Studies in Neuroscience, Psychology and Behavioral Economics

Christian Montag
Martin Reuter *Editors*

Internet Addiction

Neuroscientific Approaches and Therapeutical Implications Including Smartphone Addiction

Second Edition

Springer

Studies in Neuroscience, Psychology and Behavioral Economics

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ISSN 2196-6605 ISSN 2196-6613 (electronic)
Studies in Neuroscience, Psychology and Behavioral Economics
ISBN 978-3-319-46275-2 ISBN 978-3-319-46276-9 (eBook)
DOI 10.1007/978-3-319-46276-9

Library of Congress Control Number: 2014960140

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Dear practitioners, scientists, and students,

Research in the area of Internet addiction continues to develop so rapidly that following the launch of the first edition of this book in 2015 we immediately began work on a second edition. This resolution emerged as we became aware of new models to explain Internet addiction (see chapter by Matthias Brand), further advances—and accompanying methodological problems—when conducting MRI studies to better understand Internet addiction (see chapter by Halley Pontes, Daria Kuss and Mark Griffiths), as well as the publication of several twin studies suggesting partial evidence for a genetic component in explaining individual differences in Internet addiction (see new chapter by Elisabeth Hahn and Frank Spinath). We also include a chapter on the neuroscientific basis of online pornography addiction, a specific form of Internet addiction (see chapter by Rudolf Stark and Tim Klucken). Additional insights from practitioners treating Internet addiction on a daily basis are also included in this edition (see chapter by Bert te Wildt and Klaus Wölfling).

Aside from these new developments, all of which are covered in this second edition of the book, a sibling of Internet addiction has appeared on the horizon in recent years and has started to dramatically change everyday life: addiction to the smartphone. This little technological device is a game changer in how we communicate in everyday life, work and navigate unknown territory. Despite the manifold positives of *smart* use of the smartphone (also covered in this edition), more and more researchers have become aware of problems arising from excessive smartphone use, potentially resulting in loss of productivity and a loss of focus on how to lead happy and fulfilling lives. As a consequence we further enhanced this edition of the book with the inclusion of a fourth section dealing with smartphone addiction. Here we try to cover early insights into this phenomenon, dealing with psychodiagnostics of smartphone addiction (see chapter by Lin et al.), mechanisms leading to overuse of the smartphone (see chapter by Éilish Duke and Christian Montag), some initial therapeutic interventions and finally, the first neuroscientific evidence showing that smartphone usage could indeed change our brain (in this case, motor areas; see chapter by Arko Ghosh). These developments led us to also rethink the title of the book: *Internet Addiction: Neuroscientific Approaches and Therapeutical Interventions Including Smartphone Addiction*.

We thank all new contributors (as well as the existent authors) for their excellent chapters. Finally, special thanks again go to Éilish Duke. She not only did a fantastic job in helping to make the chapters more readable, but also contributed another chapter in the smartphone section.

Dear reader,
Thank you for your interest and please let us know if something of relevance is missing.

Best wishes

Ulm, Germany Christian Montag
Bonn, Germany Martin Reuter

Contents

Abstract

The book contains four parts. If you require only a brief overview over the neuroscientific literature as a starting point, the summary in Chap. 12 will be of help. Chapters 3–11 deal with distinct perspectives such as structural brain imaging and Internet addiction. If you are mainly interested in therapeutic interventions in the context of Internet addiction, you can skip the second part of the book (perhaps with the exception of Chap. 6 dealing with functional changes of the brain related to the treatment of Internet Gaming Disorder) and immediately go to the third part, which provides different perspectives on the treatment of Internet addiction. The fourth part of the present book is an extension to the first edition and deals with a new emerging potential disorder related to Internet addiction—smartphone addiction. Finally, the book closes with an Appendix called Neuroanatomy comprising several figures on human brain anatomy, intended to accompany the chapters of the second part. In addition, a short glossary explains key vocabulary from the book.

Part I
Introduction to Internet Addiction

Chapter 1
The Evolution of Internet Addiction Disorder

Kimberly Young

Abstract This chapter presents the history and evolution of Internet addiction and describes the risk factors identified. As the problem has become more widespread, new studies examine the neuroscientific causes of Internet addiction and ways that the disorder may be treated primarily using behavior therapy, cognitive-behavioral techniques, and residential care. The chapter also provides the theoretical frameworks to understand the etiologic models or causal factors associated with the development of Internet addiction including a brief overview of the neuroscientific studies recently done. Finally, this chapter reviews the current treatment models used in Internet addiction recovery. As an introduction to this book, it is hoped this chapter gives a historical context of the disorder and promotes future areas of research as new studies in the field continue to emerge.

1.1 Introduction

Internet addiction was first researched in 1996 and findings were presented at the American Psychological Association. The study reviewed over 600 cases of heavy Internet users who exhibited clinical signs of addiction measured through an adapted version of the DSM-IV criteria for pathological gambling (Young 1998). Since then, subsequent studies over the past decade have examined various aspects of the disorder. Early studies attempted to define Internet addiction and examined behavior patterns that differentiated compulsive from normal Internet usage. More recent studies investigated the etiologic factors or causes associated with the disorder. Much of this examined the impact of computer-mediated communication on the way people will adapt to interactive features of the Internet and initial studies from the United States spread into countries such as Taiwan, Russia, China, and the United Kingdom.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_1

As the problem has become more widespread, new studies examine the neurological causes of Internet addiction and ways that the disorder may be treated primarily using behavior therapy, cognitive behavioral techniques, and residential care. This chapter presents the history and evolution of Internet addiction and describes the risk factors identified. The chapter also provides the theoretical frameworks to understand the etiologic models or causal factors associated with the development of Internet addiction including a brief overview of the neurological studies recently done. Finally, this chapter reviews the current treatment models used in Internet addiction recovery. As an introduction to this book, it is hoped this chapter gives a historical context of the disorder and promotes future areas of research as new studies in the field continue to emerge.

1.1.1 Diagnosis of Internet Addiction

Diagnosis of Internet addiction is often complex. Unlike chemical dependency and substance abuse, the Internet offers several direct benefits as a technological advancement in our society and not a device to be criticized as addictive. Individuals can conduct research, perform business transactions, access libraries, communicate, and make vacation plans. Books have been written outlining the psychological as well as functional benefits of the Internet in our lives. By comparison, alcohol or drugs are not an integral or necessary part of our personal and professional lives nor do these substances offer any health benefit. With so many practical uses of the Internet signs of addiction can easily be masked or justified. Further, clinical assessments often cover relevant disorders for psychiatric conditions and addictive disorders. However, given its newness, symptoms of Internet addiction may not be revealed in an initial clinical interview. While self-referrals for Internet addiction are becoming more common, often the client does not present with complaints of computer addiction. People may initially present with signs of depression, bi-polar disorder, anxiety, or obsessive-compulsive tendencies, only for the treating professional to later discover signs of Internet abuse upon further examination (Shapiro et al. 2000). Therefore, diagnosing Internet addiction upon clinical interview can be challenging. It is important to understand the current definitions of Internet addiction to help treating professionals screen for patients for compulsive use of the Internet and the evolution of Internet addiction as a disorder as part of the assessment process.

1.1.2 The Evolution of Internet Addiction

While time is not a direct function in diagnosing Internet addiction, early studies suggested that those classified as dependent online users were generally excessive about their online usage, spending anywhere from 40 to 80 h/week on recreational or private use of the Internet with sessions that could last up to 20 h (Young 1998).

Sleep patterns were disrupted due to long Internet sessions where addicts often took caffeine pills to facilitate longer Internet sessions and suffered from fatigue, poor diet, poor exercise, work and/or school performance due to loss of sleep.

The best method to clinically detect compulsive use of the Internet is to compare it against criteria for other established addictions. Researchers have likened Internet addiction to syndromes similar to impulse control disorders on the Axis I Scale in the DSM (APA 1994) and utilized various forms of DSM-IV based criteria to define it. Of the all the references in the DSM-IV, pathological gambling was viewed as most akin to this phenomenon. The Internet addiction diagnostic questionnaire (IADQ) was the first screening measure developed for diagnosis (Young 1998) that conceptualized the criteria for the disorder as follows:

1. Do you feel preoccupied with the Internet (think about previous online activity or anticipate next online session)?
2. Do you feel the need to use the Internet with increasing amounts of time in order to achieve satisfaction?
3. Have you repeatedly made unsuccessful efforts to control, cut back, or stop Internet use?
4. Do you feel restless, moody, depressed, or irritable when attempting to cut down or stop Internet use?
5. Do you stay online longer than originally intended?
6. Have you jeopardized or risked the loss of significant relationship, job, educational or career opportunity because of the Internet?
7. Have you lied to family members, therapist, or others to conceal the extent of involvement with the Internet?
8. Do you use the Internet as a way of escaping from problems or of relieving a dysphoric mood (e.g., feelings of helplessness, guilt, anxiety, depression)?

Answers evaluated non-essential Internet usage such as for non-business or academically related use. Subjects were considered "dependent" when answering endorsing five or more of the questions over a 6-month period not associated with manic or hypomanic episodes. Associated features included neglect of routine duties or life responsibilities, social isolation, and being secretive about online activities or a sudden demand for privacy when online.

Throughout the late 1990–2000, the IADQ was widely used in studies on Internet addiction. As researchers adapted the IADQ, some made refinements to the instrument. Beard and Wolf (2001) recommended that all of the first five criteria be required for diagnosis of Internet addiction, since these criteria could be met without any impairment in the person's daily functioning. They also recommended that at least one of the last three criteria (e.g., criteria 6, 7, and 8) be required in diagnosing Internet addiction. These criteria impact the pathological Internet user's ability to cope and function (e.g., depressed, anxious, escaping problems), and also impact interaction with others (e.g., significant relationship, job, being dishonest with others). Other studies that empirically tested the IADQ found that using 3 or 4 criteria where just as robust in diagnosing Internet addiction as using 5 or more and suggested that the cutoff score of 5 criteria might be overly stringent (Dowling and Quirk 2009).

The most recent acceptance of Internet addiction is the inclusion of Internet Use Gaming Disorder in Sect. 1.3 of the DSM-V. Researchers had encouraged the inclusion of pathological Internet use as a disorder (e.g., Block 2008) given the volume of studies that identified it as a problem. The main concern was that various criteria had been used to diagnose and classify Internet addiction in the literature. Section 1.3 will include conditions that require further research before their consideration as formal disorders, as well as cultural concepts of distress, the names of individuals involved in DSM-V's development, and other information. As a new condition, including it in the DSM-V will provide a standardized set of criteria for future studies.

1.1.3 Internet Addiction Test

Beyond DSM criteria, the Internet addiction test (IAT) is the first validated instrument to assess Internet addiction (Widyanto and McMurren 2004). Studies have found that the IAT is a reliable measure that covers the key characteristics of problematic Internet use. The test measures the extent of client's involvement with the computer and classifies the addictive behavior in terms of mild, moderate, and severe impairment. The IAT can be utilized among outpatient and inpatient settings and adapted accordingly to fit the needs of the clinical setting.

The IAT is a worldwide accepted and validated testing instrument that examines symptoms of Internet addiction such as a user's preoccupation with Internet use, ability to control online use, extent of hiding or lying about online use, and continued online use despite consequences of the behavior. The IAT has been validated in France (Khazaal et al. 2008), Germany (Pawlikowski and Brand 2011), Norway (Johansson and Götestam 2004), Finland (Kaltiala-Heino et al. 2004; Korkeila et al. 2010), Italy (Ferraro et al. 2007), Greece (Siomos et al. 2008), Iran (Ghassemzadeh et al. 2008), Pakistan (Suhail and Bargees 2006), China (Lam et al. 2009), and Korea (Hur 2006). Tao et al. (2010) also proposed that a diagnostic score of 2 + 1, where the first two symptoms (preoccupation and withdrawal symptoms) and at least one of the five other symptoms (tolerance, lack of control, continued excessive use despite knowledge of negative effects/affects, loss of interests excluding Internet, and use of the Internet to escape or relieve a dysphoric mood) was established. This makes the IAT the first globally psychometric measure of the disorder.

1.2 Risk Factors for Internet Addiction

As Internet use disorder has gained credibility, more studies focused on risk factors associated with the development of the disorder. The risk factors can loosely be categorized as social factors, psychological factors, and biological factors, each will be further discussed.

1.2.1 Social Factors

Excessive or problematic Internet use often stems from interpersonal difficulties such as introversion or social problems (Ebeling-Witte et al. 2007). Often, Internet addicts fail to communicate well in face-to-face situations (Leung 2007). This is partly why they use the Internet in the first place. Communicating online seems safer and easier for them. Poor communication skills can also cause poor self-esteem, feelings of isolation and create additional problems in life, such as trouble working in groups, making presentations, or going to social engagements. Virtual relationships are a way of engaging with others while having the safety of avoiding rejection or the anxiety of making physical contact with others. Shyness can be consuming and the Internet offers an immediate relief the anxiety this causes. Therapy needs to address how addicts communicate offline and to establish positive new ways of interacting. Furthermore, in the context of the IAT, one study found inverse correlations between the IAT and self-directedness in a group of healthy participants from the population and first-person-shooter-video-players (Montag et al. 2011). A new study from this group shows that this effect can be found cross-cultural in seven countries (Sariyska et al. 2014).

Other research has focused on limited social support systems that Internet addicts have, which is in part why they turn to virtual relationships as a substitute for the missing social connection in their lives. They turn to others on the Internet when feeling lonely or need someone to talk with. Studies have found loneliness is associated with the development of Internet addiction (e.g., Hardie and Tee 2007; Morahan-Martin 1999). Loneliness as a risk factor is consistent with findings that suggest social relationships are a key component in the development of Internet addiction. The most addictive applications are chat rooms, interactive games, instant messaging, or social media, suggesting that the condition is socially motivated.

A more discrete social risk factor for Internet addiction is the development of online affairs (Whitty 2005). An online affair is a romantic or sexual relationship initiated via online contact and maintained predominantly through electronic conversations that occurs through email, chat rooms, or online communities (Atwood and Schwartz 2002). This again shows that interpersonal problems or loneliness can play an active role in developing an addiction to online communication and relationships. Here, marital problems and discord play a role but it is unclear to what extent. Do marital problems come first before establishing new romantic relationships online or does the anonymity of online relationships accelerate intimacy online? Or, does the accessibility of meeting others online create the opportunity for affairs to begin among otherwise stable or healthy marriages. New research is trying to address these questions.

1.2.2 Psychological Factors

There are two types of Internet addicts. The *Dual Diagnosed Internet Addict* suffers from prior psychological problems such as to depression, anxiety, obsessive-compulsive disorder, or substance abuse, to name a few syndromes associated with the disorder. Other addicts, referred to as *New Internet Addicts*, have no prior history of psychiatric illness or addiction, and their addiction to the Internet is an entirely new problem. Dual diagnosed Internet addicts may suffer from a variety of illnesses that contribute to developing Internet addiction whereas the new Internet addict do not have any psychiatric history but focus on particular activities or relationships online (a specific online affair, chat room, message board, game, gambling site, or adult site, to name a few).

Dual Diagnosis Internet Addicts suffer from depression (Ryu et al. 2004), social anxiety (Yen et al. 2007), impulsivity (Lavin et al. 1999), obsessive-compulsive disorders (Shapiro et al. 2000), and general psychiatric problems (Yen et al. 2008). Dual Diagnosed Internet Addicts suffer from alcohol or drug dependency only to find their compulsive Internet Gaming Disorder of the Internet a physically safe alternative to their addictive tendency (Young 2004). They believe that being addicted to the Internet is medically safer than being addicted to drugs or alcohol; at the same time, the compulsive behavior avoids the need to confront unpleasant feelings or situations underlying the addictive behavior.

Dual diagnosis in addiction is common. The dual diagnosed Internet addict can be displayed in a variety of ways unique from other addictive syndromes. Research has not confirmed which is cause and effect but we have established a clear correlation between Internet addiction and psychiatric problems. For instance, we know that Internet addicts suffer from depression but it is hard to know which came first. Some suggest that because a person suffers from depression that he or she uses the Internet as a means to cope with sad feelings and low self-esteem associated with the disorder. The person goes online to forget about sad feelings as they escape into the Internet. It is also possible that as a person goes online with increased frequency, he or she may feel more depressed as they become socially isolated from others.

In another example, a person suffering from anxiety may seek out companionship in a safe virtual environment. In yet another example, a sexual compulsive discovers a new source for sexual gratification through online pornography and anonymous sex chat. The Internet allows them to continue their sexual behavior without the physical need to visit strip clubs or prostitutes and provides a new and socially acceptable way to cope. Realizing the impact of this destructive behavior, the person rationalizes it and continues to engage in the activity despite its known potential risks, including possible job loss, divorce, or arrest. The online experience turns into a relief from pain and anxiety, the reward for success, and a way to avoid addressing other painful emotions. The online world becomes a private refuge and while the dual diagnosed Internet addict progressively retreats into the computer, it is unclear how psychiatric history plays a role.

New Internet addicts meet two distinct criteria. First, they become addicted to new forms of Internet use created solely online such as chat rooms, social networks, instant messaging, role-playing games, or eBay. Someone who becomes addicted to chat rooms must use the Internet to chat. Someone who becomes addicted to eBay must use the Internet to access it. Granted, these activities have now become portable through mobile devices such iPhones, Droids, or iPads or cell phones. The key element is that they are all considered Internet-specific activities.

Second, new Internet addicts are individuals with no previous significant addictive or psychiatric history. They develop an addiction to the anonymous, accessible, and interactive nature of online use. For instance, new Internet addicts may include a 50-year-old lawyer using sex chat rooms during work hours and without his wife's knowledge, a 30-year-old business executive compulsively checking his iPhone to check his match.com girlfriends, a 20-year-old college student constantly uses Facebook, or a 16-year-old boy constantly playing World of Warcraft with no other comorbidity. The compulsive Internet use is a new clinical phenomenon.

1.2.3 Biological Factors

The most recent research reflected in this book focuses on the biological studies associated with Internet addiction. I will not go into as much detail in this section as this book provides substantial depth in this new area of research. I will highlight a few notable studies that are very helpful to learn what causes Internet addiction. We know that psychological and social factors are associated with the development. We have little knowledge about the biological associations with this disorder. This is why these are important new studies that allow us to see the biology of Internet addiction and more broadly, the biology of addiction in general.

We have learned through functional magnetic resonance image (fMRI) analyzing the differences between addicts and non-addicts that brain regions such as the cerebellum, brainstem, right cingulate gyrus, bilateral parahippocampus, right frontal lobe (rectal gyrus, inferior frontal gyrus and middle frontal gyrus), left superior frontal gyrus, left precuneus, right postcentral gyrus, right middle occipital gyrus, right inferior temporal gyrus, left superior temporal gyrus and middle temporal gyrus are involved in the development of Internet addiction (Liu et al. 2010). This study was limited by studying college students and a low number of subjects of nineteen.

Along with fMRI studies, EEG studies were conducted that found that those subjects classified as Internet addicts had lower brain scan activation on a game playing procedure than the normal group. This effect was different for the event related potential components N2 and for the P3 amplitudes. They had to engage in more cognitive endeavors to complete the inhibition task in the late stage (Dong et al. 2010). The IAD students also showed less efficiency in information processing and lower impulse control than their normal peers but not behaviorally (only in the EEG signal).

Studies investigating brain gray matter density (GMD) demonstrated changes in adolescents with Internet addiction using voxel-based morphometry (VBM) analysis on high-resolution T1-weighted structural magnetic resonance images. Compared with healthy controls, Internet-addicted adolescents had lower GMD in the left anterior cingulate cortex, left posterior cingulate cortex, left insula, and left lingual gyrus (Zhou et al. 2011). Again, this study used a small sample and only college students. More meaningful data would be found with a larger and more diverse subject pool. One of the most promising new biological research interests is in the area of genetic markers. The researchers from the University of Bonn and the Central Institute of Mental Health in Mannheim compared the genetic makeup of 132 problematic Internet users with that of 132 age—and sex-matched healthy control individuals (Montag et al. 2012). Results found that the 132 problem Internet users showed higher elevations of the CC genotype of rs1044396 (genetic variation of the nicotinic acetylcholine receptor gene) compared to controls. These neurotransmitters play a significant role in activating the brain's reward system.

Han et al. (2007) examined 79 adolescent male excessive Internet gamers and 75 age- and gender-matched healthy comparison adolescents. They used the reward-dependence (RD) scale in Cloninger's Temperament and Character Inventory and the frequencies of two dopamine polymorphisms: the DRD2/ANKK1 Taq Ia and COMT Val158Met polymorphisms. Their study found the excessive gamer group had significantly higher RD scores than controls. Within the EIGP group, the presence of the Taq1A1 allele correlated with higher RD scores and an increased prevalence of the DRD2 Taq1A1 and low activity COMT alleles. Lee et al. (2008) examined 91 male adolescents with excessive Internet use and 75 healthy comparison subjects. Between group comparisons were made on genetic polymorphisms of the serotonin transporter gene and with respect to harm avoidance (HA) of Cloninger's Temperament Character Inventory. Results found that the excessive Internet user group had higher prevalence of SS-genotypes, higher harm avoidance, and depression scores suggesting that excessive users may have genetic and personality traits similar to depressed patients.

1.3 Treatment Approaches

Use of the Internet is legitimate in business and home practice such as in electronic correspondence to vendors or electronic banking. Therefore, traditional abstinence models are not practical interventions when they prescribe banned Internet use in most cases. The focus of treatment consists of moderated Internet use. While moderated Internet use is the primary goal of treatment, abstinence of problematic applications is often necessary. Specific applications such as a particular game, a particular gambling site, or a particular sex site will trigger net-binges. Abstinence of the "trigger" application is essential to help the client recover from the problematic application(s) while retaining controlled use over legitimate business Internet use.

Treatment includes a variety of interventions and a mix of psychotherapy theories to treat the behavior and address underlying psychosocial issues that are often co-existent with this addiction (e.g., social phobia, mood disorders, sleep disorders, marital dissatisfaction, or job burnout). To help clients abstain from problematic online applications, recovery interventions apply structured, measurable, and systematic techniques. The most commonly discussed therapies are Motivational Interviewing, Cognitive-Behavioral Therapy (CBT), and retreat or inpatient care.

1.3.1 Motivational Interviewing

The concept of motivational interviewing evolved from experience in the treatment of problem drinkers, and was first described by Miller (1983). These fundamental concepts and approaches were later elaborated by Miller and Rollnick (1991) in a more detailed description of clinical procedures. Motivational interviewing is a goal-directed style of counseling for eliciting behavior change by helping clients to explore and resolve ambivalence. Motivational interviewing involves asking open-ended questions, giving affirmations, and reflective listening.

Motivational interviewing is intended to confront the client in a constructive manner to evoke change, or using external contingencies such as the potential loss of a job or relationship, to mobilize a client's values and goals to stimulate behavior change. Clients dealing with addiction or substance abuse problems often feel ambivalent about quitting, even after they admit they have a problem. They fear the loss of the Internet, they fear what life might be like if they were unable to chat with online friends, engage in online activities, and use the Internet as a form of psychological escape. Motivational interview helps clients confront their ambivalence.

Typical interview questions may include: How many hours per week do you currently spend online (for non-essential use)? What applications do you use on the Internet (specific sites/groups/games visited)? How would you rank order each application from best to least important? (1 = first, 2 = second, 3 = third, etc.)? What do you like best about each application? What do you like the least? How has the Internet changed your life? How do you feel when you log offline? What problems or consequences have stemmed from your Internet use? (If this answer is difficult for the client to describe, have the client keep a log near the computer in order to document such behaviors for the next week's session)? Have others complained about how much time you spend online?

The answers to these questions create a clearer clinical profile of the client. The therapist can determine the types of applications that are most problematic for the client (i.e., chat rooms, online gaming, online pornography, etc.). The length of Internet use, the consequences of the behavior, a history of prior treatment attempts, and outcomes for any treatment attempts are also assessed. This helps clients begin the process of examining how the Internet impacts their lives.

