Cybersex addiction: Conditioning processes and implicit cognition

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Study 2

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AAT	Approach Avoidance Task
ABT	Attentional Blink Task
ACT	Attentional Cueing Task
ANOVA	Analysis of variance
AST	Addiction Stroop Task
CR	conditioned reaction
CS	conditional stimulus
EAST	Extrinsic Affective Simon Task
FLP	Flicker Paradigm
GIA	generalized Internet addiction
IAT	Implicit Association Test
NS	neutral stimulus
s-IAT	short version of the Internet Addiction Test
s-IATsex	short version of the Internet Addiction Test modified for cybersex
SIA	specific Internet addiction
PIT	Pavlovian to instrumental transfer
S-PIT	Standard Pavlovian to Instrumental Transfer Task
S-PITsex	Standard Pavlovian to Instrumental Transfer Task for cybersex
ST-IAT	Single Target Implicit Association Test
UCR	unconditioned reaction
US	unconditioned stimulus
VPT	Visual Probe Task
VST	Visual Search Task

1 General abstract

Research on cybersex addiction, as one form of specific Internet addiction, has been receiving growing attention in the past years. However, there is no consensus regarding the phenomenology, classification, and diagnostic criteria of cybersex addiction and respectively Internet addiction, so far. Some approaches suggest similarities to substance dependencies for which conditioning processes, approach/avoidance tendencies, and implicit associations are seen to be crucial mechanisms regarding development and maintenance. In the course of this dissertation, three studies were conducted which investigate these mechanisms in the context of cybersex addiction. Each study adapted an experimental paradigm used in substance dependence research while it was expected to obtain comparable results. First, to investigate conditioning processes, a Standard Pavlovian to Instrumental Transfer Task (S-PIT; Hogarth, Dickinson, Wright, Kouvaraki, & Duka, 2007) was modified. Second, an adapted version of the Approach Avoidance Task (AAT; Rinck & Becker, 2007) was used for investigating a potential role of approach/avoidance tendencies. Third, to assess effects of implicit associations on cybersex addiction, an Implicit Association Test was adapted (IAT; Greenwald, McGhee, & Schwartz, 1998). All experimental paradigms were modified with pornographic pictures. Results revealed that conditioning processes, approach/avoidance tendencies as well as implicit associations had an effect on tendencies towards cybersex addiction. Moreover, all three studies could show that self-reported symptoms of cybersex addiction were particularly high if the investigated mechanisms interacted either with specific predispositions towards sex (i.e. sexual excitation or problematic sexual behaviors) or subjective craving due to watching pornographic pictures. Overall, the findings of this dissertation provide further empirical evidence for similarities between cybersex addiction and substance dependencies. Therefore, similarities between dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) and the theoretical framework of cybersex addiction by Laier and Brand (2014) are discussed. Furthermore, extensions of the cybersex addiction framework by Laier and Brand (2014) are proposed. At last, practical implications are discussed, while limitations and future directives are pointed out.

2 General introduction

In 1988, a research report by the National Research Council in the USA marked the start of the development and implementation of a high-speed network infrastructure which built the first step to enable worldwide Internet access (Leiner et al., 2009). The impact of the Internet on everyday life has increased rapidly, while, beneath work-related applications, it is used to satisfy informational, entertainment, and social needs (Byun et al., 2009). Regarding general Internet use in 2014, it was estimated that 77% of the inhabitants living in developed countries used the Internet on a regular basis, whereas this marks an increase of 321% over the past 15 years (International-Telecommunication-Union, 2015). Recently, a representative study by the German public broadcasting service reported an average Internet use of 233 minutes per day in the age group between 14 and 29 years, while the amount of non-users is constantly decreasing (van Eimeren & Frees, 2014).

Although most of the people use the Internet and its possibilities in a functional way, it is estimated that 1.5% - 8.2% of the general population experience negative consequences in everyday life due to their Internet use (Weinstein & Lejoyeux, 2010). Since the classification and diagnostic criteria for this phenomenon are under debate, there is no consistent phenomenology, so far. However, the term “Internet addiction” seems to be dominant because of growing empirical evidence for the existence of subjective symptoms comparable to those observed in substance dependencies (e.g. Brand, Laier, & Young, 2014; Brand, Young, & Laier, 2014; Griffiths, 2001; Kuss, Griffiths, Karila, & Billieux, 2014; Young, 1998a; Young, Pistner, O'Mara, & Buchanan, 1999). Further, several researchers argue to separate between generalized and specific Internet addiction (e.g. Brand, Young, et al., 2014; Davis, 2001; Montag et al., 2014). Besides the investigation of subjectively reported symptoms, a growing amount of studies on Internet addiction could provide similarities between substance dependencies and Internet addiction on a neuropsychological and neurophysiological level. For instance, studies investigating Internet gaming addiction found indicators of cue-reactivity and craving (e.g. Ko, Li, et al., 2013; Lorenz et al., 2012; Thalemann, Wölfling, & Grüsser, 2007), which are supposed to play a crucial role within addictive behaviors (Tiffany & Wray, 2012). Thereby, cue-reactivity represents subjective and physiological responses to addiction-related cues (Drummond, 2001), while craving is mostly referred to a subjectively experienced urge to consume a drug (Sayette et al., 2000). It has frequently been argued that cue-reactivity and craving are based on conditioning processes and reinforcement learning (for review see M. D. Skinner & Aubin, 2010). Consequently, Dong and Potenza (2014) proposed a theoretical

framework for Internet gaming addiction which can be linked to dual-process models of addiction (e.g. Bechara, 2005; R. W. Wiers & Stacy, 2006) as well as neurophysiological theories from substance dependence research (e.g. Everitt & Robbins, 2005; Robinson & Berridge, 1993, 2001, 2008).

In the context of this thesis, cybersex addiction, as one form of specific Internet addiction (SIA) will be focused. Regarding existing research on cybersex addiction, several researchers have already reported symptoms comparable to substance dependencies. More concrete, studies revealed that indicators of cue-reactivity and craving might be mechanisms in cybersex addiction (Brand et al., 2011; Laier, Pawlikowski, Pekal, Schulte, & Brand, 2013). These studies reported that individuals with tendencies towards cybersex addiction showed both cue-reactivity and an increase of subjective craving when confronted with pornographic pictures. Further, there is preliminary evidence for effects of neural plasticity and functional connectivity in relation to pornography consumption (Kühn & Gallinat, 2014) as well as cue-reactivity with respect to sexually compulsive behavior (Voon et al., 2014). Additionally, while watching pornographic pictures, neuroimaging studies found activations in claustrum, hypothalamus, striatum (caudate nucleus, putamen), and paralimbic structures (anterior cingulate cortex, orbitofrontal cortex, insula) which are regions associated with arousal and reward (Arnow et al., 2002; T. Paul et al., 2008; Redouté & Stoléru, 2000). These neural structures are supposed to be involved in the development and maintenance of addictive behaviors (Everitt & Robbins, 2005). Moreover, it has been argued that addictive behaviors are related to neural adaptions, which lead to an enhanced sensitivity towards addiction-related cues and promote the continuation of addictive behaviors despite negative consequences (Robinson & Berridge, 1993, 2001, 2008).

Only a few studies concretely investigated similarities between substance dependencies and cybersex addiction. The existing evidence in this domain is preliminary because there is a lack of experimental studies (for review see Griffiths, 2012). Since it is currently under debate whether or not cybersex addiction should be classified in analogy to substance dependencies as a behavioral addiction, it seems plausible to use and adapt standardized tools from substance dependence research to enrich this discussion. Following, the aim of this thesis is to deeper investigate possible mechanisms for the development and maintenance of cybersex addiction by adapting well-established paradigms derived from substance dependence research in experimental designs.

The development of cue-reactivity and craving involves conditioning processes and reinforcement learning. Therefore, it is plausible to assume that conditioning might play a role in cybersex addiction. This assumption is also supported by the fact that sexual arousal can be conditioned (e.g. Hoffmann, Janssen, & Turner, 2004; Hoffmann, Peterson, & Garner, 2012; Klucken et al., 2009). In line with this, Hoffmann, Goodrich, Wilson, and Janssen (2014) showed that conditioning of sex-related cues might be significant within the development of compulsive sexual behavior in a sample of homosexual men. To address the role of conditioning processes in cybersex addiction, a Standard Pavlovian to Instrumental Transfer Task (S-PIT; Hogarth et al., 2007) was adapted with pornographic pictures (S-PITsex) in the first study of this thesis. The S-PIT represents an experimental paradigm that was frequently used to investigate conditioning processes in substance dependencies (e.g. Hogarth, Dickinson, Hutton, Elbers, & Duka, 2006; Hogarth et al., 2007; Löber & Duka, 2009).

Further, it might also be beneficial to deeper investigate the role of craving in cybersex addiction. For instance, it has been argued by Breiner, Stritzke, and Lang (1999) that craving represents not only an urge to consume a drug, which promotes tendencies to approach addictive behaviors. Due to negative expectancies towards drug consumption, addicted individuals might also be able to control their cravings to avoid drug consumption or relapse in an addiction-related decision situation. Therefore, the role of such approach/avoidance tendencies in cybersex addiction was investigated in the second study of this dissertation. Here, an Approach Avoidance Task (AAT; Rinck & Becker, 2007), frequently applied in studies investigating alcohol dependency (e.g. Sharbanee et al., 2014; C. E. Wiers, Stelzel, Park, et al., 2014; R. W. Wiers, Rinck, Dictus, & van den Wildenberg, 2009), was adapted for cybersex.

At last, it has been argued that implicit cognition plays a crucial role for the development and maintenance of substance dependencies (Rooke, Hine, & Thorsteinsson, 2008). One domain of this field is the investigation of implicit associations over the Implicit Association Test (IAT; Greenwald et al., 1998). More concrete, it has frequently been reported that substance dependent individuals showed positive implicit associations with addiction-related cues which are further connected with other mechanisms of addictive behaviors such as cue-reactivity and craving (e.g. Ames et al., 2014; Beraha, Cousijn, Hermanides, Goudriaan, & Wiers, 2013; Lindgren, Neighbors, et al., 2015). The IAT was already used in studies investigating Internet gaming addiction (Yen et al., 2011) or other behavioral addictions (Brevers et al., 2013; Yi & Kanetkar, 2010). In the course of the third study of this thesis, an IAT was adapted with pornographic pictures in order deeper investigate similarities between substance dependencies and cybersex addiction.

In the following chapters, the theoretical background of the studies underlying this dissertation will be explained in greater detail. First, it will be discussed what makes specific behaviors *addictive* (chapter 3.1). Second, mechanisms of substance dependencies, which incorporate the classical concepts of addiction, will be explained (chapter 3.2). Third, the introduced mechanisms will be transferred to the concept of behavioral addictions (chapter 3.3), before final theoretical conclusions are made (chapter 4).

3 Theoretical background

3.1 What is addiction?

Addiction is a widely used term, which is classically used as a synonym for substance dependencies, also referred to as substance or drug addictions (Brewer & Potenza, 2008). The term *addictive behavior* is commonly used to refer to this phenomenon (e.g. Cox, Klinger, & Fadardi, 2014; Field & Cox, 2008; Spada, Albery, & Moss, 2014; Wilcockson & Pothos, 2014). However, in the last decades, it has been discussed controversial to extend the concept of addiction from substance-related to non-substance-related behaviors, which are commonly denoted as behavioral addictions (e.g. Di Nicola et al., 2015; Grant & Chamberlain, 2014; Jović & Đinđić, 2011; Olsen, 2011; Thomsen, Fjorback, Møller, & Lou, 2014; Wölfling, Beutel, Koch, Dickenhorst, & Müller, 2013). For instance, proposed forms refer to addictive gambling (Prakash, Avasthi, & Benegal, 2012), buying (Black, 2007), eating (Hebebrand et al., 2014), exercising (Egorov & Szabo, 2013) as well as an addictive use of the Internet (Brand, Young, et al., 2014). A major argument for extending the concept of addiction to non-substance-related behaviors is that there is growing evidence for widespread similarities between substance-related and non-substance-related disorders. It is especially under debate that forms of non-substance-related behaviors are supposed to be considered as being potentially addictive.

Before discussing the usefulness of the behavioral addiction concept, it seems plausible to take a look at proposed definitions of addiction. Moreover, it is necessary to compare several approaches since there is no consensual definition of addictive behaviors, so far. For instance, Koob (2014) defines addiction as “a chronic relapsing disorder characterized by compulsive drug seeking, a loss of control in limiting intake, and the emergence of a negative emotional state when access to the drug is prevented” (p.1). Some similarities to this definition can be observed when listing the diagnostic criteria for substance use disorders, which embody the classical concept of addiction, from the DSM-5 (APA, 2013):

1. Increasing amounts of a substance are consumed over a longer period.
2. Individuals fail to control or regulate their substance use.
3. A significant amount of time is spent on substance acquisition, substance consumption and regeneration from its aftereffects.
4. Individuals suffer from an irresistible urge to consume a substance, which is also referred to as craving.

5. Individuals experience problems on performing school-, work-, or home-obligations.
6. Substance use is continued despite facing social or interpersonal problems connected with their substance use.
7. Individuals lose interest in important social-, leisure-, or work-related activities due to their substance use.
8. Substance use is recurrently enforced in risky situations (e.g. drinking and driving).
9. Despite experiencing negative substance-related psychological or physiological consequences, substance use is continued.
10. Individuals develop tolerance towards their usual dose that may lead to an increase in the dosage over time.
11. Individuals experience psychological and/or physiological symptoms of withdrawal.

In summary, it is argued that the "essential feature of a substance use disorder is a cluster of cognitive, behavioral, and physiological symptoms indicating that the individual continues using the substance despite significant substance-related problems" (APA, 2013, p.483). It is important to note that the APA (2013) refuses the application of the term *addiction* because of its "uncertain definition and its potentially negative connotation" (p.485). However, as noted before, the terms addiction or addictive behaviors are used by the majority of researchers.

Indeed, the complexity of addictive behaviors might not be embraced by a single definition. It is under debate whether all of the eleven criteria listed in the DSM-5 are necessary for the existence of addictive substance use. For instance, it is discussed controversially whether or not tolerance and withdrawal are necessary criteria (e.g. Duka, Sahakian, & Turner, 2007; Potenza, Sofuoglu, Carroll, & Rounsaville, 2011). It has also been argued that individuals might show symptoms of tolerance or withdrawal without suffering from a substance use disorder (Goodman, 2008). Further, it has been demonstrated that the criteria for alcohol-, cannabis-, and cocaine-dependence only fitted to a statistical model when omitting tolerance (Langenbucher et al., 2004). Based on this criticism, Goodman (2008) provided a broader definition of addiction without referring to the majority of commonly proposed criteria: "[A]ddiction is a condition in which a behavior that can function both to produce pleasure and to reduce painful effects is employed in a pattern that is characterized by two key features: (1) recurrent failure to control the behavior, and (2) continuation of the behavior despite significant harmful consequences" (p.270). Such an approach offers several benefits in comparison to the

DSM-5 criteria (APA, 2013). First, Goodman (2008) highlights loss of control and negative consequences in everyday life as major criteria since an existence of these symptoms imply (1) an individuals' psychological strain as well as (2) two key features that refer to implicit and explicit pathomechanisms. Second, while emphasizing an important role of both positive and negative reinforcement, this definition is linked to theoretical models of addiction which account conditioning effects and the neurobiology of addictive disorders (e.g. Bechara, 2005; Everitt & Robbins, 2005; Noël, Brevers, & Bechara, 2013; Robinson & Berridge, 1993, 2001, 2008; R. W. Wiers & Stacy, 2006). According to Goodman (2008), it is possible to draw a clear separation to other disorders like compulsive and impulsive behaviors. More concrete, Goodman (2008) argues that compulsive behaviors are connected with negative reinforcement (i.e. to reduce anxiety or negative affects) while impulsive behaviors are related to positive reinforcement (i.e. to produce positive affects). When speaking of addictive behaviors, both positive reinforcement (i.e. pleasurable effects due to dopamine release after consumption) and negative reinforcement (i.e. relief from withdrawal symptoms) are supposed to be involved (Goodman, 2008). At last, this definition is not limited to substance-related disorders and allows the investigation of similarities between substance use disorders and behavioral addictions.

To enrich the discussion on the usefulness of non-substance-related addictions, it seems to be beneficial to address this question to allow a more evidence-driven debate. For instance, despite existing criteria for diagnostic purposes, substance-related research revealed the existence of implicitly observable mechanisms of addictive behaviors as a consequence of preceding addictive processes. The aim of the following chapters is to introduce theoretical frameworks and mechanisms of substance-related addictions and compare these findings with results from studies investigating non-substance-related addictions. In a further step, these concepts are supposed to be transferred to Internet and cybersex addiction. The primary objective is thereby to derive theory-driven, empirically testable hypotheses regarding mechanisms potentially involved in the development and maintenance of cybersex addiction, which are based on the existing research on substance-related and non-substance-related addictions.

3.2 Substance dependencies

Diagnostic criteria are necessary for the application of standardized procedures regarding diagnosis, evaluation, and treatment of mental disorders. However, such criteria cannot sufficiently explain how pathological behaviors are developed and maintained. In the context of addictive behaviors, neurobiological concepts and theories can address this point. For instance, the role of specific brain regions and neurotransmitters on the development and maintenance of addictive behaviors has widely been investigated (for review see Goodman, 2008). The aim of the current chapter is to introduce and explain mechanisms of addictive behaviors. These mechanisms will be integrated into models and frameworks from addiction research theory. Since this thesis focusses on investigating possible neuropsychological and neurophysiological links between substance dependencies and cybersex addiction, this chapter rather focusses on mechanisms, models, and frameworks that are connected with neurobiological approaches to explain addictive behaviors.

3.2.1 Mechanisms underlying addictive behaviors

3.2.1.1 Conditioning processes

Conditioning is described as an essential form of learning, whereas learning can be understood as a "reversible change in behaviour or the potential to change future behaviour that reflects environmental events and exploits adaptive processes" (Toates, 2001, p. 276). When addressing emotional or motivational aspects of animal or human learning, a prominent approach is to differentiate initially between aversive and appetitive conditioning (Klucken, 2013). This differentiation is independent of the form of conditioning (i.e. classical or instrumental conditioning). Briefly summarized, aversive conditioning (e.g. fear conditioning) works with *unfavorable* stimuli (i.e. electric shocks), whereas the key elements of appetitive conditioning (e.g. reinforcement learning) are *favorable* stimuli (i.e. food). Overall, the development and maintenance of addictive behaviors is seen to be strongly connected with conditioning processes (e.g. Carey, Carrera, & Damianopoulos, 2014; Duka, Crombag, & Stephens, 2011; Everitt & Robbins, 2005; Robinson & Berridge, 1993, 2001, 2008; Torregrossa, Corlett, & Taylor, 2011). Since drug intake is frequently associated with gratification (e.g. dopamine release), researchers have especially highlighted the importance of appetitive conditioning processes in this context (Klucken, 2013; Martin-Soelch, 2010; Martin-Soelch, Linthicum, & Ernst, 2007). Moreover, conditioning processes and reinforcement learning are seen to be linked with cue-reactivity and craving (e.g. Carter & Tiffany, 1999; Drummond, 2001; Scott &

Hiroi, 2011; M. D. Skinner & Aubin, 2010; Weiss, 2005). Overall, there is a vast amount of studies investigating the role of classical and operant conditioning in drug addictions (for review see Martin-Soelch et al., 2007). However, before the role of these processes for addiction is examined in greater detail, different forms of conditioning will be summarized as follows.

Classical conditioning

According to Pavlov (1927), a requirement for classical conditioning is the existence of an unconditioned stimulus (US) which elicits an unconditioned reaction (UR). The US is seen to be a biologically meaningful effect that causes a physiological reflex (Holland, 1990). For instance, in the context of human behavior, an air puff (US) is supposed to elicit an eye-blink response (UR) as a protective reflex (Filion, Dawson, & Schell, 1998; Mata, Rodriguez-Ruiz, Ruiz-Padial, Turpin, & Vila, 2009).

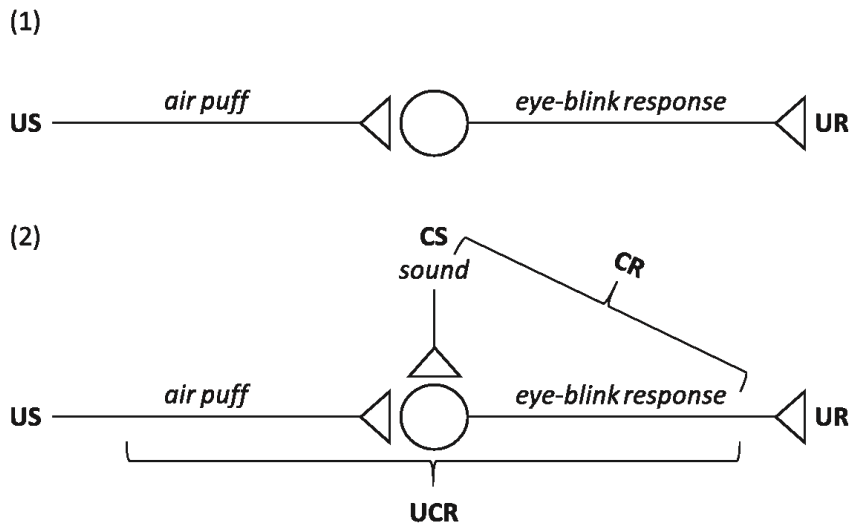

Figure 1 Schematic overview on the procedure of classical conditioning based on Toates (2001), in which (1) represents a pre-conditioning and (2) a post-conditioning state.

The UR is naturally elicited by the US, whereas the UR is a reaction that occurs without any preceding learning processes (Lefrancois, 2006). During classical conditioning, a neutral stimulus (NS) is consistently associated with the US within a short delay of time. Due to repeatedly pairing the NS with the US, the NS becomes a conditional stimulus (CS), which elicits the same response as the US. This reaction is referred to as a conditioned reaction (CR). In the context of the previously used eye-blink example, the NS could be embodied by a particular sound, whereas, after learning associations, the specific sound becomes a CS. Following, the presentation of the CS will elicit an eye-blink response as a CR. A schematic overview of this procedure is summarized in Figure 1.

The phase in which the association between the US and the CS are learned is referred to as *acquisition* (Bouton & Todd, 2014) while the number of US-CS pairings (trials) required to build an association is negatively connected with the valence of the US (Lefrancois, 2006). In other words, with increased valence of the US, the required number of trials for acquisition is decreased. Since it is broadly accepted that learning is reversible (Toates, 2001), another well-investigated concept of classical conditioning is *extinction* (Todd, Vurbic, & Bouton, 2014). That is, once an association has been built, it can be unlearned (i.e. extinct) by presenting the CS consistently without the US.

Overall, Pavlov (1927) assumed classical conditioning to be a very basic framework for learning associations, which "is often viewed as the essence of simplicity, to be contrasted with higher cognitive processes" (Holland, 1993, p. 230). However, it has been proposed to omit such strict criteria in order to view classical conditioning as a general form of associative learning, which can be beneficial for understanding cognitive phenomena more complex than simple stimulus-response (S-R) patterns (Holland, 1993; Martin & Levey, 1988).

Instrumental conditioning

Classical conditioning describes basic learning patterns, whereas human behavior is rather complex and often involves cognitive processing. Since the concept of classical conditioning is inflexible regarding the explanation of human learning and behavior, B. F. Skinner (1937, 1938) introduced a more flexible framework which is referred to as instrumental or operant conditioning. In general, B. F. Skinner (1937, 1938) separated between *type S* and *type R* conditioning, whereas *type S* conditioning is equivalent to the concept of classical conditioning. Thus, *type S* conditioning describes reactions (*respondents*) which are elicited by specific stimuli and are thereby able to explain S-R relationships (Lefrancois, 2006). Strict definitions allow the application of *type S* (or classical) conditioning only for physiological reflexes (Holland, 1993; Martin & Levey, 1988) such as an eye-blink response (e.g. Åsli & Flaten, 2008), a Hoffmann reflex (e.g. Hoseini, Koceja, & Riley, 2011), or a flexion reflex (e.g. Kolb & Timmann, 1996).

In contrast, *type R* conditioning describes behaviors in which specific (*discriminative*) stimuli can increase (or decrease) the probability of specific reactions (*operants*[1]). An operant is never elicited by a stimulus but it allows an organism to discriminate between situations in

[1] Based on this premise, the preferable term for Skinner's conditioning theory is *instrumental conditioning* since *operant conditioning* only represents *type R* conditioning and therefore only a subtype of instrumental conditioning.

which a specific consequence of showing the operant is likely or not (Lefrancois, 2006). The basic idea of *type R* conditioning is thereby that positive (*favorable*) consequences increase (*reinforce*), while negative (*unfavorable*) consequences decrease (*punish*) the probability that a specific operant is shown by an organism (see Carlson, 2008, p. 339). For learning new behaviors it is necessary that reinforcement and punishment are contingent, which means that the associated consequences need to be stable over time and space (Lefrancois, 2006).

In this context, B. F. Skinner (1937, 1938) differentiated between positive and negative reinforcement: Positive reinforcement is characterized by adding a favorable consequence (e.g. access to food), while negative reinforcement represents leaving out (or ending) an unfavorable consequence (e.g. termination of a loud noise). The reinforcing stimulus is thereby often referred to as CS+ (Klucken, 2013). However, it is important to notice that both positive and negative reinforcement *increase* the probability that a specific reaction is shown by the organism.

