after a decision, individuals receive some form of positive or negative feedback (rewards or punishments), which is processed emotionally and influences following decisions in similar decision-making situations. According to this, the relevance of emotion-related brain structures has been pointed out quite clearly with respect to advantageous decision making in daily life and measured by the Iowa Gambling Task (IGT), which is frequently used to simulate real-life decisions in the laboratory (Bechara et al., 2000; Bechara et al., 1999; Bechara et al., 2003; Bechara et al., 1994; Dolan, 2002; Naqvi, Shiv, & Bechara, 2006). Considering a cognitive science perspective, decisions under ambiguity are made rather by an intuitive system, while decisions under risk are more directed by reasoning (Brand et al., 2009; Kahneman, 2003; Schiebener et al., 2011). With respect to decision making under ambiguity, the stimulating nature and the reward-related processing of sexual pictures could interfere with the emotional feedback learning necessary for the development of advantageous decision making in the long run.

Sexual arousal is discussed as being one main motivational aspect in cybersex activity. It is thought to be multifaceted and comprises physiological, behavioral, motivational, cognitive and affective components, which can be triggered internally and externally (for overview see Janssen, 2011; Sachs, 2007). An interaction between sexual arousal and cognition has been shown, meaning that cognitive processes can impact physiologic and subjective components of sexual arousal (Janssen, Everaerd, Spiering, & Janssen, 2000). As revealed by brain imaging studies, sexual pictures showing heterosexual intercourse lead to activations of the claustrum, paralimbic structures (including the anterior cingulate cortex, the orbitofrontal cortex and the insula), the striatum and the hypothalamus in heterosexual men (Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000; Stolèru et al., 1999). Ejaculation, in cybersex mostly reached through masturbation, seems to be correlated with (amongst other structures) activity of the ventral tegmental area (Holstege et al., 2003). Thus, the processing of sexual pictures activate brain structures associated with the reward system (Rolls, 2000; Wise, 2002), emphasizing the stimulating nature of sexual pictures and the possibility of receiving gratification by watching sexual pictures on the Internet. Moreover, it was shown that individuals differ in their sexual response to sexual cues. Some individuals are more prone to sexual excitation and receiving gratification due to sexual cues than others (Bancroft et al., 2009).

Experimental research addressing the impact of sexual arousal on decision-making processes is very rare, so far. Only one study was conducted showing that individuals indicating high, self-induced sexual arousal report a greater willingness to act morally questionable in order to achieve sexual gratification as well as a greater willingness to engage in unsafe sex compared to individuals reporting low or no sexual arousal (Ariely & Loewenstein, 2006). This clearly points out the situational influence of sexual arousal on judgement and decision making, but it remains unclear, if sexual arousal influences only willingness, or if sexual arousal leads indeed to disadvantageous decision making. Although

cybersex has a functional character for many users (Döring, 2009), it is still unclear whether or not sexual arousal interferes with general decision-making performance possibly leading to diverse negative consequences for individuals. We aimed at addressing this research gap by modifying the most common decision-making paradigm with sexual and neutral pictures and assessed indicators of sexual arousal simultaneously to address possible interfering effects of sexual arousal on decision making. From a decision-making perspective, this might explain parts of the problems reported by cybersex users.

Against the theoretical and empirical evidence from studies on decision making as well as on sexual arousal, we hypothesize that decision making under ambiguity is influenced by sexual arousal. We aimed to investigate this assumption with two manipulations of the IGT in a between-subject design by integrating sexual and neutral cues into the conventional test. While in one group the sexual pictures were associated with the advantageous decision-making alternatives, in the other group sexual pictures were related to disadvantageous decision-making alternatives. In this way, we designed an experiment, in which we had two groups performing the same type of modified IGT with the exception that the decks were interchanged, while in both versions the same, but task irrelevant cues were included. By this, we argue that the stimulating nature of sexual pictures and sexual arousal interferes with the processing of feedback offered by the task leading to a preference for those decision alternatives linked to pictures promising sexual gratification, although in one group these alternatives offered higher punishments than rewards. More specifically, we formulated the following hypotheses:

Hypothesis 1: Participants' decision-making performance is more disadvantageous in the IGT, if the disadvantageous alternatives are covered with sexual pictures. In contrast, participants'

decision-making performance is more advantageous, if the sexual pictures cover the advantageous alternatives.

Hypothesis 2: Between-group differences in the IGT performance are moderated by subjective sexual arousal.

5. 3 Methods

5.3.1 Participants

We examined 82 heterosexual men (mean age: *M* = 25.21, *SD* = 6.23, range: 18-54 years). Participants were recruited by advertisements in public and in the University of Duisburg-Essen**,** and were paid at an hourly rate for participation (10€/hr.). We explicitly advertised for male, heterosexual participants with a minimum age of eighteen years and indicated that study participation included viewing and rating explicit sexual stimuli of legal sexual practices. Mean years of education in the sample was 12.21 (*SD* = 1.29). All participants gave written informed consent prior to the investigation and confirmed their heterosexual preference via questionnaire. The study was approved by the local ethics committee.

5.3.2 Procedure

The experimental paradigm was implemented within a laboratory setting and each participant was attended by one investigator. All experimental paradigms and questionnaires (see below) were assessed computer-based. The experiment took approximately one hour. At first, individuals answered some questionnaires and indicated their current sexual arousal. Then, participants were presented and rated sexual pictures, which was followed by a second

assessment of current sexual arousal. After answering some more questionnaires about sexual behavior in general, one of the modified versions of the IGT was performed. Within the investigation all participants were examined alone in one laboratory sitting behind a dividing wall ensuring their privacy.

5.3.3 The experimental task: A modified Iowa Gambling Task (IGT) with sexual and neutral pictures

To assess decision making under ambiguity, we used the IGT (Bechara et al., 1994) in two manipulated versions (see description below). In the original IGT (Bechara, Tranel, et al., 2000) participants are instructed to maximize a starting capital of 2,000 € by selecting one card at a time from four card decks, while they do not know the total number of 100 trials. Because card selections from decks A and B result in large monetary gains followed by even larger losses at certain unpredictable times, decks A and B are "disadvantageous" in the long run. Card selections from decks C and D result in small immediate gains followed by even smaller unpredictable losses. Therefore, decks C and D are "advantageous" in the long run. Participants are informed about how much money they won, and in some cases also lost, after each trial. Additionally, they are also informed that some decks are better than others and that, to win, they have to avoid the disadvantageous decks and keep selecting from the advantageous decks.

Here, we used two modified versions of the IGT in which pictures are seen instead of the original card decks. If one card was chosen, another picture appeared on the back of the following card beneath. In the first version, neutral pictures of the International Affective Picture System (IAPS) (Lang et al., 2008) were placed on the two disadvantageous decks (A and B) and pictures of heterosexual vaginal intercourse (for description see "Indicators of sexual arousal") were shown on the two advantageous decks (C and D). In the other version,

the sexual pictures were displayed on the disadvantageous (A and B) and the neutral pictures on the advantageous decks (C and D). By this, all participants played an IGT modified with the same pictures. The only difference was that the decks were interchanged. These two IGT versions were administered to the participants in a between-group design: 41 individuals performed the IGT version with the sexual pictures on the advantageous decks and 41 individuals performed the version with the sexual pictures on the disadvantageous decks.

Performance was analyzed by dividing the 100 trials into five blocks of 20 card selections. We calculated the net score for all five blocks separately as well as one overall net score by subtracting the number of selections from disadvantageous decks (A and B) from the number of selections from advantageous decks (C and D). By this, scores above zero indicate a selection of more advantageous than disadvantageous decks. Scores below zero indicate a selection of more disadvantageous than advantageous decks. Following Brand, Recknor, et al. (2007) and Bechara et al. (1997) we also calculated the net score for the first and second block (Block 1 and 2). A positive net score in Block 1 and 2 indicates fast learning from feedback.