It is helpful for the client to gain a sense of responsibility for his or her behavior. By allowing the client to resolve their ambivalence in a manner that gently pushes them, helps the client to be more inclined to acknowledge the consequences of their excessive online use and engage in treatment. Generally, the style is quiet and eliciting rather than aggressive, confrontational, or argumentative. For the therapists accustomed to confronting and giving advice, motivational interviewing can appear to be a hopelessly slow and passive process. The proof is in the outcome. More aggressive strategies, sometimes guided by a desire to "confront client denial," easily slip into pushing clients to make changes for which they are not ready.

Helping the client explore how he or she feels just before going online will help pinpoint the types of emotions being covered by the behavior (or how the client is using the Internet to cope or escape from problems). Answers may include issues such as a fight with a spouse, depressed mood, stress at a job, or a poor grade in school. Motivational interviewing should explore how these feelings diminish when online, looking for how the client rationalizes or justifies using the Internet (e.g., chatting makes me forget about the fight with my husband, looking at online porn makes me feel less depressed, gambling online makes me feel less stressed at work, killing other players in an online game makes me to feel better about my poor grade at school). Motivational interviewing is also meant to help the client recognize consequences stemming from excessive or compulsive use. Problems may consist of issues like my spouse becomes angrier, my feelings return when I turn off the computer, my job still stinks, I will lose my scholarship if I do not get my grades up. The therapeutic relationship is more like a partnership or companionship than expert/recipient roles to examine and resolve ambivalence. The operational assumption in motivational interviewing is that ambivalence is the principal obstacle to be overcome in triggering change. Overall, the specific strategies are designed to elicit, clarify, and resolve ambivalence in a client-centered and respectful therapeutic manner.

1.3.2 Cognitive Behavior Therapy

Researchers have considered Internet addiction as a new impulse control disorder and have suggested using cognitive behavioral therapy (CBT) to treat the condition. However, given the daily dependency our society has on the Internet and technology in general unlike other impulse control issues, a specialized kind of CBT called treatment cognitive behavioral therapy for Internet addiction (CBT-IA; Young 2011) was developed. In treating Internet addiction, abstinence recovery models are not practical as computers have become such a salient part of our daily lives. Research has found cognitive distortions are most associated with Internet addiction (e.g., Caplan 2002; Davis 2001; LaRose et al. 2001; Young 2007). CBT-IA was developed to address these cognitions. CBT-IA is a three phase approach that initially involves behavior modification to control Internet use, cognitive restructuring to challenge and modify cognitive distortions, and harm reduction therapy to address co-morbid issues.

The CBT-IA approach is also the only evidenced-based model based on outcome studies with 128 patients that maintained technology management goals six months post treatment (Young 2013). So there is a long-term impact for this therapy modality. Behavior therapy is used in the first phase of treatment to examine both computer behavior and non-computer behavior. Computer behavior deals with actual online usage, with a primary goal of abstinence from problematic applications, while retaining controlled use of the computer for legitimate purposes. Internet addicts feel a sense of displacement when online and were unable to manage central aspects of their lives due to their growing preoccupation with online use (Young 2004). They start to miss important deadlines at work, spend less time with their family, and slowly withdraw from their normal routines. They neglect social connections with their friends, coworkers, and with their communities, and, ultimately, their lives become unmanageable because of the Internet. They become consumed with their Internet activities, preferring online games, chatting with online friends, or gambling over the Internet, and ignoring family and friends in exchange for solitary time in front of the computer (Leung 2007). Managing their time online and offline is an initial goal of CBT-IA (Young 2011).

In the second phase, the rationalizations that justify excessive online use are identified, challenged, and modified. These cognitions serve as triggers for addictive behavior. For instance, Internet addicts often ruminate about their self-worth in the real world and form extreme self-concepts favoring the online self (e.g., "I am worthless offline, but in the online world I am someone important"). A gamer creates an avatar (an online game character) who achieves greater levels of success in the game so he thinks the real world is less desirable or fears that he is not as important or interesting offline. A woman who feels inadequate with meeting men offline creates an online persona where she is popular with the men online. CBT-IA uses cognitive restructuring to break this pattern. Cognitive restructuring puts the client's thoughts "under the microscope" by challenging him or her and re-scripting the negative thinking that lies behind him or her. In doing so, CBT-IA can help clients understand that they are using the Internet to avoid situations or feelings. Our moods are driven by what we tell ourselves, and this is usually based on our interpretations of our environment. Cognitive restructuring helps clients re-evaluate how rational and valid these interpretations are and find ways of achieving those same feelings offline.

Harm reduction therapy (HRT; Marlatt et al. 2001) is used in the third and final phase of treatment for continued recovery and relapse prevention. HRT can be used to identify and treat psychiatric issues co-existing with compulsive Internet use and/or social issues in immediate family and/or marital relationships. HRT addresses any co-existing factors associated with the development of Internet addiction. These factors can include personal, situational, social, psychiatric, or occupational issues. Often, addicts falsely assume that just stopping the behavior is enough to say, "I am recovered." Full recovery is more than simply refraining from the Internet. According to CBT-IA, complete recovery means resolving the underlying issues associated with the addiction; otherwise, relapse is likely to occur.

As there is currently no certification in the field, to help standardize the application of CBT-IA, RESTORE RECOVERY™ (see restorerecovery.com) was created as an evidenced-based training program for practitioners to learn how to assess and treat Internet addiction disorders. The program covers a variety of subtype conditions such as Internet gaming disorder, social media addictions, compulsive Internet gambling, and Internet sex addictions. The training program includes research studies to support assessment materials and documentation includes aids for the practitioners such as treatment outcome and relapse planning worksheets. The intention is to create more empirical methods for practitioners practicing in this new field.

1.3.3 Inpatient Care and Retreat Centers

In the US, ReStart at www.netaddictionrecovery.com is one of the retreat centers specializing in problematic Internet use, video game, and technology use. They have a multidisciplinary team that works with clients in a 45-day residential care program through individualized assessments, treatment of co-occurring mental health concerns, group counseling and psychotherapy, life skills, mentoring and vocational coaching, 12-step meetings and spiritual recovery. Participants stay at Heavensfield Retreat Center in rural Fall City, Washington in the Pacific Northwest.

In China, the country has led much of the research in the Internet addiction field and established the first Internet Addiction Center in 2006, a military-run boot camp in Beijing (Jiang 2009). Tao Ran, director of the treatment center and a colonel in the People's Liberation Army (PLA), helped come up with a strict definition of Internet addiction last fall: consecutive usage of the Web for 6 h a day for three straight months is addiction. Surprisingly, almost 30% of Chinese match this definition and more clinics have emerged. Life in the treatment camp is defined by strict, semi-military disciplines. Patients get up at 6:30 a.m. and go to bed at 9:30 p.m. Their daily schedule includes military drills, therapy sessions, reading and sports. While rigorous and controversial, outcome studies do not exist to show the efficacy of the camps.

In Korea, the most wired nation on earth has devoted the most resources to Internet addiction recovery. Perhaps no other country has so fully embraced the Internet. 90% of homes connect to cheap, high-speed broadband, online gaming is a professional sport, and social life for the young revolves around the "PC bang," dim Internet parlors that sit on practically every street corner. But such ready access to the Web has come at a price as legions of obsessed users find that they cannot tear themselves away from their computer screens.

To address the problem, the government has built a network of 140 Internet-addiction counseling centers, in addition to treatment programs at almost 100 hospitals and the Internet Rescue camp, a forested area about an hour south of

Seoul, was created to treat the most severe cases. The camp is entirely paid for by the government, making it tuition-free (Sang-Hun 2010).

Korea has been the most progressive of any country in its efforts to prevent and treat Internet addiction. To counter what is perceived as an epidemic, the government introduced a so-called “Shutdown Law,” which blocks gamers under 16 from playing between midnight and 6 a.m. But its effect has been limited as teens circumvent the restrictions by using their parents’ accounts (Kim and Shin 2013). The law has been semi-effective and a new trend has been suggested to enter these young people into the Riding Healing Center, a therapy organization that uses horse-riding to cure emotional and behavioral disorders, which it believes are an underlying cause of Internet addiction. The Korean Riding Association has two therapy centers and about 50 people a day go through its programs to treat a range of issues such as depression, attention hyperactivity deficit disorder (ADHD) and Internet addiction. While no outcome studies exist to their effectiveness, the association plans to build 30 more centers across South Korea, which has a population of 50 million, by 2022 to meet the rising demand for its therapy.

1.4 Final Thoughts

This chapter presents a brief overview of the studies that have been conducted on Internet addiction. Since the earlier studies in 1996, the field has grown dramatically. This chapter reviews the current diagnosis involved in detecting Internet addiction and the general set of risk factors associated with the condition. As this book focuses on the neuroscience of Internet addiction, it shows that the disorder has gained extensive credibility over the years and that new research such as this offer great opportunity to understand the underpinnings of the problem.

While not everyone who uses the Internet becomes addicted, findings show that Internet addiction is a global problem that transcends culture, race, age, and gender. As children and teenagers go online at younger ages, new risks are created and we currently know little about the lasting impact of online technologies on brain development. We may inadvertently be endangering children without realizing this impact by introducing technology at younger ages.

The research contained in this book will enable us to fully realize the potential neuroscientific impact of new technologies. This research helps us learn new diagnostic techniques for early detection. Neuroscientific studies on Internet addiction enable new psychopharmacological treatment of Internet addiction as we learn more about the biological basis of the condition. This research helps guide the mental health field in developing new therapeutic interventions in the treatment of Internet addiction and government agencies to develop comprehensive policies to assist in the prevention and education of Internet addiction.

The field is still in its infancy. As we search for a clearer understanding of the behavioral and the neurologic factors influencing the condition of addictive or compulsive use of the Internet. We have documented the ramifications of the disorder on social, personal, and occupational functioning. With continued work in the field, studies in structural brain imagining, functional MRIs, and molecular genetics not only assist in advancing Internet addiction research but it helps in understanding the similarities and differences among addictive syndromes overall.

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Chapter 2
Theoretical Models of the Development and Maintenance of Internet Addiction

Matthias Brand

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

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

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

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_2

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

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

Theoretical models and frameworks which describe mechanisms potentially underlying the development and maintenance of specific types of Internet addiction are very important. Such models should summarize previous research based on both individual studies and meta-analyses. They should also integrate results from other research areas where appropriate, e.g., in situations where less research on the variables of interest are available. For instance, when considering pathological Internet use as an addiction, concepts of the addiction processes known from substance dependency research and other behavioral addictions should be incorporated into a new theoretical framework. Theoretical models and frameworks can then inspire future research on mechanisms of development and maintenance of the disorder. Current and future studies can test the theoretical assumptions empirically, which will then result in revised versions of theoretical frameworks. This means that a theoretical model and framework is never final, but must be continuously improved and specified as it evolves in interaction with current research. These models have then a benefit for both clinical practice and science. Theoretical models and frameworks can help us to understand the etiology and classification of the phenomenon of interest. When the underlying mechanisms are understood, methods for prevention and treatment may be derived on the basis of systematic hypotheses. In other words, to develop successful prevention and treatment methods, it is essential to gain a better understanding of common and differential influences of vulnerability factors in interaction with potential moderating and mediating variables. Moderator and mediator variables should be core components of a theoretical model for a psychological disorder, since moderating and mediating variables can often be treated better than certain vulnerability factors (Brand et al. 2014a).

2.2 Recent Models of the Development and Maintenance of Internet Addiction

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

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

Although it is still a topic of debate whether a generalized Internet addiction exists in the clinical context, some studies with nonclinical samples demonstrated that generalized and specific Internet addictions differ in a meaningful manner (Montag et al. 2015; Pawlikowski et al. 2014). The model of generalized Internet addiction and the first empirical data were addressed in the study by Brand et al. (2014a). This model assumes certain personality factors (e.g., shyness, low self-esteem), psychopathological symptoms (e.g., social anxiety, depression), and social cognitions (e.g., low perceived social support and loneliness) to be predisposing factors for the development of a generalized Internet addiction. As mediating variables, a dysfunctional coping style (e.g., disengagement and conflict avoidance) and Internet use expectancies (e.g., the expectancy that social networking sites and other Internet applications can be useful for avoiding problems in real life or for escaping from reality and for regulating negative mood) have been suggested. If the Internet (or various Internet applications) is then used as a type of dysfunctional coping with everyday life requirements (Kardefelt-Winther 2014), the dysfunctional coping style and the Internet use expectancies are reinforced. This model of generalized Internet addiction has been tested empirically with a nonclinical sample, and it was indeed shown that the effect of personality, psychopathological symptoms, and social aspects are fully mediated by a dysfunctional coping style and Internet use expectancies (Brand et al. 2014a).

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

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

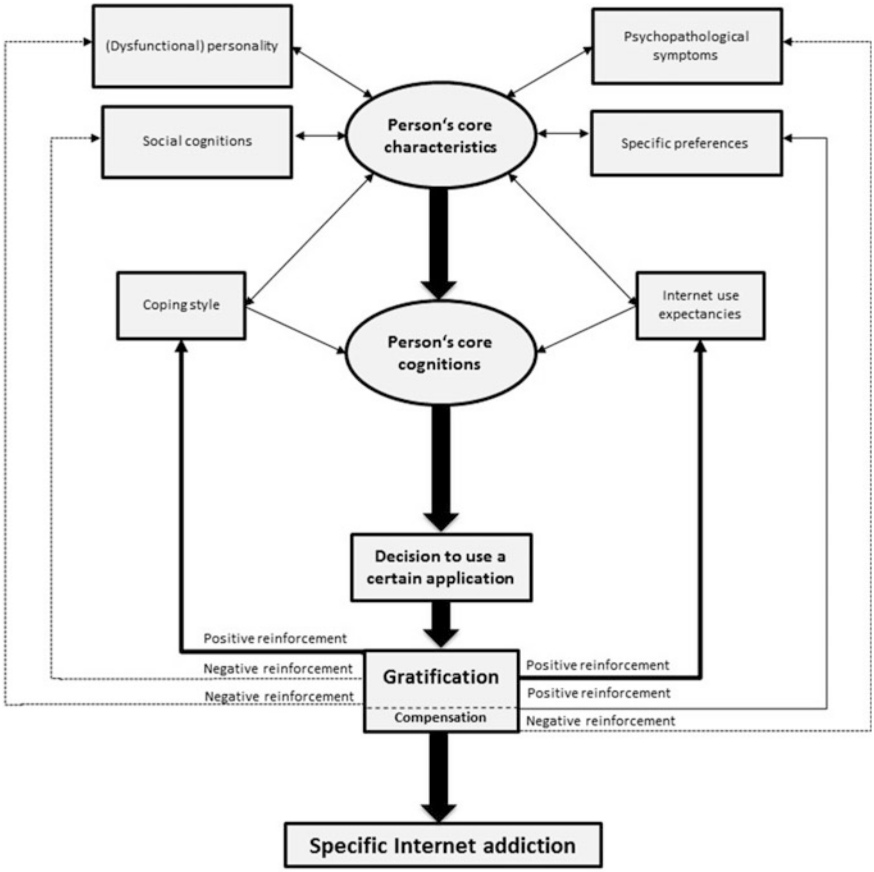

Fig. 2.1 The model (simplified) of the development and maintenance of a specific Internet addiction suggested by Brand et al. (2014b, 2016b). Specific Internet addiction refers to the addictive use of a certain Internet application, such as Internet gaming, gambling, pornography/cybersex, shopping, or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

The theoretical model proposed by Dong and Potenza (2014) focuses on Internet gaming disorder. It also includes several variables linked to a person's attitudes and cognitive processes. Central to this model is motivation seeking (craving), which is assumed to directly influence the use of Internet games. Motivation seeking itself is considered to be influenced by a person's decision-making style (preference for rewarding alternatives despite negative long-term consequences), executive control (inhibition and monitoring), stress relief (responses to previous or current stress), and reward sensation (reward sensitivity, cognitive bias towards the Internet). Dong and Potenza (2014) also refer to models of substance dependency, which are reward-centered, such as the incentive salience ideas and the distinction of "liking" a drug from "wanting" a drug (Berridge 2007; Berridge et al. 2009; Robinson and Berridge 2001, 2008). They also integrated other components of addiction models, for example the interaction between the motivation for drug seeking and reductions of executive control (Goldstein and Volkow 2011), which then may interfere with advantageous decision-making in the context of weighing short-term versus long-term positive and negative consequences (Bechara 2005; Dong et al. 2013; Pawlikowski and Brand 2011). The authors also suggest that treatment interventions should specifically target the aforementioned factors, which are assumed to influence motivation seeking/craving.

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

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

A relatively broad body of literature exists on the correlations between subjective complaints in everyday life resulting from Internet use and diverse psychopathological symptoms and personality characteristics. It was shown that Internet addiction in general is linked to depression and anxiety disorders as well as to attention deficit hyperactivity disorder (ADHD) symptoms (see meta-analysis by Ho et al. 2014). A recent study even showed that ADHD symptoms are a better predictor for Internet addiction than depressive tendencies (Sariyska et al. 2015). Distinct personality factors are also correlated with symptoms of Internet addiction (see meta-analysis by Koo and Kwon 2014). These personality factors are shyness, neuroticism, impulsivity, low conscientiousness, a tendency to procrastinate, low self-esteem, and low self-directedness (Ebeling-Witte et al. 2007; Hardie and Tee 2007; Kim and Davis 2009; Niemz et al. 2005; Thatcher et al. 2008; Floros et al. 2014; Koo and Kwon 2014; Wang et al. 2015; Sariyska et al. 2014). There is also a relatively broad literature on social aspects, particularly for generalized Internet addiction and for specific Internet addictions in which social interactions are crucial, for example gaming and SNS. It has been shown that lack of social support or perceived social isolation (Caplan 2007; Morahan-Martin and Schumacher 2003) and even loneliness in the educational setting in adolescents (Pontes et al. 2014) seem to be related to an addictive use of the Internet in general. Stress vulnerability and experienced stress in daily life, and the subsequent use of the Internet as a tool for coping with problematic or stressful life events, have also been considered important factors contributing to the development of Internet addiction (Whang et al. 2003; Tang et al. 2014). Tendencies towards impulsive coping strategies (e.g., doing the first thing that comes to the mind when facing negative mood) when confronted with daily stress have also been linked to Internet addiction (Tonioni et al. 2014), and some authors even conceptualize Internet addiction as a type of dysfunctional coping with everyday life (Kardefelt-Winther 2014).

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

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

Predisposing factors

- Depression
- Social anxiety and interpersonal sensitivity
- ADHD symptoms
- Stress vulnerability
- Impulsivity
- Low self-directedness
- Shyness
- Loneliness and low perceived social support
- Low self-esteem
- Low conscientiousness
- Genetic vulnerability

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

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

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

2.4 Neurocognitive Mechanisms Potentially Underlying Internet Addiction

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

Craving, which was originally defined within substance dependence research, describes a hardly resistible urge to consume a substance. Craving can be triggered by the confrontation with drug-related cues resulting in so-called cue reactivity (Breiner et al. 1999; Carter and Tiffany 1999). Cue reactivity is considered to be a consequence of (associative) learning mechanisms, in particular conditioning processes (Carter and Tiffany 1999; Tiffany et al. 2000; Loeber and Duka 2009), and it provides the physiological, emotional, and motivational basis for craving (Robinson and Berridge 1993, 2000). The concept of cue reactivity and craving has already been applied to behavioral addictions, for example gambling disorder (e.g., Wölfling et al. 2011). Some recent fMRI studies have investigated neural correlates of cue reactivity and craving in individuals with gambling disorder (Wulfert et al. 2009; Crockford et al. 2005; Potenza et al. 2003) and also in subjects with Internet gaming disorder (Thalemann et al. 2007; Ko et al. 2009). On a behavioral level, initial evidence for cue reactivity and craving and their impact on symptom severity has also emerged for Internet pornography addiction (Brand et al. 2011; Laier et al. 2013) and pathological buying (Trotzke et al. 2014). Transferring these concepts to the model of Internet addiction by Brand et al. (2014b), the ellipsis representing a person's core cognitions could be complemented by including "cognitive and affective responses to Internet-related cues". These components have been included explicitly in the recently published I-PACE model (Brand et al. 2016b).The predisposing factors together with Internet use expectancies should influence the intensity of cue reactivity and craving and other specific cognitive and affective processes. In addition, and more importantly, the use of certain Internet applications and the gratification received thereby should also lead to an increase of cue reactivity and craving as responses to certain stimuli, as a result of conditioning processes. Future studies are needed to test these hypotheses.

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

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

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

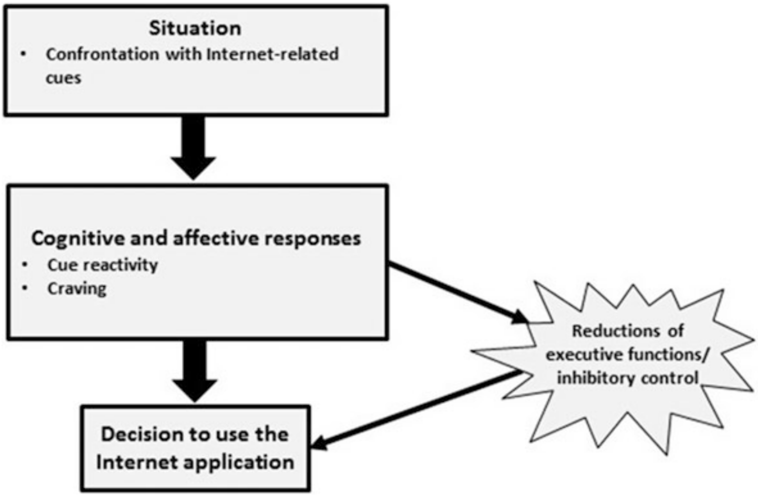

Fig. 2.3 The hypothesized interaction between cognitive and affective responses to specific Internet-related cues and reductions of executive functions and inhibitory control resulting in decisions to use a certain application as a result of craving when being confronted with certain stimuli

2.5 Conclusion

The theoretical models introduced by Brand et al. (2014b, 2016b) and by Dong and Potenza (2014) are a first step to describe potential mechanisms underlying the development and maintenance of Internet addiction or Internet gaming disorder, respectively. Most of the variables included in the models have been selected from previous studies with both treatment-seeking patients and nonclinical samples. These previous studies addressed, at least in most cases, group comparisons of patients with Internet addiction and healthy control subjects or bivariate correlations between certain variables, such as psychopathological symptoms or personality facets, and symptom severity of Internet addiction in general or specific types of Internet addiction, respectively. This means that research on interactions in terms of potential moderating and mediating effects for the relationship between predisposing factors and symptoms of Internet addiction is still very limited. The theoretical I-PACE model by Brand et al. (2016b) illustrates such potential interactions. For instance, dysfunctional copying style and Internet use expectancies are considered mediators for the link between a person's core characteristics/predisposing factors and the severity of Internet addiction. In addition, the development of cue reactivity and craving on the basis of reinforcement learning mechanisms in interaction with reduced executive functioning and inhibitory control could be further important processes underlying the development and maintenance of a specific Internet addiction. This model must be seen as a model in progress. Future studies may explicitly address the hypothesized relationships and interaction effects for several types of specific Internet addiction. Such studies can show similarities and differences across several types of Internet addiction and can also show which of the model's main assumptions seem valid. If the proposed cognitive processes would indeed play a major role in the course of the addictive behavior, this may also inspire the improvement of the specificity of intervention methods. In cognitive behavioral therapy for Internet addiction (Young 2013), working with the client on his/her cognitions about the Internet use is already a component of the intervention, but this could be tailored to specific expectancies and illusions about the Internet use. Strengthening cognitive control over the Internet use in combination with reducing cue reactivity could also be worth considering in Internet addiction therapy.

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Part II
Neuroscientific Approaches to Internet Addiction

Chapter 3
Structural Brain Imaging and Internet Addiction

Fuchun Lin and Hao Lei

Abstract In recent years, neuroimaging techniques have increasingly been used to study Internet addiction disorder (IAD), with the aim of identifying functional and structural changes in the brain, which may constitute the neurological/psychiatric causes of IAD. This chapter reviews current neuroimaging findings concerning brain structural changes associated with IAD. To aid readers in understanding these findings, the commonly used structural imaging methodologies—primarily, magnetic resonance imaging (MRI)—are also outlined. The literature review clearly demonstrates that IAD is associated with neuroanatomical changes involving prefrontal cortex, thalamus, and other brain regions. At least some of these changes appear to correlate with behavioral assessments of IAD. More importantly, these data suggest that the pattern of IAD-related structural differences in the brain resemble, to some extent, those changes observed in substance addiction.