Table 1 Overview of the differentiation between reinforcement and punishment in instrumental conditioning.

	Reinforcement **(increases probability of a specific behavior)**	**Punishment** **(decreases probability of a specific behavior)**
Positive **(stimulus added)**	Positive reinforcement	Punishment I
Negative **(stimulus left out/ended)**	Negative reinforcement	Punishment II

In contrast, punishment *decreases* the probability that a specific reaction is shown, while B. F. Skinner (1937, 1938) similarly separated between two subtypes of punishment: During the first subtype of punishment I a negative (unfavorable) consequence (e.g. electric shock) is associated with a specific behavior (e.g. lever pressing), while the second subtype of punishment II is characterized by leaving out (or ending) a positive (favorable) consequence (an overview of the differentiation between reinforcement and punishment is summarized in Table 1). Thus, the two subtypes of punishment can be seen as counterparts to positive and negative reinforcement. Accordingly, a punishment stimulus is frequently referred to as CS- (Klucken, 2013). Here, it is important to notice that within experiments investigating appetitive conditioning, the CS- is not necessarily associated with a negative consequence but frequently with no specific response at all (which is comparable to punishment II). In such a context, the

CS+ could be followed by a positive (favorable) consequence, while the CS- is followed by no (or a neutral) consequence.

Besides the differentiation between positive and negative reinforcement, B. F. Skinner (1937, 1938) also separated between primary and secondary reinforcers, whereas this differentiation is rather connected to the initial biological valence of a specific stimulus. More concrete, primary reinforcers are stimuli which already possess a biological and/or evolutionary importance and possess positive valence without any previous learning processes. In contrast, secondary reinforcers need preceding learning processes in order to obtain such a positive valence (Lefrancois, 2006). For instance, food- or sex-related stimuli might resemble primary reinforcers (Georgiadis & Kringelbach, 2012; Kringelbach, Stein, & van Hartevelt, 2012) while money or power are frequently used examples of secondary reinforcers (Sescousse, Caldú, Segura, & Dreher, 2013).

Overall, instrumental conditioning has been extensively investigated in animals and humans. In the context of human behavior, there is sufficient empirical evidence for the assumption that instrumental conditioning is potentially involved in developing and maintaining non-clinical relevant (e.g. Brom, Both, Laan, Everaerd, & Spinhoven, 2014; Hulsebus, 1974; Wetzel, 1986; Wolpaw & Chen, 2009) as well as clinical relevant behaviors (e.g. Andrzejewski, McKee, Baldwin, Burns, & Hernandez, 2013; Follette, 2001; Wyrwicka, 1984). However, it has been argued that real life learning processes in humans might not only be explainable by instrumental conditioning: Whereas some researchers generally criticized B. F. Skinner's (1937, 1938) concept of instrumental conditioning (e.g. Malone, 1978), others rather argued that an interaction between elements of classical and instrumental conditioning might be beneficial in order to be able to explain a larger amount of learning patterns (e.g. Lefrancois, 2006).

Pavlovian to instrumental transfer

A slightly different concept of conditioning theory is referred to as *Pavlovian to instrumental transfer* (PIT) and embodies elements of both classical and instrumental conditioning by separating two distinct processes of associative learning (Holmes, Marchand, & Coutureau, 2010). It is thereby necessary to notice that PIT should not be understood as an interaction between classical and instrumental conditioning: Such interactions or competitions between classical and instrumental elements should rather be seen to have possible interfering effects on building a PIT (Holmes et al., 2010). According to Everitt and Robbins (2005), the basic idea of a PIT is that "[a]ppetitive pavlovian stimuli (associated with positive reinforcers such as

food) can greatly enhance instrumental responding for the same reinforcer when presented unexpectedly (independent of the instrumental response)" (p. 1484). Motivational elements of stimuli which are conditioned to rewarding outcomes are seen to be crucial for eliciting instrumental responses aiming at achieving those rewarding outcome (Everitt & Robbins, 2005).

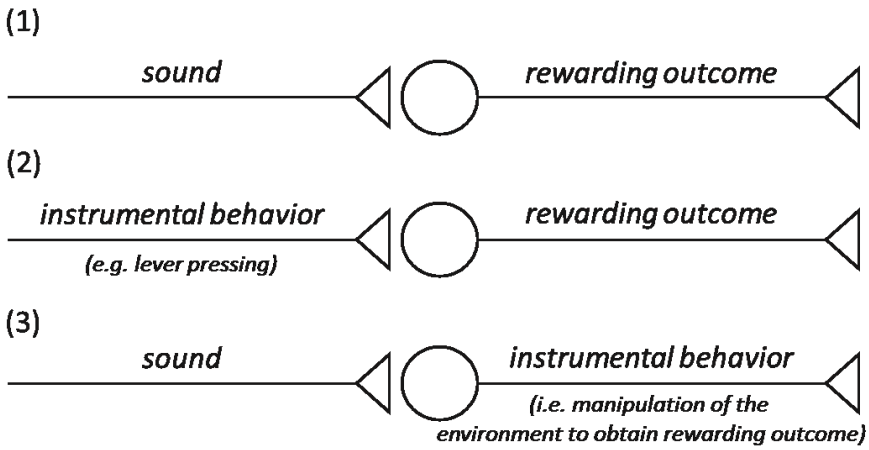

Figure 2 Abstract example of a Pavlovian to instrumental transfer (PIT) in which (1) represents the Pavlovian, (2) the instrumental component, and (3) the PIT.

An abstract example, which is also summarized in Figure 2, might be useful for understanding how a PIT is built: As already mentioned, a PIT compromises with a classical (Pavlovian) and an instrumental component two separated associative learning processes. First, during the classical phase, a rewarding outcome (e.g. food) is conditioned to a CS (e.g. a sound). Second, the same rewarding outcome is associated with a specific instrumental behavior (e.g. lever pressing) in the instrumental learning phase. Since the sound, which is now conditioned to a rewarding outcome, might possess motivational salience, its presentation is likely to elicit the same instrumental behavior in case the rewarding outcome is left out. In other words, if the CS is presented without the rewarding outcome, the organism is likely to manipulate the environment in order to obtain that outcome by executing the previously learned or other instrumental behaviors (for a more detailed explanation of establishing a PIT, please see Holmes et al., 2010).

Overall, the combination of classical and instrumental conditioning processes without assuming no specified interactions between these two forms of associative learning is one of the major advantages of the PIT concept. On a theoretical level, PIT is able to explain behaviors concerning a greater complexity than classical or instrumental conditioning could address on their own. According to Holmes et al. (2010), PIT is crucial for the understanding of

connections between single cues and goal-directed, cue-driven addictive behaviors because PIT can both explain simple S-R patterns (e.g. dopamine release due to drug intake) as well as situations in which classically conditioned CS elicits specific behaviors over the CS' motivational salience (e.g. goal-directed drug-seeking).

Relevance for addictive behaviors

As explained in the previous chapters, classical and instrumental conditioning are basic forms of learning, whereas PIT allows to explain behavior patterns of greater complexity. Beforehand, it was mentioned that addictive behaviors are supposed to be influenced by positive and negative reinforcement (Goodman, 2008).

This raises the question if individuals *learn* to be addicted. Of course, this issue is too abstract to be answerable in a scientific context. Furthermore, such a hypothesis would neglect other well-documented factors known to increase the probability of developing and maintaining addictive behaviors such as genetic factors (Volkow & Baler, 2014). It was shown that genetic variations might also have an influence on effects of appetitive conditioning (Klucken et al., 2015; Klucken et al., 2013). Nonetheless, conditioning processes can be seen as essential for developing and maintaining addictive behaviors. Many early addiction theories focused either on positive or negative reinforcement. Positive reinforcement theories mostly argued that individuals engage in and continue their drug use due to pleasurable effects of drugs (e.g. Stewart, de Wit, & Eikelboom, 1984; Wise, 1988), while authors also argued that identifying drugs as positive reinforcers does not explain their addictive potential (Wise & Bozarth, 1987). Contrary, negative reinforcement theories proposed that drug intake is due to the reduction of distress, relief from negative emotional states or withdrawal symptoms (e.g. Dackis & Gold, 1985; Mueller, Kunko, Whiteside, & Haskett, 1989; Tiffany, 1990). Going back to the observations by Goodman (2008), neither positive nor negative reinforcement theories are able to explain addictive behaviors on their own while a general importance of conditioning processes for addictive behaviors is almost beyond doubt.

In order to address these problems, Robinson and Berridge (1993) proposed another conditioning-based theory of addiction which is referred to as *Incentive Sensitization Theory*. In contrast, to previous approaches, Robinson and Berridge (1993) highlighted the role of cue-reactivity and craving, which are also seen to be strongly connected with conditioning processes. Because of the general importance of cue-reactivity and craving for the development and maintenance of addictive behaviors, these constructs will be introduced in greater detail in the next chapter. Thus, the relationship between cue-reactivity and craving, conditioning

processes, and addictive behaviors will be evaluated by referring to the Incentive Sensitization Theory (Robinson & Berridge, 1993, 2001, 2008).

3.2.1.2 Cue-reactivity and craving

Cue-reactivity and craving are frequently investigated concepts in addiction theory (for review see Tiffany and Wray, 2012). Cue-reactivity represents subjective and physiological responses to addiction-related cues (Drummond, 2001), which are obtained over Pavlovian and instrumental conditioning processes (for review see Jasinska, Stein, Kaiser, Naumer, & Yalachkov, 2014). Cue-reactivity can be observed in participants on presenting addiction-related or conditioned (former neutral) stimuli, whereas both stimulus types are supposed to elicit similar psychological and/or physiological responses. For instance, cue-reactivity paradigms used in experimental designs (Carter & Tiffany, 1999; Sayette et al., 2000), mostly focus on presenting addiction-related stimuli on a computer screen, while measuring behavioral responses (e.g. subjective ratings), implicit measures (e.g. reaction times), or physiological responses (e.g. skin conductance, heart rate, brain activation). Although the responsible mechanisms are widely unknown, there is particular evidence for the assumption that some individuals might be more *cue-reactive* than others, which might increase the risk of developing addictive behaviors (B. T. Saunders & Robinson, 2013). Overall, cue-reactivity is a well-reported phenomenon in addiction research. For instance, cue-reactivity has been reported to be existent in addicted individuals with respect to alcohol (e.g. Courtney, Ghahremani, London, & Ray, 2014; Monti et al., 1993), cannabis (e.g. K. M. Gray, LaRowe, & Upadhyaya, 2008; K. M. Gray, LaRowe, Watson, & Carpenter, 2011), cocaine (e.g. S. J. Robbins, Ehrman, Childress, & O'Brien, 1999; Wilcox, Teshiba, Merideth, Ling, & Mayer, 2011), heroin (e.g. Fatseas et al., 2011; Yung, Eickhoff, Davis, Klam, & Doan, 2014), and nicotine (e.g. Janes et al., 2009; Zhang et al., 2011).

Contrary, a consensual definition of craving is still missing (for review see M. D. Skinner & Aubin, 2010), although it is undoubted and well documented that craving plays a crucial role for the development and maintenance of addictive behaviors (Kavanagh & Connor, 2013; Potenza et al., 2011; Tiffany & Wray, 2012). Most frequently, craving is defined as a subjective urge to consume a substance (Sayette et al., 2000). Researchers who support such a one-dimensional definition craving also frequently argue that experiencing craving might elicit behavioral tendencies to approach addiction-related behaviors (M. D. Skinner & Aubin, 2010). Based on this definition of craving, there is a vast amount of studies which identified craving as a crucial mechanism for addictive behaviors. Similar to cue-reactivity these studies were

applied while referring to alcohol (e.g. Addolorato et al., 2001; Heinz et al., 2003), cannabis (e.g. Filbey & DeWitt, 2012), cocaine (e.g. Bell, Garavan, & Foxe, 2014; Risinger et al., 2005), heroin (e.g. Gardner & Lowinson, 1993; Y. Wang et al., 2014), and nicotine (e.g. Kurti & Dallery, 2014; Michalowski & Erblich, 2014). Other approaches define craving synonymously to physiological measures of cue-reactivity (Ooteman, Koeter, Vserheul, Schippers, & van den Brink, 2006) or even argue that behavioral inclinations towards drug use should be predominant (Buydens-Branchey, Branchey, Fergeson, Hudson, & McKernin, 1997; Marlatt, 1985). However, it seems implausible to use the terms cue-reactivity and craving synonymously. A differentiation could be expressed as follows: Cue-reactivity refers to an experimentally observable phenomenon, which includes all possible psychological and physiological reactions of an individual on the presentation (or perception) of specific cues, while craving should be seen as conscious or unconscious subjective urge (Robinson & Berridge, 1993, 2001, 2008). Consequently, craving measures are often based on questionnaires or the assessment of subjectively experienced urges (Tiffany & Wray, 2012), while cue-reactivity measurements frequently rely on implicit measures (Carter & Tiffany, 1999). Further, the complexity of craving should justify a clear differentiation between these two concepts. For instance, Breiner et al. (1999) criticize one-dimensional craving definitions, because such approaches fail on explaining why and how addicted individuals can learn to suppress experienced cravings in order to stop or reduce drug intake. Consequently, Breiner et al. (1999) argued that craving should be seen as a multidimensional construct, which can (1) elicit inclinations to approach addiction-related behaviors or (2) successfully suppress such urges and avoid such behaviors (see the following chapters for a more detailed explanation of the model by Breiner et al. (1999)). Nevertheless, cue-reactivity and craving seem to be related concepts (Drummond, 2001) also because it has frequently been shown that cue exposure can induce craving (e.g. Pickens et al., 2011; Sayette et al., 2000; Serre, Fatseas, Swendsen, & Auriacombe, 2015; Sinha, 2013; Zhang et al., 2011). Overall, according to M. D. Skinner and Aubin (2010), there is enough empirical data to refuse a one-dimensionality of craving. In order to be able to evaluate the complexity of craving in a greater detail, the following chapter will introduce theoretical frameworks related to cue-reactivity and craving.

Incentive Sensitization Theory

The *Incentive Sensitization Theory* was proposed by Robinson and Berridge (1993) because of problematic aspects of existing addiction frameworks. The authors criticized the competition between positive and negative reinforcement views of addiction. According to Robinson and Berridge (1993), neither of the two theoretical approaches were able to explain fully addictive

behaviors. Positive reinforcement views of addiction argue that drug intake is caused by the pleasurable states, whereas negative reinforcement views of addiction posit that drug intake is caused by alleviation of unpleasant (e.g. withdrawal) states (Robinson & Berridge, 1993). Robinson and Berridge (1993) argued that both theoretical approaches would ignore crucial empirical evidence from addiction research. For instance, positive reinforcement views cannot explain why individuals are able to develop addictive behaviors with respect to drugs, which provide no or at least very weak pleasurable effects (e.g. nicotine). Similarly, regarding negative reinforcement views, it has been shown by previous studies that both animals and humans might approach drug intake without the existence of withdrawal symptoms (e.g. Ternes, Ehrman, & O'Brian, 1985; Woods & Schuster, 1968).[2]

Therefore, Robinson and Berridge (1993) introduced a theoretical framework which addresses the before mentioned problematic aspects of positive and negative reinforcement views of addiction and put craving in the center of interest. The basic idea of their theoretical framework is that with repeated drug intake, drug-related cues get sensitized due to neural adaptations in the mesolimbic dopaminergic pathway. These neuroadaptations are persistent over longer periods of time and can thereby explain why addicts crave drugs even after long periods of abstinence. The authors differentiate between *wanting* to consume a drug, which is equivalent to subjective craving, and the pleasurable subjective effects a drug induces, which are referred to as *liking*. It is thereby supposed by the authors that in the course of developing addictive behaviors, craving (or *wanting*) gradually increases while the pleasurable subjective effects of drug intake (or *liking*) decrease (Robinson & Berridge, 1993). Another crucial component in this context is that sensitized cues are attributed with *incentive salience*, which Robinson and Berridge (1993) define as "the attractiveness of external stimuli, events, places and their mental representations" (p.280). The process of salience attributions is described by the authors as a three step process as follows:

> "First, neural substrates for pleasure are activated by the consequences of a particular act or event. Second, pleasure is associated with the object, act or event in which pleasure occurs by the processes of classical associative learning. Third, salience is attributed to subsequent perceptions and mental representations of the associated object, act, event or place […] The attribution of incentive salience causes the associated situation to become attractive and 'wanted' and it is this psychological process that produces the direct manifestation of incentive motivation: goal-directed seeking and instrumental behavior." (p.280)

[2] For an elaborate comparison of positive and negative reinforcement views of addiction, please see Robinson and Berridge (1993), p.250-255.

This description of salience attribution possesses several implications. First, salience attribution, and thereby subjective craving in the form of *wanting*, is connected with classical conditioning. The description of the processes involved in learning S-R relationships and goal-directed behaviors can be interpreted as a Pavlovian to instrumental transfer. The importance of such learning mechanisms was also highlighted by Everitt and Robbins (2005). Second, Robinson and Berridge (1993) clarify that sensitized cues possibly attributed with incentive salience can be multifaceted and represented by any internal (e.g. cognitive) or external (e.g. environmental) stimuli. Third, due to their incentive salience, drug-related cues capture the attention of an individual. This phenomenon is observable in laboratory settings and frequently referred to as a*ttentional bias* (for review see Field & Cox, 2008)[3]. Fourth, incentive salience can be interpreted as a crucial link between non-problematic wanting and pathological craving. Following, craving is not dependent on pleasurable effects a drug induces or the alleviation of withdrawal symptoms but to neuroadaptations in the mesolimbic dopaminergic pathway, which are initiated by incentive salience of sensitized drug-related cues. Consequently, Robinson and Berridge (1993) evaluate the link between *wanting* and *liking* as follows:

> "Regardless, the addict can be only subjectively aware of the outcome of excessive incentive salience attribution, craving. The addict may have little insight into the reason for the craving and indeed, may himself be bewildered by its intensity. At a conscious level addicts may recount all of the negative consequences of continued drug use, deplore their situation, even comment that the drug does not continue to give great pleasure – and not understand why their craving persists." (p.267)

In conclusion, neutral stimuli are supposed to be attributed with incentive salience on an implicit (or unconscious) level at first, while this process results in subjective (or consciously experienced) craving. Moreover, craving is supposed to elicit goal-directed drug seeking behavior. This process outlined by Robinson and Berridge (1993) assumes that with continued drug intake the mesolimbic dopaminergic pathway gets more and more sensitized due to progressions regarding association strength and the amount of sensitized cues attributed with incentive salience.

In several further publications, Robinson and Berridge (2001, 2003, 2008) reevaluated and approved the Incentive Sensitization Theory while referring to studies supporting their assumptions. In their recent theoretical article, Robinson and Berridge (2008) debated several current issues which were not addressed by preceding publications. For instance, the authors

[3] For a more detailed description of attentional biases in substance dependencies, please see chapter 3.2.1.3.

reviewed the role of learning for the Incentive Sensitization Theory, while arguing that learning addiction-related associations would indeed be a crucial mechanism for developing addictive behaviors. Based on the assumption that during the development of addictive behaviors individuals learn addiction-related associations which lead to neuroadaptations in the mesolimbic dopaminergic pathway, it is possible to explain why addicted individuals repeatedly lose control over their substance use behavior or why relapse might be a lifelong threat for abstinent individuals. However, the Incentive Sensitization Theory struggles on explaining which mechanisms could be responsible for a successful suppression of craving and repeated drug intake. Despite possible re-adaptions in the mesolimbic dopaminergic pathway, the Incentive Sensitization Theory does not address which neural structures might be involved in controlling substance use. Therefore, the following chapter will introduce theoretical frameworks which provide possible explanations for the before mentioned knowledge gap.

3.2.1.3 Implicit cognition

This chapter addresses implicit cognition as another well-documented mechanism of substance dependencies (Rooke et al., 2008). Implicit cognition is, similarly to the Incentive Sensitization Theory by Robinson and Berridge (1993, 2001, 2003, 2008), a concept which highly relies on neurobiological aspects of addictive behaviors. It seems, therefore, necessary to review neurobiological addiction frameworks in greater detail before applied research on implicit cognition can be presented.

From neural sensitizations to implicit cognition

In their theoretical publications, Robinson and Berridge (1993, 2001, 2003, 2008) argued that the mesolimbic dopaminergic pathway might be critically involved in developing and maintaining addictive behaviors. While their approach has to be referred as an excellent and valuable theoretical framework, it does not answer the question on which neural structures might be involved in non-problematic substance use. In this context, Everitt and Robbins (2005) introduced a slightly extended theoretical framework in which they argued that a shift from prefrontal to striatal control might be of crucial importance in the process of developing addictive behaviors. The authors identified two separated neural networks, which are supposed to be involved in voluntary and compulsive drug use. According to Everitt and Robbins (2005), voluntary drug use is thereby associated with processing in the prefrontal cortex which performs executive control over an individual's behavior. For example, the decision of a student with non-problematic alcohol use not to drink before but possibly after an important exam could be a result of executive control of the prefrontal cortex. Contrary, Everitt and Robbins (2005) argue

that compulsive or habitual drug use might be crucially accompanied by activations in the dorsal and ventral striatum. Since both dorsal and ventral striatum are a part of the mesolimbic dopaminergic pathway, the argumentation regarding neural structures involved in compulsive or addictive drug use is similar to Robinson and Berridge (1993, 2001, 2003, 2008). The ventral striatum is supposed to represent a key neural correlate of cue-reactivity and craving (e.g. Noël et al., 2013; Volkow & Baler, 2014) and was shown to be involved in Pavlovian and instrumental conditioning processes (e.g. Holmes et al., 2010; Klucken, 2013; Klucken et al., 2009). Subsequently, the previously used example could be adapted to illustrate processes adherent with habitual or compulsive drug use as follows: In contrast to a student with non-problematic alcohol use, an alcohol addicted student might drink alcohol not only after but also before an important exam, even though negative consequences might be associated (e.g. to fail the exam). Thus, such a behavior could be explained by subjective craving and a domination of striatal control due to developed neuroadaptations in the mesolimbic dopaminergic pathway. Overall, Everitt and Robbins (2005) presented a theoretical framework, which is able to explain how healthy individuals manage to control their substance use, while in the process of developing addictive behaviors, the influence of controlling instances progressively weakens. Since Everitt and Robbins (2005) assume the existence of two competing neural networks, their approach can be referred to as one of the first dual-process models of addiction. Recently, Everitt and Robbins (2016) reevaluated their hypotheses in the light of existing evidence, whereas the authors especially highlighted the importance of PIT as well as transitions from ventral to dorsal striatum for deeper understanding mechanisms of addictive behaviors.

Another theoretical framework, which also prominently represents dual-process models of addiction was introduced by Bechara (2005) who argued that addictive behaviors might be influenced by two separate neural networks: An impulsive (amygdala) system, which reacts to immediate rewards and punishments, and a reflective (prefrontal cortex) system, which is seen to be responsible for coding prospects of long-term consequences. Bechara (2005) assumed that the reflective system controls the impulsive system in the context of voluntary drug use in order to evaluate and decide on short- and long-term rewards and consequences. In other words, the reflective system is seen to be responsible for making decisions which increase positive long-term outcomes. For instance, the chances of passing a course and being rewarded with a good grade are higher if a student only drinks alcohol after finishing an exam. Contrary, within addictive behaviors, a hyperactive, impulsive system might override the reflective system (Bechara, 2005). The probability of overriding the reflective system and initiating drug seeking behavior could be increased by the magnitude of already developed drug-related

neuroadaptations, which enables a link to the framework proposed by Robinson and Berridge (1993, 2001, 2003, 2008).

Based on the before mentioned theoretical frameworks, R. W. Wiers and Stacy (2006) differentiate between explicit and implicit cognition. While the authors rely on the terminology by Bechara (2005) and separate between a controlled (reflective) and an automatic (impulsive) system, they argue that controlled processing is associated with explicit cognition, while automatic processing is linked to implicit cognition. A simplified overview of the dual-process model by R. W. Wiers and Stacy (2006) is summarized in Figure 3.

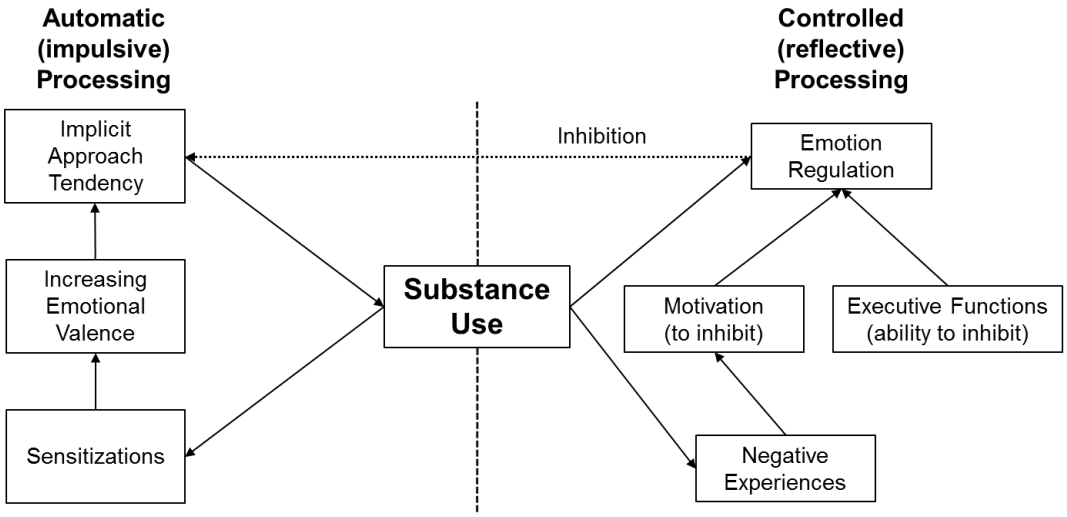

Figure 3 Simplified overview of the dual-process model of addiction by R. W. Wiers and Stacy (2006).