5.3.4 Indicators of sexual arousal

Before performing the IGT, participants were shown 100 images of ten categories of sexual pictures and were asked to rate them with respect to subjective sexual arousal (1 = not sexually arousing; 5 = very sexually arousing). The categories included heterosexual sex (vaginal intercourse, anal and oral sex, while there were two oral categories: one with the man the cunnilingus and one with the woman doing the fellatio actively), homosexual sex (anal and oral intercourse between two men, vaginal-vaginal tribadism and oral intercourse between two women) and single masturbating men and women. The picture presentation was randomized. Of particular interest for the current study is the average rating of heterosexual

vaginal intercourse (Cronbach's α = .92), because pictures of this category were also used for the manipulation of the IGT (see above). Furthermore, we calculated the average ratings for the aggregated picture sample of male, heterosexual preference (Cronbach's α = .98) as general indicator for individual arousal due to sexual stimuli. Before (t1) and following (t2) the picture presentation, participants were additionally asked to rate their current sexual arousal (1 = not sexually aroused; 100 = very sexually aroused).

5.3.5 Questionnaires

Several questionnaires were administered to the participants assessing their cybersex behavior and further personal information. For participants, cybersex was defined according to Döring (2009) as an online sexual activity including watching pornography, participating in sexually motivated chats or webcam sex, reading sexual arousing literature on the Internet, searching for sexual offline contacts or gaining sexual information on the Internet. Subjects indicated how often they participate in each of these activities and were asked afterwards how often they engage in cybersex altogether. Particularly, we were interested in the age participants engaged in cybersex for the first time, how many hours they spend on Internet sex sites per week as well as the relation of watching sexual pictures on the Internet compared to the overall Internet sex activities using a scale from 0 (= never) to 4 (= very often). Additionally, a short-version of the German Internet Addiction Test (Pawlikowski et al., 2012) was modified for Internet sex sites (s-IATsex) to assess subjective complaints due to excessive usage of cybersex in daily life. Compared to the original version, the term "Internet" was replaced by "Internet sex sites" in all items (further details and examples are given in Brand et al., 2011). All twelve items can be answered from 1 ("never") to 5 ("very often") resulting in a potential score from 12 to 60 (for a more detailed description of the s-IATsex please see section 2.3.2). In this sample, internal consistency of the s-IATsex was high (Cronbach's α =

.87). Because questionnaires queried highly personal information, participants were explicitly instructed that the answering of all questionnaires was completely optional in order to avoid false data.

5.4 Results

Participants indicated an initial contact with cybersex at the age of 15.65 (*SD* = 4.86). The current mean time spend on Internet sex sites was 1.40 hours per week (*SD* = 1.30, *n* = 50). With respect to every day complaints due to the usage of cybersex individuals report a mean score of 19.38 (*SD* = 6.26) in the s-IATsex (all subjects, *n* = 82). The two IGT groups did not differ with respect to age, age of initial contact with cybersex, mean time spend on Internet sex sites, and the score of the s-IATsex (all *p*'s > .05).

5.4.1 Manipulation check

For description of the picture ratings and the indication of sexual arousal at t1 and t2 see Table 14. The two IGT groups differed with respect to valence and sexual arousal ratings of the stimuli showing vaginal heterosexual intercourse, *M*1 = 3.79, *SD* = .64, *M*2 = 3.39, *SD* = .85, $t(77) = 2.30$, $p < .05$, $d = .38$, but did not differ in the sexual arousal rating for pictures showing sexual practices for heterosexual male's eye, *M*1 = 3.47, *SD* = .60, *M*2 = 3.16, *SD* = .81, $t(77) = 1.91$, $p > .05$. The indication of sexual arousal at t1, *M*1 = 11.73, *SD* = 22.34, *M*2 = 12.83, *SD* = 20.10, $t(80) = -.23$, $p > .05$, and t2, *M*1 = 31.05, *SD* = 24.13, *M*2 = 28.39, *SD* = 29.13, $t(77) = .45$, $p > .05$, were comparable between the groups. For both groups together, the reported sexual arousal was significantly higher after watching the sexual pictures (t2) compared to the baseline (t1), t1: *M*1 = 12.28, *SD* = 21.13, t2: *M*2 = 29.72, *SD* = 26.62, $t(81) = -5.52$, $p < .001$, $d = 1.22$.

Table 14

Results of the picture ratings and the indication of sexual arousal following sexual picture presentation.

***N* = 82**	***M***	***SD***
picture rating[1]		
vaginal sex	3.58	.78
heterosexual sex	3.31	.73
sexual arousal[2]		
t1	12.28	21.13
t2	29.72	26.62

[1] scale from 1 (= not sexually arousing) to 5 (= very sexually arousing)

[2] in percentage (0 - 100%)

5.4.2 Decision-making task

The net scores of the five IGT blocks as well as the overall net score for the two IGT groups are shown in Table 15. The IGT net score was significantly higher in the group which played the IGT with sexual pictures on the advantageous (decks C and D) compared to the group with sexual pictures on the disadvantageous decks (A and B), $t(80) = 3.12$, $p < .01$, $d = .69$). With respect to the first forty trials, the net score was also significantly higher in the group which played the IGT with sexual pictures on the advantageous decks ($M = 3.27$, $SD = 15.30$) compared with the group with sexual pictures on the disadvantageous decks ($M = -5.80$, $SD = 13.34$), $t(80) = 2.86$, $p < .01$, $d = .63$).

Table 15

Mean net scores of the five IGT blocks as well as the IGT overall net score for both groups playing the modified IGT with sexual pictures on card decks CD or on card decks AB.

IGT sexual pictures on card decks	**Block 1**		**Block 2**		**Block 3**		**Block 4**		**Block 5**		**overall**	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
CD (advantageous)	.63	9.13	2.63	9.99	5.66	10.08	6.23	9.06	4.19	9.05	19.42	32.19
AB (disadvantageous)	-5.65	6.79	-.15	8.97	.19	10.23	1.12	9.97	1.90	8.98	-2.58	31.61

In order to analyze IGT performance in more detail, repeated measures ANOVA was carried out with "group" as between-subject factor and the five IGT blocks as within-subject factor. The between-subject factor was significant, $F(1, 80) = 9.75$, $p < .01$, $\eta^2 = .11$, indicating that the IGT performance was better in the group with sexual pictures on the advantageous decks (C and D) compared to the group with sexual pictures on the disadvantageous decks (A and B). Furthermore, the within-subject effect "blocks" was significant, Wilks' Lambda = .71, $F(4, 77) = 7.82$, $p < .001$, $\eta = .29$. However, the interaction between group and IGT blocks slightly failed to reach significance, Wilks' Lambda = .94, $F(4, 77) = 1.32$, $p > .05$, $\eta^2 = .06$.

5.4.3 Moderating variables on decision-making performance

The bivariate correlations between the IGT scores, the sexual picture ratings and the sexual arousal ratings are shown in Table 16.

Table 16

Bivariate correlations of IGT net score of the first forty trials and the overall net score with the sexual picture rating and sexual arousal for both groups playing the modified IGT with sexual pictures on card decks C and D or on card decks A and B.

	IGT		**IGT**	
	sexual pictures on CD		**sexual pictures on AB**	
	net score (trials 1-40)	**net score (trials 1-100)**	**net score (trials 1-40)**	**net score (trials 1-100)**
sexual picture rating				
vaginal sex	.22	.09	-.19	-.23
heterosexual sex	.24	.10	-.20	**-.31***
sexual arousal				
t1	-.13	-.12	**-.34***	-.26
t2	**.44****	**.38***	-.16	-.11

* = $p \leq .05$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

** = $p \leq .01$ (correlation is significantly different from zero with alpha = 5%, two-tailed)

In order to test the hypothesis on the interaction effect between IGT version and subjective sexual arousal in predicting the decision-making outcome, we calculated a moderated regression analysis with group and sexual arousal at t2 as well as their interaction as predictor variables (all variables centralized, Cohen et al., 2003) and IGT's net score as dependent variable. In the first step, "group" explained 10.90% of the IGT net score ($F(1, 80) = 9.75$, $p < .01$). Adding "sexual arousal" in the second step, variance explanation did not increase significantly (changes in $R^2 = .011$, changes in $F(1, 79) = .99$, $p > .05$). When entering the interaction of group and sexual arousal (third step) the explanation of IGT net score increased

significantly (changes in R^2 = .058, changes in $F(1, 78) = 5.53$, $p < .05$). The overall explanation of IGT's net score through the three predictors remained significant (R^2 = .178, $F(3, 78) = 5.63$, $p < .01$). For further values see Table 17.