3.1 Introduction

Internet addiction disorder (IAD) was originally proposed as a mental disorder in a satirical hoax by Ivan Goldberg in 1995. It commonly refers to one's inability to control his or her urge to be online, resulting in uncontrolled use of the Internet and adverse consequences in life, such as marked distress, impaired social interaction, and loss of educational/occupational interests (Aboujaoude 2010; Douglas et al. 2008; Kuss et al. 2013). IAD, or pathological Internet use, may be caused by a spectrum of online activities including gaming, shopping, gambling, viewing pornography, and social networking. Clinical studies have demonstrated that subjects with uncontrolled use of the Internet, not only share core symptoms with

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_3

substance addiction such as tolerance, withdrawal symptoms and relapse (Beard and Wolf 2001; Young 1998), but also frequently have psychiatric comorbidity, including attention deficit/hyperactivity disorder, anxiety disorders, sleep disorders, and obsessive-compulsiveness (Bernardi and Pallanti 2009; Ko et al. 2012; Yen et al. 2007).

Although the concept of IAD is well received by the general public and has attracted extensive popular media coverage, controversy exists among the scientific community regarding whether IAD constitutes a standalone illness (Chakraborty et al. 2010; Morahan-Martin 2005). Currently, IAD is not officially recognized as a psychiatric disorder in most parts of the world. In the newly released Diagnostic and Statistical Manual of Mental Disorders Edition V (DSM-V), Internet gaming disorder, which constitutes a major subtype of IAD, is listed as one of the "conditions for further study" (http://www.dsm5.org/Pages/Default.aspx).

With reference to the criteria defining pathological gambling and substance addiction, psychometric tools have been constructed for IAD assessment, among which the Young's Internet addiction scale (YIAS) (Young 1996) and Young's diagnostic questionnaire for Internet addiction (YDQ) (Young 1998), both developed by Dr. Kimberly Young, are the most widely used. Although discrepancy and controversy still exist around such criteria, they nonetheless provide a common ground for communication and research on IAD, and have been widely used in practice.

As with many other psychiatric disorders, the fiercest debates swirling around IAD concern the problem of defining the condition scientifically. Entering the era of DSM-V, more and more neurologists, psychiatrists, and researchers would agree that defining a psychiatric/mental disorder, such as addiction, solely based on symptomatology (or psychometric assessment) may not be sufficient. More objective biomarkers, such as genetic risk factor, biochemical profile, and functional/structural changes of the brain, need to be uncovered to help achieve better understanding, diagnosis and treatment. Undoubtedly, neuroimaging can play a crucial role in this regard.

Because of their noninvasiveness and capability of providing functional/structural information on the brain in high spatial resolution, neuroimaging approaches, especially magnetic resonance imaging (MRI), have been increasingly used over the last two decades to study the neural mechanisms underlying psychiatric disorders. Through neuroimaging research, many psychiatric disorders originally thought to have no clear anatomical pathology are now known to be associated with functional/structural abnormalities of the brain at the neural circuit/network level. For example, subjects addicted to substances were consistently shown to have prominent functional as well as structural changes in the prefrontal cortex (PFC), and such PFC abnormalities are known to play crucial roles in the development of craving, compulsive use, and relapse (Goldstein and Volkow 2011).

IAD is believed by some to be a form of so-called behavioral addiction, which is expected to share similar neural mechanisms, at least in part, with substance addiction. However, there are also researchers who disagree with this concept;

skeptical about whether non-drug stimuli, such as repetitive, high-frequency and highly rewarding behaviors/experiences, could be potent enough to generate neuroadapation similar to that found in substance addiction (Holden 2001). One way to settle this disagreement and lead to a better understanding/definition of IAD is to see whether the functional/structural abnormalities known to be associated with substance addiction, as revealed by neuroimaging approaches, are also present in subjects with IAD (as defined by psychometric assessments). In fact, an increasing number of such studies have been done in the past few years. In this chapter, we shall focus on neuroimaging findings on the brain structural abnormalities associated with IAD. Literature results are reviewed, and the implications of the findings are discussed.

3.2 Methodologies for Assessing Structural Changes of the Brain

3.2.1 Three-Dimensional Anatomical MRI

Among the existing neuroimaging approaches, MRI is probably the most powerful and widely used for assessing structural changes of the brain. Three-dimensional (3D) T_1-weighted imaging (T_1WI) is the most commonly used technique for anatomical MRI, because it is fast in terms of acquisition speed, and is capable of providing high-resolution images with clear contrast among gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF). Moreover, 3D acquisition enables reconstruction of brain slices in any arbitrary orientation. With the state-of-art technology, a 3D-T_1WI dataset covering the whole human brain can be acquired in less than 10 min on the 3 T clinical scanners with an isotropic spatial resolution of 0.5 mm. With different image processing methods, volumetric and morphormetric measures could be derived from the whole-brain 3D-T_1WI dataset, and such measures are often used to assess structural changes of the brain.

3.2.1.1 Volumetric Analysis

First, the 3D-T_1WI dataset can be used for quantitative volumetric analysis of the whole brain as well as any given brain structure of interest. To measure the volume of the whole brain, the non-brain voxels on the images are removed either manually or automatically using special algorithms. The number of brain voxels can then be counted and used to derive the volume of the whole brain. To derive the volume of a given brain structure, a region-of-interest (ROI) representing the structure under concern is delineated, usually manually and with reference to the landmarks on the images, and the number of voxels in the ROI can then be counted and used to derive the volume. An atlas is often needed to guide the delineation of the ROI. For example, Makris et al. (2008b) used this method to found out that long-term alcohol users had significantly decreased reward-network (i.e., dorsolateral PFC (dlPFC) and insula) volume than normal controls. However, this method can be laborious, and the results are susceptible to objective bias and cross-subject variations in how the ROI is delineated.

3.2.1.2 Voxel-Based Morphometry

Voxel-based morphometry (VBM) is an unbiased objective technique developed to characterize subtle structural changes in the whole brain, without the need of any a prior knowledge (Ashburner and Friston 2000). The aim of VBM is to identify differences in the local composition of GM and WM at the group level. VBM involves spatially normalizing the anatomical imaging data from individual subjects into the same stereotactic space, segmenting the individual normalized images into GM/WM/CSF compartments, smoothing the segmented images spatially, and performing voxel-wise statistical analyses to localize significant inter-group differences. The output of VBM is a statistical parametric map showing brain regions where GM/WM composition differs significantly at the group level (Ashburner and Friston 2000).

GM (or WM) density and GM (or WM) volume are two frequently used measures of tissue composition in VBM analysis. Although the two are related to each other, they differ conceptually. Within a voxel on the spatially normalized images or an ROI, GM/WM density means the relative concentration of GM/WM tissue (i.e., the proportion of GM/WM to all tissue types), while GM/WM volume means the absolute GM/WM volume. Comparing GM/WM volume within the framework of VBM involves multiplying the spatially normalized GM/WM density by its Jacobian determinants derived from deformation flow information (Mechelli et al. 2005).

VBM analysis has been widely used in neuroimaging studies of addiction (Barros-Loscertales et al. 2011; Liao et al. 2012; Liu et al. 2009; Makris et al. 2008b; Schwartz et al. 2010). Such studies consistently show that subjects who are dependent on stimulant drugs have significantly reduced GM volume in the PFC (Ersche et al. 2013).

3.2.1.3 Cortical Thickness Measurement

In addition to volumetric measures and regional composition of GM/WM, 3D-T_1WI dataset can also be used to derive cortical thickness, a computational neuroanatomy measure defined as the distances between the pial surface (i.e., surface between the cortical GM and CSF) and the interface separating the cortical GM and WM underneath (MacDonald et al. 2000). Measuring cortical thickness involves segmenting the anatomical images into GM/WM/CSF compartments for each individual subject, reconstructing the individual GM/WM surfaces and pial surface, computing individual cortical thickness, registering the surface-based coordinate system of each individual subject into the same stereotactic space, spatial smoothing, and performing voxel-wise statistics to detect morphometric variations at the group level.

Figure 3.1 explains graphically the steps to measure cortical thickness from the 3D anatomical image data. Cortical thickness is thought to be related to the size, density, and arrangement of cortical cells (MacDonald et al. 2000), and has been shown to change only minimally with brain size and sex (Sowell et al. 2007). Typical cortical thickness values in adult humans are between 1.5 and 3 mm (Salat et al. 2004). Cortical thickness has been used to investigate structural changes of the cortices associated with neurodevelopment and brain diseases. During aging, a decrease (also known as cortical thinning) on the order of about 10 µm per year has been observed (Salat et al. 2004). Cocaine-dependent subjects are known to have lower cortical thicknesses in brain regions involved in executive regulation of reward and attention (Makris et al. 2008a).

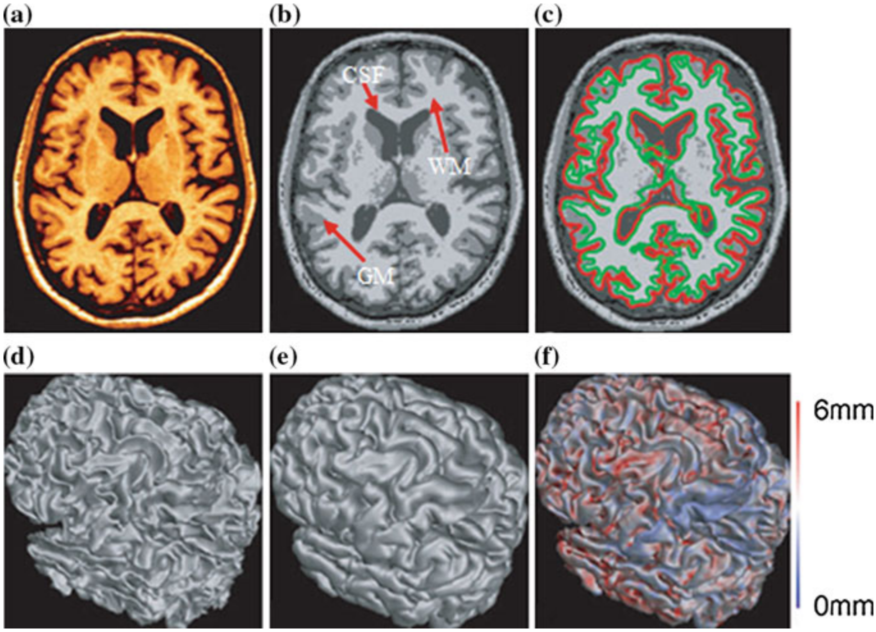

Fig. 3.1 Segmentation and cortical thickness analysis of anatomical images. The raw anatomical images were first corrected for signal intensity nonuniformity and registered into a reference stereotaxic space (**a**), and then segmented into gray matter (*GM*), white matter (*WM*) and cerebrospinal fluid (*CSF*) compartments (**b**). The inner (*green lines* in **c**) and outer (*red lines* in **c**) GM surfaces can then be extracted and fitted into three-dimensional maps using deformable models. Panel **d** shows the resultant inner GM surface, and panel **e** shows the outer GM surface. At a given coordinate in the reference stereotaxic space, cortical thickness is defined as the distance between these two surfaces (**f**). This figure is adapted from a figure from the paper by Lerch et al. (2005) with permission

3.2.2 Diffusion Tensor Imaging

Diffusion tensor imaging (DTI) is a noninvasive MRI technique that measures the diffusion properties of water molecules in vivo (Basser et al. 1994a, b; Le Bihan 2003; Pierpaoli et al. 1996). The diffusion of water molecules in a homogenous compartment, such as CSF, is isotropic, and can be characterized simply by a single diffusion coefficient. However, in biological tissues, the diffusion of water molecules is subject to restriction imposed by the microstructural organization of the tissue (e.g., membranes and other biological barriers). For instance, in the WM fibers, the water molecules would diffuse more quickly along the fibers than perpendicular to the fibers. As a result, more complicated models need to be used to characterize the anisotropic diffusion properties of water molecules in the biological tissues.

In DTI, the diffusion behaviors of water molecules are modeled by a zero mean Gaussian distribution, which is fully represented by a second-order diffusion tensor (Basser et al. 1994a, b; Pierpaoli et al. 1996). After measuring the diffusion tensor experimentally, parameterized diffusion indices, such as fractional anisotropy (FA), can be computed (Basser and Pierpaoli 1996). FA is a scalar value between zero and one that describes the degree of anisotropy of a diffusion process. A value of zero represents that the diffusion is isotropic (i.e., it is unrestricted or equally restricted in all directions). A value of one represents that the diffusion occurs only along one axis, and is fully restricted along all the other directions.

Measuring the diffusion indices of water molecules along different directions and the overall anisotropy with DTI may provide important information on the microstructural organization of the underlying tissue (Le Bihan 2003). For example, the FA value of a WM tract is thought to be closely related to fiber density, axonal diameter and myelination, thus often being used as a surrogate for the assessing the microstructural integrity of WM. It has been demonstrated that diffusion indices obtained from DTI can be used to detect tissue microstructural changes that might not be visible with the conventional MRI techniques (Basser et al. 1994a, b; Pierpaoli et al. 1996). Nowadays, DTI has become a widely used tool for revealing the tissue abnormalities associated with neurological/psychiatric diseases. Figure 3.2 shows representative DTI data that are commonly used in the studies on disease-related brain structural changes.

3.2.2.1 Voxel-Based Analysis

Voxel-based analysis (VBA) is an observer-independent voxel-wise analysis method for diffusion indices derived from the DTI data, which can circumvent the problems associated with the more traditional ROI analysis (Jones et al. 2005). The aim of VBA is to assess regional alterations of diffusion indices between groups. VBA includes spatially normalizing the maps of diffusion indices from individual subjects into a standard stereotactic space, smoothing the normalized maps, and

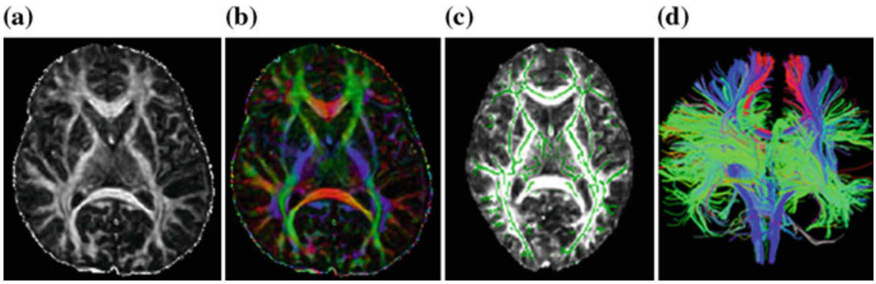

Fig. 3.2 Diffusion tensor imaging (*DTI*) and data analysis. With images acquired with diffusion-weighted gradients applied along different directions and a tensor model, fractional anisotropy (*FA*) maps (**a**), corresponding FA-weighted color directional diffusion maps (**b**), FA skeleton maps (**c**) can be calculated. Whole-brain tractography (**d**) can be performed. The data in **a**–**d** are from the same normal subject

performing voxel-by-voxel statistical comparisons to determine significant inter-group differences. With VBA, the whole brain is tested for control-patient differences without any a priori hypothesis on where the abnormalities should be. The output of VBA is a statistical parametric map showing brain regions where diffusion indices differ significantly at the group level.

3.2.2.2 Tract-Based Spatial Statistics

Tract-based Spatial Statistics (TBSS) is another observer-independent voxel-wise method for analyzing whole-brain DTI data (Smith et al. 2006). TBSS involves co-registering the FA maps from all individuals included in the study, to a standard stereotactic space, averaging the co-registered individual FA maps to create a mean FA map, thinning the mean FA map to obtain a mean FA skeleton, projecting co-registered individual FA maps onto the mean FA skeleton to create a skeletonized FA map, and finally performing voxel-wise statistics across subjects on the skeletonized FA data. TBSS retains the strengths of VBA while addressing some of its drawbacks, such as the arbitrariness of the choice of spatial smoothing.

3.2.2.3 Tractography-Based Analysis

DTI data can also be used to trace WM tracts by performing tractography according to the principal directions of neighboring diffusion tensors. The main feature of DTI tractography is that it can be used to reconstruct WM pathways in vivo, and provide information about the shape, location, and topology of fiber tracts as well as anatomical connectivity between distant brain areas (Basser et al. 2000; Conturo et al. 1999; Mori et al. 1999). Tractography is a useful tool for measuring WM deficits, and has been applied in a wide range of clinical and basic studies

(Dell'Acqua and Catani 2012). In tractography-based analysis, the fiber tract under concern is first reconstructed using fiber tracking algorithms, and the diffusion indices of the tract can then be analyzed by considering the fiber tract as a 3D ROI (McIntosh et al. 2008) or by parameterizing the fiber tract (Lin et al. 2006).

3.3 Brain Structural Abnormalities Associated with IAD

Unlike the case for substance addiction, only a limited number of structural neuroimaging studies have been performed on IAD so far, mostly by Chinese and Korean researchers. Table 3.1 lists all the structural neuroimaging studies on IAD that can be found in the literature, and summarizes the major findings from these studies. We shall also give a brief review of these results in Table 3.1.

3.3.1 Results from Anatomical MRI

3.3.1.1 VBM Analysis

Zhou et al. (2011) were among the first to use a neuroimaging approach to assess structural abnormalities in the brain associated with IAD. They acquired 3D-T_1WI data from 18 adolescents (i.e., 17.2 ± 2.6 years) who were considered to be addicted to the Internet based on the criteria of the modified eight-item YDQ (Beard and Wolf 2001), and 15 age- and gender-matched healthy controls. VBM analysis was used to compare regional GM density (GMD) between the two groups. It was reported that the IAD group had significantly reduced GMD in the left anterior cingulate cortex (ACC), left posterior cingulate cortex (PCC), left insula and left lingual gyrus. The major online activities of the IAD subjects were not specified in this study.

There have been three studies that investigated structural abnormalities in the brain of adolescent/young subjects (i.e., 16–21 years) who were specifically addicted to online games (Han et al. 2012; Weng et al. 2013; Yuan et al. 2011). YDQ or YIAS was used in these studies to screen for online game addiction (OGA). Additionally, it was confirmed that playing online game was the primary activity for the addicted subjects when they used the Internet (i.e., on average around 10 h of online game playing per day). Two studies showed similar results in that, compared to normal controls, the subjects with OGA had significantly reduced GM volume (GMV) in the orbitofrontal cortex (OFC) and supplementary motor area (SMA). OGA was also found to be associated with reduced GMV in the left rostral ACC (rACC), bilateral dlPFC, and cerebellum by Yuan et al. (2011); and with reduced GMV in the bilateral insula by Weng et al. (2013). In contrast to the observations in these two studies, Han et al. (2012) reported that the subjects with OGA had reduced GMV in the bilateral inferior temporal gyri, right middle

Table 3.1 A summary of the structural brain imaging studies on Internet addiction disorder (IAD) available so far

Studies	Subjects	Diagnosis criteria	Methodology	Main results
Zhou et al. (2011)	18 addicts (16 M/2F),17.2 ± 2.6 years old 15 controls (13 M/2F), 17.8 ± 2.5 years old	Modified young diagnostic questionnaire for internet addiction by Beard and Wolf (MYDQ)	Scanner: 3.0T Philips Achieva Acquisition: three-dimensional (3D) T_1-weighted anatomical imaging Analysis: Voxel-based morphometry (VBM) to assess gray matter density (GMD)	Compared to the controls, the addicts showed decreased gray matter density (GMD) in: Left anterior cingulate cortex (ACC) Left posterior cingulate cortex (PCC) Left insula Left lingual gyrus
Yuan et al. (2011)	18 addicts (12 M/6F), 19.4 ± 3.1 years old 18 controls (12 M/6F), 19.5 ± 2.8 years old	MYDQ Self-rating anxiety scale and the self-rating depression scale Subjects pending 19.4 ± 3.1 h per day playing online games	Scanner: 3.0T Siemens Allegra Acquisition: 3D T_1-weighted anatomical imaging + diffusion tensor imaging (DTI) Analysis: VBM to assess gray matter volume (GMV) + tract-based spatial statistics (TBSS)	Compared to the controls, the addicts showed decreased gray matter volume (GMV) in: Bilateral orbitofrontal cortex (OFC) Bilateral supplementary motor area (SMA) Bilateral dorsolateral prefrontal cortex (dlPFC) Left rostral ACC (rACC) Cerebellum and reduced fractional anisotropy (FA) in: White matter within the right parahippocampal gyrus and increased FA in: Left posterior limb of the internal capsule (PLIC) GMVs of the right dlPFC, left rACC, and right SMA in the addicts correlated negatively with the duration of addiction FA of the left PLIC correlated positively with the duration of addiction

(continued)

Table 3.1 (continued)

Studies	Subjects	Diagnosis criteria	Methodology	Main results
Dong et al. (2012)	16 addicts (16 M/0F), 22.2 ± 3.3 years old 15 control (15 M/0F), 21.6 ± 2.6 years old	Young's online internet addiction test Structured psychiatric interviews (M.I.N.I.) Subjects spending > 80% online time playing online games	Scanner: 3T Siemens Trio Acquisition: DTI Analysis: TBSS	Compared with the controls, the addicts showed increased FA in: Bilateral thalamus Left PCC Thalamic FA in the addicts correlated positively with Internet addiction severity scores
Han et al. (2012)	20 addicts (20 M/0F), 20.9 ± 2.0 years old 17 professional gamers (PG) who were not addicted (17 M/0F), 20.8 ± 1.5 years old 18 controls (18 M/0F), 20.9 ± 2.1 years old	Young's internet addiction scale (YIAS) Structured clinical interview for DSM-IV and the beck depression inventory Subjects spending > 4 h per day/30 h per week playing online games	Scanner: 1.5 T Siemens Espree Acquisition: 3D T_1-weighted anatomical imaging Analysis: VBM to assess changes in GMV	Compared to the controls, the addicts showed increased GMV in: Left thalamus and decreased GMV in: Bilateral inferior temporal gyri Right middle occipital gyrus Left inferior occipital gyrus Compared to the PG who were not addicted, the addicts showed increased GMV in: Left thalamus and decreased GMV in: Left cingulate gyrus (CG) GMV of the left CG in the addicts correlated negatively with the YIAS scores and Barratt Impulsiveness Scale total scores GMV of the thalamus in the addicts correlated positively with the YIAS scores

(continued)

Table 3.1 (continued)

Studies	Subjects	Diagnosis criteria	Methodology	Main results
Lin et al. (2012)	17 addicts (15 M/2F), 17.0 ± 2.5 years old 16 controls (14 M/2F), 17.8 ± 2.5 years old	MYDQ Mini international neuropsychiatric interview for children and adolescents	Scanner: 3.0 T Phillips Achieva Acquisition: DTI Analysis: TBSS	Compared to the controls, the addicts showed decreased FA in: Bilateral orbitofrontal white matter Genu of corpus callosum (CC) Bilateral anterior cingulum Bilateral inferior fronto-occipital fasciculus Bilateral corona radiation Bilateral anterior limb of internal capsule External capsule (EC) Left precentral gyrus FA of left genu of CC of the addicts correlated negatively with the screen for child anxiety related emotional disorders FA of the left EC of the addicts correlated negatively with the YIAS scores
Hong et al. (2013)	15 addicts (15 M/0F), 13.3 ± 2.8 years old 15 controls (15 M/0F), 15.4 ± 1.2 years old	YIAS Kiddie-schedule for affective disorders and Schizophrenia-present and lifetime version Subjects self-report to have experienced typical components of addiction to online gaming	Scanner: 3T Siemens Trio Acquisition: 3D T_1-weighted anatomical imaging Analysis: cortical thickness	Compared to the controls, the addicts showed decreased cortical thickness in: Right lateral OFC
Weng et al. (2013)	17 (4 M/13F), 16.3 ± 3.0 years old 17 (2 M/15F), 15.5 ± 3.2 years old	MYDQ Playing online game was the primary activity when the addicts used Internet	Scanner: 3.0 T Philips Intera Acquisition: 3D T_1-weighted anatomical imaging + DTI Analysis: VBM to assess GMV + TBSS	Compared to the controls, the addicts showed decreased FA in: Genu of CC Bilateral frontal lobe white matter Right EC and reduced GMV in: Right OFC Bilateral insula

(continued)

Table 3.1 (continued)

Studies	Subjects	Diagnosis criteria	Methodology	Main results
				Right SMA GMVs of the right OFC and bilateral insula correlated negatively with the YIAS scores FA of the right EC correlated negatively with the YIAS scores
Yuan et al. (2013)	18 addicts (12 M/6F), 19.4 ± 3.1 years old 18 controls (12 M/6F), 19.5 ± 2.8 years old	MYDQ	Scanner: 3.0 T Siemens Allegra Acquisition: 3D T_1-weighted anatomical imaging Analysis: cortical thickness	Compared to the controls, the addicts showed decreased cortical thickness in: Left lateral OFC Left insula Left lingual gyrus Right postcentral gyrus Right entorhinal cortex Right inferior parietal cortex and increased cortical thickness in: Left precentral cortex Left precuneus Left middle frontal cortex Left inferior temporal and middle temporal cortices Cortical thicknesses of the left precentral cortex and precuneus in addicts correlated positively with the duration of addiction Cortical thickness of the left lingual gyrus correlated negatively with the duration of addiction

occipital gyrus, and left inferior occipital gyrus, but increased GMV in the left thalamus, compared to the normal controls. They also compared regional GMV between the subjects with OGA and professional gamers who were not addicted, and found significantly lower left cingulate gyrus GMV in the addiction group (Han et al. 2012).