The differentiation between explicit and implicit cognition implies that individuals might be aware if decisions or actions are explicitly processed while they are unaware in the case of implicit processing. Based on this assumption it is possible to explain why addicted individuals might decide to cut their substance use due previously experienced negative consequences, while failing in addiction-related decision situations: Although processes of explicit cognition lead to an intent of not consuming a substance, automatic processing overrides the controlled system by initiating goal-directed drug seeking behavior in form of an implicit approach tendency (R. W. Wiers & Stacy, 2006).

R. W. Wiers and Stacy (2006) argue that processes of implicit cognition might produce observable artifacts. For instance, as suggested by Robinson and Berridge (1993), drug-related cues might capture the attention of addicted individuals. Consequently, while comparing addicted and non-addicted individuals, addicted individuals should show longer reaction times when confronted with addiction-related cues. Overall, the suggested observability of both

explicit and implicit cognition is one of the main strength of the dual-process model by R. W. Wiers and Stacy (2006). For instance, explicit cognition is supposed to be affected by executive functions, which can be assessed in a laboratory setting (e.g. Brand, Labudda, & Markowitsch, 2006; Brand, Laier, Pawlikowski, & Markowitsch, 2009; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; E. E. Smith & Jonides, 1999). Further, related constructs, such as emotion regulation (e.g. Cheetham, Allen, Yücel, & Lubman, 2010), motivation (Cox et al., 2014), or negative experiences associated with substance use (Spada, Caselli, Nikčević, & Wells, 2014) can be assessed by standardized subjective assessment methods. In contrast, dependent on preceding sensitizations, implicit processing is seen to be automatically activated in addicted individuals (R. W. Wiers & Stacy, 2006) and must be assessed by implicit measures such as reaction times or neurophysiological correlates automatic processing (e.g. skin conductance responses, brain activations, heart rate). In summary, R. W. Wiers and Stacy (2006) proposed several methods for the observation of explicit and implicit cognition besides identifying prefrontal or striatal processing using fMRI. However, due to its complexity, implicit cognition should be interpreted as a multidimensional construct. Consequently, Rooke et al. (2008) separate between different forms of implicit cognition: semantic memory associations, implicit arousal, attentional bias, and implicit attitudes. In analogy to R. W. Wiers and Stacy (2006), the basic idea behind this differentiation is not to investigate implicit cognition directly but to observe different artifacts of implicit processing. Rooke et al. (2008) summarize in their meta-analytic approach several experimental paradigms, which are used to assess the before mentioned forms of implicit cognition.[4] The main result of their study is that all facets are reliable predictors for drug use (Rooke et al., 2008).

Connecting craving and implicit cognition

While referring to the theoretical frameworks introduced up to this point, it is possible to explain why addicted individuals crave drugs and what neurobiological processes might be involved in adapting the processing of addiction-related cues. Further, the previous subchapter introduced the concept of implicit cognition which is also highly related to the before mentioned theoretical frameworks (e.g. Bechara, 2005; Everitt & Robbins, 2005; Robinson & Berridge, 1993, 2001, 2003, 2008). However, since these approaches rely on the same theoretical frameworks, it seems plausible to identify connections between craving and implicit cognition. First of all, although R. W. Wiers and Stacy (2006) do not directly integrated craving into their model, it makes sense to suppose effects of craving in the implicit cognition circle from drug use over

[4] For a detailed overview of paradigms used for assessing implicit cognition, please see chapter 3.2.2.3.

sensitizations to increasing emotional valence and implicit approach tendencies. It seems plausible in this context to assume craving as an unconscious process of "wanting" to consume a substance (Robinson & Berridge, 1993), which elicits goal-directed drug seeking behavior in the form of an implicit action tendency (R. W. Wiers & Stacy, 2006).

As already mentioned in chapter 3.2.1.2, craving can be interpreted as a multidimensional construct, which might elicit either approach or avoidance action tendencies (Breiner et al., 1999). Therefore, the theoretical framework by Breiner et al. (1999) will be explained in greater detail, since it offers the possibility to connect craving and implicit cognition in a plausible way. In order to address the complexity of craving, Breiner et al. (1999) introduced a multidimensional framework in the context of alcohol dependency, which can also be adapted for other substance dependencies (see Figure 4). The framework focuses on the role of an evaluative space in an addiction-related decision situation. This evaluative space can be separated into the following states: *approach*, *avoidance*, *ambivalence,* and *indifference*. Breiner et al. (1999) argue that the state entered in an addiction-related decision situation is influenced by either positive or negative expectancies towards consuming alcohol, which are affected by historical (e.g. physiological and/or psychological predispositions) as well as current factors (e.g. positive or negative incentives). A dominance of positive expectancies is supposed to promote *approach* while negative expectancies are linked to *avoidance* tendencies. *Approach* and *avoidance* can be interpreted as competing action-tendency states while *approach* would then be similar to the implicit action tendency assumed by R. W. Wiers and Stacy (2006). The basic idea of the framework is that *approach* is supposed to elicit alcohol consumption whereas *avoidance* characterizes an oppositional process in which alcohol-related cravings are suppressed. With respect to the assumed multidimensionality of craving, *approach* is analogous to "wanting" to consume a substance as proposed by Robinson and Berridge (1993). Consequently, approach tendencies can be interpreted as a consequence of automatic processing of the impulsive system as assumed by the Bechara (2005) as well as R. W. Wiers and Stacy (2006). In contrast, *avoidance* is supposed to be a subjectively experienced process. Avoidance tendencies refer to controlled processing, which is a result of explicit cognition. Consequently, the approach/avoidance framework by Breiner et al. (1999) is in line with dual-process models of addiction (e.g. Bechara, 2005; R. W. Wiers & Stacy, 2006), highlighting the role of automatic and controlled processes for the developing and maintaining addictive behaviors.

The framework by Breiner et al. (1999) further includes *ambivalence* and *indifference*, which can be interpreted as ambiguous states. According to the authors, *ambivalence* or

indifference might be entered in an addiction-related decision situation, if the inclinations of the action-tendency states *approach* and *avoidance* are balanced. The state *ambivalence* is supposed to be entered if the intensity of ambiguity is high, whereas *indifference* is represented by a low intensity of ambiguity. Overall, the role of *ambivalence* and *indifference* is not completely clarified by Breiner et al. (1999).

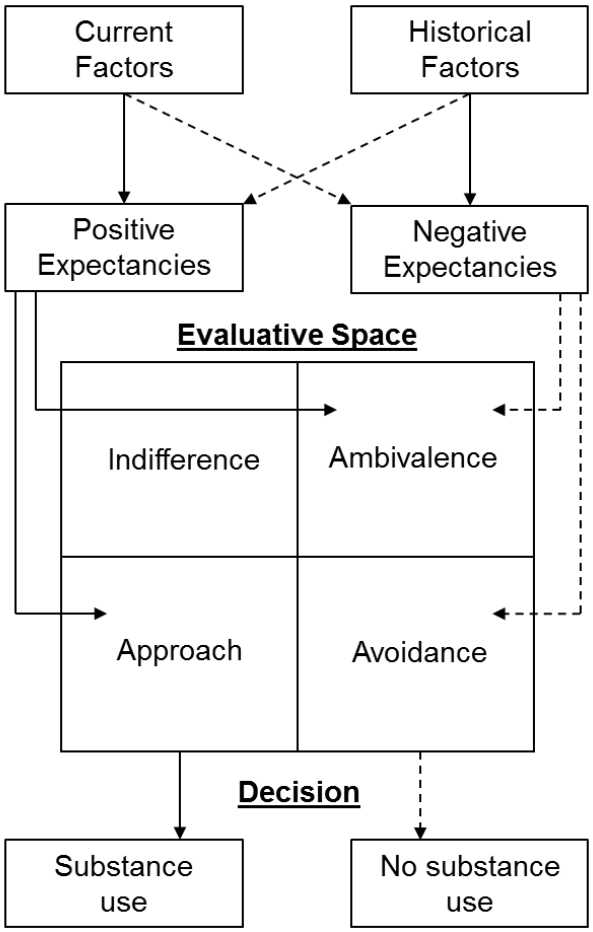

Figure 4 Overview of the approach/avoidance framework by Breiner et al., (1999).

Breiner et al. (1999) provided an excellent theoretical framework which is able to combine craving and implicit cognition. A main strength of the model by Breiner et al. (1999) is that it can explain why addicted individuals might approach substance use in a particular addiction-related decision situation whereas such behaviors might be avoided in others, although drug-related cravings might exist in both situations. This is of particular importance because there is reasonable evidence for rejecting one-dimensional interpretations of craving (for review see M. D. Skinner & Aubin, 2010). Although several researchers similarly argued that approach and avoidance might rely on separate (neural) systems (e.g. Frank & Claus, 2006; J. A. Gray, 1990; R. W. Wiers, Bartholow, et al., 2007), the theoretical framework by Breiner et al. (1999) has not been empirically validated, so far. Nonetheless, recent neurophysiological

studies supported the assumption that approach tendencies should be accompanied by implicit (i.e. mesolimbic) processing, while avoidance is seen to be related to controlled (i.e. prefrontal) processing (L. H. Ernst et al., 2012; L. H. Ernst, Plichta, et al., 2013; Schlund, Magee, & Hudgins, 2011; C. E. Wiers et al., 2015; C. E. Wiers, Stelzel, Gladwin, et al., 2014; C. E. Wiers, Stelzel, Park, et al., 2014). By strengthening this assumption, Tang, Posner, Rothbart, and Volkow (2015) recently highlighted the importance of the neurophysiological links between craving, implicit cognition, and self-control, as described in this section.

3.2.2 Experimental paradigms used in substance-related studies

Reliable tools for determining whether or not an individuals' substance use is addictive might be standardized questionnaires (e.g. J. B. Saunders, Aasland, Babor, de la Fuente, & Grant, 1993) or structured interviews (e.g. Sheehan et al., 1998). As explained in the previous chapters, addictive behaviors involve specific neural processes, which produce observable artifacts. It is possible to investigate the structure of disorders using experimental paradigms by observing such artifacts. Therefore, the current chapter follows two goals: First, experimental paradigms which aim at assessing specific mechanisms of addictive behaviors will be introduced and compared to each other. Secondly, while referring to studies from substance dependence research, it will be pointed out that irrespectively of the substance used (e.g. alcohol, nicotine, cocaine, heroin), there are broad similarities regarding artifacts observable in experimental settings. In other words, this chapter aims at identifying methods and symptomatic outcomes of addictive behaviors on a neuropsychological as well as neurophysiological level.

3.2.2.1 Measuring conditioning processes

As pointed out in chapter 3.2.1.1, processes of Pavlovian and instrumental conditioning as well as Pavlovian to instrumental transfers are crucial for developing and maintaining addictive behaviors (e.g. Belin, Jonkman, Dickinson, Robbins, & Everitt, 2009; Carey & Damianopoulos, 2015; Duka et al., 2011; Duka et al., 2007; Goodman, 2008; Mameli & Lüscher, 2011). Conditioned reward anticipation is known to elicit preparatory physiological responses (M. H. Winkler et al., 2011) while being seen to be strongly connected with cue-reactivity and craving (e.g. Drummond, 2001; Hägele, Friedel, Kienast, & Kiefer, 2014; Pickens et al., 2011; Weiss, 2005). In the context of substance dependencies, appetitive conditioning has been supposed to be of particular importance, while its assessment remains difficult in experimental settings since observable effects might be weak because of insufficient stimulus material (Martin-Soelch et al., 2007). Therefore, the role of conditioning for developing and maintaining addictive

behaviors is mostly investigated by animal studies, which cannot be generally transferred to human behaviors (e.g. Hall & Gulley, 2011; Holmes et al., 2010; LeBlanc, Ostlund, & Maidment, 2013; Lex & Hauber, 2010; N. W. Simon & Setlow, 2006; Stolyarova, O'Dell, Marshall, & Izquierdo, 2014). Consequently, most studies investigating conditioning processes in humans aim at observing artifacts, which are supposed to be connected with conditioning processes, such as attentional bias (Duka et al., 2011).

An experimental paradigm which allows the investigation of appetitive conditioning processes in a laboratory setting is the Standard Pavlovian to Instrumental Transfer Task (S-PIT; Hogarth et al., 2007). The S-PIT is based on a well-documented Pavlovian conditioning procedure (Duka et al., 2011), while it was applied in substance-related as well as non-substance-related research. The S-PIT was implemented in order to investigate the role of conditioning regarding an addictive use of alcohol and nicotine (see Table 2). Further, the S-PIT was used in non-substance-related studies addressing the role of uncertainty and attention for expectancy-based learning (Austin & Duka, 2010; Hogarth, Dickinson, Austin, Brown, & Duka, 2008; Trick, Hogarth, & Duka, 2011). In general, the S-PIT measures whether stimuli conditioned to rewarding outcomes might increase instrumental responses which aim at achieving those outcomes. The task further assesses whether the emotional reactivity towards the rewarding drug-related stimuli is based on the expectancy of the reward outcome.

Table 2 Selective overview of substance-related studies using the Standard Pavlovian to Instrumental Transfer Task (S-PIT; Hogarth et al., 2007).

Authors	Substance	Findings
Löber and Duka (2009)	Alcohol	Alcohol intoxication increased drug expectancy in trials without drug-related cues.
Hogarth et al. (2006)	Nicotine	Conditioned drug expectation elicited positive emotional states and goal-directed drug seeking behavior.
Hogarth et al. (2007)	Nicotine	Drug-associated stimuli were able to control goal-directed drug seeking behavior.
Thewissen, Havermans, Geschwind, van den Hout, and Jansen (2007)	Nicotine	Conditioning of a nicotine approach bias.

Hogarth, Dickinson, and Duka (2010)	Nicotine	Positive relationship between conditioning effects and craving.
Hogarth and Chase (2012)	Nicotine	Preference for nicotine-related cues was associated with nicotine dependence severity and subjective craving.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

The basic idea of the S-PIT is to obtain a transfer of arousal from drug-related stimuli to standardized neutral stimuli, which were used in all before mentioned studies. This transfer is supposed to be learned during an acquisition training phase, which can be summarized as follows: A positively reinforcing conditional stimulus (CS+) is consistently paired with rewarding outcomes such as drug-related pictures while a second conditional stimulus (CS-) signals neutral pictures as non-rewarding outcomes.[5] In order to increase task difficulty (e.g. to investigate the role of uncertainty for expectancy-based learning), the CS+ and the CS- are always combined with one of two neutral stimuli without any predictive value. During a single conditioning trial, the presentation of neutral stimuli is followed by a subjective rating which assesses the outcome expectancy before either a drug-related (rewarding) or neutral (non-rewarding) picture is presented to the participant. Since the presentation of the CS and rewarding/non-rewarding outcomes is not overlapping, the S-PIT embodies a trace-conditioning paradigm (Carey et al., 2014).[6] After the contingencies of the paradigm were learned during the acquisition training phase, the CS are evaluated regarding emotional reactivity by subjective ratings on different dimensions (e.g. appetence and anxiety; Hogarth et al., 2007). Consequently, the S-PIT can be subdivided into an acquisition training phase (in which associations are supposed to be learned) and an evaluation phase (in which the strength of the established transfer is assessed). Using terms of conditioning theory, the principle of the S-PIT can be described as follows: Before learning associations, the presentation of the neutral stimuli (US) should elicit an UR. During acquisition training the US should become CS, which should allow the observation of different CR during the evaluation phase because both rewarding (CS+) and non-rewarding (CS-) outcomes were used. In summary, the S-PIT

[5] For a definitive overview of terms used in conditioning theory, please see also chapter 3.2.1.1.
[6] For detailed information on different conditioning procedures, please see Lefrancois (2006).

provides excellent reliability since all studies mentioned could show that the contingencies of the task were learned by the participants.

3.2.2.2 Measuring approach/avoidance tendencies

After drug-related associations are learned over conditioning processes, individuals might show cue-reactivity and craving (see also chapters 3.2.1.2 and 3.2.1.3). According to Breiner et al. (1999), individuals might either approach or avoid drug-related behaviors. Since approach tendencies towards drug-related stimuli in addicted individuals are supposed to be associated with implicit (striatal) cognition, which is faster than explicit (prefrontal) cognition, it could be assumed that approaching drug-related stimuli is characterized by faster reaction times than avoiding drug-related stimuli. In healthy individuals who are not sensitized towards drug-related stimuli, approaching and avoiding drug-related stimuli should not lead to significant reaction time differences. On an experimental level, the relative tendency to either approach or avoid drug-related cues could then be assessed by comparing the reaction times of two blocks in which participants had to approach and avoid drug-related stimuli (or reversed).

While referring to this assumption, there are two similar and frequently used experimental paradigms, which aim at measuring approach/avoidance tendencies towards drug-related stimuli: The Stimulus-Response-Compatibility Task (SRC; Mogg, Bradley, Field, & de Houwer, 2003) and the Approach Avoidance Task (AAT; Rinck & Becker, 2007). During the SRC, a manikin figure has to be moved towards (approach) or away from (avoidance) drug-related cues. Studies using the SRC showed stronger tendencies to approach than to avoid drug-related stimuli in smokers (Mogg et al., 2003), regular cannabis users (Field, Eastwood, Bradley, & Mogg, 2006), as well as heavy alcohol and cannabis users (Cousijn et al., 2012; Field, Kiernan, Eastwood, & Child, 2008). The AAT, which was originally introduced by Rinck and Becker (2007) to measure approach/avoidance tendencies towards spiders, can be described as an extension of the SRC since the same rationale for approaching and avoiding drug-related stimuli is used. In contrast, the AAT does not use a manikin figure which has to be moved using buttons of a standard keyboard but a joystick. More concrete, the joystick is used to either pull stimuli towards the body (approach) or push them away (avoidance). Besides the application of the AAT in studies investigating fear-related behaviors (e.g. Krypotos, Arnaudova, Effting, Kindt, & Beckers, 2015; Luo et al., 2015; Rinck & Becker, 2007) or social anxiety (Heuer, Rinck, & Becker, 2007; Ly, Cools, & Roelofs, 2013; Radke, Roelofs, & de Bruijn, 2013; Voncken, Rinck, Deckers, & Lange, 2012), it was used in modified version to investigate approach/avoidance tendencies in substance dependencies (e.g. Cousijn, Goudriaan, & Wiers,

2011; Cousijn, Snoek, & Wiers, 2013; Sharbanee et al., 2014; Sharbanee, Stritzke, Jamalludin, & Wiers, 2013; Sharbanee, Stritzke, Wiers, & MacLeod, 2013; C. E. Wiers et al., 2013; R. W. Wiers et al., 2009). In this context, most experimental studies found linear relationships between addictive behaviors and approach tendencies towards drug-related stimuli. There is also support for connecting dual-process models (Bechara, 2005; Breiner et al., 1999; R. W. Wiers & Stacy, 2006) with approach/avoidance tendencies since it has also been shown that abstinent individuals might show tendencies to avoid drug-related stimuli as a consequence avoidance training programs (Eberl et al., 2013a, 2013b; R. W. Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). By strengthening this assumption, Spruyt et al. (2013) reported that abstaining alcohol-dependent individuals showed avoidance tendencies in an SRC while relapse rates were positively associated with the strength of these tendencies. An overview of substance-related studies using either the SRC or the AAT is summarized in Table 3.

Table 3 Selective overview of substance-related studies that investigate approach/avoidance tendencies.

Authors	Substance	Paradigm	Findings
Field, Mogg, and Bradley (2005b)	Alcohol	SRC	Craving was positively associated with tendencies to approach alcohol-related stimuli.
Field et al. (2008)	Alcohol	SRC	Approach tendencies towards alcohol-related stimuli were found in heavy but not in light drinkers.
R. W. Wiers et al. (2009)	Alcohol	AAT	Tendencies to approach alcohol-related stimuli in heavy drinkers carrying the OPRM1 gene were found.
R. W. Wiers et al. (2011)	Alcohol	AAT	Successful retraining of tendencies to avoid alcohol-related stimuli and improved treatment outcome in abstinent alcoholics.
L. H. Ernst et al. (2012)	Alcohol	AAT	Stronger regulatory activity in the dorsolateral prefrontal cortex during avoidance of alcohol-related stimuli compared to the approach of alcohol-related stimuli.

Eberl et al. (2013a)	Alcohol	AAT	Lower relapse rates after participating in avoidance training programs in abstinent alcoholics.
Eberl et al. (2013b)	Alcohol	AAT	Six training sessions were identified as being most effective for avoidance training programs.
Sharbanee, Stritzke, Jamalludin, et al. (2013)	Alcohol	AAT	Tendencies to approach alcohol-related stimuli were inhibited by cognitive load.
Spruyt et al. (2013)	Alcohol	AAT	Abstinent alcoholics rather showed tendencies to avoid and not to approach alcohol-related stimuli.
Korucuoglu, Gladwin, and Wiers (2014)	Alcohol	AAT	Posterior beta-ERD during EEG increased during the preparation for trials in which alcohol-related stimuli had to be approached.
Sharbanee et al. (2014)	Alcohol	AAT	Approach/avoidance training had an effect an actual alcohol consumption by changing alcohol action tendencies.
C. E. Wiers, Stelzel, Park, et al. (2014)	Alcohol	AAT	Approaching alcohol-related stimuli was positively associated with nucleus accumbens activity.
Boffo, Pronk, Wiers, and Mannarini (2015)	Alcohol	AAT	Support for the effectiveness of avoidance training programs in alcohol addiction treatment.
Lindgren, Wiers, et al. (2015)	Alcohol	AAT	No changes in tendencies to approach alcohol-related stimuli in undergraduate drinkers after participating in an avoidance training program.
C. E. Wiers et al. (2015)	Alcohol	AAT	Alcohol-dependent patients showed stronger regulatory activity in the prefrontal cortex after participating in an avoidance training program.

R. W. Wiers, K. Houben, et al. (2015)	Alcohol	AAT	Decreased alcohol consumption after taking part in a web-based avoidance training program.
Field et al. (2006)	Cannabis	SRC	Approach tendencies towards cannabis-related stimuli were found in regular cannabis users.
Cousijn et al. (2011)	Cannabis	AAT	Approach tendencies towards cannabis-related stimuli were found in heavy but not in light cannabis users.
Cousijn et al. (2012)	Cannabis	AAT	Tendencies to approach cannabis-related stimuli were positively associated with the severity of cannabis use problems in heavy cannabis users.
Cousijn, Snoek, et al. (2013)	Cannabis	AAT	Tendencies to approach for both cannabis-related and neutral stimuli were found in intoxicated cannabis users.
Cousijn, van Benthem, van der Schee, and Spijkerman (2015)	Cannabis	AAT	Attentional but no approach bias towards cannabis-related stimuli were found in adolescents with cannabis use disorder.
Mogg et al. (2003)	Nicotine	SRC	The urge to smoke was positively associated with approach tendencies.
Bradley, Field, Mogg, and de Houwer (2004)	Nicotine	SRC	Stronger tendencies to approach smoking-related stimuli in smokers compared to non-smokers.
Field, Mogg, and Bradley (2005a)	Nicotine	SRC	No effects of alcohol consumption (0.4g/kg) on approach/avoidance tendencies towards smoking-related stimuli.
C. E. Wiers et al. (2013)	Nicotine	AAT	Tendencies to approach smoking-related stimuli were found in smokers but not in non-smokers.

Macy, Chassin, Presson, and Sherman (2014)	Nicotine	AAT	Tendencies to approach smoking-related stimuli were decreased by a web-based avoidance training program.
Wittekind, Feist, Schneider, Moritz, and Fritzsche (2014)	Nicotine	AAT	Tendencies to approach smoking-related stimuli were reduced by a web-based avoidance training program.
Kong et al. (2015)	Nicotine	AAT	Tendencies to approach smoking-related stimuli were decreased by an avoidance training program.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

Overall, it can be summarized that there is strong evidence for the assumption that tendencies to approach or avoid drug-related stimuli are prevalent in substance-related addictive behaviors as initially argued by Breiner et al. (1999). As shown in Table 3, there are various studies which reported that addicted individuals showed tendencies to approach drug-related stimuli, while abstinent addicts did not. Following, such findings might illustrate a shift of striatal processing in consuming addicts to prefrontal processing in abstinent addicts since being abstinent requires a high level of cognitive control. There are also preliminary studies supporting an analogy between dual-process models of addiction and approach/avoidance tendencies. Moreover, there are non-substance-related studies, which strengthen the assumption that approaching or avoiding pictorial stimuli (or specific behaviors) is accompanied by the activation of separated neural systems (e.g. Calcott & Berkman, 2015; Demenescu et al., 2013; L. H. Ernst, Lutz, et al., 2013; L. H. Ernst, Plichta, et al., 2013; Schlund et al., 2011; J. J. Simon et al., 2010; Volman, Roelofs, Koch, Verhagen, & Toni, 2011). However, neurophysiological aspects of approaching or avoiding drug-related stimuli or behaviors in addicted individuals need to be further investigated in future studies in order to clarify the assumed connection between implicit (striatal) cognition and approach tendencies as well as explicit (prefrontal) cognition and avoidance tendencies.