Table 17

Hierarchical regression analysis with IGT net score as dependent variable.

		β	***T***	***P***
Main effects	"group"	.322	3.13	.002
	"sexual arousal"	.151	1.45	.152
	"group x sexual arousal"	.246	2.35	.021

Given the significant interaction effect of group and sexual arousal, we analyzed the simple slopes to address the moderating effect of sexual arousal across the two groups in more detail. The slope of the regression line representing "low sexual arousal" (regression-based estimation for subjects one standard deviation below the group's mean) was not significantly different from zero (t = .05, $p > .05$), indicating no effect whether sexual pictures were associated to the advantageous or disadvantageous IGT decks. The slope of regression line representing "high sexual arousal" (regressed score for subjects having a sexual arousal one standard deviation above the group's mean) was significantly different from zero (t = 3.89, $p < .001$). This indicates that the net score was higher if sexual pictures were associated with the advantageous decks and lower if sexual pictures were linked to the disadvantageous decks. This demonstrates that in individuals who reported very low sexual arousal after sexual picture presentation decision-making performance did not differ across the two IGT versions.

In contrast, in individuals who reported high sexual arousal, the decision-making performance was worse when sexual pictures were associated with the disadvantageous decks and good when the sexual pictures were linked to the advantageous card decks (see Figure 9).

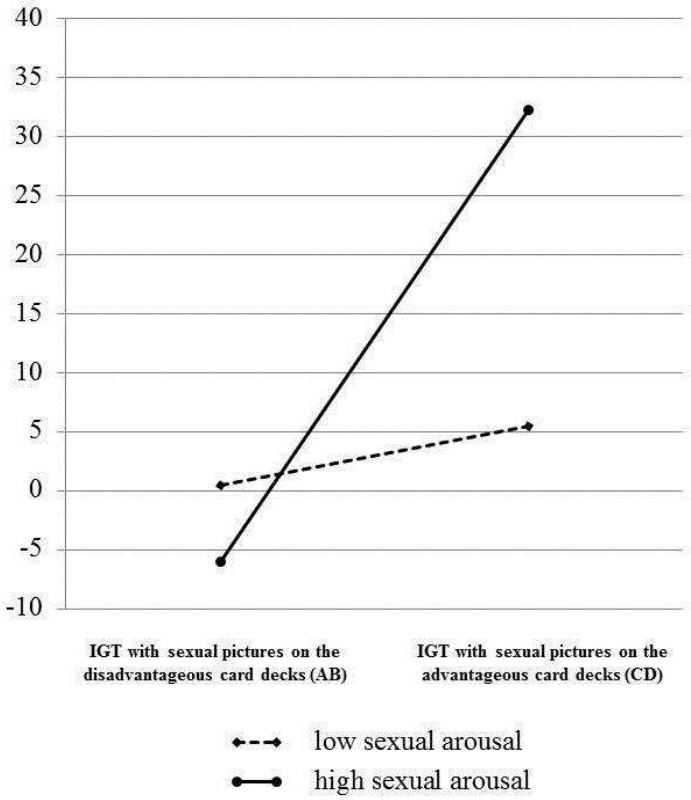

Figure 9

Demonstration of moderated regression analysis' results with the IGT net score as dependent variable. Participants reporting "low sexual arousal" show no difference between the experimental task conditions. Individuals reporting "high sexual arousal" reach a lower net score in the modified IGT with sexual pictures on the disadvantageous card decks A and B and a higher net score in the IGT version with sexual pictures on the advantageous card decks C and D.

5.5 Discussion

The aim of the present study was to explore the effect of sexual arousal on decision making under ambiguity using two modified IGT versions with sexual and neutral pictures in a

between-group design. In all participants, we induced sexual arousal by a presentation of sexual pictures prior to performing the IGT. The induction of sexual arousal was successful: the participants rated sexual pictures as arousing and, additionally, reported an increase of sexual arousal following the sexual picture presentation. The main results of the study are: decision-making performance was better when sexual pictures were associated with the advantageous alternatives and worse when sexual pictures were linked to disadvantageous alternatives. This effect was moderated by individual sexual arousal. Particularly in individuals who were highly sexually aroused after the presentation of sexual pictures showed the effect of disadvantageous decision making when the sexual pictures were on the back of the disadvantageous decks compared to those individuals who reported low sexual arousal.

The finding that decision making can be influenced by sexual stimuli, although they are not related to the decision-making rules and feedback contingencies, can be explained by two lines of argumentations. On the one hand, sexual pictures most likely have a stimulating nature and a strong incentive value for many males (Arnow et al., 2002; Brand et al., 2011; Paul et al., 2008; Redouté et al., 2000). In our investigation the stimulating and incentive character of sexual pictures is demonstrated in the finding that the confrontation with sexual stimuli led to an increase of subjective sexual arousal. By this, the stimulating nature of sexual pictures should contribute to a preference towards decision-making alternatives which are linked to sexual pictures compared to alternatives which are linked to neutral stimuli in order to receive and maintain gratification. This means that the sexual pictures on the card decks had potentially higher attraction than the neutral pictures, which leads to a higher preference of the participants for choosing these alternatives. This effect may particularly explain why subjects start to choose the card decks at the beginning of the IGT.

However, this effect cannot explain why participants keep selecting these alternatives over task duration when receiving high losses for their choices (in the group which played the

IGT with the sexual pictures on the disadvantageous decks). It is more likely that the attraction of sexual stimuli interferes with processing the feedback and learning to avoid these alternatives on the basis of the gains and losses received. We argue that sexual arousal due to the sexual pictures leads to a distraction from task requirements as well as to a neglect of feedback provided within the decision-making process, in particular in individuals who experience high sexual arousal when watching sexual pictures (in terms of a high sensitivity towards sexual stimuli). Detrimental effects of emotional arousal on IGT performance was already demonstrated in different ways. For example, it was shown that mood influences decision making, while positive mood is related to more advantageous and negative mood to more disadvantageous decision making (Suhr & Tsanadis, 2007; Vries, Holland, & Witteman, 2008). Moreover, as another example for a non-sexual arousal state, stress influences decision making negatively (Preston, Buchanan, Stansfield, & Bechara, 2007; Starcke & Brand, 2012; van den Bos, Harteveld, & Stoop, 2009). Detrimental effects of emotional stimuli on cognition were also shown e.g. regarding working memory (Dolcos & McCarthy, 2006; Erk et al., 2007; Gotoh, 2008; Kensinger & Corkin, 2003). This distractions were explained by stimuli's emotional salience, leading to a binding of attention competing with top-down control strategies of perception mediated by the amygdala (Hamann, 2001; Vuilleumier, 2005). With respect to sexual stimuli it was shown that sexual picture processing and sexual arousal interferes with working memory (Laier et al., 2012) as well as with other cognitive domains, measured for example by go/no-go, detection or choice reaction tasks (Macapagal, Janssen, Fridberg, Finn, & Heiman, 2011; Most et al., 2007; Prause et al., 2008; Schimmack, 2005; Wright & Adams, 1999). In our study, it seems plausible that the confrontation with sexual pictures bound attention, which interfered with processing the feedback provided following each decision. As processing the feedback is necessary to learn the task's contingencies and rules for winning and losing (e.g., Bechara et al., 1997; Brand et al., 2007), the interference of sexual stimuli with processing the feedback – in particular with processing

the high punishments for a disadvantageous choice – our results may explain why some individuals keep using cybersex (e.g., watching pornography on the Internet), although they experience negative consequences in their daily life (e.g., Brand et al., 2011).