3.3.1.2 Cortical Thickness Analysis

There have been two studies performed so far to assess the OGA-related abnormalities in cortical thickness. Yuan et al. (2013) showed that, compared to normal controls, subjects with OGA in late adolescence had increased cortical thickness in the left precentral cortex, precuneus, middle frontal cortex, inferior temporal and middle temporal cortices, and decreased cortical thickness in the left lateral OFC, insula, lingual gyrus, right postcentral gyrus, entorhinal cortex, and inferior parietal cortex. Hong et al. (2013) reported decreased cortical thickness in the right lateral OFC of male adolescents who were addicted to online gaming.

3.3.2 Results from DTI

Yuan and colleagues were among the first to use DTI to assess WM abnormalities associated with IAD. Their results showed that, relative to normal controls, adolescent college students with OGA were associated with significantly increased FA in the left posterior limb of the internal capsule (PLIC), but reduced FA in the WM within right parahippocampal gyrus (Yuan et al. 2011). Higher FA in the bilateral thalamus and left PCC were also reported in the subjects with OGA (Dong et al. 2012).

With the same IAD and control subjects as those reported in the study by Zhou et al. (2011), Lin et al. (2012) reported that IAD is associated with reduced FA in the orbitofrontal WM, corpus callosum (CC), cingulum, inferior front-occipital fasciculus, corona radiation, anterior limb of the internal capsule (ALIC), and external capsule (EC). These findings were largely reproduced in a subsequent study conducted by Weng et al. (2013), showing that adolescents with OGA had decreased FA in the right genu of CC, bilateral frontal WM and right EC, as compared to normal controls.

3.3.3 Correlations Between Brain Structural Alterations and Behavioral Assessments

Some of the studies also assessed the correlations between brain structural alterations and behavioral assessments in Internet addicts. For example, two studies on

OGA showed consistently that the GMV of left CG, right OFC and bilateral insula correlated negatively with the YIAS scores and Barratt impulsiveness scale total scores; while GMV of the left thalamus correlated positively with the YIAS scores (Han et al. 2012; Weng et al. 2013). The studies of Yuan et al. (2011, 2013) on OGA showed that the GMV in right dlPFC, left rACC and right SMA, and the cortical thickness of left lingual gyrus correlated negatively with the duration of Internet addiction. Positive correlation between the cortical thickness of the left precentral cortex and precuneus and the duration of Internet addition was also reported (Yuan et al. 2013).

DTI studies revealed that the addicted subjects had a negative correlation between FA in the EC and YIAS scores (Lin et al. 2012; Weng et al. 2013), and positive correlations between FA in the thalamus and YIAS cores (Dong et al. 2012). A positive correlation between FA of the left PLIC and the duration of Internet addiction was also reported (Yuan et al. 2011). Additionally, Lin et al. (2012) reported a negative correlation between FA of the left genu of CC and the Screen for Child Anxiety Related Emotional Disorders scores.

3.3.4 Synopsis of Structural Abnormalities Associated with IAD/OGA

The structural neuroimaging results summarized in Sects. 3.3.1–3.3.3 consistently demonstrate that IAD and/or OGA is associated with structural abnormalities in the brain, although the exact pattern and characteristics of the abnormalities may appear to vary from study to study. The most consistent findings from the studies available so far are atrophy in the PFC (i.e., OFC, ACC, and dlPFC) and insula. Almost all the studies demonstrate reduced GMD, GMV, or cortical thickness in these two regions, and such changes also appear to be correlated with either the YIAS scores or the duration of Internet addiction.

Thalamus is another brain region frequently reported to show structural abnormalities in subjects with IAD/OGA. But unlike the case for PFC and insula, the findings for thalamus appeared to be less consistent. Increased thalamic GMV and FA have been reported in IAD/OGA, and the increase in thalamic FA was shown to correlate positively with the YIAS scores (Dong et al. 2012; Han et al. 2012). On the other hand, although no structural changes in the thalamus was reported in the paper by Zhou et al. (2011), a trend toward decreased GMD in the bilateral anterior thalamus was found for the subjects with IAD (Fig. 3.3).

Other brain regions found to demonstrate structural changes were mainly visual-related (i.e., occipital gyrus, inferior temporal gyrus, and lingual gyrus) and sensory/motor-related (i.e., SMA, precentral/postcentral cortex, and cerebrullum) areas. DTI abnormalities associated with IAD/OGA were found to be predominately located in or along the WM tracts connecting to PFC and thalamus, such as the genu of the CC, ALIC, EC, and cingulum.

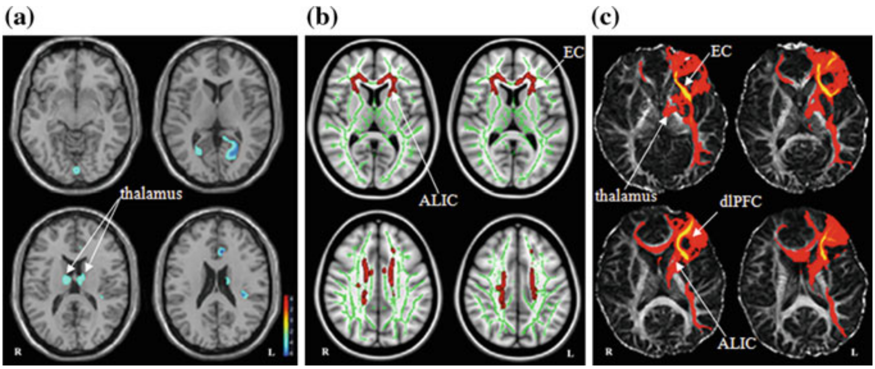

Fig. 3.3 Structural abnormalities associated with Internet addiction disorder (*IAD*) as revealed by voxel-based morphometry (*VBM*) and tract-based spatial statistics (*TBSS*). The data shown in this figure are from the same cohort of subjects reported in the papers by Zhou et al. (2011) and Lin et al. (2012), but analyzed in different ways. Panel **a** shows the brain regions with significantly ($p < 0.001$, uncorrected; voxel size > 200) decreased gray matter density (*GMD*) in IAD subjects, as compared to normal controls. In addition to the regions reported in the original VBM paper (Zhou et al. 2011), decreased GMD was found in the *left* (−14, −9, 19; 822 voxels) and right (10, −7, 14; 962 voxels) anterior thalamus. Please note that a different statistical threshold ($p < 0.05$, with FDR correction) was used in the original paper (Zhou et al. 2011). Panel **b** shows the white matter (*WM*) tracts with abnormal microstructural integrity in IAD subjects. This figure is adapted from Fig. 3.1 of the original DTI paper (Lin et al. 2012). Panel **c** shows the results of probabilistic tractography using the segment of external capsule (*EC*) showing IAD-related FA reduction as the seed. Interestingly, the IAD-related atrophic brain regions revealed by VBM are interconnected via WM tracts showing compromised microstructural integrity. For example, the atrophic thalamus and insula are interconnected to dorsolateral prefrontal cortex (*dlPFC*) via EC and anterior limb of the internal capsule (*ALIC*)

3.3.5 Comparisons with Brain Structural Abnormalities in Substance Addiction and Pathological Gambling

Abnormal GMD/GMV in the prefrontal regions (i.e., OFC, ACC, and dlPFC), insula, and thalamus are common findings in smokers (Zhang et al. 2011), heroin-dependent individuals (Yuan et al. 2010), alcoholics (Makris et al. 2008b), opiate-dependent subjects (Lyoo et al. 2006), methamphetamine abusers (Kim et al. 2006) and cocaine-dependent subjects (Franklin et al. 2002). Impaired WM integrity in the orbitofrontal regions, CC, cingulum, ALIC, EC, and corona radiation are also frequently reported in subjects exposed to addictive substances, such as alcohol (De Bellis et al. 2008), cocaine (Lim et al. 2002, 2008; Romero et al. 2010), marijuana (Bava et al. 2009), heroin (Liu et al. 2008), ketamine (Liao et al. 2010), methamphetamine (Alicata et al. 2009; Salo et al. 2009), opiate (Bora et al. 2012; Upadhyay et al. 2010), and tobacco (Lin et al. 2013). Interestingly, we found that the pattern of WM microstructural abnormality in IAD largely resembles that

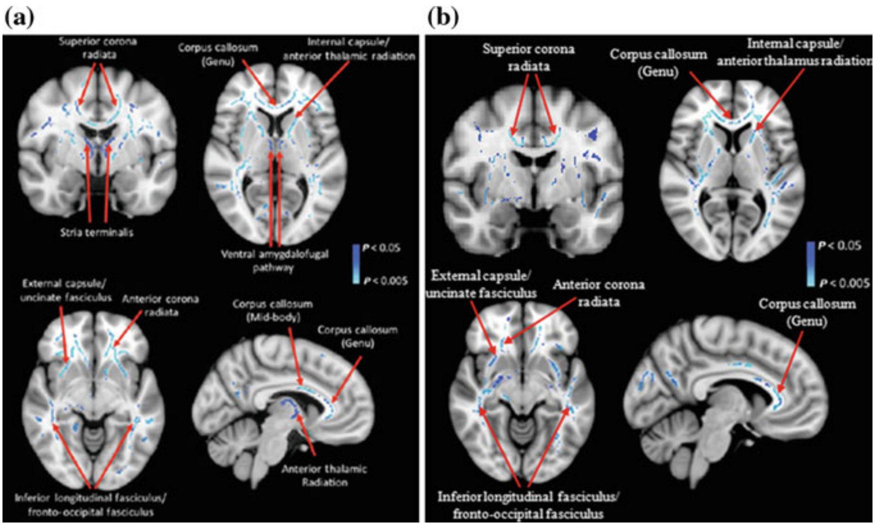

Fig. 3.4 Comparisons between the pattern of abnormal white matter integrity in Internet addiction and that in opiate addiction. The figure in panel **a** is adapted from the paper by Upadhyay et al. (2010) with permission, showing white matter tracts whose fractional anisotropy (*FA*) values were significantly ($p < 0.05$, corrected by cluster-based thresholding with $c > 3$) reduced in opiate addicts ($n = 10$), relative to normal controls ($n = 10$). The figure in panel **b** is modified from Fig. 3.1 of the paper by Lin et al. (2012). This figure is drawn in such a way that it can be directly compared with the figure shown in panel **a** by visual inspection. In this figure, the significance statistical threshold was set to $p < 0.05$ with threshold-free cluster enhancement (*TFCE*) correction. Please note that a different statistical threshold of $p < 0.01$, with TFCE correction, was used in the original paper (Lin et al. 2012). It can be seen from the figure that both the subjects with IAD and those with opiate addiction exhibited impaired microstructural integrity in the white matter tracts connecting to the prefrontal cortex, such as the genu of corpus callosum, cingulum, corona radiate, internal and external capsules. However, reduced FA in stria terminalis and ventral amygdalofugal pathway was observed only in opiate addicts, but not in subjects addicted to the Internet. These findings demonstrate that Internet addiction may, at least to some extent, share similar neural mechanisms with substance addiction

which has been observed in opiate addicts (Fig. 3.4), indicating that Internet addiction may, at least in part, share similar neural mechanisms with other types of substance addiction.

Neuroimaging approaches have also been used to study brain structural changes associated with pathological gambling, a condition originally considered an impulsive-compulsive disorder, but now classified as “addictions and related disorders” in DSM-V (http://www.dsm5.org/Pages/Default.aspx). In subjects with pathological gambling, impaired WM microstructural integrity (i.e., lower FA) was found in the genu of CC, cingulum, ALIC, inferior fronto-occipital fascicle, and anterior thalamic radiation (Joutsa et al. 2011). However, no volumetric differences in regional GM or WM were observed between pathological gamblers and normal controls (van Holst et al. 2012).

It therefore appears that IAD/OGA, substance addiction, and pathological gambling are associated with, to some extent, similar structural abnormalities in the brain, which may constitute a neural signature for the three forms of addiction.

3.4 Implications of Brain Structural Abnormalities in Internet Addiction

Overall, Internet addicts appear to have impaired microstructural integrity in the WM tracts involved in the neural circuits underlying emotion generation and processing, executive attention, decision-making, and cognitive control. From the research on substance addiction, we now know that the insula and PFC play crucial roles in addiction. The insula is a brain region that integrates interoceptive states into conscious feelings, and contributes mainly to the motivation or urge to use drugs and to decision-making processes that precipitate relapse (Naqvi and Bechara 2009). Among the complex functions of PFC, one of the most important ones, perhaps, is executive control, such as planning, prioritizing, organizing, and emotion processing (Chan et al. 2008). It is generally accepted that PFC abnormalities are central to the addiction-related behaviors related to executive dysfunction, including maladaptive decision-making and compulsive-repetitive behaviors (Goldstein and Volkow 2011). Subjects with IAD not only show symptoms such as craving and relapse, but also are known to have impaired abilities in impulse control (Whang et al. 2003). Through neuroimaging approaches, IAD subjects are shown to have structural abnormalities in the PFC, insula, and the WM fibers connecting these two regions to other parts of brain. This may be viewed as evidence in support of the notion that impaired decision-making and executive control are important features of IAD.

Thalamus is a key target for dopamine (Sanchez-Gonzalez et al. 2005) and plays an important role in reward processing, goal-directed behaviors, as well as many other cognitive and motor functions (Corbit et al. 2003; Yu et al. 2010). Altered thalamic microstructure may contribute to the development of Internet addiction by disrupting the acquisition of stimulus-reward associations.

The human visual system is very sensitive to subtle details in movements, even to weakened stimuli such as point-light walkers (Blake and Shiffrar 2007). Excessive exposure to visual stimulation (i.e., computer monitor) may lead to neuroplastic changes in the brain regions related to visual/spatial processing, such as MOG, IOG, ITG, lingular gyrus, PCC, and precuneus. Additionally, Internet addicts spend a tremendous amount of time online and become astonishingly skilled and accurate in mouse clicking and keyboard typing (Kuss and Griffithsemail 2012). Such training/overlearning processes may induce neuroplastic changes in the sensorimotor-related areas.

CC is the largest WM fiber tract connecting the neocortex of the two hemispheres (Delacoste et al. 1985). Reduced FA in the CC of the subjects with IAD may be indicative of alterations in the communication between the two hemispheres. The ALIC is a key region of frontal-subcortical circuits, providing connections between the thalamus/striatum and frontal cortical regions and comprising a system that plays an important role in reward and emotion processing (Mori et al. 2005). EC connects the ventral and medial prefrontal cortex to the striatum, and is involved in emotion generation and processing (Mori et al. 2005). Impaired WM integrity in the ALIC and EC may thus be indicative of alterations in reward and emotion processing in IAD. The corona radiation links the cerebral cortex to the internal capsule and provides important connections between the frontal, parietal, temporal, and occipital lobes (Wakana et al. 2004). The inferior fronto-occipital fasciculus is an association bundle connecting the frontal with the parietal and occipital lobes (Wakana et al. 2004). Impaired WM microstructure in the corona radiation and inferior fronto-occipital fasciculus is likely to be associated with the abnormal GM density/volumes in cerebral cortex.

3.5 Limitations of Previous Studies

Notwithstanding the insightful results on brain structural changes associated with IAD, a number of limitations in the previous studies need to be observed. First, the diagnosis criteria used for IAD and OGA are somewhat different across studies. This may potentially result in error classification in some cases, and limit the ability to draw direct comparisons among different studies. Second, the structural brain imaging studies on IAD/OGA performed so far all constituted relatively small samples. Owing to this limitation, the results summarized in this chapter should to be considered preliminary, and need to be replicated in future studies with larger sample sizes. Generalization of the findings from the available studies should also be undertaken with caution. Third, previous studies often used cross-sectional designs, such that the question of whether brain structural changes are a consequence or a precondition for IAD/OGA cannot be answered. Finally, IAD may have many subtypes (i.e., OGA) depending on the type of online activity one is addicted to. Further studies should compare the brain structural changes across different IAD subtypes to determine whether such changes are specific to online activities, or caused by uncontrolled use of the Internet per se.

3.6 Summary and Perspectives

Taken together, the structural MRI studies available thus far clearly demonstrated that Internet addiction is associated with anatomical abnormalities in the brain involving both GM and WM. Reduced GM density/volume and cortical thickness are consistently observed in the PFC and insula of the subjects addicted to the Internet, who also showed impaired microstructural integrity in the WM tracts that connect to the PFC. The brain regions showing structural changes in IAD are known to be involved in reward, emotion generation and processing, executive attention, decision-making, and cognitive control. The pattern of IAD-related structural abnormalities in the brain is also shown to be similar, to some extent, to that observed in substance addiction. It therefore may be concluded that Internet addiction may, at least in part, share similar neural mechanisms with substance addiction and pathological gambling. However, only eight structural brain imaging studies on IAD have been published to date. Further studies, especially longitudinal studies with large sample sizes, are needed to elucidate the exact relationship between uncontrolled use of the Internet and plastic structural changes in the brain.

Acknowledgements This work was partially supported by grants from National Basic Research Program of China (973 Program, 2011CB707802) and Natural Science Foundation of China (81171302 and 21221064).

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Chapter 4
Functional Imaging Study of Internet Gaming Disorder

Chih-Hung Ko and Ju-Yu Yen

4.1 Introduction

Internet gaming is now among the most popular recreational activities worldwide. While the Internet enables access to online games 24 h a day, smartphones further enable access from any location. However, loss of control over the time spent engaged in online gaming may have negative consequences. Owing to the significant difference between generalized internet addiction and internet gaming disorder (Davis 2001; Montag et al. 2015) and the potentially adverse impacts of IGD on the health of internet users, the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) proposed diagnostic criteria specific for internet gaming disorder (IGD) in 2013. It defined addiction to Internet gaming among the conditions for further study of Section III, and suggested that more evidence was needed before IGD can be included as a standard disorder in the DSM system (American Psychiatric Association 2013). Several neurobiological and neurocognitive studies have evaluated the neuropsychological mechanisms of IGD (e.g., Dong et al. 2012a, b; Han et al. 2010; Ko et al. 2009a). Although some of the proposed clinical

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience,
Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_4

presentations and diagnostic criteria for IGD resemble those for substance addiction (Ko et al. 2006; Ko et al. 2012), no studies have conclusively determined whether IGD shares similar mechanisms with substance use disorder. Since neurobiological mechanisms of the substance use disorder have been extensively researched in the past decade (Volkow et al. 2010), studying the neurobiological mechanisms of IGD might reveal whether they resemble those in substance use disorder.

The present chapter reviews functional magnetic resonance imaging (fMRI) studies of internet gaming disorder. The review includes reports of the use of fMRI, including arterial spin-labeled fMRI, for analyzing task-related performance, resting functional connectivity, or effective connectivity.

4.2 Functional Magnetic Resonance Imaging

fMRI is a functional technique used to record cerebral hemodynamic changes during a specific task to demonstrate possible brain mechanisms of a specific neurocognitive function (Tejado et al. 2010). Analyses of blood-oxygen level dependent (BOLD) contrast, i.e., the difference in magnetic susceptibility between oxyhemoglobin and deoxyhemoglobin, enable the indirect study of hemodynamic changes based on variation in magnetic signals (Huettel et al. 2009). By comparing MR signals obtained while the subject is resting and while the subject is performing a specific task, this technique can reveal hemodynamic changes related to a specific neurocognitive response.

For evaluating mechanisms of psychiatric disorders, fMRI is preferable to PET and SPECT because it does not require radiation exposure. Other advantages include its wider availability and lower expense. Moreover, fMRI provides superior spatial and temporal resolution (Tejado Lde et al. 2010). However, isolating the hemodynamic change associated with a specific stimulus is very difficult. The paradigm must be well designed to avoid artifacts and misinterpretation. Further, since the BOLD signal provides only an indirect estimation of cerebral blood flow (CBF), the fMRI should be interpreted cautiously. The combination of fMRI techniques with insights from PET provides more direct insights into the biochemical mechanism of human behaviors.

4.3 Use of fMRI for Studying IGD

fMRI is among the most important imaging tools for investigating mechanisms of addiction, including response to a substance, vulnerability to addiction, characteristics, or symptoms of addictive behavior, and consequences of addiction (Fowler et al. 2007). As fMRI is widely available in industrialized countries, which tend to have the highest prevalence of IGD and IA, the present chapter reviews fMRI results reported in brain studies of subjects diagnosed with IGD. The fMRI results should be interpreted cautiously since the hypotheses in some of these studies have not been supported by further psychopathology, cognition, or physiology studies. Additionally, before beginning a new fMRI study, a rational hypothesis must be derived based on previous evidence obtained in brain imaging studies. Therefore, a literature review of applications of fMRI for studying IGD is timely.

4.3.1 Task-Related fMRI Study

A task-related fMRI study typically uses visual, auditory, or other stimuli, to provoke two or more different cognitive processes in the subject. The typical design has two conditions, an experimental condition, and a control condition. The goal of evaluation is to test the hypothesis that the signal differs between the two conditions. The trials are designed to alternate between the experimental and control condition (Glover 2011).

Classic experimental designs in fMRI represent the block or event-related design. In a block design, each block will have a duration of a certain number of fMRI scans, about 20–30 s, and within each block, only one condition (such as pictures from a computer game) is presented. Although the block design is considered optimal for detecting activation, numerous cognitive processes may occur within 20–30 s. Therefore, other approaches, such as the event-related design, are also used in fMRI studies. Event-related designs enable the researcher to detect changes in the BOLD hemodynamic response in response to specific events. Event-related designs are presented in a randomized sequence, and the between-stimuli duration is varied. Therefore, an event-related design is better able to characterize the timing of the change in amplitude of the hemodynamic response in the form of the BOLD signal.

For example, in the Go/Nogo task, an fMRI study with an event-related design can distinguish the BOLD response to the Go, Nogo, and failed inhibited trials. Therefore, an fMRI study is preferable for assessing the functional anatomy of response inhibition and error processing (Criaud and Boulinguez 2013). Both the block design and event-related design have been used to study IGD, particularly in the cue-induced reactivity paradigm. Such paradigms confront IGD patients with pictures from their favorite computer game while they are in an fMRI setting and their brain activity is being recorded. These designs have also been used to study reward sensitivity, inhibitory control, and risk decision.

4.3.1.1 The fMRI for Analyzing Cue-Induced Reactivity in IGD or IA (Ko et al. 2009a)

Ko et al. (2009a, b) recruited ten adults who met the diagnostic criteria for IGD according to psychiatric interviews and ten healthy controls without IGD. All subjects in the experimental group were addicted to the same online game.

This block design study of the cue-induced craving paradigm performed fMRI scans while the subjects were shown screenshots of video games. The significance threshold was set to $p < 0.0005$, and the cluster size was >50 voxels. The experimental results revealed that, compared to controls, the IGD group had higher activations in the right orbitofrontal cortex, bilateral anterior cingulate, right dorsolateral prefrontal cortex (DLPFC), right nucleus accumbens, and right caudate nucleus. The authors suggested that these areas may be considered neural substrates of the cue-induced gaming urge in IGD. The results also indicated that cue-induced brain reactivity in IGD resembles that in substance use disorder.