3.2.2.3 Measuring implicit cognition

As previously mentioned in chapter 3.2.1.3, Rooke et al. (2008) separated implicit cognition in their meta-analytic approach into the facets semantic memory associations, implicit arousal, attentional bias, and implicit attitudes. Although, the authors reported the largest effect size for

semantic memory associations, which can be assessed using word association techniques (Rooke et al., 2008), this facet will not be reviewed in greater detail because of the following reason. Semantic memory associations are supposed to measure implicit cognition by involving explicit processing (i.e. free verbal associations to words which can be interpreted as drug-related and non-drug-related). While several researchers have argued that these procedures measure facets of implicit cognition because participants would be unaware of the interest of research (e.g. Liebermann, 2006; Nelson, McEvoy, & Dennis, 2000), it seems, at least, questionable whether or not these procedures assess *implicit* memory associations. Thus, the large effect size reported by Rooke et al. (2008) could partially be explained by methodological differences regarding the assessment of semantic memory associations and other facets of implicit cognition.

Another facet of implicit cognition is implicit arousal, which can be compared to cue-reactivity and craving since implicit arousal "may involve automatically activated arousal-related cognitions in response to drug cues, or actual physiological arousal in response to drug cues" (Rooke et al., 2008, p. 1316). Consequently, Rooke et al. (2008) draw connections to the Incentive Sensitization Theory by Robinson and Berridge (1993) and refer to the review by Carter and Tiffany (1999) on the role of cue-reactivity in substance dependence. Rooke et al. (2008) reported rather small effect sizes for implicit arousal. These findings could be explained while referring to the assumption by Breiner et al. (1999) that the existence of craving might predict not only substance use (approach) but also a suppression of this urge (avoidance). Based on this argumentation, implicit arousal will be used synonymously with implicit measures of cue-reactivity and craving (see also chapter 3.2.1.2).

The third facet of implicit cognition mentioned by Rooke et al. (2008) is attentional bias, whereas this facet includes the largest amount of different experimental paradigms used. The basic idea of paradigms assessing attentional bias is to measure reaction times while combining the presentation of verbal or pictorial drug-related or neutral stimuli with specific tasks. Based on the Incentive Sensitization Theory by Robinson and Berridge (1993) which argues that drug-related stimuli might, due to their incentive salience, capture the attention of addicted individuals, it is possible to generate the following assumptions: First, addicted individuals should show longer reaction times in trials with drug-related stimuli when compared to trials with neutral stimuli. Second, addicted individuals should show longer reaction times in trials with drug-related stimuli when compared with reaction times of non-addicted individuals. Third, the relative strength of the observed attentional bias, which is frequently calculated by subtracting the reaction times of neutral trials with reaction times of drug-related trials (Field

& Cox, 2008), could predict subjectively experienced craving because there could be a relationship between attentional bias and the magnitude of developed neural sensitizations. Overall, the most prominent experimental paradigms which are supposed to assess attentional bias are the Addiction Stroop Task (AST; Barrós-Loscertales et al., 2011; Bruce & Jones, 2004; Cane, Sharma, & Albery, 2009; Cousijn, Watson, et al., 2013; Cox, Fadardi, & Pothos, 2006; Hester, Dixon, & Garavan, 2006) and the Visual Probe Task, which has also been referred as Dot Probe Task (Bradley, Field, Healy, & Mogg, 2008; VPT; Christiansen, Mansfield, Duckworth, Field, & Jones, 2015; Ehrman et al., 2002; Field, Mogg, Zetteler, & Bradley, 2004; VPT; Mogg & Bradley, 2002; Mogg et al., 2003). Both the AST and the VPT are task-irrelevant paradigms. Thus, the content of the stimuli presented to the participant are independent of the task which has to be executed. For instance, during the AST, participants have to identify the color of the presented verbal or pictorial stimuli by using four buttons on a standard keyboard. Contrary, the basic idea of the VPT is to present a neutral and a drug-related picture at the same time (left and right side of a computer monitor), which is followed by a small dot behind one picture, while the participants task is to identify on which side the dot appeared or in which direction it points. Less frequently used paradigms to assess attentional bias are the Attentional Blink Task (ABT; Munafò, Johnstone, & Mackintosh, 2005; Tibboel, de Houwer, & Field, 2010; Waters, Heishman, Lerman, & Pickworth, 2007), the Attentional Cueing Task (ACT; Ceballos, Tivis, Lawton-Craddock, & Nixon, 2005; Chanon, Sours, & Boettiger, 2010; Impey, Chique-Alfonzo, Shah, Fisher, & Knott, 2013), the Flicker Paradigm (FLP; Jones, Bruce, Livingstone, & E., 2006; Jones, Jones, Smith, & Copley, 2003; Schoenmakers, Wiers, Jones, Bruce, & Jansen, 2007), and the Visual Search Task (VST; Abroms & Fillmore, 2004; M. Ernst, Heishman, Spurgeon, & London, 2001; Huestegge, Radach, Kunert, & Heller, 2002). Irrespective of the paradigm used, there is enough empirical evidence supporting the existence of attentional bias as well as a relationship to subjectively experienced craving (Coskunpinar & Cyders, 2013; Field & Cox, 2008; Field, Marhe, & Franken, 2014; Field, Munafò, & Franken, 2009; Marhe, Luijten, & Franken, 2014; Rooke et al., 2008; R. W. Wiers, Boelema, Nikolaou, & Gladwin, 2015).

Aside from semantic memory associations, implicit arousal, and attentional bias, there is a vast amount of studies which investigated implicit attitudes. Rooke et al. (2008) reported the largest effect size for implicit attitudes if semantic memory associations are not considered because of the before mentioned arguments. Therefore, experimental paradigms and results regarding effects of implicit attitudes on substance use will be explained in greater detail in the following subchapter.

Implicit attitudes

The most frequently used paradigm for measuring implicit attitudes is the Implicit Association Test (IAT), which was originally introduced by Greenwald et al. (1998) in order to assess implicit racial stereotypes. According to Greenwald, Nosek, and Banaji (2003) the IAT is supposed to evaluate the "strength of automatic associations" (p.197) with respect to the investigated concepts. Basically, the IAT is a word classification task, in which individuals categorize verbal or pictorial stimuli according to two target and to two attribute concepts as fast as possible. The basic rationale of the IAT is thereby that it should be easier to respond to congruent than to incongruent concept-pairings. On a methodological level, reacting to congruent pairings should then lead to faster reaction times compared to incongruent pairings. The procedure of the IAT is separated into different blocks, in which participants first learn to classify target and attribute concepts alone (e.g. "flowers vs. insects" and "positive vs. negative"), before these categories are combined to congruent (e.g. "flowers or positive" vs. "insects or negative") and incongruent pairings (e.g. "flowers or negative" vs. "insects or positive"). Overall, the IAT is supposed to provide good psychometric properties regarding reliability and validity (Greenwald et al., 2003; Greenwald, Poehlman, Uhlmann, & Banaji, 2009; Nosek, Greenwald, & Banaji, 2007; R. W. Wiers & Stacy, 2013). There is also experimental evidence for the assumption that the IAT is indeed assessing aspects of implicit cognition (Forbes et al., 2012; O'Toole, Barnes-Holmes, & Smyth, 2007; Stefanutti, Robusto, Vianello, & Anselmi, 2013).

Since the concept of the IAT is transferable to arbitrary target and attribute concepts, it was frequently applied in substance dependence research (Rooke et al., 2008), while researchers mostly reported positive relationships between the relative strength of implicit associations and addiction-related measurements (e.g. cue-reactivity, craving, the severity of addiction-related symptoms). This applies for instance to studies investigating a problematic use of cannabis (Ames et al., 2007; Beraha et al., 2013) and alcohol (e.g. Ames et al., 2014; Foster, Neighbors, & Young, 2014; Hendershot, Lindgren, Liang, & Hutchison, 2012; Houben, Rothermund, & Wiers, 2009; Lindgren, Neighbors, et al., 2015; Lindgren et al., 2013). A selective overview of substance-related studies using the IAT is summarized in Table 4.

Table 4 Selective overview of substance-related studies using the Implicit Association Test (IAT; Greenwald et al., 1998).

Authors	Substance	Findings
R. W. Wiers, van Woerden, Smulders, and de Jong (2002)	Alcohol	Heavy drinkers associated alcohol with arousal in an arousal IAT. Both heavy and light drinkers showed negative implicit associations with alcohol in a valence IAT, while reporting explicit positive associations.
Jajodia and Earleywine (2003)	Alcohol	Positive implicit associations with alcohol predicted actual alcohol consumption in a sample of undergraduate students.
R. W. Wiers, van de Luitgaarden, van den Wildenberg, and Smulders (2005)	Alcohol	Expectancy challenge interventions decreased positive implicit associations with alcohol in heavy drinking college and university students.
Houben and Wiers (2007)	Alcohol	Positive implicit associations with alcohol predicted self-reported drinking behavior.
Ostafin, Marlatt, and Greenwald (2008)	Alcohol	Positive implicit associations with alcohol predicted actual alcohol consumption under depleted self-control.
Houben, Nosek, and Wiers (2010)	Alcohol	A comparison of unipolar and bipolar versions of the IAT showed that the classical bipolar IAT ("positive vs. negative") outperformed all other versions while it was positively associated with positive alcohol use expectancies and actual alcohol use.
Pieters, van der Vorst, Engels, and Wiers (2010)	Alcohol	Children showed stronger implicit associations for alcohol-related stimuli and negative facial expressions compared to positive facial expressions. Paternal drinking behavior was connected with negative implicit associations and explicit arousal.

Reich, Below, and Goldman (2011)	Alcohol	This meta-analysis provided evidence for the assumption that implicit and explicit alcohol-related associations are weakly connected while each might possess unique components.
Burton, Pederson, and McCarthy (2012)	Alcohol	Positive implicit associations with alcohol were connected with actual alcohol consumption.
Cohn et al. (2012)	Alcohol	Positive implicit associations with alcohol were accompanied by stronger subjective craving.
Hendershot et al. (2012)	Alcohol	Genetic COMT and ALDH2 polymorphisms moderated implicit alcohol associations, which suggests that genetic variations might be risk increasing or protective factors regarding the development and maintenance of addictive behaviors.
Lindgren et al. (2013)	Alcohol	Implicit associations in a bipolar drinking identity IAT ("drinker vs. me") predicted alcohol consumption, craving, and alcohol-related problems.
Ames et al. (2014)	Alcohol	Heavy drinkers showed stronger positive implicit associations with alcohol compared to light drinkers. Further, heavy drinkers had greater activity in the insula and left putamen during congruent pairings than light drinkers.
Foster et al. (2014)	Alcohol	High implicit drinking identity was positively associated with actual alcohol consumption.
Lindgren, Neighbors, et al. (2015)	Alcohol	Positive implicit associations with alcohol predicted alcohol use behaviors.

Field, Mogg, and Bradley (2004)	Cannabis	Stronger negative implicit associations with cannabis-related words in non-users compared to users.
Ames et al. (2013)	Cannabis	Cannabis users showed greater bilateral activity in the dorsal striatum during congruent pairings than non-users.
Beraha et al. (2013)	Cannabis	Heavy cannabis users showed stronger positive implicit associations with cannabis compared to a control group.
Marhe, Waters, van de Wetering, and Franken (2013)	Cocaine/ Heroin	Positive implicit associations with drugs were connected with relapse rates.
P. W. Wang et al. (2015)	Heroin	Positive implicit associations with heroin were positively connected with the frequency of heroin use.
Huijding, de Jong, Wiers, and Verkooijen (2005)	Nicotine	Although smokers indicated less negative implicit associations with smoking, both smokers and non-smokers showed negative implicit associations with smoking.
de Houwer, Custers, and de Clercq (2006)	Nicotine	Positive implicit associations with smoking in smokers in an IAT with personalized stimuli.
Sherman, Chassin, Presson, Seo, and Macy (2009)	Nicotine	Positive implicit associations in smokers were accompanied by positive implicit smoking associations in their children. Further, positive implicit associations with smoking in adolescents predicted smoking initiation in an 18-month follow-up study.
Chassin, Presson, Sherman, Seo, and Macy (2010)	Nicotine	Positive implicit associations with smoking predicted actual cessation success in smokers who were planning to quit.
Rydell, Sherman, Boucher, and Macy (2012)	Nicotine	Watching public service announcements on consequences of smoking led to negative implicit associations in non-deprived smokers.

Macy, Chassin, and Presson (2013)	Nicotine	Positive implicit associations with smoking were negatively associated with support for tobacco control policies.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

The results of the studies summarized in Table 4 illustrate that implicit associations measured by the IAT seem to be prevalent in substance-related addictive behaviors. The results emphasize that although not all studies were able to report connections between implicit associations and addiction-related measurements, the majority of research provided evidence for the assumption that addicted individuals possess stronger positive implicit associations with drug-related cues than non-addicted individuals. However, a major concern regarding the IAT is that is supposed to measure not only the association of interest (e.g. “alcohol or positive”) but rather the implicit associations regarding both target-attribute pairings (e.g. “alcohol or positive” vs. “water or negative”). Therefore, several researchers have used single-target IATs (ST-IAT) which were designed only to measure implicit associations regarding one target and two attribute concepts (e.g. “alcohol or positive” vs. “alcohol vs. negative”). Results from studies using ST-IATs could approve previous research by showing that positive implicit associations with drugs were prevalent in individuals with problematic or addictive drug use (Houben & Wiers, 2006, 2008; Huijding & de Jong, 2006; Thush & Wiers, 2007; R. W. Wiers, Houben, & de Kraker, 2007; Woud, Hutschemaekers, Rinck, & Becker, 2015). Another paradigm introduced to assess implicit associations with drug-related cues is the Extrinsic Affective Simon Task (R. W. Wiers, Ganushchack, van de Ende, Smulders, & de Jong, 2003). Although used in several studies (Chen, Wang, Zhang, Zhang, & Shen, 2015; de Houwer, Crombez, Koster, & de Beul, 2004; de Houwer & de Bruycker, 2007; de Jong, Wiers, van de Braak, & Huijding, 2007), the EAST was not able to compete with the IAT.

Overall, it seems plausible to prefer the application of the IAT over the EAST in order to investigate implicit attitudes. This should especially be the case if the role of implicit attitudes for a particular phenomenon is studied for the first time. Since ST-IATs also provided consistent results, these modifications could be beneficial for examining more specific research questions or approving results from studies using the non-modified IAT.

3.3 Behavioral addictions

As noted before, addiction is a widely used term, which is classically applied to substance dependencies. However, in the last decades, experimental psychologists and clinicians observed newly emerging pathological phenomena aside from substance dependencies, which were connected to specific behaviors such as gambling (Conversano et al., 2012), eating (Volkow & Baler, 2015), buying (A. Müller, Mitchell, & de Zwaan, 2013), sex (Reay, Attwood, & Gooder, 2013), exercising (Egorov & Szabo, 2013), or Internet use (Brand, Young, et al., 2014). Early approaches on the classification of these phenomena applied existing diagnostic criteria from impulse-control disorders, obsessive-compulsive spectrum disorders, or substance dependencies (Grant, Potenza, Weinstein, & Gorelick, 2010). Although still under debate, there is growing support for the assumption that specific behaviors could be referred to as being potentially addictive (Conversano et al., 2012; Garcia & Thibaut, 2010; Leeman & Potenza, 2013a; Lourenço Leite, Pereira, Nardi, & Silva, 2014; Prakash et al., 2012; Schreiber, Odlaug, & Grant, 2013; D. G. Smith & Robbins, 2013; van Holst, van den Brink, Veltman, & Goudriaan, 2010). Researchers transferred the concept of addiction from substance-related to non-substance-related behaviors, commonly referred to as behavioral addictions (e.g. Di Nicola et al., 2015; Grant & Chamberlain, 2014; Jović & Đinđić, 2011; Leeman & Potenza, 2013b; Olsen, 2011; Potenza, 2014a; T. W. Robbins & Clark, 2015; Salicetia, 2015; Thomsen et al., 2014; Wölfling et al., 2013). Consequently, gambling disorder was recently added to the section "Substance-Related and Addictive Disorders" of the DSM-5 (APA, 2013). Internet gaming disorder (IGD) was included in the appendix of the DSM-5 (APA, 2013) in order to indicate the need for further empirical research in this field.

Nonetheless, researchers have also raised the question whether or not the introduction of behavioral addictions might lead to an overpathologizing of everyday life (Billieux, Schimmenti, Khazaal, Maurage, & Heeren, 2015). Possible reasons for this criticism might lie in confirmatory research designs (Billieux et al., 2015) or the introduction of more and more possible types of behavioral addictions such as argentine tango addiction (Targhetta, Nalpas, & Pascal, 2013), pathological publishing (Buela-Casal, 2014), pathological flying (S. A. Cohen, Highham, & Cavaliere, 2011), or street addiction (Bergen-Cico, Haygood-El, Jennings-Bey, & Lane, 2013). Therefore, more research is needed in order to be able to separate between different types of behaviors suitable for a classification in analogy to substance dependencies. There is a lack of research regarding the prevalence of the mechanisms similar to substance dependencies such as conditioning processes, cue-reactivity and craving, approach/avoidance

tendencies or implicit cognition (see also chapter 3.2.1). Table 5 illustrates existing research on conditioning processes, approach/avoidance tendencies, and implicit cognition with respect to buying, eating, and gambling. It is important to note at this point that since this dissertation aims at investigating mechanisms of Internet and respectively cybersex addiction, these concepts will be explained and reviewed in greater detail in chapter 3.4. Studies investigating the before mentioned mechanisms for other sex-related offline behaviors, which are frequently referred to as hypersexuality (e.g. Walters, Knight, & Långström, 2011) or sex addiction (e.g. K. P. Rosenberg, Carnes, & O'Connor, 2012), will also be summarized in chapter 3.4.3.

Table 5 Selective overview of studies investigating the prevalence of mechanisms derived from substance dependencies in non-substance-related behaviors.

Authors	Mechanism	Behavior	Findings
Brockmeyer, Hahn, Reetz, Schmidt, and Friederich (2015)	Approach/ avoidance tendencies	Eating	Subjective craving for food was positively associated with tendencies to approach food-related cues.
Neimeijer, de Jong, and Roefs (2015)	Approach/ avoidance tendencies	Eating	Tendencies to approach low-caloric but not high-caloric food in patients with anorexia nervosa. In a one year follow-up, patients showed tendencies to both approach low- and high-caloric food.
de Castro, Fong, Rosenthal, and Tavares (2007)	Craving	Gambling	Subjective craving in pathological gamblers.
Meule and Kübler (2012)	Craving	Eating	Higher subjective food craving in individuals with tendencies towards addictive eating behaviors.
van Holst, Veltman, Büchel, van den Brink, and Goudriaan (2012)	Craving	Gambling	Higher bilateral activity in the ventral striatum in problem gamblers during high monetary reward trials compared to a control group.

Starcke, Schlereth, Domass, Schöler, and Brand (2013)	Craving	Buying	Positive relationship between subjective craving and tendencies towards pathological buying in a sample of female participants.
Fernie et al. (2014)	Craving	Gambling	Positive relationship between subjective craving and self-reported gambling-associated problems.
Trotzke, Starcke, Pedersen, and Brand (2014)	Craving	Buying	Higher skin-conductance responses on presenting buying cues in pathological buyers compared to a control group. Pathological buyers reported higher subjective craving towards buying than the control group.
van Holst, Chase, and Clark (2014)	Craving	Gambling	Ventral striatum connectivity with the insula was positively associated with the severity of gambling-related problems.
C.-B. Park et al. (2015)	Craving	Gambling	Evidence for the existence of cue-induced craving in pathological gambling.
Trotzke, Starcke, Müller, and Brand (2015)	Craving	Buying	Positive relationship between cue-subjective craving towards online shopping and tendencies towards online pathological buying tendencies.
Wölfling et al. (2011)	Cue-reactivity	Gambling	EEG evidence pointing towards the existence of cue-reactivity in pathological gambling.
Lawrence, Ciorciari, and Kyrios (2014)	Cue-reactivity	Buying	EEG evidence pointing towards the existence of cue-reactivity in pathological buying.

Johansson, Carlbring, Ghaderi, and Andersson (2008)	Implicit cognition	Eating	Individuals with eating disorders showed an attentional bias towards food-related words.
Brevers et al. (2013)	Implicit cognition	Gambling	Positive implicit and explicit associations with gambling in problem gamblers.
Kakoschke, Kemps, and Tiggemann (2014)	Implicit cognition	Eating	Successful attentional bias modification towards healthy food choices in a sample of undergraduate women.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

Aside from the studies mentioned in Table 5 there is further evidence for similarities between substance dependencies and behavioral addictions which are related to decision making (Cocker & Winstanley, 2015; Derbyshire, Chamberlain, Odlaug, Schreiber, & Grant, 2014; Voth et al., 2014; Wiehler & Peters, 2015), reward sensitivity (Gaher, Hahn, Shishido, Simons, & Gaster, 2014), impulsivity (Albein-Urios, Martinez-González, Lozano, Clark, & Verdejo-García, 2012; Balodis et al., 2012; Leeman & Potenza, 2013a), lifetime psychiatric comorbidity (Black, Shaw, McCormick, Bayless, & Allen, 2012), and neurobiological similarities (Hebebrand et al., 2014; Kaye et al., 2013; Marqués-Iturria et al., 2015; Meng, Deng, Wang, Guo, & Li, 2014; Pandit, de Jong, Vanderschuren, & Adan, 2011; Potenza, 2014b; van Holst et al., 2010). Consequently, it seems safe to say that there is, at least, preliminary evidence for crucial similarities between substance dependencies and addictive behaviors. At the same time, this summary of experimental research in the field of behavioral addictions illustrates a great need for further studies. For example, there are no experimental studies investigating conditioning processes in behavioral addictions. Table 5 demonstrates that cue-reactivity and craving were frequently investigated and seem to be prevalent in behavioral addictions, whereas there is only limited research on approach/avoidance tendencies and implicit cognition. However, although there is a great need for studying the distinctiveness of behavioral addictions, there are only a few studies which aim at comparing specific behavioral addictions with each other or with substance dependencies (e.g. Black et al., 2015; S.-W. Choi et al., 2014; de Castro et al., 2007; Farré et al., 2015; Geisel, Panneck, Hellweg, Wiedemann, & Müller, 2014; Meyer, Taranis, Goodwin, & Haycraft, 2011; Tonioni et al., 2014). Overall,

the existing research on behavioral addictions provides promising results, whereas further research is needed.

3.4 Internet addiction

Subjective complaints in everyday life due to an overuse of the Internet are multifaceted and might include a loss of control regarding one's Internet use, experiencing negative emotional states as well as social- or work-related problems (Brand, Young, et al., 2014; Byun et al., 2009; Griffiths, 2010; Weinstein & Lejoyeux, 2010). Until today, it has been frequently suggested to classify an overuse of the Internet in analogy to substance dependencies and gambling disorder as a behavioral addiction (e.g. Chou, Condron, & Belland, 2005; Kiefer, Fauth-Bühler, Heinz, & Mann, 2013; van Rooij & Prause, 2014; Widyanto & Griffiths, 2007). Preliminary approaches on classifying an overuse of the Internet argued to adapt and use the suggested criteria for pathological gambling (Young, 1998b, 1999; Young et al., 1999). However, diagnostic criteria and a consensual terminology are still missing. While referring to an overuse of the Internet, different terms have been used. One key question is thereby whether an overuse of the Internet leads to symptoms comparable to impulse-control disorders (e.g. Beard & Wolf, 2001; Shapira, Goldsmith, Keck, Khosla, & McElroy, 2000), obsessive-compulsive spectrum disorders (e.g. Ha et al., 2007; Pratarelli, Browne, & Johnson, 1999), or substance dependencies (e.g. Kuss, Shorter, van Rooij, Griffiths, & Schoenmakers, 2014; Kuss, Shorter, van Rooij, van de Mheen, & Griffiths, 2014). Subsequently, this phenomenon has been referred to as *excessive Internet use* (e.g. A. Müller et al., 2011; D.-L. Sun et al., 2009), *pathological Internet use* (e.g. Davis, 2001; Durkee et al., 2012; Morahan-Martin & Schumacher, 2000; Niemz, Griffiths, & Banyard, 2005), *problematic Internet use* (e.g. Gámez-Guadix, Calvete, Orue, & Las Hayas, 2015; J. Kim, LaRose, & Peng, 2009; Spada, 2014), *compulsive Internet use* (e.g. Meerkerk, van den Eijnden, Vermulst, & Garretsen, 2009; Muusses, Finkenauer, Kerkhof, & Billedo, 2014; Vink, van Beijsterveldt, Huppertz, Bartels, & Boomsma, 2015), or *Internet addiction* (e.g. Adiele & Olatokun, 2014; Brand, Young, et al., 2014; Burnay, Billieux, Blairy, & Larøi, 2015; Chou et al., 2005; Dong, Huang, & Du, 2011; Hansen, 2002; Widyanto & Griffiths, 2006; Young, 2004). Because of widespread similarities to substance dependencies, Internet addiction is the most used and preferable term (e.g. Brand, Laier, et al., 2014; Brand, Young, et al., 2014; Griffiths, 2001; Kuss, Griffiths, et al., 2014; Young, 1998a; Young et al., 1999). Further, the suggested criteria for IGD in the appendix of the DSM-5 (APA, 2013) share important commonalities with diagnostic criteria for substance use disorder (see also chapter 3.1), including preoccupation, withdrawal, tolerance, or the continuation of an engagement in Internet gaming activities due to experiencing negative consequences in everyday life.