Taken both lines of argumentation together, we assume that the good performance on a group's mean level in the group with sexual pictures on the good decks and the overall worse performance of the group with the sexual pictures on the bad decks is at first explainable by sexual pictures' character of invitation promising gratification leading to distraction from task requirements and reduced feedback learning. Research showed that individuals react differentially to sexual cues, while some are more prone for sexual excitation (Bancroft et al., 2009). This is also reflected in our data, as shown in the moderated regression analysis. Those subjects who report a high sexual arousal and who have to learn on the basis of the feedback that those alternatives, which are linked to pictures which promise gratification are the bad options, had clear reductions in their overall decision-making performance (the kept choosing the disadvantageous alternatives irrespective of the punishments they received). In turn, individuals who report high sexual arousal and who have to learn that those alternatives, which are linked to sexual pictures are good options, learned even more quickly to decide advantageously (they simply kept choosing the sexually masked options for which the received little punishments). In summary, the results support the hypothesis that sexual picture processing leads to interference of sufficient processing of emotional feedback in ambiguous decision-making situations (Bechara, Damasio et al., 2000; Bechara et al., 1999; Bechara et al., 2003; Naqvi et al., 2006) and may therefore explain why some individuals – in particular those who are sensitive for sexual gratification – make disadvantageous decisions in the context of their cybersex use.

The effect that subjective sexual arousal may contribute to dysfunctional decision making should be even stronger in real-life cybersex activities than in a laboratory setting.

Watching sexual pictures or videos at home might lead to even greater sexual arousal compared to an experimental situation, because individuals are in private and are able to control their environment, browse for sexual stimuli, which fit better to their personal preferences and pornography consumption might be accompanied by masturbation. Our main findings emphasize the view that sexual arousal in combination with the availability of sexual stimuli in the cybersex context can lead to neglecting potential negative short- or long-term consequences such as forgetting appointments, missing sleep, disregarding partnership, social life, school, academic or job performance and so on during participating in cybersex (Griffiths, 2001). Furthermore, those individuals who receive more gratification by cybersex due to a greater sensitivity for sexual excitation might be more prone to develop an increase of incentive sensitization due to pornography use (Martin-Soelch et al., 2001; Robinson & Berridge, 2001) potentially leading to addicted or excessive involvement in cybersex (Brand et al., 2011). Moreover, these results can be interpreted with relevance for different facets of cybersex (Döring, 2009). Since all kinds of cybersex regards any kind of decision making, sexual arousal or its expectation in combination with the availability of sexual stimuli might lead to disadvantageous decisions, which may cause negative consequences in the users' life.

Limitations and future directions

Although in some previous studies with the original IGT, the participants were paid contingently to IGT performance for motivational reasons, our participants received the same payment (independent from their final balance in the IGT) for several reasons: Firstly, there is an on-going ethical debate on whether or not to pay study participants depending on their performance. Secondly, there was research addressing this question showing no differences between IGT versions using real versus virtual money (Bowman & Turnbull, 2003). Finally, if motivation to perform the IGT would depend on or influenced by and performance

contingent payment, this effect should be the same for both groups in our study, since both groups were paid identically for their participation. This means that the group differences found cannot be attributed to the type of payment for study participation. With respect to the IGT performance, the net score in both versions was relatively low compared to IGT performance of healthy individuals reported in earlier studies, which applied the original IGT without pictures (e.g. Bechara, 2007; Brand & Altstötter-Gleich, 2008; Brand et al., 2007). The lower net scores may indicate that solving the modified IGT is more difficult irrespective of the picture content. To the best of our knowledge, no other studies using the IGT with picture manipulations has been published so far, so a direct comparison is not possible. Furthermore, by using an innovative modification of the IGT, we cannot prove that the design changed the underlying conditions of ambiguity by adding two paired card decks of neutral and sexual cues. However, the variance of IGT performance across studies is relatively high (overview in Buelow & Suhr, 2009; Dunn et al., 2006). Irrespective from the modification's effect on the IGT's conditions, one has to keep in mind that we had two groups in the study: One group saw the sexual pictures on the disadvantageous decks (and the neutral pictures on the advantageous decks) and the other group saw the sexual pictures on the advantageous decks (and the neutral pictures on the disadvantageous decks). The results are based on the comparison of these two groups. Consequently, if the ambiguity in the task would have been decreased, this must be true for both groups and the significant group differences and interactions reported are not confounded by a potential reduction of the ambiguity or complexity in the task. Since sexual arousal was identified as a main variable to improve the understanding of between-group differences in the experimental conditions, investigations aiming at exploring the effect of sexual arousal on different facets of cognition need to advance the induction as well as the monitoring of sexual arousal. Using different methods of measuring sexual arousal beyond simple self-reported subjective perception (Janssen et al., 2007; Kalmus & Beech, 2005) might improve our understanding of different facets of sexual

arousal (Janssen, 2011; Sachs, 2007) in interaction with cognitive functions. As a last limitation it has to be mentioned that the assessment of sexual arousal might underlie some unknown and uncontrollable biases. On the one hand, engaging in cybersex at home might e.g. be associated to fear of being discovered by a partner. Watching pornography within a laboratory setting might be associated to similar fears of being observed, or might give the participant the permission to respond to the same. Even though participants indicated an increase of sexual arousal and shared some information about sexual preferences and sexual (online) behavior, both might be biased since sexuality is a highly sensitive personal matter.

Even though cybersex use and especially watching pornography is widespread in the general population, it seems to be more widespread in males (e.g. Short, Black, Smith, Wetterneck, & Wells, 2012). Nevertheless, the effect of sexual arousal on decision making needs to be addressed in heterosexual women and homosexual men and women as well. Furthermore, to complement the results of this study, one could assign similar experimental designs on decision making under risk (Brand et al., 2006). Moreover, studies showing decision-making problems under ambiguity in different samples of addicted patients such as alcohol, cocaine or pathological gamblers (Bechara & Martin, 2004; Bolla et al., 2003; Brand et al., 2006; Goudriaan et al., 2005), could be transferred to individuals suffering from cybersex addiction (Kuss & Griffiths, 2011; Young, 2008). Changes in fronto-striatal brain loops seem to reflect changes in reward anticipation, planning, working memory, inhibitory control and feedback processing in dependent subjects (Koob & Volkow, 2010). Similar alterations could be relevant to cybersex addicted individuals, but this hypothesis needs to be tested empirically in the future.

6. General conclusion and future studies

Sexually motivated behaviors on the Internet are widely spread within the general population (e.g. Daneback et al., 2005; Döring, 2009). Although diverse Internet applications can be used for sexual purpose, particularly watching pornography on the Internet seems to be the most used facet of cybersex, especially by males (Short et al., 2012). While cybersex can be used for several reasons and in different viewing contexts, the main predictor of Internet pornography consumption is that individuals anticipate and gain sexual arousal and gratification from watching pornography (Paul, 2009). Although most individuals are able to use cybersex in a healthy and enriching way to satisfy and complement to their sexual needs (e.g. Grov et al., 2011; Hald & Malamuth, 2008), others report from symptoms of dependency and personal distress regarding their cybersex use. That means, they experience a loss of control about their cybersex use as well as diverse persistent negative consequences, for example spending money, neglecting, forgetting, or missing job or social responsibilities, appointments, or sleep (for review see Kuss & Griffiths, 2011). Given the clinical relevance of these disturbances, the aim of this thesis was to investigate mechanisms potentially underlying the development of cybersex addiction and mechanisms behind the occurrence of negative consequences resulting from cybersex use. To address these aims, four experimental studies with analogue samples have been presented: The first study investigated the role of sexual arousal, cue-reactivity, and the role of a poor or unsatisfying sex life for cybersex addiction. The second study focused on cue-reactivity as well as on the predisposing factors of sensitivity to sexual excitation, a problematic use of sex in general, and a pre-existing psychopathology in terms of vulnerability for cybersex addiction. The third study explored the effect of the stimulating nature of pornographic pictures on working memory, and the fourth study examined the effect of pornographic picture processing on decision making.

Within the following paragraphs, the main results of the four studies will be summarized and the observed effects will be inspected as well as compared critically regarding the methods applied. Afterwards, the results of the four studies will be integrated, discussed with respect to the theoretical background, and explained how they contribute to the gain of scientific knowledge. Furthermore, perspectives for future studies will be given.