Ko et al. (2013a) recruited 15 adults with IGD, 15 remitted subjects, and 15 healthy controls. Internet gaming disorder was diagnosed according to the modified diagnostic criteria of IA (DCIA) observed in psychiatric interviews (Ko et al. 2009b). All subjects recruited for the study had been diagnosed with addiction to the same online game for at least one year. All subjects in the remission group had a history of addiction to the same online game, and all had been in remission from IGA for at least six months, according to DCIA criteria. In this event-related study of the cue-induced craving paradigm, subjects viewed screenshots of online gaming activity while undergoing fMRI scans. The significance threshold in the between-group analyses was $p < 0.001$, and the cluster size was >10 voxels. Compared to the control group, the IGD group showed higher activations in the bilateral DLPFC, precuneus, left posterior cingulate, parahippocampus and right anterior cingulate in response to gaming cues. The authors hypothesized that these brain areas are associated with the gaming craving activated by cue exposure. The authors suggested that the activation pattern was consistent with the model of substance use disorder developed earlier by Volkow et al. (2010). Lastly, compared with the remission group, the IGA group had higher activation over the right DLPFC (BA46), left parahippocampus (BA19), and left middle temporal gyrus (BA 39). Therefore, the authors suggested that the DLPFC and parahippocampus are potential markers of cue-induced brain activation in subjects currently in a state of addiction to online gaming.

Han et al. (2010) recruited 11 adults diagnosed with IGD and 8 healthy controls. The IGD diagnoses were based on a self-report questionnaire combined with a score of at least 50 on the internet addiction test (IAT) (Widyanto and McMurran 2004; Young 1998). In this block design study, all subjects viewed online gaming cues while undergoing fMRI scans. The significance threshold for a correction in the False Discovery Rate for 100 adjacent voxels was set to $p < 0.05$.

The results showed that, compared to controls, subjects with IGD had higher brain activation in response to gaming cues over the left occipital lobe, DLPFC, and parahippocampus. However, after six weeks of treatment with bupropion extended-release tablets (SR), the subjects showed significant decreases in β values over the DLPFC ($p = 0.04$) and in craving scores ($p = 0.04$). Therefore, the authors suggested that the effects of bupropion SR on the brain activity of craving for online gaming among subject with IGD.

Lorenz et al. (2013) recruited eight adult males with IGD and nine healthy controls. The recruitment criteria for the experimental group of males with IGD were at least three of the following six criteria for IGA within the last 12 months: craving, impaired control of playing, withdrawal, development of tolerance, progressive neglect of other pleasure, and playing despite harmful consequences. The healthy controls were casual computer game players who were familiar with WoW, World of Warcraft, the online role player game. All subjects underwent fMRI scans while viewing screenshots of WoW in short presentation and long presentation trials of the dot probe task. The dot probe task is designed to assess attention bias. Participants are instructed to indicate the location of this dot as quickly as possible.

In the dot probe paradigm, subjects with IGD show an attentional bias toward stimuli with a positive valence. Analyses of the fMRI data revealed that the experimental group had a different activation in short presentation trials (with the contrast computed as [(WoW > neutral) > (positive emotion picture > neutral)]) in areas known to be associated with craving in addiction (e.g., ventral visual path, right hippocampus, and right inferior frontal gyrus). However, this activation pattern was only observed when stimuli were presented for durations shorter than 2 s. The stimulus duration related modulation of connectivity strength from the right inferior gyrus to cue-reactivity related regions suggested the presence of an inhibiting effect during the long presentation trials.

The authors further hypothesized that subjects with IGD might reveal inhibition of motivation-related brain regions in long presentation trials but not in short presentation trials. An explorative post hoc psychological interaction analysis was used to test for altered functional connectivity between the right inferior frontal gyrus and other brain areas. The analysis revealed significant group differences in the presentation duration dependent modulation of coupling strength between the right inferior gyrus and areas related to cue-reactivity, which was consistent with the hypothesis of the authors of that study.

However, these results should be interpreted cautiously because of the small sample size. Furthermore, the complex contrast [(WoW > neutal) > (positive emotion picture > neutral)] made it difficult to explain the significant activation. That is, the significant difference in subtraction might result from, not only the higher response to the WoW pictures, but also the lower response to the positive emotion pictures.

Ko et al. (2013b) recruited an experimental group of 16 adults with concurrent IGD and nicotine dependence and 16 healthy controls. The recruitment criteria for the experimental group were psychiatric interview results indicating that the subject met both the diagnostic criteria for Internet addiction (Ko et al. 2009b) and the DSM-IV criteria for nicotine dependence (American Psychiatric Association 2000). Additionally, all subjects in the experimental group were currently addicted to the same game. In contrast, the healthy controls had no history of IGD or nicotine dependence. All subjects then underwent fMRI scans while viewing screenshots of computer games, photographs associated with cigarette smoking, and neutral stimuli. The selection of stimuli in this event-related design was based on the cue-induced reactivity paradigm. The analysis identified the brain correlates of gaming urge (game cue-reactivity of the comorbid group—that of the control group) and smoking craving (smoking cue reactivity of the comorbid group—that of the control group). Conjunction analysis is defined as "the joint refutation of multiple null hypotheses" (Friston et al. 2005). That is, it identifies a significant difference in the activation of a brain area during two different tasks. Conjunction analysis with conjunction null hypothesis (Nichols et al. 2005) was performed ($p < 0.05$ with small volume correction) to identify the brain correlates common to both gaming and smoking. The results demonstrated activations over the bilateral parahippocampal gyrus, precuneus, left DLPFC, and anterior cingulate were significantly higher in the IGD group than in controls. The literature suggests that the brain correlates of cue-induced gaming urge resemble those of cue-induced substance craving (Han et al. 2010; Ko et al. 2009a, 2013a). However, these conclusions are not based on a direct comparison between BOLD response to gaming urge and substance craving in addicts craving for the Internet or nicotine only. Furthermore, even if a study had used a similar design to compare the BOLD response to gaming use of IGD subjects and that to substance craving of a drug abuser, the comparison might have been biased by differences in subject characteristics between two disorders. The present study included a comorbid group to enable comparisons of brain activation between cue-induced gaming urge and cue-induced smoking craving in the same brain. The comparisons showed that, before subtracting the reaction of the control group, the gaming cue-activated a brain pattern similar to that activated by the smoking cue in the comorbid group. After subtracting the reaction of the control group, the comorbid group showed that cue-induced gaming urge and cue-induced smoking craving activated the parahippocampus and the anterior cingulate. A further conjunction analysis showed significant activation of the bilateral parahippocampal gyrus by both the gaming urge and smoking craving. Therefore, the parahippocampus may be associated with mechanisms of cue-induced brain activities common to both IGA and nicotine dependence.

Liu and his colleagues had recruited 39 male subjects with internet gaming disorder and 23 male matched healthy controls to complete a cue reactivity task under fMRI scanning. Subjects with IGD demonstrated higher brain activity over ventral and dorsal striatum (Liu et al. 2016). They also claimed the similarity in cue-induced craving response between IGD and substance use disorder.

Summary of Gaming Cue-Induced Reactivity

Despite the different designs in the aforementioned studies of gaming cue-induced reactivity, they all reported cue-induced reactivity over the parahippocampus, anterior cingulate, precuneus, striatum, and DLPFC (Han et al. 2010; Ko et al. 2009a, 2013a, b; Lorenz et al. 2013). These consistent results indicate that these areas participate in brain reactivity to the cue-induced gaming urge.

One of the most consisted results is the parahippocampus. The literature agrees that the parahippocampus has a role in cue-induced craving in substance use disorder (Skinner and Aubin 2010). The parahippocampus receives input from the nucleus accumbens and amygdala and evaluates the behavioral significance of sensory information (Salzmann et al. 1993). It also provides a contextual representation function and is an important afferent pathway to the hippocampus (Rudy 2009). Thus, it may contribute to the emotional response produced by cues such as screenshots of online gaming activity. Exposure to gaming cues causes the hippocampus to produce an emotional response based on contextual memory. By integrating contextual representations with their emotional significance, the parahippocampus contributes to the craving for an online gaming experience. It may explain why both the gaming urge and smoking craving cause a strong activation of the bilateral parahippocampal gyrus (Ko et al. 2013b). However, as a limitation on the number of subjects and the design of the study, other critical brain regions responsible for cue-induced craving were not repeatedly proved in these studies, such as nucleus accumbens or DLPFC. Thus, a well-designed study with adequate sample size under effective definition was necessary to prove the similarity in craving response between IGD and substance use disorder.

4.3.1.2 fMRI Studies Focus on Response Inhibition Task

Ding and his colleagues had recruited 17 male adolescents with internet gaming disorder and 17 male matched healthy controls to complete Go/Nogo task under fMRI scanning. There is no difference in behavior performance. Subjects with IGD demonstrated higher activation during N-Go trials in the left superior medical frontal gyrus, right anterior cingulate cortex, right frontal gyrus, left inferior parietal lobule, left precentral gyrus, and left precuneus and cuneus based on AlphaSim correction. This result suggested that the prefrontal cortex may be involved in the circuit correlated with impulsivity, during its impaired among adolescents with IGA.

Ko and his colleagues had recruited 26 male adults with internet gaming disorder for more than two years and 23 male matched healthy controls to complete event-related designed Go/Nogo task under fMRI scanning (Ko et al. 2014). There is no difference in behavior performance. Subjects with IGD demonstrated higher activation when processing response inhibition over the left orbital frontal lobe and bilateral caudate nucleus than controls in small-volume FWE correction. Further, the activation for error processing over the right insula was lower in the subjects with IGD than the control group. This result suggested that adults with IGD have impaired insular function in error processing and greater activation of the frontostriatal network to maintain their response inhibition performance.

Dong et al. (2012a, b) recruited 12 adults with IGD and 12 healthy controls. Subjects were classified into an internet addiction disorder (IAD) group if they had a score of 80 or higher on the self-report questionnaire developed by Young (1998) (and psychometrically tested by Widyanto and McMurran 2004). Subjects with IA also met the criteria of the Chinese Internet addiction test (Wang et al. 2009). All participants were asked to perform a color-word Stroop task while undergoing an fMRI scan. The IAD and control groups showed no performance difference. The difference in BOLD signal during the Stroop effect between IAD and control groups was calculated as ((IAD incongruent-IAD congruent)-(control incongruent-control congruent)) with a false discovery rate set at a threshold of $p < 0.05$. The IAD group revealed higher activity over the anterior and posterior cingulate compared to the control group. The authors suggest that adults with IAD have impaired inhibitory control and diminished efficiency of cognitive control.

Zhang and his colleagues had recruited 19 male subjects with internet gaming disorder and 21 male-matched-healthy controls to complete an addiction Stroop task under fMRI scanning. Subjects with IGD demonstrated higher cue-induced activity over inferior parietal lobule, the middle occipital gyrus and the dorsolateral prefrontal cortex (Zhang et al. 2016a). The authors claimed that subjects with IGD had impaired visual and cognitive control ability while dealing with gaming-related words. However, in the analysis, the author calculated the response for the word stimulating (IGD related words – neutral words), but not the Stroop effect. It might limit the generalization of the result to indicate the cognitive control function.

All of these studies mentioned above claimed a deficit in cognitive control and demonstrated higher brain activation over inferior frontal lobe and anterior cingulate. However, all these studies could not demonstrate the deficit in behavior performance in cognitive tasks. The cognitive control is the essential ability to success in gaming. The ability could be well trained and prerequired to get the winning feeling in the game to have a positive reinforcement effect. Thus, whether they have a deficit in cognitive control should be provided in a future study. On the other side, other function involving response inhibition, such as error processing, could be another factor contributed to their daily life functional impairment and deserved further studied.

4.3.1.3 Other Tasks fMRI Study for Rewarding Sensitivity and Risk Taking

Dong et al. (2011) recruited 12 males with IGD and 12 healthy controls. Subjects were enrolled in the IGD group based on a score of 80 or higher on the self-report questionnaire developed by Young to test for internet addiction (Widyanto and McMurran 2004). All subjects in the IGD group also met the criteria of the Chinese internet addiction test (Wang et al. 2009). They were required to complete a reality-simulated guessing task. The subjects need to choose one of two cards in 245 guessing trials. Depending on the color of the chosen card the subjects either win (red playing cards) or lose (black playing cards) 10 Dollars. In the win condition, the IGD group revealed higher activation of the orbitofrontal cortex than controls. Under the loss condition, the IGD group revealed lower activation of the anterior cingulate than controls. The authors claimed that the IGD group had higher reward sensitivity but lower loss sensitivity.

Chun and his colleagues had recruited 19 male adolescents with internet gaming disorder and 19 male-matched-healthy controls to discriminate swear, negative, and neutral words under fMRI scanning (Chun et al. 2015). There is no difference in behavior response. Adolescents with IGD demonstrated lower activation in the right

OFC related to cognitive control and in the dorsal anterior cingulate cortex (dACC) related to social rejection during the swear word condition in FDR correction. This result suggested that the alterations in emotional processing among adolescents with IGD.

Lin and his colleagues had recruited 19 male adolescents with internet gaming disorder and 21 male matched-healthy controls based on IAT. They completed probability discounting task under fMRI scanning (Lin et al. 2015a). Subjects with IGD prefer the probabilistic options to fixed ones and short reaction time. They had lower activation in the inferior frontal gyrus and the precentral gyrus in choosing the probabilistic options in the alphasim correction. The author claimed that subjects with IGD had impaired risk evaluation which might contribute to why they continue playing online games despite the risks of widely known negative consequence.

Wang and his colleagues had recruited 19 subjects with internet gaming disorder and 21 matched-healthy controls based on IAT and DSM5 IGD criteria. They completed probability discounting task under fMRI scanning (Wang et al. 2016a). Subjects with IGD preferred the risky to the fixed options and showed shorter reaction time. They had higher task-related activity in default mode network (DMN) and less engagement in the executive control network (ECN) when making the risky decisions. The authors claimed this result could be the reason for why subjects with IGD continue to play online games despite the potential negative consequences.

Qi and his colleagues had recruited 23 male adolescents with internet gaming disorder and 24 male matched-healthy controls based on Yang Diagnostic Questionnaire and IAT. They completed balloon analog risk task under fMRI scanning (Qi et al. 2015). Subjects with IGD had complete more pump in the task. There are no significant differences in other indicators of the task. Subjects with IGD demonstrated lower modulation of the risk level of the activation of the right dorsolateral prefrontal cortex (DLPFC) during the active BART under alphasim correction. The author claimed a critical decision-making-related brain region is less sensitive to risk among subjects with IGD.

Dong and his colleagues had recruited 20 subjects with internet gaming disorder and 16 male-matched healthy controls based on IAT. They complete risk decision task under fMRI scanning (Dong and Potenza 2016). Subjects with IGD selected more risk-disadvantageous trials and demonstrated less activation of the anterior cingulate, posterior cingulate and middle temporal gyrus when they are undergoing risk taking. They had shorter response times and activated lower over the inferior frontal and superior temporal gyri when decision-making. The authors claimed that deficit in executive control in selecting risk-disadvantageous choices among subjects with IGD.

Wang and his colleagues had recruited 18 subjects with internet gaming disorder and 21 matched healthy controls based on IAT. They completed a delay discounting task under fMRI scanning (Wang et al. 2016b). They demonstrated the executive control network and the basal ganglia network were associated with IGD.

Subjects with IGD had stronger FC when selecting small and now options. Further, the delay discounting rates were positively correlated with the modulation of the two networks. They claimed that the IGD patients had enhanced reward sensitivity and impaired ability to control the impulsivity.

Summary of Task fMRI Studies

Most study all claimed a deficit on risky evaluation or executive control in risky decision-making task. However, subjects with IGD had an adequate behavior performance. For example, they all had an adequate result with short reaction time. How could conclude their impairment? Further, there are many studies with the similar design or designed by the same team. These studies could reasonably recruit some repeated subjects. However, the brain regions corresponding for the deficit on risk decision were different in these studies. In fact, the effect of IGD on cognitive function is controversial. Since most illegal substances are known to have damaging effects on the brain, a reasonable assumption is that they impair cognitive function. However, most online games exercise many specific cognitive functions (Granic et al. 2014). Further, since perfect performance in online gaming requires good cognitive function and decision-making, particularly under risk, the hypothesis that online gaming produces a deficit in cognitive function or risk decision is questionable. Further studies to compare the cognitive functions and behavioral characteristics of decision-making among subjects with IGD and causal gamer are needed to clarify the role of cognitive functions in the process of addiction to online gaming.

4.3.2 Resting fMRI Study

A growing body of evidence shows that several neural circuits exhibit spontaneous activity at rest. These slow-frequency fluctuations are temporally correlated within spatially distinct but functionally related networks. Studies consistently show that, in healthy subjects, numerous networks in this resting-state functional connectivity represent specific patterns of synchronous activity (Rosazza and Minati 2011). Evaluation of resting-state functional connectivity provides an opportunity to characterize distributed circuit abnormalities in neuropsychiatric illnesses. For example, seed analyses of the amygdala, insula, and nucleus accumbens have revealed reduced functional connectivity in subjects with opioid dependence (Upadhyay et al. 2010). Representing the specific neurobiological network underlying reward, affective and cognitive processes regarding functional connectivity may reveal possible mechanisms of addictive disorder (Sutherland et al. 2012).

4.3.2.1 Regional Homogeneity of IGD

Dong et al. (2012a, b) recruited 15 males diagnosed with IGD according to the Young Internet addiction scale (Widyanto and McMurran 2004) and 14 healthy comparison subjects. The cut-off point in this study was 80. Regional homogeneity (ReHo) was evaluated in a resting-state during an 8-min fMRI scan. The significance threshold was set to $p < 0.05$ FDR correction. Comparisons with controls showed that the IGD subjects had higher ReHo in the brain stem, inferior parietal lobe, left posterior cerebellum, and left middle frontal gyrus. However, the IGD subjects had lower ReHo in the temporal, occipital, and parietal brain regions.

Liu recruited 19 college students with Internet addiction and 19 controls (Liu et al. 2010). The diagnoses of IA were based on a version of the Young diagnostic questionnaire modified by Beard and Wolf (2001) (Beard and Wolf 2001). Regional homogeneity was evaluated by 9-min fMRI scans with the subjects in a resting-state. Subjects with IA increased ReHo over the cerebellum, brainstem, right cingulate gyrus, bilateral parahippocampus, right frontal lobe, left superior frontal gyrus, left precuneus, right inferior temporal gyrus, left superior temporal gyrus and middle temporal gyrus.

Kim and his colleagues had recruited 16 subjects with internet gaming disorder and 14 subjects with alcohol use disorder and 15 healthy controls to complete a resting-state fMRI scanning (Kim et al. 2015). The result demonstrated increased ReHo in the posterior cingulate cortex (PCC) and decreased ReHo in the right superior temporal gyrus (STG) among subjects with IGD. The authors had suggested higher ReHo in the PCC may be a common neurobiological feature of IGD and AUD and that lower ReHo in the STG may be a candidate neurobiological marker for IGD.

Lin and his colleagues had recruited 35 subjects with internet gaming disorder and 36 matched healthy controls to complete Whole-brain voxel-based analysis (Lin et al. 2015b). Comparing to healthy subjects those with IGD demonstrated lower fALFF values in the cerebellum, posterior lobe, and higher fALFF values in superior temporal gyrus. The author had suggested these altered brain regions had been suggested to associated with the executive function and decision-making.

Although these three studies run the same way with the same analyzing way, except fALFF, they did not report the similar data. The heterogeneity of IGD and the limited in sample size might contribute to the difference in results. Further, as the physiological, psychological, or cognitive implication of regional homogeneity and fALFF had not been concluded now, it is difficult to have a clear clinical implication based on these results.

4.3.2.2 Functional Connectivity Study: The Most Published fMRI Studies of IGD in Recent Three Years

Hong et al. (2013) recruited 12 adolescents diagnosed with IA based on the Young Internet Addiction Scale (Widyanto and McMurran 2004) and 11 healthy control subjects. Functional connectivity was evaluated by fMRI scans performed for 6 min 45 secs with the subjects in a resting state. Compared to the control group, the IA group showed lower functional connectivity spanning a distributed network. Most of the impaired connections involved the subcortical brain region. No between-group differences were noted in the average clustering coefficient, the characteristic path length, or the small-worldness ratio, an indicator of the extent to which the synchronization networks of cortical neurons exhibit the small-world topology. This result suggested that, in this group, IA was associated with a large and widespread decrease in functional connectivity in the cortico-striatal circuit.

Ding recruited 17 adolescents with IGD and 24 controls (Ding et al. 2013). The diagnoses of IGD were based on a modified version of the self-report Young diagnostic questionnaire developed by Beard and Wolf (2001). Default network resting-state functional connectivity was evaluated by 4400-s fMRI scans with the subjects in a resting-state. The default network was evaluated by the functional connectivity to the posterior cingulate as defined by WFU-Pick Atlas (Maldjian et al. 2003). The significance threshold was set at $p < 0.05$ with AlphaSim correction. The subjects with IGD exhibited increased functional connectivity (FC) in the bilateral cerebellum, posterior lobe, and middle temporal gyrus but decreased FC in the bilateral inferior parietal lobe and right inferior temporal gyrus. The author suggested that the alterations were partially consistent with those in subjects with substance use disorder.

Dong and his colleagues had recruited 35 subjects with internet gaming disorder and 36 matched healthy controls to complete a resting-state fMRI scanning (Dong et al. 2015a, b). Subjects with IGD demonstrated decreased FC in the executive control network and increased FC in the reward network. This result suggested that impairments in executive control lead to inefficient inhibition of cravings to gaming among subjects with IGD.

The same team had recruited 35 subjects with internet gaming disorder and 36 matched healthy controls to complete a resting-state fMRI scanning and a Stroop task inside of fMRI (Dong et al. 2015a, b). This result functional connectivity measures in executive control networks were negatively correlated with Stroop effect and positively correlated with brain activations in executive control regions across groups. The within-group analysis demonstrated positive trends were found between functional connectivity in ECNs and brain activations in Stroop task. The authors suggested that higher functional connectivity in ECNs may underlie better executive control and may provide resilience on IGD.

Han and his colleagues had recruited 78 adolescents with internet gaming disorder and 73 matched healthy controls to complete a resting-state fMRI scanning (Han et al. 2015a, b). Subjects with IGD demonstrated an over connectivity of the default mode and executive control networks.

Han and his colleagues had recruited 15 subjects with internet gaming disorder and 16 patient with alcohol use disorder to complete a resting-state fMRI scanning (Han et al. 2015a, b). Both groups had a positive functional connectivity between the dorsolateral prefrontal cortex (DLPFC), cingulate, and cerebellum. Further, both groups have negative functional connectivity between the DLPFC and the orbitofrontal cortex. These indicate both groups may share a problem with executive function. However, as no control group, we could not know whether this connectivity existed among healthy subjects.

Hong and his colleagues had recruited 12 adolescents with internet gaming disorder and 11 males matched controls to complete a resting-state fMRI scanning (Hong et al. 2015). Adolescents with Internet gaming disorder had lower connectivity between dorsal putamen and the posterior insula-parietal operculum. On the other hand, controls had lower function connectivity between the dorsal putamen and bilateral sensorimotor cortices. Although the author had claimed the result is indicating a biomarker of IGD, the same result was not reproduced by any other study.

Park and his colleagues had recruited 19 male adolescents with internet gaming disorder and 20 age-matched controls to complete a resting-state fMRI scanning (Park et al. 2015). A graph-theoretical approach was used to analyze functional magnetic resonance imaging data. Subjects with IGD had higher impulsiveness, and they had a higher global efficiency and lowered local efficiency in the functional network. The authors claim that their finding supported to the proposition that the brain of IGD could be in the state similar to pathological states in topological characteristics of functional networks in the brain.

Wang and his colleagues had recruited 17 male adolescents participants with internet gaming disorder and 24 healthy controls to complete a resting-state fMRI scanning (Wang et al. 2015). A voxel-mirrored homotopic connectivity (VMHC) was used to analyze functional magnetic resonance imaging data. Subjects with IGD had lower VMHC between the left and right superior frontal gyrus (orbital part), inferior frontal gyrus (orbital part), middle frontal gyrus and superior frontal gyrus in Alphasim correction. The authors claim the important role of altered interhemispheric rsFC in the bilateral prefrontal lobe in the brain mechanism in IGD.