According to Weinstein and Lejoyeux (2010), prevalence estimations with respect to Internet addiction lie between 1.5% and 8.2%. Regarding adolescents, a representative study reported a prevalence of 3% in male and 0.3% in female adolescent Internet users (Rehbein, Kleimann, & Mößle, 2009). However, the assessment of prevalence rates for Internet addiction faces several problems, whereas one major aspect is that consensual diagnostic criteria are still missing. Therefore, studies have used different instruments in order to assess Internet addiction (e.g. Beard, 2005; Caplan, 2002, 2010; Cho et al., 2014; Demetrovics, Szeredi, & Rózsa, 2008; Gámez-Guadix, Villa-George, & Calvete, 2012; Holstein et al., 2014; Meerkerk et al., 2009; Pawlikowski, Altstötter-Gleich, & Brand, 2013; Pontes & Griffiths, 2015; Siciliano et al., 2015; Young, 1998a). Consequently, such prevalence estimations can hardly be compared to each other. Existing studies have been applied in different cultural contexts, which increases the problems associated with comparability (Laconi, Rodgers, & Chabrol, 2014). In summary, more research is needed in order to achieve reliable prevalence estimates, whereas existing evidence points towards a clinical importance of Internet addiction (Adiele & Olatokun, 2014; Cash, Rae, Steel, & Winkler, 2012; Du, Jiang, & Vance, 2010; K. W. Müller, Beutel, & Wölfling, 2014; Shapira et al., 2000; A. Winkler, Dorsing, Rief, Shen, & Glombiewski, 2013; Wölfling, Beutel, Dreier, & Müller, 2014; Young, 2004, 2010).

There is a large amount of studies which investigated comorbidities between Internet addiction and other psychological disorders or influencing factors on Internet addiction. Regarding comorbidity, studies have reported connections between Internet addiction and drug use (Bibbey, Phillips, Ginty, & Carroll, 2015; Evren, Dalbudak, Evren, & Demirci, 2014; Rücker, Akre, Berchtold, & Suris, 2015; Yen, Ko, Yen, Chen, & Chen, 2009) as well as symptoms of depression, anxiety, attention-deficit/hyperactivity disorder, and aggression (for review see Carli et al., 2012). Further, studies have identified personality factors potentially associated with Internet addiction, such as shyness (Chak & Leung, 2004; Ebeling-Witte, Frank, & Lester, 2007), impulsivity (J.-S. Choi et al., 2014; Mottram & Fleming, 2009; Z. Zhou, Zhu, Li, & Wang, 2014), stress (Jun & Choi, 2015), self-control (E. J. Kim, Namkoong, Ku, & Kim, 2008), self-esteem (H.-K. Kim & Davis, 2009; Sariyska et al., 2014), loneliness (J. Kim et al., 2009; McIntyre, Wiener, & Saliba, 2015; Yao & Zhong, 2014), or family-related problems (Li, Garland, & Howard, 2014; Senormancı, Senormancı, Güçlü, & Konkan, 2013; Yao, He, Ko, & Pang, 2013). A meta-analysis by Koo and Kwon (2014) revealed that Internet addiction was strongly associated with a person's characteristics (i.e. escapism, disrupted self-control or dysfunctional coping), whereas for interpersonal factors (i.e. relationship quantity/quality or parental factors) rather small effect sizes were found. Overall, factors associated with Internet

addiction are well documented since their investigation received growing attention in the past 20 years.

The studies which were introduced up to this point are not able to address the following two issues. First, the Internet offers various activities, whereas it not clear whether or not different activities (e.g. gaming or cybersex) might be equally addictive. It has not been addressed so far if Internet addiction should be separated into further subtypes. This is of particular importance because it has already been pointed out by earliest studies in the field of Internet addiction research that individuals might use specific activities in an addictive way while other activities are not (Young et al., 1999). Second, most studies investigated potential correlates of Internet addiction, whereas little attention has been given to a clear differentiation between functional (non-problematic) and dysfunctional (addictive) Internet use. Therefore, the following chapter will introduce theoretical frameworks of Internet addiction research which are able to address systematically these issues. Further, the following chapter aims at comparing these theoretical frameworks with models from substance dependence research in order to identify similarities from a modeling perspective (see also chapter 3.2).

3.4.1 Theoretical frameworks

As one of the first researchers aiming to establish a theoretical framework for Internet addiction, Davis (2001) introduced a cognitive-behavioral approach[7]. Contrary to earlier studies, Davis (2001) did not focus on describing symptoms of Internet addiction such as tolerance and withdrawal (e.g. Young, 1996) but rather on the role of dysfunctional cognitions for developing and maintaining an addictive use of the Internet. Davis (2001) argued that dysfunctional cognitions might both promote and be promoted by an addictive use of the Internet. For example, an individual might possess thoughts about being worthless offline. Such dysfunctional cognitions might be affected by already existing psychopathologies, such as low self-esteem, anxiety, or depression. However, if the Internet is being used for coping purposes, already existing dysfunctional cognitions could be strengthened. For instance, although feeling worthless offline, someone could be respected by online peers. Thus, the Internet might appear to be a functional coping mechanisms, whereas in consequence the Internet use might be increased. Such behaviors might indeed be dysfunctional since they could strengthen thoughts

[7] In his article, Davis (2001) used the term *pathological Internet use* in order to describe an overuse of the Internet. However, due to consistency reasons, the term Internet addiction will also be used when referring to the theoretical framework by Davis (2001).

about being worthless offline, which might promote the development and maintenance of an addictive use of the Internet.

A further key feature of the model by Davis (2001) is the differentiation between generalized (GIA) and specific Internet addiction (SIA). A GIA is supposed to be connected with an addictive use of several Internet activities while no specific activity is preferred. Further, Davis (2001) assumed that a GIA might be developed due to social isolation or a lack of social support. Consequently, the Internet might be used because of its possibility to socialize with others online in order to compensate social needs which might not be satisfied offline. Contrary, an SIA is seen to be connected with a preference for a specific online activity, whereas Young et al. (1999) proposed to separate between activities related with cybersex (e.g. pornography consumption), an over involvement in online relationships (e.g. using social network sites), net compulsions (e.g. online shopping or gambling), information search (e.g. web surfing), and gaming (e.g. playing online or offline computer games). Concerning both GIA and SIA, Davis (2001) assumed that individuals might be reinforced by the use of the Internet. Although no clear differentiation between positive and negative reinforcement is made, Davis (2001) refers to processes in which the engagement in an online activity might reinforce future usages due to experienced gratification. In the process of developing and maintaining an SIA, the experienced gratification due to the use of a specific Internet activity might decrease over time. Thus, its use has to be increased in order to obtain a similar gratification. This process can be compared to the development of cue-reactivity and craving since it is argued that an initially non-problematic gratification might promote dysfunctional urges or cognitions to engage in a specific Internet activity. By strengthening this assumption, Davis (2001) assumes that situational cues, such as the noise of a computer, might elicit responses similar to cue-reactivity.

Overall, the cognitive-behavioral model of Internet addiction by Davis (2001) is one of the first systematic approaches and a valuable contribution to the field of Internet addiction research. However, several limitations have to be noted briefly. First of all, the proposed framework can hardly be transferred to an empirically testable model because most of the assumptions made by Davis (2001) do not rely on empirical observations but rather on other theoretical frameworks or heuristic methods. Second, Davis (2001) argued that a preexisting psychopathology would be necessary for developing and maintaining an addictive use of the Internet whereas contrary cases have been frequently reported (e.g. Young, 2008). Third, although Davis (2001) connected existing psychopathologies with reinforcing effects of Internet use and dysfunctional cognitions, the mechanisms underlying the development and

maintenance of Internet addiction, especially regarding the differentiation between GIA and SIA, remain mostly unclear. At last, the approach by Davis (2001) is limited with respect to a characterization of functional Internet use.

In order to address the limitations of the model by Davis (2001), an extended theoretical framework for Internet addiction was proposed by Brand, Young, et al. (2014). The authors differentiate, in analogy to Davis (2001), between functional and dysfunctional Internet use, whereas dysfunctional Internet use is again separated into GIA and SIA. While referring to neuropsychological and neurophysiological studies from substance dependence and Internet addiction research, Brand, Young, et al. (2014) argue that conditioning processes, i.e. positive and negative reinforcement, might be crucial for developing and maintaining an addictive use of the Internet. Basically, the authors suggest that functional Internet use is characterized by achieving goals and respectively satisfying needs in situations for which the Internet might be an appropriate tool. Once goals and needs are satisfied (e.g. a desired information has been obtained by using the Internet), an individual's specific cognitions about the Internet are positively reinforced because the Internet acted as expected. Brand, Young, et al. (2014) argue that these cognitions are embodied by an individual's coping style and Internet use expectancies. Following, the probability that an individual aims at using the Internet in similar situations is increased. If the Internet is used in a functional way, it should not be used if individual's goals and needs cannot be satisfied. For instance, if an individual suffers from social isolation or lack of social support as proposed by Davis (2001), using the Internet in order to escape from real-life problems would not be functional. According to Brand, Young, et al. (2014) such dysfunctional coping could rather characterize a crucial mechanism for developing and maintaining a GIA. The authors argue that a dysfunctional coping could positively reinforce Internet use expectancies (e.g. "Using the Internet helps to escape from reality.") and an individual's coping style (e.g. "I can do something for less thinking about my problems."). On the other hand, using the Internet to compensate real-life problems could negatively reinforce preexisting aspects of social cognition (e.g. loneliness), dysfunctional personality (e.g. low self-esteem) or psychopathology (e.g. depression), because for the time the Internet is used, symptoms of loneliness or depression might be less experienced. Such dysfunctional coping does not help to solve preexisting real-life problems. Moreover, such behaviors might be likely to increase social isolation or the lack of social support, eliciting a vicious circle in which an individual gets more and more isolated while losing control over his or her Internet use. Overall, Brand, Young, et al. (2014) assume, in analogy to Davis (2001), compensatory mechanisms for GIA.

In contrast, it is assumed that a crucial mechanism for SIA is experienced gratification. As mentioned before, frequently bespoke forms of SIA are related to Internet activities such as gaming, the use of social networking sites, online shopping, or the engagement in cybersex activities (Young et al., 1999). In this context, the aim of this dissertation is to contribute to a better understanding of mechanisms underlying cybersex addiction as one form of SIA. With regard to gratification as potential mechanism of SIA, Brand, Young, et al. (2014) argue that the use of specific Internet applications such as playing computer games or consuming Internet pornography might have reinforcing effects on an individual (e.g. achieving goals/having fun in a computer game or being sexually aroused by the consumption of Internet pornography). The authors argue that the existence of specific predispositions might increase the experienced gratification received from the use of a specific Internet activity. For instance, if an individual possesses specific predispositions towards sex (e.g. high sexual sensation seeking), the consumption of Internet pornography might be accompanied by a high level of anticipated or experienced sexual arousal and gratification. Similar to GIA, it is assumed that the use of specific Internet applications positively reinforces Internet use expectancies (e.g. "Using Internet pornography helps me to satisfy my needs.") and an individual's coping style (e.g. "Consuming Internet pornography is a good way to have fun."), while preexisting psychopathologies might be negatively reinforced (e.g. experiencing less depressive symptoms while consuming Internet pornography).

In summary, Brand, Young, et al. (2014) argue that GIA might underlie compensatory mechanisms while SIA is characterized by gratificational mechanisms (see also Figure 5). The authors assume that conditioning processes, and thereby cue-reactivity and craving, might be crucial for developing and maintaining an addictive use of the Internet while drawing clear connections to mechanisms prevalent in substance dependencies. The model by Brand, Young, et al. (2014) provides important similarities to the approach/avoidance model by Breiner et al. (1999) since both frameworks assume that historical/situational factors, as well as Internet/substance use expectancies, might be of particular importance for developing and maintaining addictive behaviors. Furthermore, the authors are providing an empirically testable model which has been preliminarily validated for GIA (Brand, Laier, et al., 2014) and SIA with respect to an addictive use of social networking sites (Wegmann, Stodt, & Brand, 2015). Regarding the general distinction between GIA and SIA, there is further empirical support (e.g. Király et al., 2014; Laconi, Tricard, & Chabrol, 2015; Montag et al., 2014; Strittmatter et al., 2015). Overall, the model by Brand, Young, et al. (2014) is a promising theory-driven model

(Dong, Lin, & Potenza, 2014; Luijten, Meerkerk, Franken, van de Wetering, & Schoenmakers, 2015; Seok, Lee, Sohn, & Sohn, 2015), which needs further empirical testing.

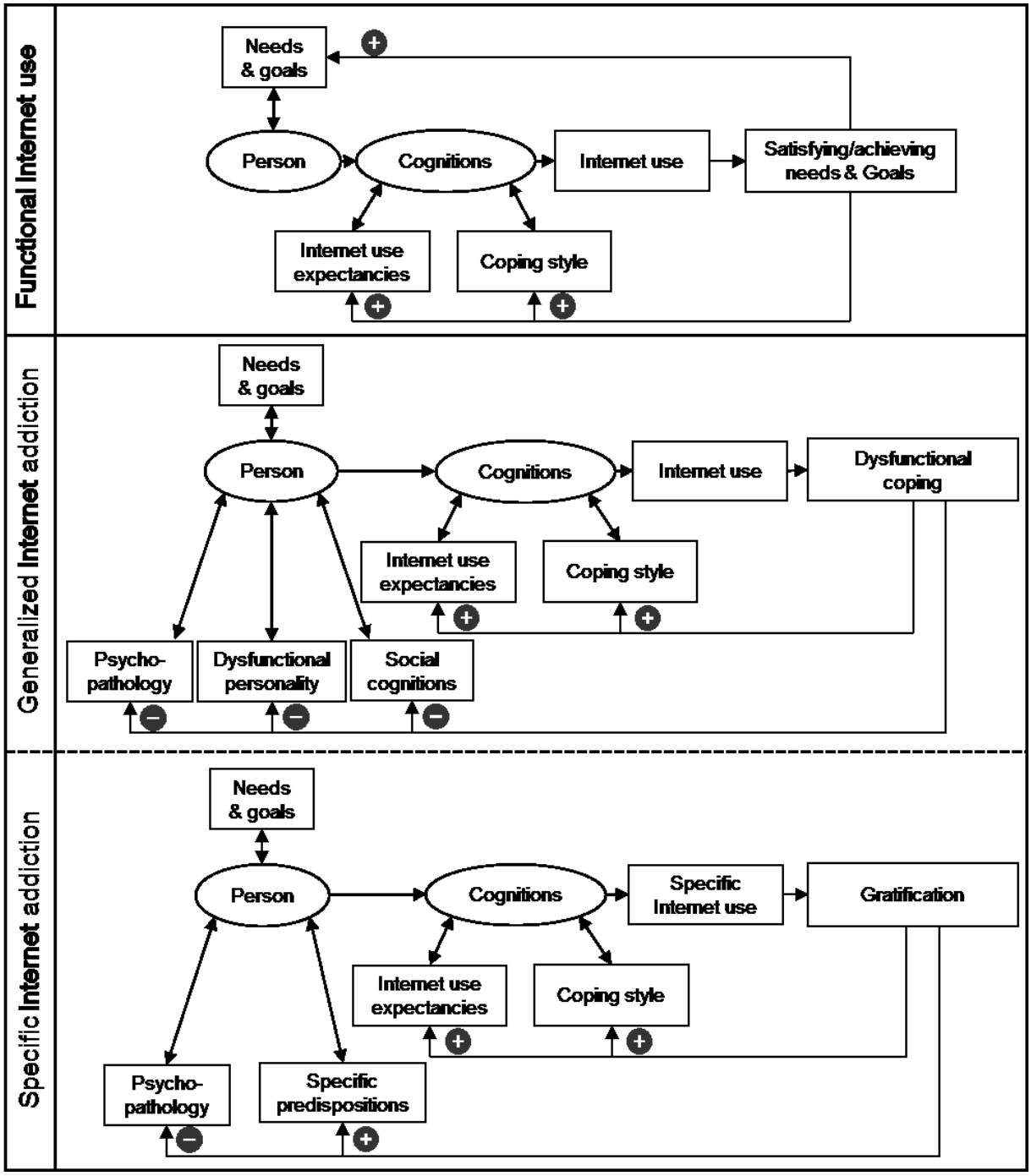

Figure 5 Internet addiction framework by Brand, Young, & Laier (2014). The plus/minus icons are referring to assumed processes of positive (+) and negative (-) reinforcement.

A further crucial point which is mentioned by Brand, Young, et al. (2014) is the question of how the assumed processes of positive and negative reinforcement might be connected with higher-order cognitive functions. For example, why do individuals continue to engage in Internet-related activities despite having already experienced negative consequences in everyday life due to their Internet use? This question could be answered while referring to

processes of implicit cognition (see chapter 3.2.1.3). Consequently, Dong and Potenza (2014) proposed a cognitive-behavioral model for IGD, as a form of SIA, which highly relies on mechanisms prevalent in substance dependencies such as craving, executive functioning, and implicit cognition. Although these mechanisms have been shown to be prevalent in IGD on their own, the assumptions by Dong and Potenza (2014) regarding the relationships between these concepts have to be tested in future studies. The model by Dong and Potenza (2014) possesses strong connections with the framework by Brand, Young, et al. (2014) since both are based on neuropsychological and neurophysiological assumptions derived from substance dependence research. Both frameworks are presenting theory-driven, empirically testable models, which are based on existing experimental research.

Because existing findings in the field of Internet addiction research regarding conditioning processes, cue-reactivity and craving, approach/avoidance tendencies, and implicit cognition are of particular importance for this dissertation, these findings will be summarized in the following chapter.

3.4.2 Similarities to substance dependencies

The amount of experimental studies in the field of Internet addiction research investigating mechanisms of addictive behaviors by using methods from substance dependence research are limited. According to Brand, Young, et al. (2014) most studies were conducted in Asia and addressed IGD. The inclusion of IGD into the appendix of the DSM-5 (APA, 2013) could be referred to limited research regarding GIA or other forms of SIA. Subsequently, the proposition to include Internet addiction (Block, 2008) in the appendix of the DSM-5 (APA, 2013) was dismissed.

In the course of this dissertation, mechanisms regarding conditioning processes, approach/avoidance tendencies, and implicit cognition are of particular interest. However, there are only a few studies investigating these concepts. For instance, there is no experimental study so far, which aimed at directly investigating conditioning processes as well as approach/avoidance tendencies. An overview of existing studies, which investigated one of the before mentioned mechanisms is summarized in Table 6. It has to be noted that, due to consistency reasons, studies addressing cybersex addiction as a form of SIA will be reviewed separately in the following chapter.

Table 6 Selective overview of studies investigating the prevalence of mechanisms derived from substance dependencies in the field of Internet addiction research.

Authors	Mechanism	Activity	Findings
Ko et al. (2009)	Craving	Gaming	Subjective gaming-related craving was positively associated with activations in the orbitofrontal cortex and the nucleus accumbens when watching gaming-related cues.
Stoeber, Harvey, Ward, and Childs (2011)	Craving	Gaming	Gaming-related craving was positively associated with passion for computer games.
Y. Sun et al. (2012)	Craving	Gaming	Subjective gaming-related craving was positively associated with activations in the prefrontal/ anterior cingulate cortex and right inferior parietal lobe when watching gaming-related cues.
Ko, Liu, et al. (2013)	Craving	Gaming	Subjective gaming-related craving was positively associated with activations in the prefrontal cortex in pathological gamers when watching gaming-related cues.
Hormes, Kearns, and Timko (2014)	Craving	Social networking sites	Higher subjective craving in pathological compared to non-pathological users of social network sites.
Thalemann et al. (2007)	Cue-reactivity	Gaming	Higher event-related potentials on the presentation of gaming-related cues in excessive compared to casual gamers.
D. H. Han et al. (2011)	Cue-reactivity	Gaming	Cue-induced brain activations on the presentation of gaming-related

			cues in the prefrontal/orbitofrontal cortex and thalamus.
Lorenz et al. (2012)	Cue-reactivity	Gaming	Cue-reactivity in pathological gamers compared to healthy controls.
Ko, Li, et al. (2013)	Cue-reactivity	Gaming	Comparable brain activations on the presentation of gaming- and smoking-related cues to pathological gamers who smoke.
Dong, Zhou, and Zhao (2011)	Implicit cognition	Gaming	Attentional bias (color-word Stroop) towards gaming-related cues in pathological gamers compared to healthy controls.
Metcalf and Pammer (2011)	Implicit cognition	Gaming	Attentional bias (color-word Stroop) towards gaming-related cues in gamers compared to non-gamers.
Yen et al. (2011)	Implicit cognition	Gaming	Positive implicit associations with gaming in pathological gamers compared to healthy controls.
Lorenz et al. (2012)	Implicit cognition	Gaming	Attentional bias (Visual Probe Task) towards gaming-related cues in pathological gamers compared to healthy controls.
van Holst, Lemmens, et al. (2012)	Implicit cognition	Gaming	Higher levels of subjective problem gaming were positively associated with an attentional bias (color-word Stroop & Visual Probe Task) towards gaming-related cues.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

Besides the mechanisms, which are concentrated in this dissertation, studies reported analogies between substance dependencies and Internet addiction regarding decision making (Buelow, Okdie, & Cooper, 2015; Dong, Hu, Lin, & Lu, 2013; Dong, Lin, Zhou, & Lu, 2014; Dong, Shen, Huang, & Du, 2013; Pawlikowski & Brand, 2011; Z. Zhou et al., 2014), stress (Snodgrass et al., 2014), impulsivity (Choi et al., 2013; S.-W. Choi et al., 2014), reward sensitivity (Dong, Hu, & Lin, 2013; Dong, Huang, et al., 2011; J.-E. Kim et al., 2014), and inhibition (J.-S. Choi et al., 2014; Dong, DeVito, Du, & Cui, 2012; Liu et al., 2014; Luijten et al., 2015). Further, several studies suggested that long-term Internet use might have an effect on striatal dopamine release (Hou et al., 2012; S. H. Kim et al., 2011), functional connectivity (Ding et al., 2013; Dong, Lin, & Potenza, 2014; J. W. Han et al., 2015; Hong, Zalesky, et al., 2013; B. Li et al., 2014; Li et al., 2015; Yuan et al., 2015), or structural brain adaptions (Dong, DeVito, Huang, & Du, 2012; Feng et al., 2013; Hong, Kim, et al., 2013; Kühn et al., 2011; F. Lin et al., 2012; X. Lin, Dong, Wang, & Du, 2015; Y. Sun et al., 2014; Weng et al., 2013; Weng et al., 2012; Yuan et al., 2013; Yuan et al., 2011; Y. Zhou et al., 2011). However, until now it seems, at least, questionable if the identified differences regarding functional connectivity and neuroplasticity are clearly referable to an addictive use of the Internet.

Based on this short summary regarding empirical evidence for similarities between substance dependencies and Internet addiction, it is possible to note the following assumptions. First, the existing empirical evidence clearly suggests the existence of similarities between Internet addiction and substance dependencies, although further research is needed. Second, most studies addressed IGD, while other possible forms of SIA were less frequently investigated. Consequently, future studies should aim at transferring designs already used in the context of IGD to other forms of SIA. Third, the amount of different paradigms used in the studies mentioned is limited. For instance, most studies investigating implicit cognition in Internet addiction used either a color-word Stroop or a Visual Probe Task. The use of the mentioned paradigms seems plausible because a possible existence of attentional bias in Internet-addicted individuals can be deviated from theoretical frameworks of substance dependence research (e.g. Robinson & Berridge, 1993; R. W. Wiers & Stacy, 2006). As pointed out in chapter 3.2.1.3, implicit cognition is a multidimensional construct. Consequently, future studies should aim at expanding the focus on further paradigms such as the Implicit Association Test (Greenwald et al., 1998), which was only used in a single study on IGD, yet (Yen et al., 2011).

Cybersex addiction, as another form of SIA, has been receiving growing attention (Griffiths, 2012). Since it has been shown that sex-related cues are processed similar to

reinforcers such as drugs or food (Georgiadis & Kringelbach, 2012), it seems plausible to assume widespread similarities between cybersex addiction and substance dependencies. Therefore, the following chapter will review existing research on cybersex addiction and deduce research needs.