6.1 Summary of the main results

The main result of the first study is that indicators of sexual arousal and reward craving, but not indicators of a poor or unsatisfying sex life predicted a tendency towards cybersex addiction. Moreover, it was shown that the reported satisfaction with the quality of real-life sex moderated the relationship between craving reactions and cybersex addiction. Results converge to the view that individuals with high craving reactions and a high satisfaction with real-life sex are more prone to cybersex addiction. This gives reason to assume that gratification in terms of positive reinforcement is a mechanism of development and maintenance of cybersex addiction. Results contradict the assumption that a poor or unsatisfying sex life can be considered as risk-factor in the development cybersex addiction. The main result of the second study is that assumed predefining factors for cybersex addiction as well as an indicator of reward craving predicted tendencies towards cybersex addiction. Moreover, craving partially mediated the relationship between vulnerability and tendencies towards cybersex addiction. These findings strengthen the assumption that mainly positive reinforcement received by cybersex mediated by processes of conditioning results in cue-reactivity and craving as main mechanisms underlying the development of cybersex addiction. Moreover, the results point out that these mechanisms might be particularly relevant for individuals with a high vulnerability for cybersex addiction. The third study showed that working memory-performance for pornographic pictures was worse than working memory-performance for neutral, negative and positive pictures. The sexual arousal as well

masturbation urges resulting from pornographic picture presentation interfered with working memory-performance within the pornographic picture condition, while individuals reporting high sexual arousal and high masturbation urges showed worst working memory-performance. The fourth study demonstrated that decision making under ambiguity was impaired when pornographic pictures had to be processes simultaneously. Sexual arousal resulting from pornographic picture presentation explained decision-making performance within the experimental task modification. Results support the assumption that sexual arousal disturbs emotional feedback processing following decision making and leads to a preference for rewarding behavior in the short run, while negative consequences in the long run are disregarded. Due to the findings of the third and the forth study the processing of pornographic pictures is associated with an increase of sexual arousal which itself interferes with cognitive processes important for goal-directed behaviors. Altogether, the findings of the four experimental studies identified indicators of sexual arousal as the main variables to explain tendencies towards cybersex addiction as well as interference with cognitive processes. Since sexual arousal is highly reinforcing (for review see Georgiadis & Kringelbach, 2012), it seems plausible to discuss these findings within the theoretical background of positive reinforcement and learning mechanisms. Nevertheless, to legitimate this discussion, a critical comparison regarding the methods applied needs to be conducted at first.

To assess subjective complaints in everyday life resulting from cybersex use and symptoms of cybersex addiction, a German short version of the IAT (Pawlikowski et al., 2012) modified for Internet sex sites was used. The s-IAT has twelve items asking for symptoms of dependency, which can be answered on a scale from 1 (= never) to 5 (= very often) and assigned to the two factors “loss of control and time management” and “craving and social problems”. The authors recommend using the overall sum score for general analyses and the sum scores of the two factors for specific analyses. Moreover, cut-off scores

for the s-IAT were defined: A problematic use of the Internet is indicated by an overall sum score above 30 and a pathological use of the Internet is indicated by an overall sum score above 37 (Pawlikowski et al., 2012). In the four studies, the modification of the this questionnaire for Internet sex sites was done comparable to Brand et al. (2011), i.e. terms like "online" or "Internet" were replaced by the terms "online sexual activity" or "Internet sex sites" (for a more detailed description of the s-IATsex please see section 2.3.2). A mean overall sum score of the s-IATsex was reported in the first, in the second and in the fourth study. Applying the cut-off scores defined for the s-IAT to the s-IATsex, the mean values of the three samples suggest an unproblematic use of cybersex on group level. Looking at individual sum scores, all samples included participants reporting a problematic or a pathological use of cybersex. In the first study, 154 participants used cybersex non-problematically, 14 individuals used cybersex problematically and three participants used cybersex pathologically. In the second study, the use of cybersex was not problematic in 117 of the participants, while six reported a problematic and two a pathological use of cybersex. In the fourth study, 75 participants indicated a cybersex use which can be considered as unproblematic, six individuals used cybersex problematically, and one participant reported a pathological use of cybersex. Taken as a whole, the observed variance of the s-IATsex in the three studies is as expected when investigating analogue samples. Although the observed main results of the studies need to be replicated in studies using clinical samples (for more detailed comment on limitations please see section 6.3), the s-IATsex showed variance allowing interpreting the results within the proposed theoretical framework.

To assess indicators of cue-reactivity and reward craving, in all of the four studies the same experimental paradigm was used. This paradigm consisted of the presentation of 100 pornographic pictures displaying explicit pornographic scenes between one man and one woman, between two males, between two females, or masturbating males or females. All pictures had to be rated regarding subjective sexual arousal, viewing times of the pictures

were recorded and participants were asked to indicate their sexual arousal as well as their need to masturbate previous and following the pornographic picture presentation. Applying this kind of experimental paradigm has been justified under the consideration the consideration of cybersex addiction in analogy to substance and other behavioral addictions. Studies addressing craving in substance and behavioral addictions have previously used similar experimental paradigms, i.e. addiction associated cues have been presented and reward craving has been measured subjectively (e.g. Garavan et al., 2000; Goudriaan et al., 2010; Gray et al., 2008; Grüsser et al., 2000; Ko et al., 2009; Kushner et al., 2008; Thalemann et al., 2007). Aiming at investigating the role of craving in cybersex addiction, this kind of experimental paradigm has been modified with pornographic pictures to address cybersex addiction. The pictures included had to fulfill several criteria, e.g. no fetish relevant material has been shown (for description of criteria please see Brand et al., 2011). In all of the four studies, the pornographic picture presentation led to a comparable increase of sexual arousal and of the need to masturbate. Although the increase was moderate on group level, high standard deviations were observed indicating a great variance with respect to these craving reactions. This is in line with studies addressing sexual arousal which converge to the view that individuals differ with respect to their sensitivity for sexual excitation by external sexual stimuli (Bancroft et al., 2009; Janssen et al., 2009). Taken together and against the background drawn by previous studies, the modification of the experimental paradigm seems to be appropriate to address the role craving reactions in cybersex addiction.

In the third study, a n-back task (for reviews see Jaeggi et al., 2010; Owen et al., 2005) modified with neutral, negative, positive, and pornographic pictures was administered to the participants. In the fourth study, the IGT (Bechara, 2007) was modified with pornographic and neutral pictures. Both or similar modifications have not been published in working memory and decision making literature yet. Because of that a direct comparison of the performance in both tasks to other studies cannot be drawn (for limitations regarding study 3

please see section 4.5, for limitations regarding study 4 please see section 5.5). With respect to the other methods applied in the four studies, mostly validated questionnaires were used to ensure the validity of the measured constructs. Taken together, the applied methods in the studies are appropriate to measure the intended psychological constructs. Therefore, the observed effects can be discussed with respect to the underlying theoretical assumptions and can be integrated into a broader framework regarding addictive behaviors.