Zhang and his colleagues had recruited 35 male adolescents participants with internet gaming disorder and 24 healthy controls to complete a resting-state fMRI scanning (Zhang et al. 2015). Subjects with IGD had lower functional connectivity between the VTA and right NAcc under AlphaSim correction. The authors claimed the possible neural functional similarities between individuals with IGD and individuals with substance addictions.

Ko and his colleagues had recruited 30 young adults with internet gaming disorder and 30 male matched controls to complete a resting-state fMRI scanning (Chen et al. 2016). Subjects with IGD had a lower FC with the left insula over the left dorsolateral prefrontal cortex (DLPFC) and orbital frontal lobe and a higher FC with the insula with the contralateral insula than controls in small-volume FEW correction. The authors claimed that the elevated interhemispheric insula FC may involve in the mechanism of IGD.

Zhang and his colleagues had recruited 19 young adults with internet gaming disorder and 19 male matched controls to complete a resting-state fMRI scanning (Zhang et al. 2016b). Subjects with IGD had a lower functional connectivity of left posterior insula over the bilateral supplementary motor area and middle cingulated cortex, FC of right posterior insula over right superior frontal gyrus, and decreased functional integration between insular subregions. The author claimed that the lower functional connectivity between the interoception and the motor/executive control regions could reflect reduced ability to inhibit online gaming among subjects with IGD.

Zhang and his colleagues had recruited 74 young adults with internet gaming disorder and 41 male matched controls to complete a resting-state fMRI scanning (Zhang et al. 2016b). Subjects with IGD had higher FC of anterior insula over anterior cingulate cortex (ACC), putamen, angular gyrus, and precuneus. They also had higher FC of the posterior insula over postcentral gyrus, precentral gyrus, supplemental motor area, and superior temporal gyrus (STG). The authors claimed the key role of the insula in the manifestation of the core symptoms of IGD.

4.3.2.3 Summary of Resting fMRI Studies

The studies for resting fMRI among subjects with IGD extensively increased in the last three years. It is easier to run resting fMRI than to run task fMRI. Further, there are many ways to analyze resting fMRI data, such as regional homogeneity, default model, ICA analysis, seed analysis, voxel-mirrored homotopic connectivity, graph-theoretical approach, and small-world analysis. For the seed analysis, the selection of seed could make the result different. A variety of analysis could demonstrate resting FC in a different way. These differences make a head-to-had comparison impossible. Moreover, it is also difficult to find the similar result among above extensive studies to have a conclusion. The inconsistent results of these studies may have resulted from different definitions of IA, different indicators of functional connectivity, and different ages and numbers of subjects. The last three studies had the similar analysis way for insula connectivity. Two studies demonstrated a decreased FC to the frontal lobe, but one study show increased FC of anterior insula. The difference in subregion of insula to be the seed of analysis might contribute to their differences. Lastly, the indicator for FC in resting fMRI had implicated to explain the mechanism of psychiatric disorder. However, the interpretation of this connectivity was varied. For example, both lower connectivity and over connectivity were suggested to indicate the impaired function. Many studies claim some connectivity represent the executive function. However, the analyzed data was recruited under resting without executive performance. Thus, an over interpretation for the FC result of IGD without clear evidence should be prevented. Further, resting fMRI studies with clear definitions, such as diagnostic interviewing, adequate numbers of subjects, and clear hypotheses are needed to obtain additional data regarding functional connectivity in IGD. Further, since online gaming might also train the brain, some subjects with IGD could hypothetically show improved functional connectivity. However, other impairments in functional connectivity might contribute to their lack of control over their internet use. Thus, detailed studies of specific networks are still needed.

4.3.3 The Structure Analysis of IGD

Sun and his colleagues had recruited 18 subjects with internet gaming disorder and 21 matched healthy controls to complete Whole-brain voxel-based analysis (Sun et al. 2014). Mean kurtosis metrics (MK), radial kurtosis (K perpendicular), and axial kurtosis had been calculated and compared with $P < 0.05$ in AlphaSim corrected. The IGA group demonstrated diffusional kurtosis parameters that were significantly less in GM of the right anterolateral cerebellum, right inferior and superior temporal gyri, right supplementary motor area, middle occipital gyrus, right precuneus, postcentral gyrus, right inferior frontal gyrus, left lateral lingual gyrus, left paracentral lobule, left anterior cingulate cortex, and median cingulate cortex. VBM showed that IGA subjects had higher GM volume in the right inferior and middle temporal gyri, and right parahippocampal gyrus, and lower GM volume in the left precentral gyrus. This result suggested that. The lower diffusional kurtosis parameters in IGA suggest multiple differences in brain microstructure, which may contribute to the underlying pathophysiology of IGA.

Ko and his colleagues had recruited 30 young adults with internet gaming disorder and 30 male matched controls to complete a resting-state fMRI scanning (Ko et al. 2015). The subjects with IGD had a lower GMD over the bilateral amygdala than the controls. Further, the subjects with IGD had lower FC with the left amygdala over the left dorsolateral prefrontal lobe (DLPFC) and with the right amygdala over the left DLPFC and orbital frontal lobe (OFL). They also had higher FC with the bilateral amygdala over the contralateral insula than the controls. The results of this study suggested that the amygdala plays a very influential role in the mechanism of IGD. Its detailed role should be further evaluated in future study and should be considered in the treatment of IGD.

Cai and his colleagues had recruited 27 adolescents with internet gaming disorder and 30 age, gender, and education matched healthy controls to complete FreeSurfer to measure subcortical volume (Cai et al. 2016). They also complete the Stroop task outside of fMRI scanning. Subjects with IGD committed more incongruent errors during the task and demonstrated higher volumes of dorsal striatum and ventral striatum. The author claimed that the striatum might be implicated in the underlying pathology of IGD.

Lin and his colleagues had recruited 26 subjects with internet gaming disorder and 26 matched healthy controls based on a self-reported questionnaire. They were arranged to complete resting fMRI scanning to evaluated their gray matter density by using voxel-based morphometric analysis. (Lin et al. 2015c). Subjects with IGD had lower gray matter density over bilateral inferior frontal gyrus, left cingulate gyrus, insula, right precuneus, and right hippocampus. They also had lower white matter density in the inferior frontal gyrus, insula, amygdala, and anterior cingulate. The author had suggested that the altered brain regions involved in decision-making, behavior inhibition, and emotional regulation.

In conclusion, all study demonstrated a decreased gray matter density among subjects with IGD. However, all the results were not reproduced in any another study. Although the way to analyze the brain structure data was more consisted, the difference in sample recruiting, the stage of disorder (newly onset or chronic), and comorbidity could contribute to these difference in result.

4.3.4 Arterial Spin-Labeled Perfusion Magnetic Resonance Imaging

Perfusion provides oxygen and nutrients to tissues and is closely tied to brain function, which is an essential indicator of psychiatric disorder. Arterial spin label (ASL) perfusion MRI offers absolute quantification of cerebral blood flow (CBF). In ASL technique, arterial blood water is magnetically labeled using radiofrequency irradiation. The magnetically labeled arterial water decays with T1 relaxation. Since ASL MRI provides absolute quantification of CBF, which is coupled to regional neural activity, it can also be used to measure resting brain function independently of any specific sensorimotor of a cognitive task (Detre et al. 2009).

Feng et al. (2013) recruited 15 adolescents with IGD and 18 controls (Feng et al. 2013). The diagnoses of IGD were based on self-reported results on the Young diagnostic questionnaire, as modified by Beard and Wolf (2001) (Beard and Wolf 2001). The subjects were arranged to undergo scanning with a 3T MRI scanner. Pseudocontinuous ASL perfusion images were collected by 3D fast spin echo acquisition with background suppression, 1500 ms labeling, and a postlabeling delay of 1500 ms. Multiple comparison corrections were performed with AlphaSim program at a combined threshold of $p < 0.05$ and a minimum cluster size of 54 voxels.

Compared with the control group, the IGD group showed higher CBF in the left inferior temporal lobe, left parahippocampal gyrus/amygdala, right medial frontal lobe/anterior cingulate, bilateral insula, right middle temporal gyrus, right precentral gyrus, left supplementary motor area, left cingulate, and right inferior parietal lobe. The CBF was decreased in the left middle temporal gyrus, left middle occipital gyrus, and right cingulate gyrus. The authors suggest that IGD is a behavioral addiction that may share similar neurobiological abnormalities with other addictive disorders.

4.4 Limitations and Controversial Issues in Previous fMRI Studies of IGD or IA

The major problem in fMRI studies of IGD is the extreme heterogeneity of the subjects resulting from their widely varied online gaming activities, variety in age, difference in disease stage, and the varied chronicity. If the aim of the study is identifying potential predictors of IA, a highly homogeneous group is needed.

However, that sample selection is limited by the constraints of minimizing confounds, e.g., that all participants with IGD need to be addicted to the same game in a study. This might explain why all studies had a limited sample size. Further, if the aim of the study is to discuss sequelae of IGD, a specific group with similar addiction experiences should be selected, which might explain why most research targets subjects with IGD for brain imaging studies. However, the wide variability in Internet games may result in different consequences. Further, most subjects with IGD had an above average performance in online gaming, which requires the presence of cognitive functions such as decision-making, attention, concentration, and response inhibition, even though their daily life function in the real world was impaired. Since most cognitive skills used in games are similar to those used in cognitive tasks of researches, a diagnosis of impaired brain function in a cognitive task should be made cautiously until the deficit is further evaluated or confirmed by a behavioral assessment. Thus, a rational hypothesis based on clinical experience and on the literature is essential before performing a brain imaging study.

Compared to other event-related studies (Murphy and Garavan 2004), the sample sizes used in fMRI studies of IGD have been small. Recruiting greater numbers of subjects would provide more robust results and would help prevent type II error. Furthermore, most studies have focused on male subjects despite reports of gender differences in factors associated with IA (Ko et al. 2007, 2008; Yeh et al. 2008). Although evaluations of brain reactions specific to males or to females are clearly needed, most studies have focused on males because males have a higher risk of IGD. Further studies are needed to study hypothesized mechanisms specific to females.

Finally, previous studies have not applied consistent definitions of IGD and IA. Since the DSM-5 has proposed diagnostic criteria for IGD, future works should consistently define IGD or IA according to DSM-5 criteria.

4.5 Future Studies of Internet Gaming Disorder

The findings of this literature review show that further fMRI studies are needed to investigate the following issues:

1. According to a previous review of event-related studies (Murphy and Garavan 2004), each group should have a minimum of 20 subjects.
2. Since the number of subjects is usually limited, psychiatric interviews are needed to identify IGD based on DSM-5 criteria (American Psychiatric Association 2013).
3. Before beginning a study, a rational hypothesis must be made based on clinical experience or on previous epidemiological, neurocognitive, molecular, or neurobiological studies.
4. Future studies should consider mechanisms specific to females.

5. An integrated team including a clinical psychiatrist, a psychologist, an expert in fMRI physiology, a brain imaging technician, and an expert in imaging data analysis would improve the design and implementation of an fMRI study.
6. Advanced design in task and advanced analyses such as psychological interaction analysis or dynamic caudal model could be used to explore and/or validate hypothesized mechanisms of IGD. However, such studies should only be put in place after a reasonable hypothesis is developed by an integrated team.
7. A hypothesis testing design that integrates psychopathology, prospective behavioral presentations, neurocognitive performance, neurophysiology, and brain imaging studies would help to achieve a comprehensive understanding of IGD.

4.6 Conclusion

Studies of gaming cue-induced reactivity have shown that the parahippocampus have similar roles in the gaming urge response. Most task studies suggest impairment in inhibitory control and decision-making. However, the mechanism had not been concluded now as the correlated brain region is different in the previous study. Thus, any conclusion regarding the mechanisms of IGD would be premature due to the many limitations of previous studies. Future work should apply the diagnostic criteria used in the DSM-5 when recruiting subjects with IGD. Further fMRI studies with adequate sample sizes of at least 20 participants, reasonable hypotheses, effective designs, and precise data analysis by integrated research teams, are needed for further elucidation of mechanisms of IGD.

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Chapter 5
Internet Addiction and PET

Hyun Soo Park and Sang Eun Kim

Abstract Pathological use of the Internet is a new and rapidly growing worldwide phenomenon; however, few studies have examined the neurobiological factors underlying this condition. Internet addiction has been considered a behavioral addiction that is accompanied by withdrawal symptoms and tolerance, characteristics that may result from abnormalities in neural substrates involved in impulse control and reward processing. Recent studies on Internet addiction have highlighted symptoms of cognitive and emotional dysfunction that are similar to other types of drug and/or behavioral addiction. In this chapter, we describe the results of neurobiological investigations of the underlying mechanisms of Internet addiction using positron emission tomography (PET). The altered cerebral glucose metabolism and the reduced striatal dopamine D2 receptor availability found in people exhibiting pathological use of the Internet are discussed in terms of the similarities of these characteristics to those observed in substance abusers.

5.1 Introduction

Everyone is using the Internet these days, it seems—all the time, and everywhere. Internet addiction is a new, rapidly growing and worrying addictive worldwide phenomenon (Young 2010). Extreme cases of Internet addiction have even been

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience,
Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_5

reported with very dire consequences (CNN 2010). More than one out of eight adults in the United States shows signs of being addicted to the Internet (Aboujaoude et al. 2006). A similar or higher rate has been reported in several countries in Asia (Yen et al. 2007) and Europe (Ferraro et al. 2007). Among these, South Korea may be one of the countries that suffer the most from this phenomenon. In 2011, the National Information Society Agency of Korea reported that 6.8% of Korean adults were classified as exhibiting a definitive Internet addiction, defined as using the Internet for an average of 2.7 h a day. It was noted that 41.3% of the Internet addicts' online time was spent playing interactive online games (Ko et al. 2012). For many researchers, Internet addiction has been considered seriously as a type of behavioral addiction that is accompanied by withdrawal symptoms, tolerance, and comorbid psychiatric symptoms (mood disorders, depression, etc.) that contribute to the pathological pattern of behavior. However, despite the increasing number of individuals suffering from Internet addiction, few studies have examined the neurobiological factors underlying this condition.

In this chapter, we introduce the results of PET studies on Internet addiction using radioligands designed to assess glucose metabolism [^{18}F-2-fluorodeoxyglucose (FDG)] and dopamine availability [^{11}C-raclopride (RAC)]. Specifically, we examined the differences in neural substrates and dopaminergic function between young individuals with Internet addiction and those with normal use. We hypothesized that the Internet addicts would show altered cerebral glucose metabolism in the prefrontal and striatal regions, which are areas of the brain implicated in impulse control and reward processing. In addition, we expected that the addicts would exhibit abnormal dopamine D2 receptor availability in the striatal brain regions, given that these receptor populations are known to modulate reinforcement in addiction.

5.2 PET Studies of Neurobiological Mechanisms of Addiction

PET is designed to map biological and physiological processes in living subjects following administration of positron-emitting radioisotopes. This nuclear imaging technique is based on the detection of photons released by annihilation of positrons emitted by radioisotopes. Positron-emitting radioisotopes are produced in a cyclotron by bombarding target material with accelerated protons. When such a radioisotope is injected into the body of a living subject, the radionuclides emit positrons that are annihilated with nearby electrons, resulting in the release of two photons. PET detects these events and translates this information to reveal the location and extent (radioactive concentration) of the annihilation. The resulting image data can be used to determine the distribution of radioligand in the body (Miyoshi et al. 2011). PET provides an opportunity to observe biological and physiological phenomena in vivo. The application of PET for neurobiological studies can be variously extended when a radioisotope, such as ^{18}F and ^{11}C, is labeled with molecules that exhibit agonism or antagonism for the various receptors or enzymes. In this sense, the radiolabeled molecules act like *tracers* for the target substrates and PET monitoring of the behavior of the tracer reveals the status of the target receptors (e.g., neurotransmitter availability) or metabolism (e.g., glucose consumption). Using this concept, for example, not only can we measure altered glucose metabolism related to an abnormal condition of tissue cells using a glucose analogue labeled with ^{18}F (^{18}F-FDG), but we can also assess pathological neurotransmitter availability underlying psychiatric disorders using one radiotracer for specific types of neurotransmission. Because these measurements are noninvasive, the technology allows researchers to track biochemical transformation in the living human and animal body without perturbing the system that is measured. For decades, functional neuroimaging using PET and radioligands has gained widespread acceptance as a tool of psychiatric research. Because ^{18}F-FDG PET images represent activation of regional brain function, researchers frequently use this technique to map differences between normal and abnormal regional brain function.

Abnormal cerebral activation linked with addiction is primarily found in the frontal cortex, especially in the pre- and/or orbitofrontal cortex, with both hypo- and hyper-metabolism being reported. PET studies have shown that cocaine (Volkow et al. 1993) and methamphetamine (Volkow et al. 2001; Bolla et al. 2003) reduce the activity of the orbitofrontal cortex, an area which is implicated in executive functions, such as decision-making, planning, and judgment; notably, these functions contribute to the inhibition of impulsive behavior in normal subjects. Poor judgment has in fact been associated with lower activation of the orbitofrontal cortex in cocaine addicts (Bolla et al. 2003). Both cocaine and alcohol addicts showed increased relative activation of the orbitofrontal cortex which was associated with improved performance of a cognitive task; by comparison, normal control subjects showed worse performance with increased orbitofrontal activation, suggesting that a reversal of the role of the orbitofrontal cortex occurs as a function of addiction (Goldstein et al. 2001). Orbitofrontal activation was significantly and dose-dependently decreased and executive function was reduced in the group of methamphetamine abusers compared to control subjects (Kim et al. 2009). The relationship between orbitofrontal activation (hypo- and hyper-metabolism) and performance of cognitive task seem contradictory. Greater activation in the orbitofrontal cortex may therefore be indicative of task-independent mental hyperactivity and the greater effort required to implement inhibitory control. That is, Internet game addicts may be more likely to be engaged in random thoughts and to constantly place them in regulatory control mode for better everyday performance. Alternatively, it is possible that the association between higher activity in the orbitofrontal cortex and impulsivity is nonlinear; if this was the case, either high activation or low activation might result in abnormal impulse control.

Abnormal activation in the orbitofrontal cortex has also been observed in individuals with a behavioral addiction, such as pathological gambling. Hollander and colleagues demonstrated that relative glucose metabolic rates in the orbitofrontal cortex and medial frontal cortex were significantly increased at baseline in a group of pathological gamblers compared to normal controls (Hollander et al. 2008). We can hypothesize that such deficits in metabolism in the orbitofrontal cortex may result in the improper inhibitory control and compulsive behaviors which comprise the cognitive behavioral aspects of addiction.

PET has shown its greatest value in allowing psychiatric researchers to better understand the relationships between neurotransmitter systems and psychiatric diseases, including substance abuse disorder. Much of this work has focused on the dopamine system, contributing to the supposition that dopamine plays a key role in addiction (Volkow et al. 1993, 2002, 2009; Wang et al. 2001). A deteriorated reward processing function associated with reduced dopamine D2 receptor availability primarily in the striatum, a complex of the caudate nucleus and the putamen, has been reported repeatedly in addicted individuals (Volkow et al. 1990, 1993, 1996, 2001; Wang et al. 1997). This is also supported by evidence showing that A1+ carriers of the ANKK1/DRD2 Taq Ia polymorphisms are prone to get addicted to the Internet and other addictions such as to alcoholism (Munafo et al. 2007). Of note, the A1 allele is associated with a 30–40% reduced dopamine 2 receptor density in striatal regions (Noble 2000).

A group has conducted a set of PET studies using multiple tracers across studies to investigate the relationship between dopaminergic function and brain glucose metabolism in the prefrontal cortex. These studies demonstrated the presence of negative association between brain glucose metabolism in prefrontal cortical regions and changes in dopamine levels by methylphenidate, a dopamine transporter blocker, treatment in the striatum of control subjects. Thus, the higher the metabolism in the prefrontal region, the lower the methylphenidate-induced changes in striatal dopamine levels. In contrast, glucose metabolism in the prefrontal cortical regions was not correlated with striatal dopamine changes in alcoholics (Volkow et al. 2007). These findings suggest that in addicts the normal regulation of striatal dopamine activity by signals from the prefrontal cortex is disrupted; thus, the decreased striatal dopamine activity of addicts may reflect abnormal prefrontal regulation of the mesolimbic dopamine system (Thanos et al. 2008). Dopamine is believed to play the most significant role in mediating drugs' reinforcing effects by acting on the mesolimbic dopamine system. Furthermore, accumulating evidence has suggested that abnormalities in the dopaminergic system play an important role in various types of behavioral addiction that do not involve chemical substances (Holden 2001).

5.3 Altered Regional Glucose Metabolism in Internet Game Addicts

Recent research has suggested that Internet addiction may be based on psychological and cognitive mechanisms that are similar to those underlying pathological gambling (Johansson and Gotestam 2004; Goudriaan et al. 2005; Hollander et al. 2005; Aboujaoude et al. 2006). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM), pathological gambling is a type of impulse control disorder that involves the inability to resist the impulse to perform an action that is harmful to oneself or others. Internet addiction is similar to pathological gambling as it is does not directly involve intoxicant or psychoactive substances, but entails dysfunctions in impulse control (Shapira et al. 2000) and reward processing (Han et al. 2007; Ko et al. 2010). Thus, Internet addiction may result from abnormalities in neural substrates that are involved in impulse control and reward processing. Based on the previous results, investigators have established an opinion that Internet addiction should be included in DSM as an impulse control disorder or as a definitive disorder. Recently, Internet Gaming Disorder was mentioned in Section III as a condition warranting more clinical research and experience before it might be considered for inclusion in DSM as a formal disorder.

To investigate differences in cerebral activation (regional cerebral glucose metabolism) between individuals with pathological Internet game use and those with normal use, we performed a ^{18}F-FDG PET study. We hypothesized that the addicts would show altered metabolism in the orbitofrontal and striatal regions, which are implicated in impulse control and reward processing, respectively.

Severity of addictive Internet game use was assessed using a standardized questionnaire for Internet game addiction (IGS) (Oh et al. 2005) and impulsiveness was assessed using the Barratt Impulsiveness Scale Version 11 (BIS) (Patton et al. 1995). An interview regarding game use was also conducted. Among 464 respondents who received the questionnaire, 7.9% were identified as Internet addicts who habitually engage in game playing. The score of the IGS was a sum of level of game-dependent behavior, declined self-control, hypersensitivity, functional deficits, and absorption in Internet game use; naturally, scores were higher in the identified group of Internet addicts than in the normal user group. Participants in the addict group reportedly spent an average of 22.6 h per week on Internet games during the previous month and 63.6% had been playing Internet games >4 years. The longest continuous span during which the addicts had played a game without a break was 11.5 h on average. The most common type of game was a multi-player, online strategy simulation game (e.g., World of Warcraft III and Starcraft II, Blizzard Entertainment, Inc.). Consistent with previous studies investigating impulsive traits of addicts, results of the BIS score showed that the game addicts were more impulsive than normal users (Fig. 5.1a). Moreover, IGS scores were positively correlated with level of impulsiveness in the addicted group (Fig. 5.1b).

Significant differences in cerebral regional activation (resting-state glucose metabolism) between the Internet game addicts and the normal users were demonstrated using ^{18}F-FDG PET. Participants had not been engaged in any psychological and/or pharmacological intervention during the ^{18}F-FDG PET study. The Internet game addicts had significantly increased activation in the right middle orbitofrontal gyrus (BA 11), the left caudate nucleus, and the right insula (BA 13), compared to the normal users (Fig. 5.2). In addition, the Internet game addicts had significantly decreased activation in the bilateral postcentral gyrus (BA 2/3), the left precentral gyrus (BA 4), and the right superior parietal lobule (BA 7), as well as in the right superior occipital gyrus (BA 18) and the left inferior occipital gyrus (BA 19).