3.4.3 Cybersex addiction

Since it was estimated by Short, Black, Smith, Wetterneck, and Wells (2011) that the Internet is supposed to contain over four million pages related to cybersex, it seems plausible to assume that the consumption of cybersex is a frequently used Internet activity. According to Döring (2009) cybersex can be divided into six subtypes: Pornography, sex-shops, sex-work, sexual education, sex contacts, and sexual subcultures. Although representative data is still missing, the consumption of pornography is supposed to make up the largest part (Short et al., 2011). Studies investigating pornography consumption in men and women found higher pornography use rates in men, while a stable percentage of women also reported consuming cybersex on a regular basis (Brown & L' Engle, 2009; Daneback, Cooper, & Månsson, 2005; Ferree, 2003; Shaughnessy, Byers, & Walsh, 2011; Wright, Bae, & Funk, 2013). The main motive for engaging in cybersex activities for both men and women is to elicit and experience sexual arousal (B. Paul, 2009). Most studies on cybersex consumption focused on negative consequences such negative effects on sexual role models, a change of sexual expectations in relationships, higher sexual difficulties as well as increased loneliness, sex-related aggression, or less closeness to others (Barak, Fisher, Belfry, & Lashambe, 1999; Landripet & Štulhofer, 2015; Makin & Morczek, 2015; Malamuth, Addison, & Koss, 2000; Popovic, 2011; Reid, Li, Gilliland, Stein, & Fong, 2011; Stulhofer, Baćak, Ajduković, & Graham, 2010; Vega & Malamuth, 2007). Some studies have also highlighted positive outcomes of cybersex consumption, such as increased sexual openness, higher sexual education or higher life satisfaction (Grov, Gillespie, Royce, & Lever, 2011; Hald & Malamuth, 2008). Overall, it is assumed that most people engage in cybersex activities in a functional way. However, a minority of cybersex users has to face a loss of control regarding their cybersex use. Cooper, Delmonico, Griffin-Shelley, and Mathy (2004) proposed to separate generally between *recreational* and *compulsive* cybersex users. Regarding compulsive cybersex users, Carnes, Delmonico, and Griffin (2001) further differentiate between discovery-users, predisposed-users, and lifelong-sexually-compulsive-users. More concrete, it is supposed that discovery-users did not possess any preexisting psychopathology before initial contact with cybersex activities was made. The compulsive use of cybersex can be retraced to properties of the

cybersex activities by themselves (e.g. reinforcing effects of cybersex consumption). Carnes et al. (2001) argue that predisposed-users possess sex-related predispositions (e.g. high sexual excitation), which were under control before the engagement in cybersex activities started. At last, regarding lifelong-sexually-compulsive-users, Carnes et al. (2001) state that these individuals suffer from pathological sexual behaviors already before initial contact with cybersex activities is made. In this case, a compulsive use of cybersex would be a continuation of a preexisting psychopathology. The differentiation by Carnes et al. (2001) is of particular importance because there is an ongoing debate whether or not an addictive use of cybersex should be referred to a symptom of hypersexuality (Kafka, 2010) or as a form of SIA (Brand et al., 2011). While referring to Carnes et al. (2001), it seems plausible to assume that tendencies towards hypersexuality should be prevalent in lifelong-sexually-compulsive-users. Lifelong-sexually-compulsive-users could use cybersex in a compensatory way (e.g. in situations in which an offline satisfaction of sexual urges is not possible). In contrast, it can be argued that for predisposed- and discovery-users a plausible connection to hypersexuality is missing. Before engaging in cybersex activities, no significant psychopathology was prevalent. In this case, it could be argued that, due to the highly reinforcing effects of cybersex (Georgiadis & Kringelbach, 2012), a central mechanism for predisposed- and discovery users could be gratification.

While referring to Brand, Young, et al. (2014), the assumption of gratification as a crucial mechanism would meet a central criterion for SIA. Similarly, Laier and Brand (2014) proposed a theoretical model for cybersex addiction, which puts gratification in the focus of interest. Moreover, it was argued by several researchers that cybersex would be the riskiest activity on the Internet to develop an Internet addiction (Meerkerk, van den Eijnden, & Garretsen, 2006; Young, 2008). One explanation for this assumption was introduced by Cooper (1998) who argued that the Internet would promote cybersex use because it offers easy accessibility as well as high affordability and anonymity to its users. These factors have frequently been referred to as “Triple-A engine” (e.g. Cooper, 1998; Daneback et al., 2005; Kor et al., 2014; Sessoms, 2011; Southern, 2008). Another explanation for this hypothesis might be that there are widespread similarities between the sexual response cycle and substance dependencies regarding neural processing and reinforcement learning in the mesolimbic dopaminergic pathway (Georgiadis & Kringelbach, 2012). More concrete, neuroimaging studies which investigated neural correlates of watching pornographic pictures found activations in claustrum, hypothalamus, striatum (caudate nucleus, putamen), and paralimbic structures (anterior cingulate cortex, orbitofrontal cortex, insula), which are regions associated

with arousal and reward (e.g. Arnow et al., 2002; T. Paul et al., 2008; Redouté & Stoléru, 2000; Stark et al., 2005). These brain regions were identified to play a crucial role within substance dependencies (see chapter 3.2). For an elaborate overview of brain regions involved in processing sexual stimuli, please see Stoléru, Fonteille, Cornélis, Joyal, and Moulier (2012).

Furthermore, studies have shown that the consumption of cybersex is supposed to elicit sexual arousal (Grov et al., 2011; B. Paul, 2009; Pfaus et al., 2012; Svedin, Akerman, & Priebe, 2011). When interpreting sexual arousal as motivational state which aims at approaching sexual behaviors, experiencing sexual arousal in the absence of sex-related situations or cues could be operationalized as a form of craving. While strengthening this assumption, studies could already show that sexual arousal and other sexual responses can be conditioned to neutral cues (Both, Brauer, & Laan, 2011; Both, Laan, et al., 2008; Both, Spiering, et al., 2008; Hoffmann et al., 2004; Hoffmann et al., 2012; Klucken et al., 2009; Letourneau & O'Donohue, 1997; O'Donohue & Plaud, 1994). Moreover, studies provided evidence for the existence of different parts of learning processes known from conditioning theory, such as acquisition, extinction, second-order conditioning, or discriminative learning (Crawford, Holloway, & Domjan, 1993; Pfaus, Kippin, & Centeno, 2001). This is of particular importance because a conditionability of sexual arousal and a similarity to learning patterns prevalent in substance dependencies is a necessary condition for the existence of cue-reactivity and craving with regard to cybersex-related cues. In summary, the consumption of and the engagement in cybersex activities is meeting crucial phenomena prevalent in substance dependencies. Going further, Georgiadis and Kringelbach (2012) draw clear connections between sex-related behaviors and the Incentive Sensitization Theory (Robinson & Berridge, 1993, 2001, 2003, 2008). Consequently, since no other form of SIA involves a processing of such reinforcing stimuli, the assumption of widespread similarities to substance dependencies seems most likely for cybersex addiction when compared with other forms of SIA.

However, systematic research distinctly examining cybersex addiction is widely missing. The first studies on cybersex addiction reported cases of lifelong-sexually-compulsive-users who showed tendencies towards an addictive use of cybersex (Schneider, 2000a, 2000b, 2003) while preliminary discussing differences between pathological sex-related behaviors conducted either online or offline (Orzack & Ross, 2000). Following, four studies, which used the same dataset, aimed at investigating psychometric characteristics of sexually compulsive cybersex users (Cooper, Delmonico, & Burg, 2000; Cooper, Delmonico, et al., 2004; Cooper, Galbreath, & Becker, 2004; Cooper, Griffin-Shelley, Delmonico, & Mathy, 2001). In the course of the first study, Cooper et al. (2000) reported higher sensation seeking in sexually compulsive

cybersex users compared with controls. Based on their results, the authors argued to extend sexual education and to develop specific therapeutic programs for sexually compulsive cybersex users (Cooper et al., 2000). In their later published studies (Cooper, Delmonico, et al., 2004; Cooper, Galbreath, et al., 2004; Cooper et al., 2001), the authors aimed at identifying sociodemographic characteristics as well as possible predictors of an addictive use of cybersex, such as preexisting psychopathologies, obsessive sex-related phantasies, or a dysfunctional coping style. Griffiths (2012) identified several problematic issues regarding these studies. For instance, the authors used different instruments in order to separate between problematic and non-problematic cybersex use, such as an online sexual activity questionnaire (Cooper, Scherer, Boies, & Gordon, 1999) or the Kalichman Sexual Compulsivity Scale (Kalichman et al., 1994), which was initially developed to assess sexually-compulsive offline behaviors. Moreover, none of these questionnaires was explicitly designed for measuring cybersex addiction in the context of specific Internet addiction. According to Griffiths (2012), these studies can hardly be compared to each other, while the psychometric properties of the instruments used are at least questionable. These studies mostly reported descriptive rather than inferential result, which decreases the significance of the presented findings. Since the authors of these studies were able to recruit more than 9000 participants for their online studies (Cooper et al., 2000), they, at least, give valuable insights into the psychopathology of cybersex addiction.

Another experimental study which investigated sexually compulsives who used the Internet for sexual purposes was introduced by Daneback, Ross, and Månsson (2006). This study is of particular importance since it is one of the first studies conducted in Europe while applying sophisticated statistical methods. Using a logistic regression approach, Daneback et al. (2006) reported that sexually compulsives in the sample were likely to be males in a committed relation while spending more than 15 hours a week for online sexual activities, whereas no effects of age could be found. However, Daneback et al. (2006) also used the Kalichman Sexual Compulsivity Scale (Kalichman et al., 1994) as the dependent variable. Therefore, it is not possible to differentiate between lifelong-sexually-compulsive-users suffering from hypersexuality and predisposed/discovery users who might rather show symptoms of cybersex addiction.

One of the first approaches distinctly examining cybersex addiction on a theoretical level was made by Young (2008), in which it was argued that experienced gratification, as well as anticipated sexual arousal, might be crucial factors for the development and maintenance of cybersex addiction. While based on these assumptions, Brand et al. (2011) could show in an experimental study that subjective sexual arousal that was induced by watching pornographic

pictures, predicted tendencies towards cybersex addiction. The authors argued that experienced gratification due to watching pornographic pictures might positively reinforce cybersex use, which could lead to the development of cue-reactivity and craving (see also chapter 3.2.1.2). In line with this, a following study, which compared problematic with non-problematic cybersex users, could report stronger subjective craving due to watching pornographic pictures in problematic cybersex users (Laier, Pawlikowski, et al., 2013). Consequently, Laier and Brand (2014) proposed a theoretical framework for cybersex addiction highlighting the importance of gratification and positive as well as negative reinforcement for the development and maintenance of cybersex addiction (see Figure 6). Laier and Brand (2014) argued that specific predispositions towards sex (e.g. high sexual excitation or a problematic sexual behavior) might interact with processes of positive and negative reinforcement due to cue-reactivity and craving, leading to an increased risk for developing and maintaining a cybersex addiction.

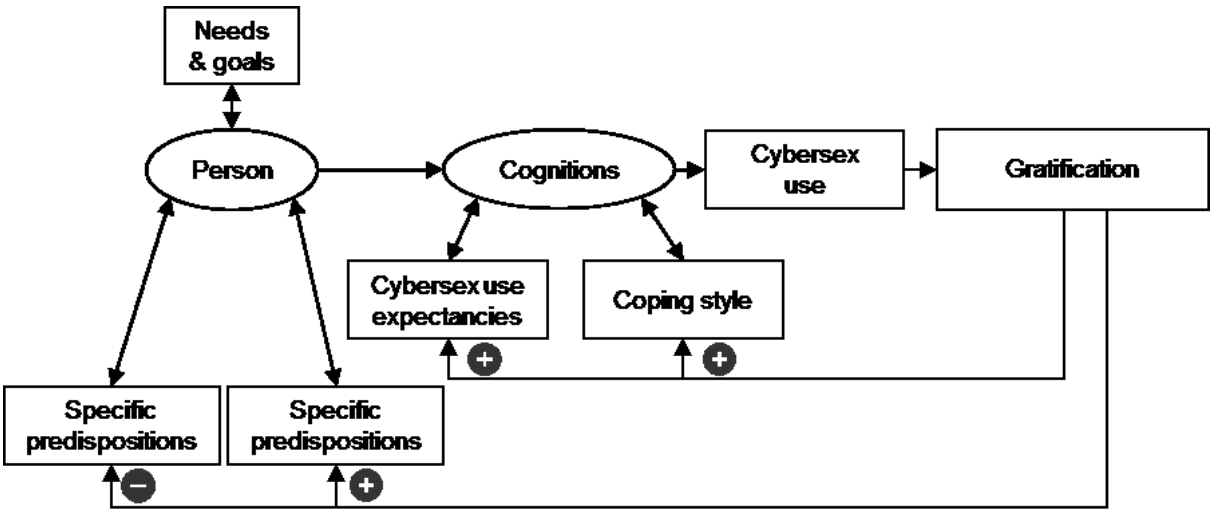

Figure 6 Cybersex addiction framework by Laier and Brand (2014). The plus/minus icons are referring to assumed processes of positive (+) and negative (-) reinforcement.

Because the existence of specific predispositions is not assumed to be necessary for developing an addictive use of cybersex, Laier and Brand (2014) drew a crucial link to Carnes et al. (2001), who proposed to classify between predisposed- and discovery-users. Further, the model by Laier and Brand (2014) possesses similarities to the approach/avoidance framework by Breiner et al. (1999) since both models suggest a crucial role of specific predispositions, respectively historical or situational factors. At last, it is important to note that the cybersex addiction framework by Laier and Brand (2014) is compatible to the definition of addiction by Goodman (2008) since it is suggested to interpret cybersex addiction as a disorder which is affected by processes of both positive and negative reinforcement (see also chapter 3.1).

However, as shown in Table 7, there is still a lack of studies distinctly investigating the role of conditioning processes, cue-reactivity and craving, approach/avoidance tendencies, or implicit cognition for cybersex addiction. Therefore, Table 7 also included studies using erotic or pornographic stimuli while applying experimental paradigms introduced in chapter 3.2.2. When reviewing the research on cybersex addiction regarding the before mentioned mechanisms, it is possible to note that there is empirical evidence suggesting that cue-reactivity and craving might play a crucial role for the development and maintenance of cybersex addiction; both on a subjective as well as a neurophysiological level. There is only limited research on the effect of conditioning processes on cybersex addiction. This is of particular importance because cue-reactivity and craving are supposed to rely on such learning processes. Furthermore, no study has so far addressed the question whether or not a conditionability of sexual arousal might be a specific predisposition for developing and maintaining a cybersex addiction. Since specific predispositions are seen to possibly increase the risk for developing a cybersex addiction (Laier & Brand, 2014), it would be plausible to assume that an interaction between subjective craving and a vulnerability towards developing conditioned responses with respect to sexual stimuli might have an accumulating effect on cybersex addiction.

Table 7 shows that, until today, cybersex addiction studies conceptualized craving solely as an urge to consume pornography, which is referring to a one-dimensional definition of craving. Nonetheless, while adapting the framework by Breiner et al. (1999), craving might not only be represented by an approach towards pornography consumption but also by an avoidance of this urge. However, there is only one study in the field of cybersex addiction research so far, which provided data on the role of approach/avoidance tendencies in cybersex addiction (Schiebener, Laier, & Brand, 2015). Although the evidence provided by Schiebener et al. (2015) is valuable, the findings on approach/avoidance tendencies were rather a side-result because (1) no AAT but a multitasking paradigm was used and (2) the main objective of this study was to investigate the interfering effect of pornographic stimuli on multitasking performance. The study by Schiebener et al. (2015) was inspired by previous studies on cybersex addiction which showed that pornographic pictures had an interfering effect on working memory performance (Laier, Schulte, & Brand, 2013), decision-making under ambiguity (Laier, Pawlikowski, & Brand, 2014) and inhibition (Yu et al., 2012). Similarly, there is only a little research on the role of implicit cognition in cybersex addiction.

Table 7 Selective overview of studies investigating the prevalence of mechanisms derived from substance dependencies with respect to cybersex addiction and other sex-related disorders.

Authors	Mechanism	Findings
Schiebener et al. (2015)	Approach/ avoidance tendencies	Individuals with high tendencies towards cybersex addiction preferred to either work on a pornographic or a neutral picture set in a multitasking paradigm.
Hoffmann et al. (2014)	Conditioning	Individuals with tendencies towards sexually compulsive behaviors showed greater conditioned responses to cues associated with pornography than individuals without tendencies towards sexually compulsive behaviors.
Laier, Pawlikowski, et al. (2013)	Craving	Subjective craving due to watching pornographic pictures was higher in problematic compared to non-problematic cybersex users. Further, subjective craving was positively associated with tendencies towards cybersex addiction.
Laier, Schulte, et al. (2013)	Craving	Subjective craving due to watching pornographic pictures interfered with working memory performance.
Kraus and Rosenberg (2014)	Craving	Subjective craving for pornography was associated with sexual history, preoccupation with pornography and tendencies towards Internet addiction.
Laier and Brand (2014)	Craving	Subjective sexual arousal during the consumption of pornographic pictures was positively associated with craving-related symptoms of cybersex addiction.
Laier, Pekal, and Brand (2014)	Craving	Subjective craving due to watching pornographic pictures was positively associated with tendencies towards cybersex addiction in female cybersex users.

H. Rosenberg and Kraus (2014)	Craving	Subjective craving for pornography was positively associated with a passionate attachment for pornography.
Brand et al. (2011)	Cue-reactivity	Subjective sexual arousal during the consumption of pornographic pictures was positively associated with tendencies towards cybersex addiction.
Kühn and Gallinat (2014)	Cue-reactivity	Weekly pornography consumption was positively associated with activations in the left putamen when watching pornographic pictures.
Voon et al. (2014)	Cue-reactivity	Higher activations in the dorsal anterior cingulate and the ventral striatum due to watching pornographic cues in individuals with compulsive sexual behaviors when compared with individuals without compulsive sexual behaviors.
Brand, Snagowski, Laier, and Maderwald (2016)	Cue-reactivity	Tendencies towards cybersex addiction were positively associated with ventral striatum activity while watching preferred pornographic pictures.
Prause, Janssen, and Hetrick (2008)	Implicit cognition	Attentional bias towards sexual stimuli was positively associated with sexual desire.
Kagerer et al. (2014)	Implicit cognition	Attentional bias towards sexual stimuli was positively associated with sexual sensation seeking.
Mechelmans et al. (2014)	Implicit cognition	Individuals with tendencies towards sexually compulsive behaviors showed a greater attentional bias towards sexual stimuli compared to individuals without towards sexually compulsive behaviors.

Note. The presented overview might not represent all studies using the addressed experimental paradigm(s) since strict selection criteria were applied. The result summaries might not be exhaustive but rather focused on describing mechanisms of addictive behaviors which are investigated in the course of this dissertation.

Besides the investigation of conditioning processes, cue-reactivity and craving as well as implicit cognition, studies reported that cybersex is used for purposes of emotion regulation (Downing, Antebi, & Schrimshaw, 2014; Reid et al., 2011) and stress relief (Grubbs, Volk, Exline, & Pargament, 2013; Kor et al., 2014), which are further factors comparable to substance dependencies.

4 Conclusion from theoretical background

Overall, there is preliminary evidence for assuming similarities between substance dependencies and Internet as well as cybersex addiction. However, the classification of cybersex addiction is still under debate. Regarding mechanisms of addictive behaviors, it was pointed out in chapter 3.2.1 that conditioning processes, cue-reactivity and craving, approach/avoidance tendencies, and implicit cognition are prevalent in substance dependencies. While referring to the prevalence of these mechanisms, it is possible to explain why addicted individuals fail on controlling addiction-related behaviors even though negative consequences have already been experienced in everyday life. If cybersex addiction represents an addictive disorder, the before mentioned mechanisms should also be prevalent in individuals with tendencies towards cybersex addiction. This assumption is strengthened by empirical evidence which already pointed out that sex-related behaviors might underlie conditioning processes. Further, the processing of sex-related stimuli involves activations in the mesolimbic dopaminergic pathway, which was shown to be crucial within substance dependencies (see also chapters 3.2.1.2 and 3.4.3).

As pointed out in chapter 3.4.3, there is only limited research regarding the prevalence of mechanisms derived from substance dependencies in cybersex addiction. There are no studies distinctly examining conditioning processes, approach/avoidance tendencies, and implicit cognition in cybersex addiction. As shown in chapter 3.4.3, there are indeed few studies, which adapted experimental paradigms from substance dependence research with sex-related stimuli, whereas these studies did not investigate cybersex addiction. None of these studies referred to the theoretical frameworks by Laier and Brand (2014) or Breiner et al. (1999). Therefore, the aim of this dissertation is to conduct three studies which investigate conditioning processes, approach/avoidance tendencies, and implicit cognition in the context of cybersex addiction.

In the course of the first study, the aim is to investigate the role of conditioning in cybersex addiction. Therefore, a Standard Pavlovian to Instrumental Transfer Task (S-PIT; Hogarth et al., 2007) is supposed to be adapted with pornographic pictures. Based on existing research on the conditionability of sexual arousal and previously shown similarities regarding neural processing of sex- and drug-related cues (see chapter 3.4.3), it is hypothesized that (1) sexual arousal can be conditioned to neutral cues, (2) the conditionability of sexual arousal is associated with tendencies towards cybersex addiction, and (3) an interaction between

subjective craving and the conditionability of sexual arousal might have an accumulating effect on the severity of symptoms related to cybersex addiction.

The aim of the second study is to investigate analogies between substance dependencies and cybersex addiction with regard to approach/avoidance tendencies by adapting an Approach Avoidance Task with pornographic pictures (Rinck & Becker, 2007). While based on the theoretical framework by Breiner et al. (1999) and the existing empirical evidence introduced in chapter 3.4.3, it is thereby assumed that individuals with tendencies towards cybersex addiction should either show inclinations to approach or to avoid pornographic pictures while no effect should be prevalent for neutral pictures. Since approach/avoidance tendencies represent a multidimensional definition of craving, it seems plausible to hypothesize that such approach/avoidance tendencies could interact with specific predispositions towards sex such as a high sexual excitation or generally problematic sexual behavior.

The aim of the third study is to address the role of implicit cognition in cybersex addiction. As introduced in chapter 3.2.1.3, implicit cognition can be separated into different subtypes, while implicit associations have been identified as a frequently investigated concept which possesses a high predictive value for addictive behaviors (see also chapter 3.2.2.3). Therefore, an Implicit Association Test (Greenwald et al., 1998) is supposed to be adapted with pornographic pictures, while it is assumed that there will be a positive relationship between tendencies towards cybersex addiction and positive implicit associations with pornography. In analogy to study 1 and study 2, it is expected that positive implicit associations with pornography might interact with subjective craving and could thereby have an accumulating effect on cybersex addiction.

Overall, the aim of all three studies conducted in the course of this dissertation is to provide systematic evidence for analogies between cybersex addiction and substance dependencies. The results of this dissertation are supposed to enable a more evidence-based discussion regarding the classification of cybersex addiction. While referring to Everitt and Robbins (2005), each study thereby addresses a different aspect of the hypothesized process from “actions to habits to compulsion” (p. 1481). Conditioning processes (study 1) are seen to be necessary for experiencing and expecting gratification as well as developing craving (Everitt & Robbins, 2005). Especially PIT has been argued to be crucial for eliciting motivational aspects of instrumental behavior (Everitt & Robbins, 2016), such as approaching or avoiding addiction-related stimuli (study 2). Once a problematic use of cybersex has been established, individuals might explicitly aim at controlling their use patterns, whereas implicit cognitions

(study 3) might be crucial for failing on such intentions. In summary, the studies conducted in the course of this dissertation aim at contributing to a better understanding of mechanisms underlying the development and maintenance cybersex addiction as one form of SIA. It is thereby hypothesized that the mechanisms investigated are comparable to those observed in substance dependencies, which would further support to classify cybersex addiction in analogy to substance dependencies as a behavioral addiction.

5 Summary of the studies‘ main results

The three studies conducted in the course of the dissertation provided new empirical data with respect to mechanisms involved in the development and maintenance of cybersex addiction. All studies recruited heterosexual male participants while the experiments were conducted in laboratories of the University of Duisburg-Essen (Germany). Due to the recruitment of non-treatment seekers, all three studies used regression designs in order to investigate the relation of specific mechanisms to tendencies towards cybersex addiction.

The first study (Snagowski, Laier, Duka, & Brand, under re-review) addressed the role of conditioning processes in cybersex addiction. More concrete, study 1 investigated the effect of sexual arousal, subjective craving, and expectancy-based learning as well as their interaction on cybersex addiction. As hypothesized, results showed that sexual arousal could be conditioned to a neutral stimulus (CS+), which was associated with pornographic pictures during an acquisition training phase. Contrary, no conditioning effects of sexual arousal could be found for a second neutral stimulus (CS-), which was associated with neutral pictures. Results showed a significant positive relationship between the conditioned reaction to the CS+ and tendencies towards cybersex addiction. At last, the effect of subjective craving on cybersex addiction was moderated by the conditioned reaction to the CS+. Simple slopes showed that individuals with a high subjective craving, who showed a high conditioned response to the CS+ particularly tended towards cybersex addiction. Overall, study 1 provided evidence for the assumption that conditioning processes might be involved in the development and maintenance of cybersex addiction, whereas sexual conditionability could represent a crucial specific predisposition towards sex.