6.2 General conclusion

In the first and the second study it has been shown that indicators of reward craving were associated to and predicted tendencies towards cybersex addiction. Within the general framework of substance addiction it has been demonstrated by numerous studies that most notably cue-reactivity and craving are substantial key concepts with respect to their development and maintenance (for reviews see Everitt & Robbins, 2005; Hyman et al., 2006; Tiffany & Wray, 2012). On the one hand it has been revealed that the highly positive reinforcing effects of the drug of choice mediated by processes of classical and operant conditioning result in cue-reactivity and reward craving. That means, addiction related cues induce a strong urge to repeatedly consume a drug in the anticipation for their rewarding effects, because addicted individuals have learned that addiction related use are followed by this anticipated effects. On the other hand it has been shown that neural changes accompanied by chronic drug use leads to symptoms of withdrawal. Within this aversive state, withdrawal relief craving emerges to avoid the aversive physiological and psychological states (for reviews an craving see Anton, 1999; Drummond, 2001). Against this background of positive reinforcement's important role in the development of addictions, it has been hypothesized that positive reinforcement received by sexual arousal in cybersex might be the relevant key factor within the development of cybersex addiction (e.g. Young, 2008). This assumption can be

deduced by two lines of arguments: First, it has been shown that sexual arousal is indeed strongly associated to reward related brain activity (e.g. Arnow et al., 2002; Holstege et al., 2003; Paul et al., 2008). Second, it has been observed that sexual arousal can be conditioned in humans (Hoffmann et al., 2004; Klucken et al., 2009; Lalumiere & Quinsey, 1998). First empirical evidence for the link of learning based cue-reactivity and cybersex addiction was given in the study of Brand et al. (2011) and are underlined by the results observed in the first and the second study. Theoretical assumptions and empirical evidence lead convincingly to the legitimate assumption that processes of conditioning and cue-reactivity are the key elements to describe the development of cybersex addiction. Following the principles of conditioning (e.g. Martin-Soelch et al., 2007), both classical and operant conditioning should contribute to its development. If individuals receive gratification (i.e. they are reinforced by cybersex), operant conditioning should lead to an increased probability of repeated cybersex use. If cybersex is done recurrently, classical conditioning should lead to an association of sexual arousal with diverse internal and environmental cues. That means that sexual arousal as an US may be associated to internal (e.g. negative emotions, stress) or external stimuli (e.g. computer, home environment). In turn, the occurrence of these cues should lead to the anticipation of sexual arousal after conditioning has led to cue-reactivity. In consequence this means, if addiction related cues are not followed by the learned reinforcing effects, reward related craving should emerge, probably leading to repeated cybersex use. Accordingly to the symptoms reported by cybersex addicted individuals (Kuss & Griffiths, 2011b) this mechanism explains why cybersex is indulged in repeatedly in the face of growing, but neglected negative consequences. The proposed mechanism should be particularly relevant for individuals with a high vulnerability to cybersex addiction, because individuals with sensitivity for sexual excitation, a generally problematic use of sex as well as with a generally high severity of psychological-psychiatric symptoms should be more prone for being reinforced by cybersex. With regard to the sensitivity for sexual excitation, its importance has

already been outlined for the development of hypersexual behaviors (e.g. Kafka, 2010a). On a speculative level, receiving stronger reinforcement due to sexual cues might result from a genetic predisposition. Contributing to this assumption, a candidate gene was identified to be associated with Internet addiction recently (Montag, Kirsch, Sauer, Markett, & Reuter, 2012). However, a genetic vulnerability to sexual excitation might explain why some individuals have greater reward sensitivity for sexual cues. With respect to the neglect of negative consequences resulting from cybersex use, it seems plausible that these may result from the conditioned incentive salience of cybersex, since addiction related cues lead to stronger emotional arousal and greater interference of goal-directed behaviors (Carter & Tiffany, 1999; Tiffany & Wray, 2012). Taking the theoretical implications of the conducted studies into account, positive reinforcement due to cybersex seems to be the main factor in the development and maintenance of cybersex addiction.

In the third and in the fourth study it has been shown that sexual arousal elicited by pornographic pictures interfered with cognitive processes important for goal-directed behaviors. Regarding executive functioning previous research outlines the relevance of abilities to focus attention, to inhibit irrelevant information, to switch between relevant information, but moreover, to plan, monitor and code information in working memory (Alvarez & Emory, 2006; Chan et al., 2008; Jurado & Rosselli, 2007; Miyake et al., 2000). The main result of the third study is that indicators of sexual arousal interfered with working memory. This is in line with other studies reporting detrimental effects of sexual stimuli on cognitive processes (Most et al., 2007; Prause et al., 2008; Wright & Adams, 1999). Since pornographic picture processing is linked to brain structures associated with emotion, arousal, and attention (e.g. Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000), it seems plausible to interpret the observed results against the theoretical background of emotional attention capturing (e.g. Vuilleumier, 2005). According to this, the pornographic pictures in the working memory task seem to have captured the participants' attention resulting in worse

working memory-performance caused by distraction from task demands. In the fourth study it has been found that decision making in a modified version of a decision-making task was worse, if pornographic pictures were associated to disadvantageous decision-making alternatives. Accordingly, decision making was better, if pornographic pictures where associated to advantageous decision-making alternatives. The finding that decision making can be influenced by pornographic stimuli, although they are not related to the decision-making task's rules and feedback contingencies can be explained by the reinforcing nature of pornographic pictures. It seems plausible that the pornographic pictures bound attention, which interfered with the processing of the feedback provided by the task following each decision. As processing this feedback is necessary to learn the task's contingencies and rules for winning and losing (e.g., Bechara et al., 1997; Brand et al., 2007), the interference of pornographic pictures with feedback processing might explain the preference for decision-making alternatives linked to pornographic pictures. Against the background of executive functioning, the interference of pornographic picture processing with working memory and decision making may partly explain why some individuals keep using cybersex, although they experience negative consequences during or following engaging in cybersex. Sexual arousal received during cybersex might lead to a preference for short-term reinforcement, neglecting potential negative short- or long-term consequences (e.g. leading to forgetting appointments, missing sleep, disregarding partnership, social life, school, academic or job performance, etc.). This conclusion gains in importance against the relevance of conditioning, cue-reactivity and reward craving in the development and maintenance of cybersex addiction. If negative consequences experienced during or following cybersex use cannot be anticipated or are disregarded, this should in terms of conditioning (Martin-Soelch et al., 2007) expose the relevance of positive reinforcement due to cybersex. Most notably, neglecting possible negative consequences should (particular in highly vulnerable individuals) contribute to repeated engagement in cybersex, if cue-reactivity has developed and craving (e.g. Anton,

1999; Drummond, 2001; Tiffany & Wray, 2012) emerges due to addiction related cues or withdrawal. The findings of the four studies that positive reinforcement due to pornographic pictures is associated to reward craving responses and interferes with cognitive processes important for goal-directed behaviors need to be embedded into the underlying theoretical framework of Internet addictions.

The most influential theoretical model addressing PIU is the cognitive-behavioral model developed by Davis (2001). As summarized in the Introduction (pp. 16-18) as well as in the first (p. 41) and second study (pp. 65-66), it explains PIU within a diathesis-stress framework and assumes that a general, multidimensional overuse of the Internet develops based upon on a pre-existing psychopathology, maladaptive cognitions as well as by social aspects for GPIU and by mechanisms of reinforcement gained for SPIU. The Internet is proposed to offer immediate reinforcement and is said to be used to cope with negative affect and negative thoughts about one self, but offers only short-term, immediate reinforcement. As the core mechanism in the development of PIU, maladaptive cognitions are introduced. Maladaptive cognitions and processes of reinforcement are postulated to lead to recurrent Internet use and the maintenance and intensification of the affective and behavioral symptoms of GPIU. For SPIU, a pre-existing psychopathology, maladaptive cognitions, and specific effects of reinforcement offered by several specific Internet applications are outlined, while social issues are said not to be relevant for the development of specific pathological Internet use (Davis, 2001). Although the model conceptually improved our understanding of pathological Internet use, it misses the opportunity to postulate differential mechanisms of development and maintenance of generalized and specific PIU with respect to positive and negative reinforcement. The studies conducted within this thesis give reason to assume that mainly positive reinforcement serves a as mechanism underlying cybersex sex addiction.

With respect to cybersex addiction as a SPIU, studies addressing psychological correlates as well as mechanisms of development and maintenance are rare. One explanation for this circumstance might be that most of the previous studies addressing Internet addiction did not assess the Internet use of choice and treated Internet addiction as a unitary construct neglecting the potential multidimensional nature of Internet addiction (Weinstein & Lejoyeux, 2010; Young et al., 1999). Regarding cybersex addiction, it has been shown that a general psychological-psychiatric symptom severity and subjective sexual arousal due to pornographic stimuli are associated to symptom severity of cybersex addiction (Brand et al., 2011; Kuss & Griffiths, 2011). Neuroimaging studies demonstrate that sexual cues activate brain structures associated to reward (e.g. Arnow et al., 2002; Paul et al., 2008; Redouté et al., 2000) and that amygdala activity as a reaction on sexual cues is associated to general sexual desire (Demos, Heatherton, & Kelley, 2012). The role of a specific for sexual excitation for the development of sex or cybersex addiction has been pointed out theoretically, but has not been investigated empirically, so far (Kafka, 2010a).