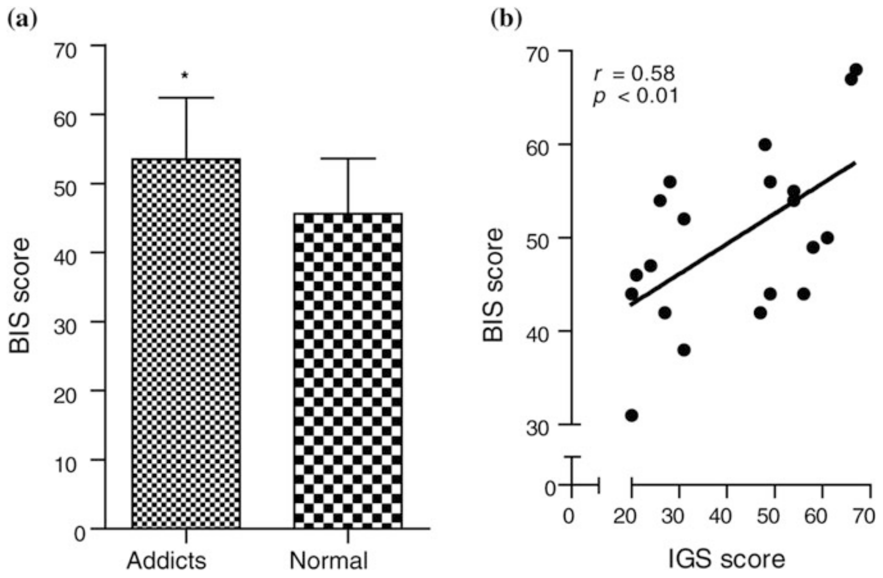

Fig. 5.1 **a** Comparison of BIS scores between the Internet game addicts and normal users, **b** relationship between the severity of Internet game addiction (IGS score) and the level of impulsiveness (BIS score), *BIS* Barratt impulsiveness scale, *IGS* Internet game addiction scale (Park et al. 2010). $*p < 0.05$

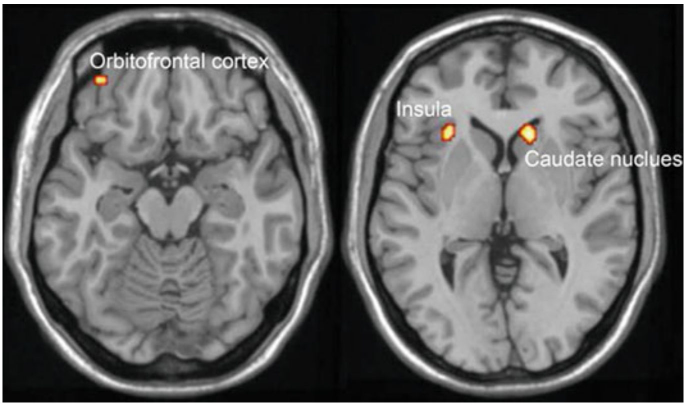

Fig. 5.2 A representative image of increased activation in Internet game addicts (Park et al. 2010)

We found that Internet game addicts had greater activation in the orbitofrontal cortex, striatum, and somatosensory regions, which are areas of the brain implicated in impulse control, reward processing, and somatic representation. The orbitofrontal cortex has been implicated in impulsivity and inhibitory control (Buckholtz et al. 2010). For example, individuals with borderline personality disorder, who suffer from high levels of impulsivity, have shown significantly reduced glucose metabolism in the medial orbitofrontal cortex (Soloff et al. 2003). In substance abusers, higher glucose metabolism in the orbitofrontal cortex has been associated with better performance on the Stroop task, a measure of the ability to inhibit impulses, or more specifically, a prepotent response tendency (Goldstein et al. 2001). Bolla et al. (2003) found that better performance on a computerized risk-taking task was associated with greater activation in the right orbitofrontal cortex during the task in both cocaine addicts and normal controls. These previous studies suggested that abnormal activity (either higher or lower activation) in the orbitofrontal cortex was associated with dysfunctional impulsive behavior and response control.

The striatum has been strongly implicated in addiction and reward processing (Robbins and Everitt 1999; Hyman and Malenka 2001; Volkow et al. 2002). In the present study, the Internet game addicts had increased activity in the left caudate nucleus. These results are consistent with the findings of previously reported studies. For example, methamphetamine abusers had increased activity in brain regions including the ventral striatum and lateral orbitofrontal cortex (London et al. 2004). Moreover, various types of substance abusers and behavioral addicts showed decreased dopamine D2 receptor availability (Volkow et al. 2008; Pallanti et al. 2010). However, a functional magnetic resonance imaging (fMRI) study showed a reduction of ventral striatal and ventromedial prefrontal activation during a gambling task in pathological gamblers, which was correlated with gambling severity (Reuter et al. 2005). The striatal functional activity associated with substance and nonsubstance-related addiction is unclear. Because the striatum and orbitofrontal cortex receive extensive dopaminergic innervation (Volkow and Fowler 2000; Volkow et al. 2002; Hollander et al. 2005; Chang and Haning 2006), altered metabolic activities in these regions may be associated with altered dopaminergic neurotransmission in Internet game addicts, as suggested by a genetic study (Han et al. 2007).

The insula is known to play a crucial part in addiction because of its role in conscious urges to take drugs of abuse. Recently, an fMRI study revealed a cue-induced activation of the right insula in subjects with Internet game addiction (Ko et al. 2009). These results, together with our data, support the notion that the insula is involved in conscious urges to engage in addictive behaviors and the decision-making processes that precipitate relapse.

This study demonstrated that Internet game addiction may be associated with abnormal neurobiological mechanisms in the orbitofrontal cortex, striatum, and somatosensory regions, which are implicated in impulse control, reward processing, and somatic representation of previous experiences. Altered resting glucose metabolism in the ventromedial prefrontal cortex and striatum may be associated with abnormal dopaminergic neurotransmission in Internet game addiction similar to associations that have been observed in subjects with substance abuse and other types of behavioral addiction. Together with previous behavioral and cognitive findings on Internet game addiction, our imaging and behavioral results suggest that

Internet game addiction may be considered a type of impulse control disorder or nonsubstance-related addiction that shares psychological and neural mechanisms with substance-related addiction.

5.4 Reduced Striatal Dopamine D2 Receptor Availability in Internet Addicts

Abnormalities in the dopaminergic neural system have been widely reported in individuals with substance abuse disorders. For example, reductions in dopamine D2 receptors and in dopamine release have been consistently observed in individuals who are addicted to cocaine, marijuana, or alcohol in studies using PET and the radiolabeled dopamine D2 receptor antagonist ^{11}C-RAC (Volkow et al. 2009). Moreover, accumulating evidence has suggested that abnormalities in the dopaminergic system may also play an important role in various types of behavioral addictions that do not involve chemical substances (Holden 2001). For example, a recent ^{18}F-FDG PET study found that patients who exhibit pathological gambling have altered levels of glucose metabolism in the ventral parts of the striatum compared to normal controls (Pallanti et al. 2010). People with morbid overeating behavior were also found to have lower densities of dopamine receptors in the striatum (Wang et al. 2001; Volkow et al. 2008). Taken together, these findings suggest that behavioral addiction, like substance-related addiction, may be partly due to impaired dopaminergic neural systems (Reuter et al. 2005; Potenza 2006). Given the evidence that Internet addiction shares neurocognitive and emotional deficits with other types of addiction (Park et al. 2010), we hypothesized that people with Internet addiction would have reduced dopaminergic receptor availability in striatal brain regions. To test this hypothesis, we recruited adult men with or without Internet addiction. Although the Internet addiction is thought to be categorized into "generalized" and "specific" according to the domain (video gaming, shopping, social networking, and/or pornography) of problematic use of Internet (Davis 2001; Montag et al. 2015), we did not distinguish participant's type of Internet addiction in the present study. Internet addiction was assessed using Young's Internet Addiction Test (IAT) questionnaire (Young 1998). Dopamine D2 receptor availability was assessed with PET and the radioligand ^{11}C-RAC, which binds to dopamine D2 receptors without eliciting neurochemical response.

We found that Internet addicts have significantly reduced dopamine D2 receptor availability in the left dorsal caudate and putamen, and in the right dorsal caudate. A trend for reduced dopamine D2 receptor availability in the addict group was also seen in the right putamen (Fig. 5.3a). Moreover, the relationship between dopamine D2 receptor availability and Internet addiction score was significant in the left dorsal caudate and putamen (Fig. 5.3b).

These findings suggest that Internet addiction is associated with dysfunctions in the brain dopaminergic systems, consistent with previous reports of reduced

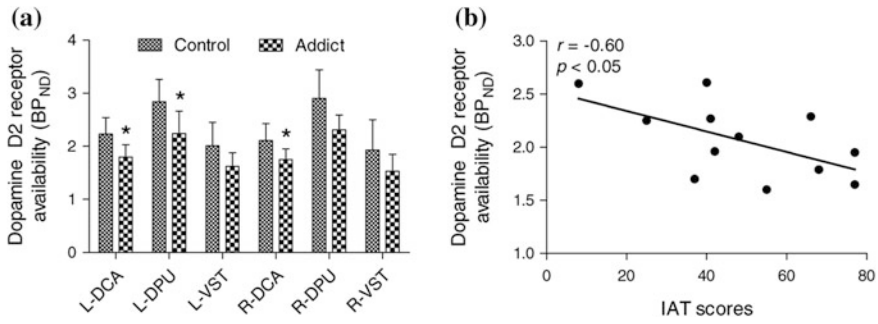

Fig. 5.3 **a** Comparison of dopamine D2 receptor availability in subdivisions of the striatum between Internet addicts and normal controls, and **b** the relationship between the severity of Internet addiction (IAT score) and dopamine D2 receptor availability in the left dorsal caudate *L* left; *R* right; *DCA* dorsal caudate; *DPU* dorsal putamen; *VST* ventral striatum; *IAT* Internet addiction test (Kim et al. 2011). $*p < 0.05$

dopamine D2 receptor availability in both substance-related and behavioral addiction (Volkow et al. 2008; Pallanti et al. 2010). The striatum is strongly implicated in addiction, reward processing, and reinforcement. In the present studies, addicts had increased glucose metabolism in the left caudate nucleus and bilaterally decreased dopamine D2 receptor availability in caudate nucleus and putamen. These results are consistent with the findings of previously reported studies. For example, methamphetamine abusers had increased glucose metabolism in brain regions including the ventral striatum and lateral orbitofrontal cortex (London et al. 2004). Moreover, numerous studies have reported that decreased striatal dopamine D2 receptor availability is associated with various addictive states (Volkow et al. 2008; Pallanti et al. 2010). Reduced dopamine receptor availability has been suggested to contribute to reward deficiency syndrome, characterized by the presence of an increased need for high levels of excitement and stimulation in people with genetically derived alterations in dopaminergic neurotransmission in the reward pathway (Comings and Blum 2000). People who suffer from this syndrome may seek drugs or alternatives to drugs such as gambling, in order to normalize their hypodopaminergic activity. Using Internet games and being engaged in online activities may also stimulate the reward pathway, consequently eliciting feelings of excitement and pleasure. In fact, experiencing pleasure was found to be the strongest predictor of Internet addiction (Chou and Hsiao 2000). Recent neuroimaging studies have also provided supporting evidence that Internet activities, such as online games, stimulated dopaminergic brain areas including the striatum and prefrontal regions (Ko et al. 2009; Han et al. 2010). In an fMRI study, people who were addicted to the popular online game "World of Warcraft" elicited greater activation in brain regions including the striatum, orbitofrontal, and dorsolateral prefrontal regions when viewing visual images from the game compared to non-addicted controls (Ko et al. 2009). More direct evidence suggesting increased dopamine release during Internet gaming can be drawn from a neurochemical imaging study in which research participants were asked to play a video game that involved navigating a tank for monetary reward. In this study, dopamine D2 receptor availability in the dorsal and ventral striatum were decreased in participants playing the video game compared with a control activity of viewing a black screen (Koepp et al. 1998). Therefore, currently available neuroimaging evidence suggests that the Internet may provide a rewarding experience and that Internet addiction is possibly associated with lower levels of dopaminergic activity in brain reward pathways, similar to other addictive disorders. Thus, our findings support the claim that Internet addiction may be characterized by neurobiological abnormalities similar to those of other addictive disorders (Potenza 2006; Park et al. 2010).

5.5 Conclusion

Our data demonstrate that Internet gaming addicts show abnormal resting-state glucose metabolism in the orbitofrontal cortex, striatum, and insular cortex, which are regions implicated in impulse control, reward processing, and modulating urges. In addition, Internet-addicted subjects exhibited bilaterally decreased dopamine D2 receptor availability in the dorsal striatum, an area of the brain implicated in the modulation of reinforcement in addiction. This finding is consistent with previous results and contributes to our understanding of the neurobiological mechanisms of Internet addiction. Our results suggest that Internet game addiction should be considered an impulse control disorder or nonsubstance related addiction that shares psychological and neural mechanisms with substance-related addictions.

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Chapter 6
Functional Brain Changes in Response to Treatment of Internet Gaming Disorder

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Abstract This chapter consists of three parts. First, we suggest the possible therapeutic mechanisms of dopaminergic and serotonergic medications for Internet gaming disorder (IGD) through an overview of the results of pharmacological trials. Second, we review the functional brain changes, especially in terms of cortico-striatal circuitry, in response to pharmacological treatments in individuals with IGD. Finally, we discuss the functional brain changes observed in response to non-pharmacological interventions, including family therapy and abstinence from online gaming. Although the studies discussed in this chapter suggest that a partial recovery of dysfunctional brain activity may be possible, the existence of a causal relationship between brain functional abnormalities and IGD is still open to debate. Functional neuroimaging studies with novel and efficient designs are needed for the development of more effective treatments for IGD as well as for increasing the understanding of the pathophysiology of IGD.

6.1 Introduction

In a meta-analysis of 16 studies with appropriate effect sizes, Winkler et al. (2013) concluded that psychological and pharmacological interventions were effective for improving clinical symptoms, time spent online, depressive mood, and anxiety in individuals with Internet gaming disorder (IGD) and Internet addiction (IA). Here, IA refers to the generalized form of Internet addiction, which is problematic Internet use, including a broad range of online activities, otherwise, IGD is a specific form of Internet addiction. Specific forms of Internet addiction refer to the problematic Internet use of distinct activities such as online video gaming, online sex, online

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_6

gambling, online shopping, or online social-networking. The importance of distinguishing between a generalized form—and specific forms—of Internet addiction has previously been proposed by Davis (2001) and has received empirical support from a cross-cultural study by Montag et al. (2015). Montag et al. (2015) compared generalized and specific Internet addiction and showed that the two were discrete constructs. Thus far, only a limited number of studies have examined the effectiveness of pharmacological treatments for IGD and IA, and even fewer studies have assessed the functional brain changes that occur in response to pharmacological or non-pharmacological interventions. The pharmacological trials have been designed to target impulsivity by regulating synaptic levels of dopamine or serotonin: escitalopram (Dell'Osso et al. 2008), methylphenidate (Han et al. 2009), and bupropion (Han et al. 2010a; Han and Renshaw 2012). As mentioned in the previous chapter regarding functional neuroimaging studies of IGD, biological theories of IGD have focused on possible alterations in cortico-striatal circuitry. Some studies have assessed functional brain changes in response to pharmacological (Han et al. 2010a) or non-pharmacological intervention (Han et al. 2012a; Kim et al. 2012) in individuals with IGD.

In this chapter, we will initially discuss the possible therapeutic mechanism of dopaminergic and serotonergic medications for IGD through an overview of the results of pharmacological trials. Then, we will discuss the functional brain changes, especially in terms of cortico-striatal circuitry, in response to pharmacological treatments in individuals with IGD. Later in this chapter, we will discuss the functional brain changes observed in response to non-pharmacological interventions, including family therapy (Han et al. 2012a) and abstinence from online gaming (Kim et al. 2012).

6.2 Dopamine and Serotonin in Internet Gaming Disorder

6.2.1 Dopamine in Internet Gaming Disorder

Pleasure can be triggered by dopamine release in response to external stimuli including alcohol, drugs, gambling, food, sex, and risk-taking behaviors (Comings and Blum 2000). Urge-driven behaviors in pathologic gamblers are thought to be mediated by dopamine neurons in the mesolimbic pathway (Bechara 2003). Alterations in dopamine release have also been associated with video game play (Koepp and Silver 1998; Schultz et al. 1993). Based on reports that video game play released dopamine in striatal areas (Bechara 2003; Koepp and Silver 1998; Schultz et al. 1993), online game play is thought to induce neuronal release of dopamine in striatal areas, resulting in reduced craving and negative emotions. As a trial for displacement of dopamine release induced by game playing, pharmacological interventions using bupropion (Han and Renshaw 2012) and methylphenidate (Han et al. 2009) were conducted and changes in the severity of clinical symptoms were assessed.

6.2.1.1 Pharmacological Intervention Using Bupropion (Han and Renshaw 2012)

Han et al. (2012b) conducted a 12-week, open-label bupropion trial for individuals with IGD comorbid with major depressive disorder. In this study, IGD was defined as excessive time for game play (more than 4 h per day or 30 h per week), scores greater than 50 on the Young Internet Addiction Scale (YIAS) (Young 1996), and maladaptive behaviors and distress resulting from uncontrollable online game play. Eleven participants who met inclusion criteria for IGD and eight healthy comparison participants who had experience of playing StarCraft for less than 3 days per week and 1 h per day were recruited. During a 12-week prospective trial, including 8 weeks of active treatment and 4 weeks of posttreatment followup, bupropion was shown to improve depressive mood as well as to reduce the severity of problematic online game play. During the active treatment period, mean YIAS scores were significantly reduced from 71.2 to 45.2 and mean Beck Depression Inventory (BDI) scores were also significantly decreased from 27.6 to 17.7. In addition, mean Clinical Global Impressions-Severity scale scores (CGI-S) (Guy 1976) improved significantly from 3.7 to 1.7 (lower scores indicating an improvement). During the 4-week posttreatment follow-up period, there were no significant changes in mean YIAS scores (from 45.2 to 42.4) while mean BDI scores were increased from 17.7 to 20.5. There was a small and statistically insignificant increase in mean CGI-S scores from 1.7 to 2.0.

Dysfunction in dopaminergic neurotransmission may be associated with dysregulation of reward-seeking behavior and subsequent substance use disorders or impulse control disorders (Bowirrat and Oscar-Berman 2005). Increased dopamine release within the brain reward system can reduce negative emotions due to withdrawal symptom and reduce craving for addictive substances or behaviors. Bupropion treatment is effective, through dual norepinephrine and dopamine reuptake inhibition (Cooper et al. 1980, 1994), in reducing craving and relapse rates in individuals with nicotine dependence (Durcan et al. 2002; Hays et al. 2009), cocaine dependence (Margolin et al. 1995), as well as pathologic gambling (Dannon et al. 2005). Han et al. (2012a, b) reported that the bupropion improved clinical symptoms in individuals with IGD and major depressive disorder. Increased extracellular concentrations of dopamine as a result of bupropion treatment may replace dopamine release originally induced by online game play in individuals with IGD. Subsequently, dopamine replacement results in reduced negative emotion and craving for gaming during abstinence.

6.2.1.2 Pharmacological Intervention Using Methylphenidate (Han et al. 2009)

Additional evidence for the effectiveness of dopamine replacement was provided by a study of methylphenidate treatment of children with attention deficit hyperactivity disorder (ADHD) who had been playing online video games (Han et al. 2009).

Sixty-two drug-naive children diagnosed with ADHD and excessive online video game play participated in this study. Eight weeks of methylphenidate treatment reduced the severity of attentional dysfunction, assessed using DuPaul's ADHD Rating Scale, Parent and Teacher Version (DuPaul 1991) from a mean of 43.0–32.6. In addition, mean YIAS scores were also significantly reduced from 54.0 to 41.2. Changes in YIAS scores during treatment were positively correlated with changes in DuPaul's ADHD Rating Scale scores.

Reduced dopaminergic neurotransmission in the cortico-striatal pathway, which may reflect prefrontal dysfunction in individuals with ADHD, has been consistently reported (Volkow et al. 2007). In addition, it has been suggested that individuals with ADHD use nicotine and alcohol as self-medication in order to induce dopaminergic activity (Levin et al. 1996; Mihailescu and Drucker-Colin 2000). The blockade of dopamine transporters (DAT) by methylphenidate activates dopaminergic neurotransmission and enhances task-specific signaling (Volkow et al. 2007). Additionally, oral methylphenidate activates dopaminergic neurotransmission, as proven by a decrease in dopamine D2 receptor availability in the striatum (Volkow et al. 2001). Prevalence of the TaqIA minor (A1) allele of the D2 dopamine receptor in individuals with IGD was investigated (Han et al. 2007). In this study, prevalence of A1+(A1A1 and A1A2 genotypes) allelic carriers was significantly higher in the IGD group, which was associated with higher reward dependency. A1+allelic carriers are known to have 30–40% fewer mesolimbic D2 receptors (Jonsson et al. 1999; Pohjalainen et al. 1998). Han et al. (2009) have suggested that children with ADHD might use online game play as a form of self-medication in order to improve attention and reduce distractibility by activating cortico-striatal circuitry and inducing dopaminergic neurotransmission.

6.2.2 Serotonin in Internet Gaming Disorder

IGD is characterized by pathological repetitive thoughts and behaviors, which are also observed in pathological gambling as well as in obsessive compulsive disorder. Pathological repetitive behaviors and ruminative thinking are associated with increased impulsivity (Petry 2001). Shapira et al. (2000) evaluated the psychiatric features of 20 individuals with IA and found that all of the participants met criteria for an impulse control disorder—not otherwise specified (ICD-NOS) according to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association 1994). Similarly, in a clinical setting, individuals with IGD and IA often receive the diagnosis of ICD-NOS because there is no specific diagnosis for these disorders in the DSM-IV, although IGD is identified in Sect. 6.3 of DSM-5 (American Psychiatric Association 2013) as a condition requiring more research in order to be included in Sect. 6.2 as one of the formal disorders. IGD and IA are highly comorbid with depression and social phobia (Ko et al. 2008; Yen et al. 2007). Serotonin is thought to play a major role in depressive mood and anxiety as well as in impulsivity (Lesch and Merschdorf

2000). Selective serotonin reuptake inhibitors (SSRIs) have been widely used to treat both obsessive compulsive disorder and major depressive disorder (Dell'Osso et al. 2005; Greist et al. 1995). In this context, SSRIs may have therapeutic potential for treating IGD and IA.

6.2.2.1 Pharmacological Intervention Using Escitalopram (Dell'Osso et al. 2008)

Dell'Osso et al. (2008) evaluated the effectiveness of escitalopram for the treatment of IA in a two-phase trial: Nineteen subjects were enrolled at a 10-week open-label phase. At the end of tenth week, individuals who completed first phase (17 patients) were randomly assigned to the escitalopram group or placebo group for 9 weeks. For this trial, the authors recruited participants with uncontrollable, distressing, and excessive Internet use, which caused social, relational, occupational, and financial problems. At the end of 10-weeks of open-label treatment with escitalopram, a significant decrease in mean time spent online, from 36.8 to 16.5 h per week, was noted. In addition, 64.7% of participants with IA showed positive therapeutic responses defined as a rating of "*much improved*" or "*very much improved*" on the Clinical Global Impressions-Improvement scale (CGI-I) (Guy 1976). At the end of a 9-week discontinuation phase, both groups taking escitalopram and placebo maintained the effects achieved during the open-label phase without any significant differences. The authors suggested that 9 weeks might be too short for further improvement to be shown in the escitalopram group or for the effect during the open-label phase to be disappeared in the placebo group. These favorable results suggest a role for serotonin dysregulation in IGD, as well as the utility of SSRIs as potential therapeutic agents for IGD in terms of improving impulsivity as well as depression. Further studies using neurobiological assessments are needed to determine the influence of SSRI treatment on functional brain changes associated with IGD.