The second study (Snagowski & Brand, 2015) aimed at investigating the multidimensionality of craving in cybersex addiction. A curve-linear regression analysis provided evidence for the assumption that individuals with tendencies towards cybersex addiction either tended to approach or to avoid pornographic pictures during an adapted Approach Avoidance Task (AAT; Rinck & Becker, 2007). Moderated regression analyses showed that the effect of specific predispositions towards sex, i.e. sexual excitation, and problematic sexual behavior, on craving-related symptoms of cybersex addiction was moderated by approach/avoidance tendencies. Simple slopes showed that individuals with a high sexual excitation and problematic sexual behavior, who tended to avoid pornographic pictures in the AAT particularly reported high craving-related symptoms of cybersex addiction. By strengthening this finding, a linear regression analysis showed that sexual excitation,

problematic sexual behavior, and approach/avoidance tendencies significantly explained unique variance of craving-related symptoms of cybersex addiction. At last, there were positive relationships between an attentional bias towards pornographic pictures and subjective craving, sexual excitation as well as problematic sexual behavior. In conclusion, study 2 provided preliminary evidence for the assumption that craving reactions in cybersex addiction might be represented by either tendencies to approach or avoid cybersex-related behaviors. Moreover, analogies between dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) and cybersex addiction are shown.

The third study (Snagowski, Wegmann, Pekal, Laier, & Brand, 2015) addressed the role of implicit associations in cybersex addiction. More concrete, there were significant positive relationships between positive implicit associations with pornographic pictures and subjective craving, problematic sexual behavior, sexual excitation as well as tendencies towards cybersex addiction. The effect of subjective craving on craving-related symptoms of cybersex addiction was moderated by implicit associations. Simple slopes showed that individuals with a high subjective craving who showed positive implicit associations with pornographic pictures particularly reported high craving-related symptoms of cybersex addiction. Overall, study 3 provided first empirical evidence for supporting the assumption that implicit associations might be involved with regard to developing and maintaining a cybersex addiction. This study provided further evidence for analogies between cybersex addiction and dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006).

6 General discussion

The findings of the three experimental studies conducted in the course of this dissertation provide novel implications regarding theory and practice in the field of cybersex addiction research. The findings possess implications for Internet addiction as well as the more global field of behavioral addictions. The aim of this chapter is to draw broader conclusions on a theoretical and practical level. Based on the underlying results, adapted theoretical frameworks for cybersex addiction and approach/avoidance tendencies are proposed. This chapter will summarize limitations of the conducted studies while future directives are pointed out. However, it is important to note that the specific results of the conducted studies are reviewed in the discussion section of each manuscript.

Beforehand, it can be summarized that the findings of this dissertation consistently provide evidence for further analogies between cybersex addiction and substance dependencies with regard to underlying mechanisms of development and maintenance. The conducted studies addressed the role of conditioning processes, approach/avoidance tendencies, and implicit associations. These mechanisms have been highlighted as being crucial for developing and maintaining addictive behaviors in prominent theoretical frameworks from substance dependence research (e.g. Everitt & Robbins, 2016; Robinson & Berridge, 1993; R. W. Wiers & Stacy, 2006). Due to the fact that all of these investigated mechanisms predicted tendencies towards cybersex addiction, this dissertation's findings point towards transferring the before mentioned frameworks to the field of cybersex addiction. Furthermore, all investigated mechanisms of development and maintenance interacted either with subjective craving or with specific predispositions towards sex, whereas these findings further support the cybersex addiction model by Laier and Brand (2014).

6.1 Theoretical considerations

The findings of this dissertation provide further evidence for similarities between substance dependencies and cybersex addiction. It has been shown that conditioning processes, approach/avoidance tendencies, and implicit associations as one form of implicit cognition were related to tendencies towards cybersex addiction. Since the experimental designs applied in the three studies of this dissertation were closely related to studies from substance dependence research, it appears that (1) comparable measurements were conducted and that (2) the similarity of the present findings to results from substance dependence research suggests further analogies to substance-related addictions. The findings of the conducted studies are of

particular importance because they investigated mechanisms prevalent in different stages of developing and maintaining addictive behaviors. To be more specific, conditioning processes might be essential for establishing initial cybersex-related associations. Once such associations have been built, craving can be assessed by tendencies to either approach or avoid cybersex-related behaviors. At last, implicit associations represent a construct which is frequently referred in order to explain why addicted individuals might explicitly try to cut addictive behaviors while they repeatedly fail on controlling these.

The results of this dissertation possess theoretical implications, which will be summarized in the following sections. First, the present findings are supposed to be integrated into existing theoretical frameworks of Internet addiction research. More specifically, the following sections will summarize theoretical implications of the underlying findings with regard to cybersex addiction and functional cybersex use. Extensions for the theoretical frameworks by Laier and Brand (2014) and Brand, Young, et al. (2014) will be proposed. Second, the approach/avoidance framework by Breiner et al. (1999) will be reviewed in greater detail. An adapted model will be proposed in which the role of *ambivalence* and *indifference* in an addiction-related decision situation is outlined more precisely. Suggestions for a measurable operationalization of *ambivalence* and *indifference* are made.

6.1.1 Cybersex addiction

In their theoretical framework for functional Internet use, Brand, Young, et al. (2014) proposed that an individual possesses needs and goals, which could be achieved by using the Internet. Once an individual's goals and needs are satisfied, specific cognitions about the Internet are assumed to be positively reinforced because the Internet acted as expected. More specific, Brand, Young, et al. (2014) suggest that these cognitions might be embodied by an individual's coping style as well as Internet use expectancies. Following, the probability that an individual aims at using the Internet in similar situations is increased. Functional Internet use is characterized by an individual's ability to differentiate between situations in which the Internet might be or might not be an appropriate tool to satisfy goals and needs. Brand, Young, et al. (2014) highlight the importance of an individual's specific cognitions about the Internet since these cognitions are supposed to be crucial for deciding whether or not the Internet should be used in specific situations. Based on these assumptions, the model of functional Internet use by Brand, Young, et al. (2014) can easily be transferred to a functional use of cybersex: Similarly, it could be assumed that an individual might possess specific cybersex-related needs and goals, such as consuming pornography with a partner in order to experience sexual arousal. Specific

cognitions about cybersex use might have an influence on whether or not the consumption of pornography might be appropriate for satisfying these needs and goals. For instance, in the absence of the partner, the need for partnered-arousal, as defined by Shaughnessy et al. (2011), could not be satisfied. Consequently, cybersex use would not embody an appropriate activity to satisfy/achieve individual goals and needs and should not be approached. In contrast, if the partner is available, pornography could be consumed in order to experience partnered-arousal. Cybersex use would be an appropriate tool to satisfy/achieve individual goals and needs. If approached, the individual's coping style and cybersex use expectancies would be positively reinforced because cybersex use was followed by the expected consequence (i.e. partnered-arousal).

Recently, Laier and Brand (2014) proposed a cybersex addiction model, which is based on the SIA framework by Brand, Young, et al. (2014). Since the studies conducted in the course of this dissertation provided preliminary empirical data which suggests an importance of implicit cognition for cybersex addiction, it is proposed to extend the model by Laier and Brand (2014) by separating between explicit and implicit cognition. Moreover, it is suggested to apply dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) by assuming competing influences between an impulsive and a reflective system in a cybersex-related decision situations. In analogy to Rooke et al. (2008), implicit cognition could be represented by (1) implicit arousal, which is comparable to cue-reactivity (see also chapter 3.2.1.3), (2) attentional bias, and (3) implicit associations (see Figure 7). In general, it is assumed that regarding the development and maintenance of cybersex addiction, the influence of the impulsive system increases over time. As already proposed by Laier and Brand (2014), it is basically expected that a person's core characteristics are affected by specific and non-specific predispositions. Laier and Brand (2014) argued that non-specific predispositions could be represented by a preexisting psychopathology (e.g. depression or anxiety) and aspects of dysfunctional personality (e.g. low self-esteem). Further, it was proposed by the authors that specific predisposition towards sex could be embodied by a high sensitivity for sexual excitation or general problematic sexual behavior (Laier & Brand, 2014). Based on the studies conducted in the course of this dissertation and the proposed integration of dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006), further specific and non-specific predispositions potentially involved in the development and maintenance of cybersex addiction can be proposed. First, regarding non-specific predispositions, it is plausible to assume an effect of an individual's general ability to inhibit specific responses, since R. W. Wiers and Stacy (2006) highlight this ability as a specific vulnerability within their theoretical framework. More

specific, R. W. Wiers and Stacy (2006) attribute the ability to inhibit specific responses, analogous to E. E. Smith and Jonides (1999), to executive functions. As similarly suggested by Brand, Young, et al. (2014), the question remains if a low inhibition ability in general or in relation to a cybersex-related stimuli might critically increase the risk for developing and maintaining a cybersex addiction. For example, an individual might not show dysfunctions regarding inhibitory control when confronted with neutral but with pornographic pictures. The results of this dissertation's studies showed interactions between specific predispositions towards sex and the investigated mechanisms of development and maintenance.

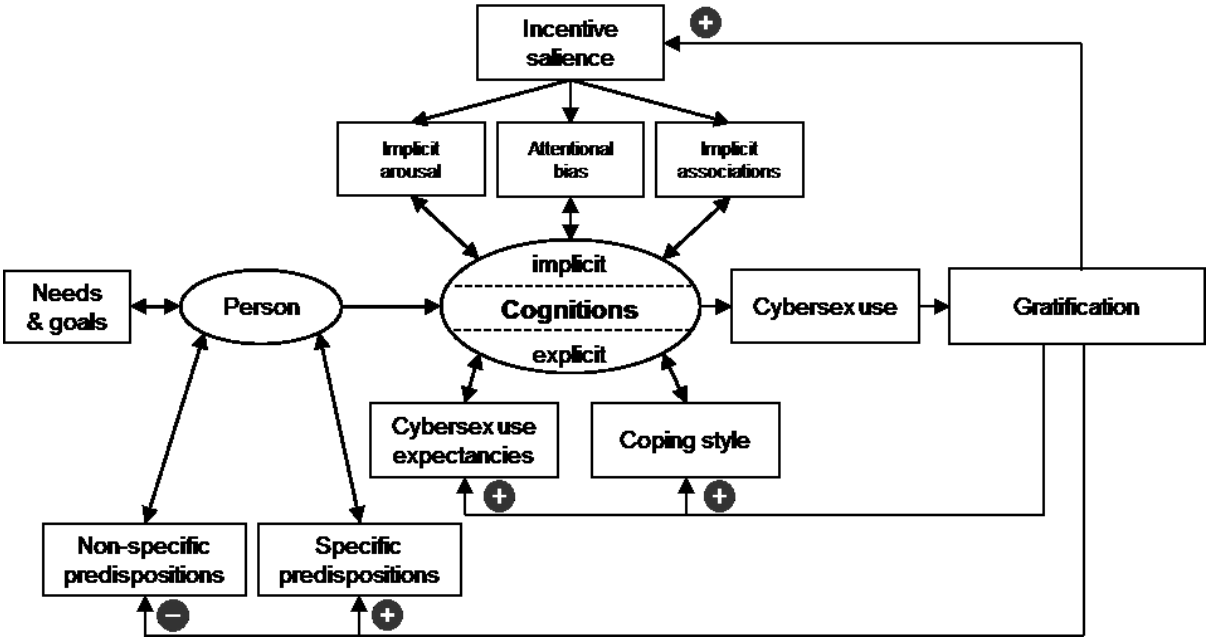

Figure 7 Proposed extension of the cybersex addiction model by Laier and Brand (2014) in which an individual's sex-related conditionability can be interpreted as a specific predisposition towards sex. The plus/minus icons are referring to assumed processes of positive (+) and negative (-) reinforcement.

Therefore, such behaviors could be explained by preexisting effects of specific predispositions towards sex. For instance, a high vulnerability towards implicit arousal might provoke that an individual could show an attentional bias towards pornographic pictures although no tendencies towards cybersex addiction have been developed, so far. If this would be the case, a dysfunctional inhibitory control with respect to addiction-related cues should rather be categorized as a specific predisposition. Since this question has not adequately been addressed yet, there is very limited evidence for the assumption that executive control (Voon et al., 2014) or executive functions in general (Schiebener et al., 2015) might have an effect on cybersex addiction. However, this proposition is especially supported by the second and third study if this dissertation by showing effects of approach/avoidance tendencies as well as implicit associations on tendencies towards cybersex addiction.

Regarding further specific predispositions towards sex, it could be argued to include the conditionability of sexual arousal. While this assumption is strengthened by the more general observation that individuals might be distinctly cue-reactive (B. T. Saunders & Robinson, 2013), the following hypotheses can be summarized. First, if an individual possesses a specific vulnerability towards establishing cybersex-related associations over classical and instrumental conditioning processes, this might result in (1) a higher relative strength of cybersex-related associations and (2) a greater amount neutral cues conditioned to sexual arousal. Such a vulnerability could promote that cybersex-related cravings might be elicited more frequently and in more demanding manner. Further, according to Everitt and Robbins (2016), PIT could be crucial for the transition between conditioning processes as basic forms of learning and the elicitation of motivational aspects which lead to goal-directed behaviors (e.g. approaching pornography consumption). Second, connections to the incentive salience of conditioned, former neutral cues can be drawn. According to Robinson and Berridge (1993), the incentive salience of cues, which is referred to as "the attractiveness of external stimuli, events, places and their mental representations" (p. 280), has to be actively attributed by the brain, while it is assumed that individuals are unaware of this process. The attribution of incentive salience is seen to be strongly connected with conditioning processes. Incentive salience is suggested to be crucial for developing adaptations in the mesolimbic dopaminergic pathway and to elicit reward expectation as well as goal-directed drug-seeking behavior (Robinson & Berridge, 1993). Thus, a vulnerability towards establishing cybersex-related associations over classical and instrumental conditioning processes might be crucially connected with the risk of developing and maintaining an addictive use of cybersex. The first study of this dissertation, which showed an effect of conditioning processes on tendencies towards cybersex addiction, particularly supports this assumption.

Closely related to this argumentation, it is proposed that the attribution of incentive salience to cybersex-related stimuli due to the experienced gratification of cybersex use might be the crucial distinction regarding the effect of implicit cognition on either functional or dysfunctional cybersex use. It is assumed that the experienced gratification of cybersex use positively reinforces the incentive salience of cybersex-related cues, whereas, in consequence, effects of implicit arousal, attentional bias, and implicit associations in cybersex-related decision situations might be strengthened. It is further suggested that the existence of specific predispositions towards sex (i.e. sexual excitation, problematic sexual behavior or a conditionability towards sexual arousal) might critically increase the experienced gratification of cybersex use. In analogy to Stark et al. (2015), it is further suggested that trait sexual

motivation might represent another specific predisposition towards sex. For instance, it can be assumed that trait sexual motivation as a habitual factor might have an effect on situational factors such as subjective craving or cybersex use expectancies. Consequently, a high trait sexual motivation might further increase the risk to develop and maintain a cybersex addiction. Thus, the existence of specific predispositions towards sex could lead to an increased attribution of incentive salience that could strengthen the effect of implicit cognitions in cybersex-related decision situations. In consequence, it is proposed that the ability of the reflective system to control the impulsive system gets decreased in the process of developing and maintaining an addictive use of cybersex, whereas this process could possibly lead to a state in which the impulsive system overrides the reflective system due to its influence and general speed (see also Kahneman & Tversky, 1979). A very recent study by Brand et al. (2016) further supports these assumptions since it was shown that tendencies towards cybersex addiction were positively correlated with activity in the ventral striatum, a structure that is well-known to be involved addictive behaviors and implicit processing (Everitt & Robbins, 2016). Overall, these assumed processes might be able to explain why individuals continue using cybersex although negative consequences in everyday life have already been experienced. Therefore, the integration of the Incentive Sensitization Theory (Robinson & Berridge, 1993) as well as dual-process models (Bechara, 2005; R. W. Wiers & Stacy, 2006) into to theoretical framework for cybersex addiction seem to be beneficial.

Another interesting question in this context is whether or not the mechanisms investigated in this dissertation might be transferable to other forms of SIA. Although this question cannot be answered by referring to the results of the conducted studies, some assumptions regarding this issue are supposed to be summarized briefly. However, it has to be noted that these assumptions remain highly speculative and need empirical testing. In general, the application of dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) appear to be reasonable for other Internet activities because several studies could already point towards a possible importance of implicit cognition for other forms of SIA (e.g. Dong, Hu, Lin, et al., 2013; van Holst, Lemmens, et al., 2012; Yen et al., 2011). There are preliminary studies which provided evidence for the assumption that other forms of SIA, especially IGD, might be accompanied by neuroadaptive processes (e.g. Hong, Kim, et al., 2013; H. S. Park et al., 2010; Yuan et al., 2013). Nonetheless, since other SIA are related to activities such as gaming, shopping, web surfing, or using social networking sites, they are accompanied by the processing of secondary reinforcers. Consequently, since sex-related cues are classified as primary reinforcers, cybersex addiction appears to be the only form of SIA for which it seems

plausible to assume that processes of implicit cognition might already exist within functional use since sex-related cues possess biological importance and preexisting emotional salience. Moreover, the observation that cybersex might be the riskiest activity on the Internet to develop an Internet addiction (Meerkerk et al., 2006; Young, 2008) might be connected with the fact that cybersex addiction is the only form of SIA which contributes the processing of primary reinforcers. Thus, it could be argued that the possibility of preexisting effects of implicit cognition due to the biological importance and emotional processing of sex-related cues (Vuilleumier, 2005) is making the crucial difference to other forms of SIA. However, as mentioned before these hypotheses are speculative and need to be addressed by future research.

6.1.2 Functional cybersex use

The studies conducted in the course of this dissertation did not address functional cybersex use but rather mechanisms for developing and maintaining an addictive use of cybersex. Nonetheless, while referring to (1) dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) and (2) the biological importance of sex-related cues, it is possible to bring forward the argument that implicit cognition might not only be involved in dysfunctional but also in functional use of cybersex. However, it has to be pointed out that these assumptions do not rely on data assessed in the course of this dissertation but rather on a theory-driven argumentation. Therefore, the following hypotheses are highly speculative and need empirical testing.

(1) According to the dual-process model by R. W. Wiers and Stacy (2006), implicit cognition is not only involved in addictive but also in healthy behaviors. The dual-process approach would allow to explain why individuals with a functional Internet use might be able to both decide whether or not the Internet is an appropriate tool for satisfying individual needs and eliciting appropriate behaviors (i.e. approach or avoid Internet use), whereas individuals with an addictive Internet use might especially fail on eliciting appropriate behaviors. In the context of functional cybersex use, these processes could be explained as follows: An individual possesses both implicit as well as explicit cognitions about cybersex. As mentioned before, the explicit cognitions about cybersex use might be embodied by cybersex use expectancies and an individual's coping style. While applying the theoretical framework by R. W. Wiers and Stacy (2006), explicit cognitions about cybersex provide the necessary information for a controlled processing, which evaluates if cybersex use might be appropriate for satisfying needs and goals in a specific situation. As suggested in the last chapter, implicit cognitions about cybersex could be represented by implicit arousal, attentional bias, and implicit associations. If a functional

cybersex use is prevalent, there might be analogies between explicit and implicit cognitions. For example, an individual might possess positive associations with cybersex on both an explicit (i.e. cybersex use expectancies) and an implicit (i.e. implicit associations) level. While referring to Bechara (2005), a functional cybersex use might be characterized by a dominance of reflective processing regarding cybersex use decisions, which are based on the information provided by explicit cognitions. In case the impulsive system would be activated by processes of implicit cognition and elicit an implicit approach tendency (R. W. Wiers & Stacy, 2006), such tendencies could be inhibited in inappropriate situations because of controlling effects of the reflective system. For instance, the perception of cybersex-related cues in the workplace (e.g. cybersex-related pop-ups during work-related Internet activities) might elicit implicit arousal. Since the consumption of cybersex in the workplace is inappropriate and might lead to negative consequences, the implicit approach tendency is suppressed by the reflective system. In other words, even though an individual might experience the need for sexual satisfaction, a reflective processing would lead to the conclusion that the immediate cybersex use would not be appropriate for satisfying this need. The individual might decide to engage in cybersex activities after work in order to satisfy the need for sexual satisfaction. Since such a reflective processing would involve an explicit processing, which includes the consideration of long-term consequences, criteria for functional cybersex use would have been met. Nonetheless, it is important to note that processes of implicit cognition might still be involved, whereas they have been suppressed by the reflective system.

(2) The biological importance of sex-related cues is closely connected with the assumption that processes of implicit cognition might be involved in both functional and addictive cybersex use. As introduced in chapter 3.2.1.1, reinforcers can be separated into primary and secondary rewards. This differentiation is linked to the initial biological valence of specific stimuli. Primary rewards are represented by stimuli which already have a biological and/or evolutionary importance. They possess positive valence without any preceding learning processes. Contrary, secondary rewards need learning processes in order to obtain such a positive valence (Lefrancois, 2006). If this classification is applied consequently, primary rewards would only be represented by important evolutionary reinforcers such as sex or food, which are crucial for an individual's survival and respectively reproduction. It has been frequently suggested that primary and secondary reinforcers might be processed in distinct brain regions, which could also lead to differences regarding reward preference or priority (for review see Schultz, 2000). However, a recent meta-analysis by Sescousse et al. (2013) could not strengthen the assumption that primary rewards might be preferred or processed with higher

priority than secondary rewards. Nonetheless, the authors showed that erotic stimuli elicited robust activations in the amygdala, whereas this was not the case for food- or money-related stimuli. This finding is of particular importance because the amygdala is seen to be crucial for the assignment of emotional values to specific rewards (Sescousse et al., 2013). Since emotional salience is known to modulate attention (Vuilleumier, 2005), it can be assumed that pornographic stimuli should draw the attention of an individual without any preceding learning processes. Furthermore, the perception of pornographic stimuli is supposed to elicit reward expectancy (Brom et al., 2014; Pfaus et al., 2012; Stoléru et al., 2012). On a theoretical level, it can be argued that watching pornographic pictures might elicit both implicit arousal as well as an attentional bias towards these cues even though no cybersex-related psychopathology is prevalent. Consequently, this assumption is strengthened by empirical evidence regarding neural correlates of processing as well as attentional modulation of pornographic cues (for reviews see Georgiadis & Kringelbach, 2012; Imhoff et al., 2010).

Both the application of dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006), as well as the biological importance of sex-related cues, give reason to assume that processes of implicit cognition could already be involved in functional cybersex-related decision situations. In analogy to Robinson and Berridge (1993), incentive salience might represent the crucial link between functional and dysfunctional cybersex use. More specifically, cybersex-related stimuli should not be actively attributed with incentive salience in functional cybersex use, which would prohibit that the influence of the impulsive system over the reflective system gets increased over time. In summary, it is assumed that in functional cybersex use, these facets of implicit cognition might be prevalent without having any negative consequences on cybersex-related decisions, since the impulsive system is supposed to be controlled by the reflective system. Since cybersex is only used to satisfy individual needs in a functional way, there should be no instance which could increase the general influence of the impulsive system, i.e. over processes of positive reinforcement.[8]

6.1.3 Approach and avoidance vs. ambivalence and indifference

The theoretical considerations on the theoretical frameworks of functional and dysfunctional Internet use were inspired by the results of the studies conducted in the course of this dissertation. Regarding the approach/avoidance framework by Breiner et al. (1999), study 2

[8] It is important to note that the impulsive system might override the reflective system in specific situations without causing long-term negative consequences. However, when speaking of functional cybersex use, the majority of cybersex-related decision situations should be dominated by reflective processing.

provided evidence for the assumption that the approach/avoidance framework might be transferable to cybersex addiction. Participants with tendencies towards cybersex addiction either showed tendencies to approach or to avoid pornographic stimuli, whereas it was argued that approach tendencies could be related to an automatic processing and avoidance tendencies to a controlled processing as introduced by R. W. Wiers and Stacy (2006).

Besides *approach* and *avoidance*, Breiner et al. (1999) proposed the states *ambivalence* and *indifference* as possible states in the evaluative space of a decision situation. While approach and avoidance can be investigated using experimental paradigms (e.g. Field et al., 2008; Rinck & Becker, 2007), a measurable operationalization for *ambivalence* and *indifference* is missing. Nonetheless, the assumption of such ambiguous states seems plausible, since a multidimensional definition of craving implies that individuals might experience inclinations to consume or not to consume a drug at the same time. More specific, Breiner et al. (1999) argue that *ambivalence* is characterized by both a high inclination to drink as well as not to drink. In contrast, *indifference* is assumed to be accompanied by both a low inclination to drink and not to drink. Overall, this classification system seems to be reasonable since it is a logical extension of the assumption that addicted individuals might, based in their expectancies, either show tendencies to approach or to avoid addiction-related behaviors. According to Breiner et al. (1999) there is empirical evidence supporting the assumption of such a multidimensional ambivalence framework (e.g. Avants, Margolin, Kosten, & Cooney, 1995; Greeley, Swift, & Heather, 1993; Greeley, Swift, Prescott, & Heather, 1993).

However, the approach/avoidance framework by Breiner et al. (1999) lacks on explaining (1) how the states *approach* and *avoidance* are related to *ambivalence* and *indifference*, (2) what processes might be elicited if either *ambivalence* or *indifference* are entered in an addiction-related decision situation and (3) how *ambivalence* and *indifference* could be operationalized. Therefore, a slightly adapted model on the assumed relationships between approach/avoidance and ambivalence/indifference is suggested as follows (see Figure 8). The main argumentation will rely on the dual-process model by R. W. Wiers and Stacy (2006) since tendencies to approach or to avoid addiction-related behaviors can be linked to automatic and controlled processing.