As mentioned above, the main results of the first and second study conducted within this thesis are that the severity of cybersex addiction is associated and predicted by indicators of sexual arousal, craving reactions, and predefining factors of vulnerability. This strengthens the assumption that processes of conditioning and resulting cue-reactivity are important processes in the development and maintenance of cybersex addiction. Based upon the aggregation of theoretical assumptions and empirical findings, a pre-existing psychopathology, sensitivity for sexual excitation as well as a generally problematic use of sex can be understood as predefining factors for cybersex addiction. Moreover, processes of classical and operant conditioning should lead to the development and maintenance of cybersex addiction by associating internal (e.g. emotions, stress) or external (e.g. computer, home environment, etc.) cues with gratification received by cybersex resulting in cue-reactivity, craving reactions, and repeated engagement in cybersex. Based upon the theoretical

embedding and empirical findings regarding SPIU, a revised model of specific pathological Internet use is illustrated in Figure 10. The model aims at outlining positive reinforcement as the main mechanism of development and maintenance for SPIU. On a speculative level, a revised model of GPIU will be outlined afterwards.

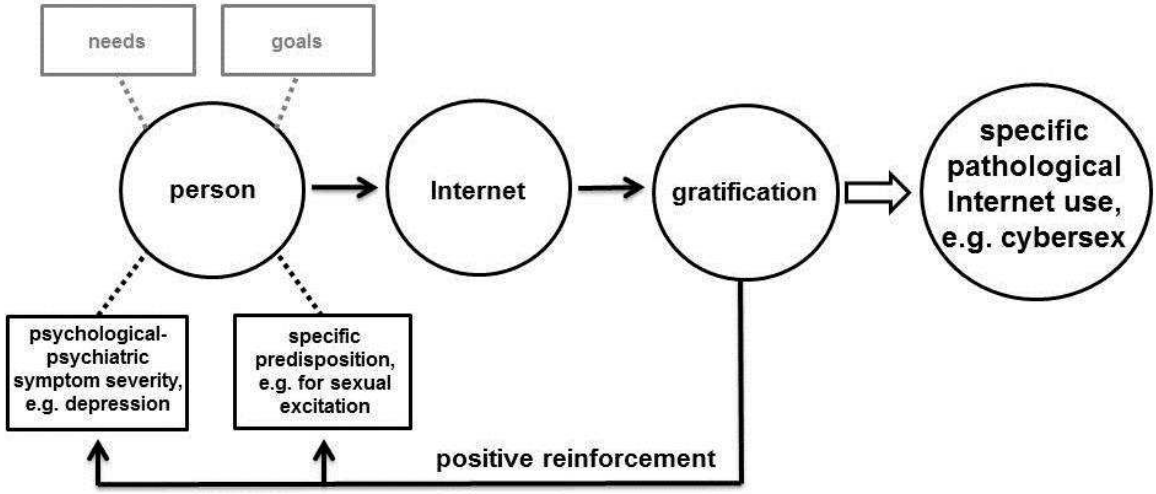

Figure 10

Model of specific pathological Internet use, e.g. cybersex addiction. Individuals predefined by psychopathology and a specific predisposition (e.g. for sexual excitation) receive strong gratification from cybersex. Positive reinforcement as learning mechanism is proposed to be the main mechanism of development and maintenance of cybersex addiction.

Some individuals use the Internet for sexual motivated behaviors and develop an addictive usage pattern resulting in personal distress, loss of control, symptoms of dependency as well as the persistent experience of negative consequences (Kuss & Griffiths, 2011b). The introduced model assumes positive reinforcement as the main mechanism of development and maintenance of cybersex addiction. The revised model of SPIU postulates that besides a

psychological-psychiatric pathology, a specific predisposition (e.g. sensitivity for sexual excitation, using sex problematically in general) is a further factor of vulnerability for the SPIU of cybersex addiction. Highly vulnerable individuals should be more prone to receive positive reinforcement due to cybersex. Consequently and against the background that individuals cannot anticipate or neglect negative consequences of their cybersex use, positive reinforcement should lead to the development of cue-reactivity maintaining SPIU. Therefore, positive reinforcement is supposed to be the main mechanism in the development and maintenance of cybersex addiction.

From the results of the studies conducted within this thesis no conclusions can be drawn regarding GPIU. On a speculative level, but based upon the conclusions which can be drawn by other studies, a revised model of GPIU is presented in Figure 11.

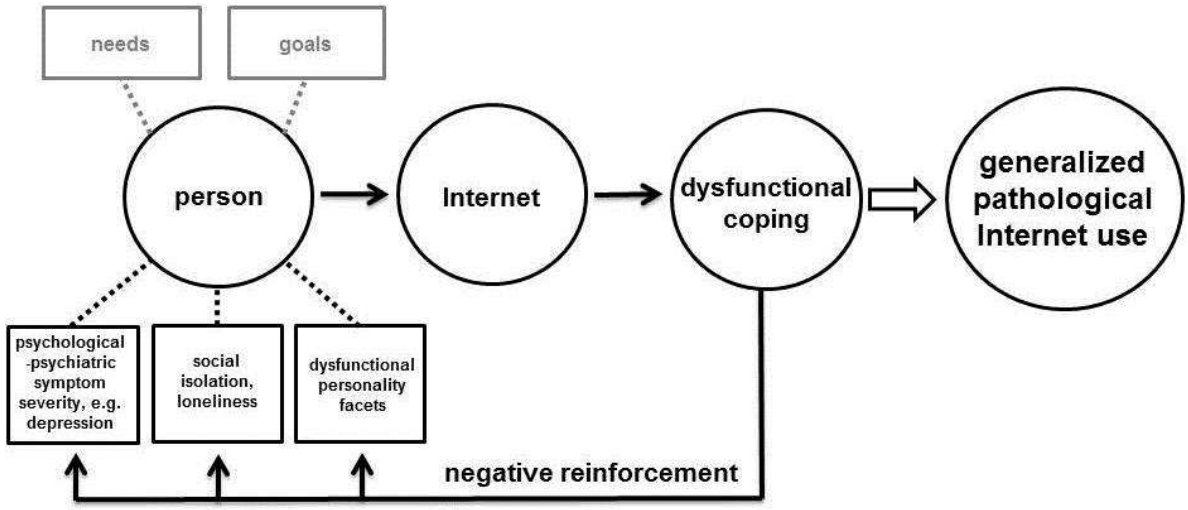

Figure 11

Postulated model of generalized pathological Internet use. Individuals predefined by psychopathology, social isolation and loneliness as well as by dysfunctional personality facets use the Internet as dysfunctional coping mechanism. Due to being negatively reinforced by the Internet, a generalized pathological Internet use develops.

Several studies demonstrate that a pre-existing psychopathology (Ko et al., 2012; Whang et al., 2003; Yang et al., 2005), social isolation and a lack of social support (Caplan, 2005; Morahan-Martin & Schumacher, 2000) as well as neuroticism, social anxiety, shyness, tendencies to procrastinate, low self-efficacy, and stress vulnerability (Caplan, 2007; Chak & Leung, 2004; Ebeling-Witte et al., 2007; Hardie & Tee, 2007; Kim & Davis, 2009; Niemz et al., 2005; Thatcher et al., 2008; Whang et al., 2003) are associated to symptom severity of GPIU. It becomes apparent that besides a pre-existing psychopathology differential correlates regarding personality facets and social support have been identified to be relevant factors in the development of GPIU. On a speculative level this gives reason to assume that within GPIU, the Internet is generally functionalized as a dysfunctional coping and emotion regulation mechanism to avoid aversive states experienced by predefined individuals. The theoretical embedding of reinforcement leads to the conclusion that negative reinforcement might be the main mechanism of development and maintenance of GPIU. However, these assumption needs to be tested empirically.

In conclusion, the four studies conducted contribute significantly to the understanding of cybersex addiction. While the number of previous studies is very limited and most assumptions were drawn theoretically, the four studies give insight into the mechanisms of development and maintenance of cybersex addiction. Most notably, empirical experimental evidence has been demonstrated supporting the assumptions that mainly positive reinforcement received by cybersex is associated to both craving reactions as well as to interference with cognitive processes. Since the formulation of the hypotheses as well as the experimental designs applied were reasoned upon the findings and experimental methods used in substance dependence research, the observed effects give further evidence to consider a cybersex use accompanied by subjective complaints in everyday life, symptoms of

dependency, and personal distress as an behavioral addiction. Nevertheless, the studies' limitations have to be mentioned to ensure their range of validity. Moreover, suggestions for future studies, necessary for a legitimate inclusion of cybersex addiction into the international classification systems of diseases, will be given (APA, 2000; WHO, 1993).

6.3 General limitations and future studies

The insights of the studies rely on the investigation of freely recruited heterosexual males of middle age. Therefore, the generalization of the findings is limited to this group and need to be replicated in samples of interest to draw similar conclusions with respect to other populations. It has been reported that adolescents (e.g. Brown & L' Engle, 2008) and adult females (e.g. Ferree, 2003) use the Internet for sexual purposes, too. But investigating factors of vulnerability for or mechanisms of development and maintenance of cybersex addiction in adolescents or adult females might lead to differential different results. As another limitation of the studies it has to be outlined that the experimental paradigms for inducing sexual arousal included only self-reported indicators of sexual arousal as well as viewing times. Moreover, the used pornographic stimuli included only displayed sexual practices excluding attributes potentially associated to fetishes. Therefore, neither a conclusion about physiological correlates of cybersex addiction nor about an excessive use of specific pornographic materials can be drawn. Furthermore, within the investigations of middle-aged heterosexual males, several aspects have not been analyzed in detail potentially giving further insight into the characteristics of individuals using cybersex. For example, the influences of partnerships, of age, or several personality facets have not been addressed.

However, the results of the studies conducted within this thesis imply to investigate diverse questions to assure the reported findings and to contribute to a broader understanding of cybersex addiction. First of all, the model of SPIU presented in the general discussion

needs to be addressed empirically stepwise. Following this rational, the postulated process of conditioning leading to cue-reactivity could be investigated in a further study with a predefined sample. For this, modifications of paradigms established in substance dependency research could be modified, for example conditioning tasks (e.g. Trick, Hogarth, & Duka, 2011). Modifying this kind of task with pornographic pictures as reinforcing cues it would be possible to investigate the proposed learning mechanism of positive reinforcement.

Secondly, the proposed specific predisposition for cybersex addiction could be investigated in more detail. The predefining factor of sexual excitation due to sexual cues might result from a genetic predisposition. Recently, a candidate gene was identified to be associated with Internet addiction (Montag et al., 2012). Moreover, specific risk-factors for cybersex addiction could be addressed for different populations of sexual preference. As outlined by Döring (2009), using the Internet for sexual purposes might have some greater relevance for sexual subcultures, because they use Internet sex related websites not only to gain sexual arousal or to gain sexual information, but moreover to make social contacts with individuals sharing the same sexual preference more often. It was shown that cybersex addiction also occurs in homosexual males and females (Green et al., 2012; Grov et al., 2008), the greater linkage of both, the possibility to make social contacts and to gain sexual arousal by cybersex, could be considered as a specific risk-factor for bi- and homosexual individuals. Although it was shown that poor or unsatisfying real-life sex was not associated to tendencies towards cybersex addiction, it needs to be investigated if this is also true for deviant sexual preferences not being fulfilled in real-life sex at all, for example a preference to sadomasochism (Reiersøl & Skeid, 2006), fetishism (Kafka, 2010b) or pedophilia (Blanchard et al., 2009; Seto, 2009). To address this, future studies need to assess the number of sexual contacts, the satisfaction with their frequency and quality, and moreover, the fantasizing about the desired but not actually lived sexual preference. Against the background that a fantasy type of cybersex users has been postulated to be at risk for developing a cybersex addiction

(Cooper et al., 2004), it seems worth investigating the role of fantasies for cybersex addiction in general and for specific sexual interests.

Thirdly, although identifying effects in predefined samples gives reason to assume same effects are relevant and found within patient samples, the observed effects need to be verified in samples of cybersex addicted individuals. This kind of validation is necessary to give cybersex addiction the necessary empirical background to understand and classify it as a distinct mental-health problem, especially for an entry of sex and cybersex addiction into the international coding systems of diseases (APA, 2000; WHO, 1993). After showing the same or even stronger effects within a clinical sample of cybersex addicted patients, neurophysiological correlates of cybersex addiction need to be addressed to draw conclusions about the similarity to substance addictions. In a neuroimaging study it has been shown that addicted related cues elicited activations in brain regions associated with emotion, arousal and craving in excessive gamers of to the online game World of Warcraft (Ko et al., 2009). The pattern of activation was comparable to those known from substance addiction research (e.g. Grüsser et al., 2004; Heinz et al., 2009). Finding the same differences in neural activations of cybersex addicted individuals with respect to brain structures classically linked to addiction would strongly support a classification of cybersex addiction.

Fourthly, with respect to the interfering effect of sexual arousal on cognitive processes, it seems worth describing the mechanism of such interferences in more detail. One could assume that pornographic picture processing and sexual arousal do not only lead to worse working memory-performance, but might also interfere with monitoring processes. To address this, voluntary task switch paradigms (e.g. Arrington & Logan, 2004) could be modified with pornographic pictures. Moreover, since executive functioning is important for decisions under risk (e.g. Brand et al., 2007), one could assume that sexual arousal leads to worse decision making under risk as well.

Moreover, one very important challenge of future studies is to investigate the relationship between cybersex and sex addiction. The phenomenology of patients ranges from individuals suffering from sex addiction, cybersex addiction, or both (Delmonico & Miller, 2003; Garcia & Thibaut, 2010; Kafka, 2010a; Levine, 2010). The risk of other addictive behaviors, which can be carried out offline and online, is discussed for example with respect to gambling, too (Kairouz, Paradis, & Nadaeu, 2012). The research question remains, if sex addiction and cybersex addiction can be understood as two dimensions underlying hypersexuality as proposed by e.g. Kafka (2010a), or if cybersex addiction is a specific Internet addiction as proposed e.g. by Young (2008).

Finally, a further important challenge for future studies is to develop and review effective treatment programs for cybersex addiction. It has been shown that cognitive-behavioral therapy is efficient to treat addictions (for review see McHugh, Hearon, & Otto, 2010). Moreover, first evidence has been provided that cognitive-behavioral works well in Internet addiction, too (Rooij, Zinn, Schoenmakers, & Mheen, 2010). The findings of this thesis imply that cue-reactivity and craving can be considered as mechanisms of development and maintenance of cybersex addiction. To prevent reward craving induced relapse (Weiss, 2005), it should be important to support the executive control of cybersex addicted individuals. Therefore, methods used in cognitive-behavioral therapy (e.g. motivational interventions, contingency management, and particularly relapse prevention) could be applied in the treatment of cybersex addiction. However, to prove which therapy is most efficient for treating cybersex addiction, several clinical trials have to be conducted and compared.

7. References

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8. List of Tables

9. List of Figures

10. Erklärung über die eigenständige Verfassung der vorgelegten Dissertation

Hiermit versichere ich, dass die vorgelegte Dissertation gemäß §9 der Promotionsordnung der Fakultät für Ingenieurwissenschaften der Universität Duisburg-Essen vom 9. Juni 2009 eine selbstständig durchgeführte und eigenständig verfasste Forschungsleistung darstellt und ich keine anderen als die angegebenen Hilfsmittel und Quellen benutzt habe. Die Arbeit hat weder in gleicher noch in ähnlicher Form einem anderen Prüfungsausschuss vorgelegen.

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