Regarding the question of how the states *approach* and *avoidance* might be related to *ambivalence* and *indifference*, it is basically suggested to interpret *ambivalence* and *indifference* as optional states. *Ambivalence* or *indifference* might be entered before *approach* or *avoidance*, whereas they should not be entirely predictive for the outcome of an addiction-related decision

situation. Analogous to Breiner et al. (1999), it is assumed that *ambivalence* or *indifference* might be entered in an addiction-related decision situation if the inclinations to engage or not to engage in addictive behaviors are conflictive. Because *ambivalence* is seen to be connected with a high intensity of both inclinations, it seems likely to assume that an individual might be aware of the existing conflict, which should enhance the probability of a controlled processing. Consequently, *ambivalence* should increase the probability that avoidance tendencies are elicited. In contrast, *indifference* is assumed to be accompanied by a low intensity of both inclinations which should increase the probability of an automatic processing and a triggering of approach tendencies. Although the adapted model of the approach/avoidance framework suggests separating between approach/avoidance and ambivalence/indifference by introducing an optional level which provides different probabilities for entering either approach or avoidance, it is assumed that there is no causal relationship between *ambivalence* and *avoidance* or *indifference* and *approach*. Consequently, future studies should aim at identifying processes which might interfere in the evaluative space of an addiction-related decision situation. Furthermore, an operationalization for *ambivalence* and *indifference* has to be provided.

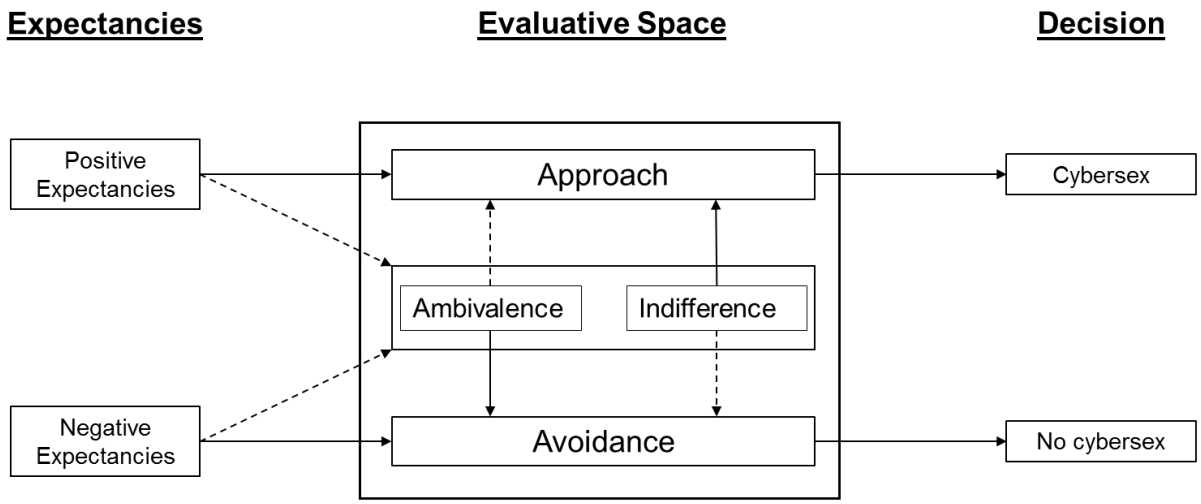

Figure 8 Overview of the adapted approach/avoidance framework based on Breiner et al., (1999). Straight lines represent possible paths with high probabilities while dashed lines rather embody low probabilities.

A similar argumentation regarding the separation between approach/avoidance and ambivalence/indifference was provided by McEvoy, Stritzke, French, Lang, and Ketterman (2004). However, the authors did not interpret *ambivalence* and *indifference* as optional but rather as equal states to *approach* and *avoidance*, which might promote the decision to drink or not to drink by themselves. Further, McEvoy et al. (2004) did not propose an operationalization for *ambivalence* and *indifference*.

Based on the assumptions of Breiner et al. (1999), it could be argued that an imbalance of positive and negative expectancies towards cybersex in a specific addiction-related decision situation might predict that *ambivalence* (i.e. both high positive and negative expectancies) or *indifference* (i.e. both high positive and negative expectancies) are entered (as suggested in Figure 8). It could be argued that high positive and low negative expectancies should predict approach tendencies whereas the opposite should be the case for avoidance tendencies. But even if such predictions might be approved in future studies, the initial question on how to operationalize ambivalence and indifference would remain unanswered. Since the Approach Avoidance Task (Rinck & Becker, 2007) compares reaction times for pushing and pulling the joystick in order to get a score which represents the relative strength of approach/avoidance tendencies, adaptions of this paradigm could be beneficial for assessing *ambivalence* and *indifference*. For example, during the execution of a standard AAT as introduced by Rinck and Becker (2007), reaction times for pushing and pulling target cues with a joystick are compared in separated blocks. Furthermore, participants are instructed to pull target stimuli towards themselves in one block, whereas in another block the target stimuli have to be pushed away from the body. Pushing cues away is operationalized as *avoidance* while pulling them towards one's body is supposed to represent *approach* (Rinck & Becker, 2007). With respect to an operationalization for *ambivalence* and *indifference*, this basic rationale could be adapted in order to be able to operationalize *ambivalence* and *indifference* based on a participants' reaction times. Moreover, the application of sophisticated statistical methods such as Bayesian hierarchical diffusion modeling (Krypotos, Beckers, Kindt, & Wagenmakers, 2014) might be beneficial since such methods might allow to investigate latent processes such as *ambivalence* and *indifference* in greater detail. Another possibility to operationalize *ambivalence* and *indifference* was suggested by Lee, Cho, and Lee (2014) who modified the Approach and Avoidance of Alcohol Questionnaire (McEvoy et al., 2004) and allocated self-reported *approach* and *avoidance* inclinations. The study by Lee et al. (2014) preliminary supports the proposed adaptation of the approach/avoidance framework since problem drinkers with high levels of ambivalence showed, at first, an attentional bias towards alcohol-related cues, whereas the attention was shifted to neutral pictures in consecutive sequences. However, more research is needed regarding a validation of appropriate measures for ambivalence and indifference as well as the proposed adaptation of the approach/avoidance framework.

6.1.4 Cybersex in the context of behavioral addiction research

As introduced in the preceding chapters, cybersex addiction can be connected with theory-driven frameworks, which is increasing the systematization of this field of research. However, the question remains whether or not cybersex addiction should be classified in analogy to substance dependencies as a behavioral addiction. Although the studies conducted in the course of this dissertation provide further empirical evidence for similarities between cybersex addiction and substance dependencies, this question cannot be answered, so far. Even though theoretical frameworks on Internet addiction (Brand, Young, et al., 2014) and cybersex addiction (Laier & Brand, 2014) suggested mechanisms which enable a distinction from hypersexuality or sex addiction, the line between these disorders remains still relatively thin. Therefore, the aim of the following section is to discuss this dissertation's findings in the light of a recent debate on the usefulness as well as current interpretations of the behavioral addiction concept (see Billieux et al., 2015). Suggestions are made in order to enhance the standardization of the methodology applied in this field of research.

Problems regarding the investigation and classification of newly emerging potentially addictive behaviors are multifaceted and can briefly be summarized as follows. First, the field of behavioral addiction research is still relatively young. The amount of systematically conducted experimental studies is still limited when compared to the field of substance dependence research. The section "Substance-related and addictive disorders" was included into the DSM-5 (APA, 2013) quite recently, allowing a categorization of non-substance-related addictive behaviors. Second, and closely related to the first reason, there is a lack of standardized instruments for investigating and classifying different forms of behavioral addictions. A systematic investigation of implicit and neural processes involved in behavioral addictions, which for might valid and reliable comparisons between different behaviors and substance dependencies, are widely missing. Third, the field of behavioral addiction research is not clearly arranged because more and more potential forms of behavioral addictions are proposed. Some behaviors which have been suggested to be potentially addictive such as gambling, sex, buying, eating or Internet use seem reasonable while the supporting empirical evidence is constantly growing. On the other hand, resilient empirical evidence for other proposed forms such as argentine tango addiction (Targhetta et al., 2013) or street addiction (Bergen-Cico et al., 2013) is widely missing (see also chapter 3.3). In this context, Billieux et al. (2015) pointed out that a significant amount of studies suggesting potentially addictive behaviors have relied on anecdotal observations and confirmatory research designs, which considered specific behaviors *a priori* as being addictive. The authors further criticized weak

psychometric properties of instruments used to assess behavioral addictions, which might lead to an overpathologizing of everyday life (Billieux et al., 2015). The opinion by Billieux et al. (2015) received great attention from several commentaries. For instance, it was highlighted by Blaszczynski (2015) that inflationary propositions for new behavioral addiction might endanger an acknowledgment of this field of research. Blaszczynski (2015) argued that it has to be investigated elaborately if newly emerging pathological behaviors might be indeed behavioral addiction or rather a manifestation of an existing psychopathology. Furthermore, Maraz, Király, and Demetrovics (2015) pointed out boundaries of screening instruments by stating that such instruments might not be able to diagnose addictive behaviors. Whereas most commentaries in this debate aimed at highlighting problematic issues of recently suggested forms of behavioral addictions, it was stated by Clark (2015) that even the research on pathological gambling still suffers from methodological problems such as a the clear specification of neurophysiological correlates.

Overall, this current debate highlighted important problematic issues in the field of behavioral addiction research. Based on the before mentioned difficulties and the arguments provided by Billieux et al. (2015), the following recommendations can be made: First, researchers should be more cautious regarding the proposition of new forms of behavioral addictions. Second, behavioral addiction research should both focus on generating consensual diagnostic criteria which are applicable to all forms of potentially addictive behaviors. Closely related with this, there is a need for screening instruments which possess excellent psychometric properties in order to be able to identify tendencies towards addictive behaviors. Subsequently, screening instruments should be designed in an adaptable way in order to be able to compare tendencies towards different potentially addictive behaviors in a valid way. While referring to Maraz et al. (2015), it is important to note that screening instruments are limited and cannot replace diagnostic interviews. Third, since there is a great lack of research regarding implicit cognition as well as the neurophysiology of behavioral addictions, future research should aim at deeper investigating such phenomena. For instance, given the existence of a common neural reward cycle (Sescousse et al., 2013), which might be sensitive for both primary and secondary rewards in a similar manner, it is plausible to assume that every behavior stimulating this cycle might be potentially addictive. Therefore, future studies should adapt and use experimental paradigms from substance dependence research in order to systematically point out commonalities between behavioral addictions and substance dependencies.

In the context of cybersex addiction research, it is reasonable to argue that the existing empirical evidence points towards a classification as a behavioral addiction. Existing studies on

cybersex addiction could systematically provide evidence for a prevalence of mechanisms frequently observed in substance dependent individuals. This assumption is strengthened by the observation that the processing of sex-related stimuli involves an activation of the mesolimbic dopaminergic pathway, which is referred to as being crucial for developing and maintaining addictive behaviors (Robinson & Berridge, 1993, 2001, 2003, 2008). With regard to this dissertation's findings, further support for classifying cybersex addiction in analogy to substance dependencies has been provided since crucial mechanisms of addictive behaviors were shown in individuals with tendencies towards cybersex addiction. More specifically, the studies conducted in the course of this dissertation provided evidence for a potential importance of (1) conditioning processes, (2) approach/avoidance tendencies, and (3) implicit associations for developing and maintaining an addictive use of cybersex. While referring to Everitt and Robbins (2005), the mechanisms investigated in this dissertation represent a different aspect of the process of developing and maintaining addictive behaviors, which increases the finding's explanatory power.

However, existing results remain preliminary and need to be replicated. Furthermore, differences and commonalities of hypersexuality and cybersex addiction should be deeper investigated by future research, since systematic comparisons have not been conducted, so far.

6.2 Practical implications

Besides the theoretical considerations mentioned in the preceding sections, it is possible to highlight some practical implications of this dissertation's findings. However, the implications noted have to be seen in the context of the following premises. First, it is assumed that the studies conducted in the course of this dissertation indeed reflect crucial similarities between cybersex addiction and substance dependencies regarding pathomechanisms of development maintenance. It is postulated that there are effects of conditioning processes, approach/avoidance tendencies, and implicit associations on cybersex addiction as suggested by the studies conducted in the course of this dissertation. Furthermore, it is presumed that the integration of the dual-process model by R. W. Wiers and Stacy (2006) into the cybersex addiction framework by Laier and Brand (2014) is valid. Second, since most implications will suggest the adoption of treatment methods derived from substance dependence research, it is important to keep in mind that further research is necessary in order to validate this dissertation's findings. New treatment methods should be established with great caution while systematic studies have to be conducted in order to evaluate the usefulness of these methods. Third, and closely related to the second premise, clinicians have to be involved in the process of designing new treatment methods, since the results of this dissertation remain preliminary while representing fundamental research. Based on these premises, practical implications of this dissertation's findings are suggested as follows.

(1) It has already been argued by Brand, Laier, et al. (2014) that the application of cognitive-behavioral therapy for Internet addiction (Young, 2011), which addresses an individual's specific cognitions about the Internet, seems to be a promising approach. In line with this, the importance of cognitive-behavioral methods and interventions for the treatment of compulsive sexual behavior was highlighted by Southern (2008). From a modeling perspective, specific cognitions about the Internet were suggested to be essential for developing and maintaining an Internet addiction by Davis (2001) as well as Brand, Young, et al. (2014). The findings of this dissertation strengthen this assumption by providing preliminary evidence for an effect of not only explicit but also implicit cognition on tendencies towards cybersex addiction. Therefore, it appears to be important to address both explicit as well as implicit cognitions in a therapeutic setting. Regarding explicit cognitions, valuable recommendations were made by Young (2011) which are more generally derived from methods of cognitive-behavioral therapy. However, since it has been suggested that implicit and explicit cognition, as well as an individual's conditionability, might interact with each other (e.g. Bernardin,

Maheut-Bosser, & Paille, 2014; Forrest, Smith, Fussner, Dodd, & Clerkin, 2016; R. W. Wiers, S. R. Boelema, et al., 2015), the question is raised on how dysfunctional implicit cognitions could be addressed by treatment methods. First of all, as suggested by Lee and Lee (2015), basics of implicit and explicit cognition as well as the role of approach/avoidance tendencies could be implemented into therapy as a part of a patient's psychoeducation. Further, studies from substance dependence research have already pointed out that dysfunctional effects of implicit cognition can potentially be retrained, i.e. to increase the probability that experiencing craving might result in avoidance rather than approach tendencies (e.g. Eberl et al., 2013a, 2013b; R. W. Wiers et al., 2011). One way to transfer the concept of retraining to the treatment of cybersex addiction could be to adapt existing training programs in which patients constantly avoid cybersex-related stimuli by pushing them away with a joystick. On this way, addiction-related decision situations might be stronger effected by controlled processing and in consequence an avoidance of addictive behaviors. However, it has to be noted that, in analogy to Eberl et al. (2013b), systematic studies would have to be conducted in order to identify the optimal number of training sessions. New treatment methods could also aim at retraining implicit associations. In this context, it was already shown by Houben, Schoenmakers, and Wiers (2010) that evaluative conditioning of the association alcohol/negative led to decreased positive implicit associations towards alcohol in a follow-up experiment. Since an Implicit Association Test (Greenwald et al., 1998) was already successfully used for retraining social anxiety associations (Clerkin & Teachman, 2010), a potential application for the treatment of cybersex addiction could, at least, be addressed by upcoming studies. Furthermore, Houben, Wiers, and Jansen (2011) provided evidence for the hypothesis that working memory training could enhance cognitive resources in addiction-related decision situations leading to an increased capability to control automatic impulses. Since Laier, Schulte, et al. (2013) already showed interfering effects of pornographic pictures on working memory performance, the application of such methods appears to be highly beneficial. Moreover, a combination of avoidance and working memory training as a part of cybersex addiction therapy could have positive effects on treatment outcome. But overall, it has to be noted that there is only a little evidence to support the effectiveness of such methods, so far (R. W. Wiers & Stacy, 2013).

(2) Closely related to implicit cognition are the concepts of self-control and inhibition. On a theoretical level, it was argued by R. W. Wiers and Stacy (2006) that an individual's ability to inhibit specific responses might be of crucial importance for suppressing urges to engage in addictive behaviors. It was suggested by R. W. Wiers and Stacy (2013) that an interaction between a low inhibitory control and implicit cognition might have an accumulating effect on

the risk for developing addictive behaviors. While addressing such a vulnerability, studies have shown that an individual's ability to inhibit specific actions can be trained (e.g. Bowley et al., 2013; Houben & Jansen, 2011; Houben, Nederkoorn, Wiers, & Jansen, 2011), whereas most studies used modified versions of the visual Go/NoGo paradigm (Verdejo-García & Pérez-García, 2007). Furthermore, it was argued by Tang et al. (2015) that other techniques, such as mindfulness meditation, could be applied to improve self-control. Consequently, an adoption of these techniques might be beneficial for increasing an individual's inhibition and self-control and might, therefore, be included into the treatment of cybersex addiction. In order to bring forward a more speculative hypothesis, a recent study by N. Cohen et al. (2016) could show that executive control training decreased amygdala reactivity. In the context of cybersex addiction, this finding is of particular importance because pornographic stimuli are known to elicit robust activations in the amygdala (Sescousse et al., 2013). Since the amygdala is seen to be crucial for the assignment of emotional values to specific rewards and emotional salience is known to modulate attention (Vuilleumier, 2005), executive control training could decrease attentional bias towards cybersex-related stimuli. In conclusion, the application of such methods might be crucial for significantly improving an individual's ability to control cybersex-related stimuli.

(3) Besides executive control training, attentional bias might also be decreased by attentional retraining programs (e.g. Christiansen, Schoenmakers, & Field, 2014; Schoenmakers et al., 2010; Schoenmakers et al., 2007; R. W. Wiers et al., 2006). By applying such methods for the treatment of cybersex addiction, it could be possible to further reduce a high-priority processing of cybersex-related stimuli, which might decrease the risk for addictively using cybersex.

(4) Given that conditioning processes have an effect on the development of cue-reactivity and craving in cybersex addiction, it is implied that cybersex addicted individuals have learned dysfunctional cybersex-related associations. It should theoretically be able to extinct, such associations. Consequently, extinction is seen to be crucial for treatment of sexual addictions (Garcia & Thibaut, 2010). However, according to Klucken (2013), little is known about methods which might increase extinction intensity in order to implement extinction paradigms into the treatment of sexual addictions. Another way to encounter effects which are based on conditioning processes is to apply methods of cue-exposure therapy (e.g. C.-B. Park et al., 2015). While cue-exposure therapy cannot extinct already built associations, the intensity of experienced craving might be reduced (Pericot-Valverde, García-Rodríguez, Gutiérrez-Maldonado, & Secades-Villa, 2015). Furthermore, Vollstädt-Klein et al. (2011) provided

evidence for a reduction of neural cue-reactivity in abstinent alcoholics due to cue-exposure treatment. It has to be tested whether or not cue-exposure therapy might be applicable to the treatment of cybersex addiction, since pornographic pictures, which had to be used, would not represent an addiction-related proxy but rather be the addictive material by itself. However, Everitt and Robbins (2016) recently argued that the effectiveness of cue-exposure therapy for treating substance dependencies might be relatively ineffective. Thus, systematic studies regarding its effectiveness for the treatment of cybersex addiction need to be conducted.

(5) It can briefly be noted that it might be beneficial for the treatment of cybersex addiction to apply intervention techniques from substance dependence research since crucial similarities between marijuana dependency and cybersex addiction have been reported regarding their impact on romantic or family relationships (Pyle & Bridges, 2012). Further, widespread similarities were reported by an elaborate study between pathological gambling and sex addiction (Farré et al., 2015). Besides the adoption of intervention techniques from substance dependence research, few studies have also reported medical treatment (i.e. naltrexone) for cybersex addicted individuals (e.g. Bostwick & Bucci, 2008). However, although the results of this dissertation emphasize further links between substance dependencies and cybersex addiction, there is not enough empirical evidence so far to support a medical treatment of cybersex addiction.

In summary, it is possible to suggest the adoption of several treatment methods derived from substance dependence research, which might also be of particular importance for the treatment of cybersex addiction. Because there are no diagnostic criteria for cybersex addiction so far, it remains difficult to classify treatment seekers as cybersex addicted individuals. Furthermore, it appears to be important to note that the introduction of new treatment methods should be accompanied with great caution.

6.3 Limitations and future directives

Beyond the limitations noted in the discussion sections of the three conducted studies, there are several further limitations as well as future directives to be mentioned, which are based on a more general level.

(1) It has to be noted that although tendencies towards cybersex addiction could be assessed, the findings of this dissertation cannot be completely generalized for treatment seeking cybersex users. Cybersex addiction research is generally facing the problem that classic between-design studies, which compare addicted individuals with healthy controls, are widely missing. However, this problem can be referred to the fact that there are still no consensually accepted criteria for cybersex addiction. Therefore, it appears to be crucial that future studies aim at the extraction of diagnostic criteria for cybersex addiction, in order to be able to conduct studies with between-designs.

(2) There are only preliminary studies investigating cybersex addiction in homosexual individuals (e.g. Laier, Pekal, & Brand, 2015) or women (e.g. Laier, Pekal, et al., 2014). Similar to the first limitation, it seems, at least, questionable up to which extent existing evidence derived from studies investigating heterosexual men can be generalized to homosexual individuals or women. Although, on a neural level, studies reported strong commonalities between men and women (Wehrum et al., 2013) as well heterosexual and homosexual males (Kagerer et al., 2011). With regard to the investigation of women, there is empirical evidence for the assumption that subjective sexual arousal due to watching pornographic pictures might differ in the course of the menstrual cycle (e.g. Burleson, Trevathan, & Gregory, 2002; Heiman et al., 2011; Suschinsky, Bossio, & Chivers, 2014; Zhu et al., 2010). Further, it was shown that the availability of sex hormones modulated neural activations during extinction learning (Merz et al., 2012). It has been argued that women, in general, respond less to pornographic stimuli while having distinct preferences (Rupp & Wallen, 2008). Therefore, future research should aim at addressing these issues. For instance, future studies could conduct multiple assessments of subjective sexual arousal due to watching pornographic pictures in the course of the menstrual cycle. Moreover, it should be discussed if questionnaires for assessing specific predispositions towards sex need to be adapted. For example, Velten, Scholten, Graham, and Markgraf (2015) recently introduced an adapted scale for measuring sexual excitation as well as sexual inhibition in women, since the originally proposed scale was designed to be applied to male samples (Carpenter, Janssen, Graham, Vorst, & Wicherts, 2010).

(3) It needs to be pointed out that the findings of this dissertation are not transferable to other forms of SIA without further empirical testing. Due to the fact that sex-related stimuli represent primary reinforcers (Sescousse et al., 2013), it could be argued that adapted experimental paradigms, as used in the three studies of this dissertation, might provide weaker effects when secondary reinforcers are used (e.g. online-shopping cues). This might especially be the case for investigating conditioning processes since it was suggested that its assessment frequently fails because of insufficient stimulus material (Martin-Soelch et al., 2007). Future studies should aim at adapting the experimental paradigms used in the course of this dissertation in order to investigate other forms of SIA and respectively behavioral addictions. Furthermore, it was argued by R. W. Wiers and Stacy (2013) that the research on implicit cognition in the context of substance dependencies is still facing great knowledge gaps. Therefore, it appears to be necessary to monitor progresses in substance dependence research and to adapt upcoming research designs for the field of behavioral addiction research.

Overall, it can be summarized that the systematic investigation of cybersex addiction, as well as other forms of SIA, is still at the beginning. Therefore, there is a great need for empirical studies in this field in order to address the limitations and future directives mentioned here as well as in the discussion sections of the three conducted studies.

6.4 General conclusion

The findings of this dissertation provide further evidence for similarities between substance dependencies and cybersex addiction. Results revealed that conditioning processes, approach/avoidance tendencies as well as implicit associations had an effect on tendencies towards cybersex addiction. All three studies could show that self-reported symptoms of cybersex addiction were increased if the investigated mechanisms interacted either with specific predispositions towards sex (i.e. sexual excitation or problematic sexual behaviors) or subjective craving due to watching pornographic pictures. The results of the conducted studies are in line with the cybersex addiction framework by Laier and Brand (2014). The findings of this dissertation are of particular importance since they addressed mechanisms, which are prevalent in different stages of developing and maintaining addictive behaviors. It can, therefore, be concluded that the mechanisms involved for developing as well as maintaining a cybersex addiction might be comparable to those reported in substance dependencies. The underlying results clearly strengthen the proposition to classify cybersex addiction. Potential similarities between dual-process models of addiction (Bechara, 2005; R. W. Wiers & Stacy, 2006) regarding the role of implicit cognition as well as self-control and inhibition have been pointed out and need further empirical testing. Finally, it can be concluded that this dissertation's findings highlighted crucial similarities between cybersex addiction and substance dependencies. The underlying implications of this dissertation might hopefully inspire future research on cybersex and respectively Internet addiction.

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8 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 6. August 2015 eine selbstständig durchgeführte und eigenständig verfasste Forschungsleistung darstellt und ich keine anderen als die angegebenen Hilfsmittel und Quellen benutzt habe. Alle Stellen, die wörtlich oder sinngemäß aus anderen Schriften entnommen sind, habe ich als solche kenntlich gemacht. Die Arbeit hat weder in gleicher noch in ähnlicher Form einem anderen Prüfungsausschuss vorgelegen.

Ort, Datum Jan Snagowski, M.Sc.