6.3 Functional Brain Changes in Response to Pharmacological Interventions

As noted in a previous chapter, research on IGD has consistently utilized fMRI paradigms. It has been demonstrated that gaming cues activate the dorsolateral prefrontal cortex (DLPFC), parahippocampus, anterior cingulate, orbitofrontal cortex (OFC), nucleus accumbens, and dorsal striatum in individuals with IGD and IA (Han et al. 2010b, 2011; Ko et al. 2008; Lorenz et al. 2013; Sun et al. 2012). Participant craving for online games has been shown to positively correlate with activation of the brain reward system, including the prefrontal cortex, striatum and amygdala (Han et al. 2010b, 2011; Ko et al. 2008; Sun et al. 2012). The results from these studies may support the hypothesis that online game play induces dopamine release in the brain reward circuitry. In another study conducted by Montag et al. (2012), increased activation of DLPFC and temporal regions of the brain in gamers was demonstrated during an exposure to stills from the game in excessive first person-shooter-video-players. In this case, increased response of DLPFC could reflect the activation of action scripts associated with the game. With the assumption that online game play induces dopamine release in the brain reward circuitry and dopaminergic agents reduce negative emotions and craving for gaming through replacement of dopamine, Han et al. (2010a) have assessed changes in brain activity in response to bupropion treatment in IGD.

6.3.1 Functional Brain Changes in Response to Bupropion Treatment (Han et al. 2010a)

Han et al. (2010a) investigated whether bupropion sustained release (SR) treatment would change the intensity of craving for gaming and gaming cue-induced brain activity in individuals with IGD. The inclusion criteria for the IGD group were: spending a lot of time gaming (i.e., more than 4 h per day or 30 h per week), a score greater than 50 on the YIAS, and maladaptive behaviors and distress due to extensive online video game play. At baseline assessment, individuals with IGD demonstrated greater brain activity when exposed to visual gaming cues in the left occipital lobe cuneus, left DLPFC, and left parahippocampal gyrus, compared to healthy matched comparison subjects. After 6-weeks of bupropion SR treatment, the level of craving for online gaming, the amount of time spent gaming, and the activity of the DLPFC induced by gaming cues were reduced in individuals with IGD. Additionally, the gaming cue-induced activity within the DLPFC was shown to positively correlate with the level of craving for online gaming.

Bupropion SR may change the intensity of craving and brain activity in individuals with IGD in similar ways to those observed in individuals with substance or behavioral addiction (Dannon et al. 2005; Durcan et al. 2002; Hays et al. 2009; Margolin et al. 1995). Decreased gaming cue-induced activity in the DLPFC following a 6-week period of bupropion SR treatment could be explained by the mechanism of action of bupropion, i.e., blocking the reuptake of norepinephrine and dopamine. This mechanism of action of bupropion increases extracellular concentrations of these catecholamines in the frontal cortex, hypothalamus, and nucleus accumbens of rats (Li et al. 2002; Nomikos et al. 1992). In turn, this may result in the reduction of cue-induced surges of norepinephrine and dopamine release within the DLPFC (Dazzi et al. 2001a, b; Dazzi and VignoneV Seu 2002), an important region in cue-elicited craving (Crockford et al. 2005; Maas et al. 1998). Decreases in cue-induced surges of norepinephrine and dopamine release may attenuate the positive reinforcing properties of gaming, and consequently reduce craving for game playing. In this study, gaming cue-induced activity in the striatum was not significantly changed after 6-week bupropion SR treatment, although a high abundance of dopamine in this area (Ciliax et al. 1999). This could be explained by previous study results indicating that sustained administration of bupropion exerted its therapeutic influence by increasing synaptic availability of norepinephrine rather than dopamine (Dong and Blier 2001; El Mansari et al. 2008). The prefrontal cortex is an important area in which noradrenergic system exerts its effects by promoting cognitive abilities, including response inhibition, behavioral flexibility, and attention (Cole and Robbins 1992; Lapiz and Morilak 2006).

In the same context, bupropion treatment has been reported to reduce impulsivity and increase attention in children with ADHD, who are thought to have functional deficits in the DLPFC (Barrickman et al. 1995; Kuperman et al. 2001; Wilens et al. 2001). The therapeutic effects of bupropion in ADHD, i.e., reducing impulsivity and improving attention, may be consistent with those of methylphenidate treatment on Internet video game play in children with ADHD (Han et al. 2009), which we discussed earlier in this chapter, in terms of increasing dopaminergic neurotransmission within the cortico-striatal pathway.

Further mechanisms for bupropion's effectiveness in IGD may rely on its role as a norepinephrine reuptake inhibitor. Bupropion is known to be effective for alleviation of withdrawal symptoms in cocaine dependence, including fatigue, psychomotor retardation, and hypersomnia, by increasing noradrenergic activity (Ascher et al. 1995; Cooper et al. 1980, 1994). Additionally, bupropion is reported to improve negative affect during smoking cessation (Lerman et al. 2002). This mechanism may increase the effectiveness of bupropion treatment in IGD, in terms of alleviating negative affect during abstinence, through norepinephrine reuptake inhibitor inhibition, which results in reduced levels of craving for gaming.

6.4 Functional Brain Changes in Response to Non-pharmacological Interventions

A few studies have assessed functional brain changes in response to non-pharmacological interventions, although various types of intervention have been reported to be effective for improving the clinical symptoms of IGD and IA, including cognitive behavior therapy, family therapy, as well as parent and teacher education (Winkler et al. 2013). Based on previous results reporting an association between dysfunctional family structure and adolescent substance abuse (Fröjd et al. 2007; Roustit et al. 2007), and an association between dopaminergic reward circuitry and recognition of maternal and romantic love (Bartels and Zeki 2004; Fisher et al. 2005), Han et al. (2012a, b) conducted an fMRI study regarding the effect of family therapy on IGD. In another study, Kim et al. (2012) evaluated whether a short abstinence period from online game play would change brain activity induced by working memory tasks in IGD, based on previous studies reporting deficits in working memory in adolescents with substance dependence (Tapert et al. 2002, 2004).

6.4.1 Functional Brain Changes in Response to Family Therapy (Han et al. 2012a)

Han et al. (2012a) assessed the effects of a 3-week family therapy intervention on the severity of IGD as well as on the patterns of brain activity when exposed to visual cues depicting scenes of parental affection and cues depicting online game scenes in adolescents with IGD. For this study, 15 adolescents with IGD and their families who reported moderate to severe family dysfunction were recruited. Inclusion criteria for participants with IGD were excessive time spent gaming (more than 4 h per day or 30 h per week), scores greater than 50 on the YIAS, and maladaptive behaviors and distress due to uncontrollable online game play. Members from these 15 families were requested to complete homework assignments focused on cultivating family cohesion for more than 1 h day, 4 days a week, over a 3 week period. At baseline, adolescents with IGD showed decreased activity in the caudate, middle temporal gyrus, and occipital lobe in response to cues depicting scenes of parental affection and increased activity in the middle frontal and inferior parietal cortices in response to gaming cues, compared to healthy adolescents with relatively functional family structures. At followup assessment, adolescents with IGD reported improvement in the perceived level of family cohesion. The changes in the perceived level of family cohesion were positively correlated with an increase in the activity of the caudate nucleus in response to cues depicting scenes of parental affection, and were negatively associated with changes in time spent gaming. Conversely, activity within the DLPFC in response to gaming cues was reduced following 3-weeks of family therapy.

Craving for romantic and parental love and craving for gaming in individuals with IGD might, in part, share the same biological underpinnings. Brain reward pathways, including the ventral tegmental area and the caudate nucleus, are thought to mediate the response to stimuli depicting romantic and parental love (Bartels and Zeki 2004; Fisher et al. 2005). Aron et al. (2005) reported increased activity in the right caudate in response to images of lovers in the early stage of romantic passion. In addition, Vrticka et al. (2008) reported that secure adult attachment style was associated with an increased activation of striatum and the ventral tegmental area in response to stimuli regarding positive social relationships, such as a smiling face. The characteristics of love, such as particular attention to someone, increased drive, excited mood, as well as desire to have a close relationship with a partner, are associated with dopamine release in the brain reward system (Aron et al. 2005; Bartels and Zeki 2004). Additionally, it has been reported that college students with poor parental care during early life showed increased dopamine release in ventral striatum in response to stress-inducing tasks, compared to students who experienced good parental care (Pruessner et al. 2004). An excessive dopamine release in response to substances or stressful events is thought to contribute vulnerability to substance dependence (Marinelli and Piazza 2002; Piazza et al. 1998). In this context, Han et al. (2012a, b) suggested that adolescents with problematic IGD in dysfunctional families tended to have reduced salience for parent–child relationships. In addition, the authors suggested that adolescents with low levels of perceived family cohesion might play online games in order to compensate for striatal dopamine deficits related to poor parental care during early life. Increases in the perceived level of family cohesion and parental love during family therapy may facilitate dopamine release in brain reward circuits and, in turn, this may help reduce the level of craving for gaming.

6.4.2 Functional Brain Changes in Response to Abstinence from Online Game Play (Kim et al. 2012)

Kim et al. (2012) evaluated whether 4 weeks of abstinence from online game would change brain activity in response to simple and complex working memory tasks in adolescents with IGD. Adolescents who reported extensive time spent on gaming (more than 4 h per day or 30 h per week), scores greater than 50 on the YIAS, and distress due to excessive online game play, were recruited in this study. At baseline, adolescents with IGD demonstrated increased activity in response to working memory tasks within the right middle occipital gyrus, left cerebellar posterior lobe, left premotor cortex, and left middle temporal gyrus, relative to healthy comparison subjects. After 4-weeks of abstinence from online gaming, adolescents with IGD showed increased activity in the right DLPFC, and left occipital fusiform gyrus when exposed to working memory tasks. In addition, reductions in the severity of IGD were correlated with increases in functional changes in the right DLPFC in response to complex working memory tasks.

The DLPFC is known to play a central role for working memory, including selective attention, inhibition of perseverative errors, and impulse control (Kane and Engle 2002; Leiserson and Pihl 2007). The major involvement of the DLPFC in working memory performance and its activation when human subjects carry out working memory tasks have been well established by neuroimaging studies (Goldman-Rakic 1995). In addition, working memory deficits and correlated dysfunction in the DLPFC have been shown in various neuropathological conditions, including schizophrenia, Parkinson's disease, as well as age-related cognitive decline (Goldman-Rakic 1995). It has been reported that DLPFC activity in response to working memory tasks increases during short-term abstinence from cannabis dependence (Pope et al. 2001; Yurgelun-Todd et al. 1998). Kim et al. (2012) suggested that the dysfunction of working memory in individuals with IGD might be similar to that observed in individuals with substance dependence. Based on the result of those studies, excessive game play might impede the appropriate function of the DLPFC on working memory tasks. However, there has been a large strain of research that shows gaming can have positive effects of working memory. Several studies have reported that action video games seem to improve visuospatial working memory capacity, selective attention, and task-switching ability in healthy individuals (Bavelier et al. 2012; Green and Bavelier 2003; Green et al. 2012). In addition, as we discussed earlier, Han et al. (2009) suggested that children with ADHD might use online game for enhancing task-specific signaling by compensating for striatal dopamine deficits. It seems that the beneficial or harmful effects of gaming on working memory are determined by both the characteristics of a gamer, including casual use and problematic use, and the genre of a game. In addition, methodological limitations, such as cross-sectional comparisons of gamers and non-gamers, make it impossible to distinguish baseline differences in cognitive skills from the consequences of gaming. Further studies are needed to understand effects of gaming on working memory and related cognitive abilities.

6.5 Future Studies of Functional Brain Changes in Response to Treatment

Although the studies discussed in this chapter imply that a partial recovery of dysfunctional brain activity may be possible, the existence of a causal relationship between brain functional abnormalities and IGD is still open to debate. Distinguishing underlying vulnerability from the consequences of excessive Internet and online game use is important in order to better understand the pathophysiology of—and to develop improved treatment strategies for—IGD. As part of an effort to investigate a possible causal relationship between IGD and brain functional abnormalities, Han et al. (2012a) compared the regional brain volumes of individuals with IGD to those of professional gamers. Although professional gamers play online games extensively, they are able to regulate their game use and do not have functional impairment in their daily routine. In this study, professional gamers were characterized by increased gray matter volume in the left cingulate gyrus in comparison with individuals with IGD, as well with healthy comparison subjects. The gray matter volume of the left cingulate gyrus was negatively correlated with levels of impulsivity and perseverative errors in professional gamers. Larger gray matter volumes in the left anterior cingulate could be associated with superior attentional control and decision-making in professional gamers, which might predispose them to successful game play. Decreased gray matter volume and reduced baseline regional cerebral blood flow in the anterior cingulate were reported in individuals with substance dependence (Childress et al. 1999; Franklin et al. 2002). During an exposure to substance-related stimuli, substance users demonstrated increased cerebral blood flow in the anterior cingulate (Brody et al.

2007; Childress et al. 1999). The anterior cingulate cortex is known to play an important role in monitoring and resolving conflict. Individuals with substance addiction are prone to be confronted with the conflict between seeking immediate reward (e.g., taking the drug) and avoiding long-term negative consequences (Bush et al. 2000; Pochon et al. 2008).

Future studies comparing functional brain changes in individuals with IGD to those of professional gamers may also be helpful for distinguishing underlying vulnerability from the consequences of IGD in terms of neurobiology. Imaging genetics, which refer to combining molecular genetics with neuroimaging, would help to further disentangle the vulnerability to—and consequences—of gaming. This technique makes it possible to deduce how genetic variants impact certain brain areas, both structurally and functionally, from the obtained data (de Geus et al. 2008). A good example is a study by Montag et al. (2010), comprising an imaging genetics study in the field of addiction research. The interaction effect of functional variants on brain derived neurotrophic factor (BDNF) and dopamine receptor D2 (DRD2) genes on gray matter volume of the anterior cingulate was demonstrated. These efforts would also facilitate the development of effective therapies focused on reducing or eliminating vulnerability factors for IGD.

6.6 Conclusion

According to the results of fMRI studies conducted with pharmacological and non-pharmacological therapeutic interventions in individuals with IGD, increases in activity in the DLPFC and in dopaminergic neurotransmission within the cortico-striatal pathway while not playing seem to be significantly related to positive therapeutic outcomes. However, because of the limited number of studies to date, it would be premature to draw any firm conclusions regarding functional brain changes in response to treatment of IGD and IA. Further pharmacological trials with placebo-controlled, double blind designs using neurobiological assessments are needed in order to investigate the influence of medication on functional brain change in IGD and IA. Furthermore, non-pharmacological trials with functional neuroimaging methods using relevant stimulation paradigms would be helpful for evaluating the specific effects and strength of different treatment programs. Functional neuroimaging studies with novel and efficient designs are needed for the development of more effective treatments for IGD and IA as well as for increasing understanding of the pathophysiology of IGD and IA. For specific forms of Internet addiction other than IGD, such as problematic online sexual behavior, online shopping, and online gambling, therapeutic interventions for each disorder in real life (offline) could be considered first. For example, pharmacotherapy using serotonin reuptake inhibitors, opioid antagonists, and mood stabilizers, as well as cognitive behavior therapy, are known to be effective in the treatment of pathological gambling (Gooding and Tarrier 2009; Sood et al. 2003). Cognitive behavioral and hormonal therapies for the treatment of sexually compulsive behavior (Codispoti 2008) and group cognitive behavioral therapy for the treatment of compulsive buying (Müller et al. 2013), are also thought to be promising treatment strategies. The pharmacological and behavioral therapeutic interventions for these disorders in real life could be also effective for directly-related, specific Internet addictions.

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Chapter 7
Neuroscientific Approaches to (Online) Pornography Addiction

Rudolf Stark and Tim Klucken

Abstract The availability of pornographic material has substantially increased with the development of the Internet. As a result of this, men ask for treatment more often because their pornography consumption intensity is out of control; i.e., they are not able to stop or reduce their problematic behavior although they are faced with negative consequences. There is a long lasting debate whether these kinds of problems should be conceptualized as a behavior addiction. In the last two decades, several studies with neuroscientific approaches, especially functional magnetic resonance imaging (fMRI), were conducted to explore the neural correlates of watching pornography under experimental conditions and the neural correlates of excessive pornography use. Given previous results, excessive pornography consumption can be connected to already known neurobiological mechanisms underlying the development of substance-related addictions. In the introduction, phenomenological, epidemiological, and diagnostic aspects of a syndrome, which is here labeled pornography addiction, will be described knowing that the adequacy of this terminology has to be further validated. In the second section, after aetiological considerations, contemporary neurobiological models will be presented to offer reference points for the question whether excessive pornography consumption can result in an addiction. In the third section of the chapter, neurobiological findings concerning three topics will be summarized: Neural correlates of watching pornography, cue reactivity and appetitive conditioning, and finally neurobiological characteristics of men with pornography addiction. The present contribution will be rounded off with a short conclusion highlighting possible future research questions.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_7

7.1 Introduction

Pornography addiction describes a phenomenon by which people, especially men, are not able to control their excessive use of pornography although they are trying to stop or reduce their consumption due to pronounced negative consequences.

There is evidence that these clinically relevant problems have increased with the development of high-speed Internet access and smartphones. Already Cooper (1998) labeled the Internet as the triple A machine due to high accessibility, affordability, and anonymity. More than ten percent of the Internet traffic contains pornographic material (Buchuk 2013). A study by Meerkerk et al. (2006) suggests that watching pornography has the highest potential for addictive use among various Internet activities. Epidemiological studies estimate the prevalence of sexual addiction to range from 2 to 6% with a sex ratio of 4/1 men dominating (Kuzma and Black 2008; Ross et al. 2012; Odlaug et al. 2013). Thus, sexual addiction seems to be mainly a male problem and most of the studies on sexual addiction to date have been conducted with men.

Sexual addiction covers the addiction toward different online sexual behaviors (e.g., watching pornography, visiting sexual themed chat rooms) as well as offline sexual behaviors (e.g., excessive sexual dating, telephone sex). However, pornography addiction seems to be the most prominent form of sexual addiction (Reid et al. 2012).

Subjects with addictive consumption use of pornography often report to watch pornography on a daily basis for several hours. Usually, the use of pornography is accompanied by masturbation. There is an ongoing debate whether masturbation and/or orgasm is the actual drug (pornographic material would then merely be a cue) or whether sexual material is rewarding per se. Most likely, sexual material is both a reward and a cue. Due to the time spent on the use of pornography, other areas of life are neglected. Problems at work or in relationships—if existing—are the consequences. Facing these negative consequences, people affected try to reduce their behaviors but usually fail in their attempt to do so. The experience of loss of control is often a reason to search for treatment.

There is an ongoing scientific and sometimes political debate whether the symptomatology—excessive sexual behaviors, loss of control, negative consequences—should be conceptualized as addiction (Carnes et al. 1983), compulsion (Coleman 1991), impulse control disorder (Barth and Kinder 1987), or as hypersexuality (Kafka 2010). However, as shown in this article, there is growing evidence that the syndrome shares many similarities with other behavioral and substance-related addictions. This is why we prefer the label sexual addiction or in case of an excessive use of pornography the label of (online) pornography addiction.

Beside millions of sites of pornography, the Internet also offers chat rooms with sexual content, cybersex, and sexual dating platforms which can also promote the development of a sexual addiction. While for men the excessive use of pornography is the most relevant addictive problem with regard to Internet misuse (Reid et al. 2012), sexual addicted women mostly excessively use dating platforms despite massive negative consequences. Whether the related behaviors in women are indeed variants of sexual addiction or whether these behaviors can be diagnosed otherwise, for example as symptoms of a borderline personality disorder, must be clarified by further research.

There are several self-report questionnaires, which measure the extent of sexual addiction and pornography addiction, respectively. A prominent screening instrument is the *Sexual Addiction Screening Test—Revised* (SAST-R, Carnes 2010) which is freely available on the Internet. For the diagnosis of pornography addiction, one can also specifically ask for the presence of the criteria of hypersexuality as proposed by Kafka (2010). For clinical diagnosis, the *Hypersexual Behavior Inventory* by Reid et al. (2011a) is also available. Further helpful questionnaires for measuring the severity of the related problems are the *Sexual Compulsivity Scale* (SCS, Kalichman and Rompa 1995) and the short form of the *Internet Addiction Test*, modified for cybersex (s-IATsex; Laier et al. 2013). Different aspects related to pornography addiction are measured by the *Pornography Consumption Inventory* (PCI, Reid et al. 2011b), the *Sexual Sensation Seeking Scale* (SSSS, Kalichman and Rompa 1995), and the *Trait Sexual Motivation Questionnaire* (TSMQ, Stark et al. 2015).

Until now, neither the ICD 10 (World Health Organization 1992) nor the DSM 5 (American Psychiatric Association 2013) offers a specific diagnosis for pornography addiction. To date, the related symptoms are diagnosed in the ICD 10 as 'obsessive-compulsive disorder, unspecified' (F42.9), as 'excessive sexual drive' (F52.7), or as 'habit and impulse disorder, unspecified' (F63.9). Likewise, possible diagnoses in the DSM 5 are 'unspecified obsessive-compulsive and related disorder' (300.3), 'unspecified sexual dysfunction' (302.70), or 'unspecified disruptive, impulse-control, and conduct disorder' (312.9). Kafka (2010) proposed a definition of hypersexuality for the DSM 5 (American Psychiatric Association 2013), but the experts did not consent to the proposal due to a lack of research in this field. This all leads to a vicious circle because epidemiological data cannot be collected if a well-accepted definition of the syndrome is not available and therefore the research in this field is hindered.

7.2 Use of Pornography: What Are the Prerequisites for an Addiction Diagnosis?

Many people, especially men, get in contact with pornography in their adolescence, but only few of these develop an addictive consumption pattern. So the question arises what are the concomitants of the transition from sporadic to excessive, addictive use? Is this course comparable with the course of the development of a substance-related addiction?

According to a major Norwegian study by Traeen et al. (2006) 96% of men and 76% of women at the age of 18–49 years reported contact with pornography at least once. From a study with US college students, it is known that 87% of the young men and 31% of the young women have used pornography at college age (Carroll et al. 2008). Asking for the reasons of the use of pornography, several studies revealed the motives for consumption of pornography: Paul and Shim (2008) identified four factors in an Internet online questionnaire study of motives which they called *Relationship*, *Mood Management*, *Habitual Use*, and *Fantasy*. The factor *Mood Management* (exemplary item: 'to relieve stress') and the factor *Habitual Use* (exemplary item: 'because you couldn't stop yourself') can be linked to aspects of addiction (negative reinforcement, loss of control). Reid et al. (2011b) also identified four factors of motives in a sample of men who described themselves as sex addicted and who were looking for treatment. These factors were labeled *Emotional Avoidance*, *Sexual Curiosity*, *Excitement Seeking*, and *Sexual Pleasure*. Again, the factors can be associated with positive and negative reinforcement, which are important aspects of explanatory behavioral learning theories for the development of addiction: The use of pornography results in positive feelings like pleasure and lust, which lead to a positive reinforcement, and also to a cessation of negative feelings such as loneliness, boredom, or depressive feelings which lead to a negative reinforcement. It can be assumed that at the beginning of a habitual pornography use, the consumption is mainly driven by positive reinforcement, whereas later in the course it is driven by negative reinforcement. This is comparable to the course of substance-related addictions where the drug intake is first positively and later on negatively reinforced.

According to the DSM 5, the eleven criteria of a substance use disorder can be clustered in criteria regarding impaired control, social impairment, risky use, and finally tolerance and withdrawal as pharmacological indicators (American Psychiatric Association 2013). The severity of a substance use disorder is classified as mild, moderate, or severe depending on whether 2–3, 4–5, or more than 5 criteria are fulfilled. The term addiction is used synonymously to a severe substance use disorder with substantial loss of self-control indicated by compulsive drug taking despite the intention to stop taking the substance. Modern neurobiological theories of addiction understand an addiction as a brain disease (Volkow et al. 2016). The transition from a sporadic use of the drug to a sustained, intensified, and escalated use to a full addictive use of the drug is accompanied by neurophysiological changes in the brain (Piazza and Deroche-Gamonet 2013). If addiction is manifest, an addicted person passes through three recurring phases, which are called the addiction circle: binge and intoxication phase, withdrawal and negative affect phase, and anticipation and craving phase (Koob and Volkow 2010).

During the binge and intoxication phase, the dopamine release within the reward system, with the nucleus accumbens as a core structure, is central. The repeated exposure to a reward leads to a cue responsivity toward stimuli over time, which predicts the intake of the substance. Hereby, classical conditioning is the prominent associative learning mechanism (Schultz et al. 1997). The increasing craving can be explained by the incentive sensitization theory of Robinson and Berridge (1993). According to this theory, the development of an addiction is accompanied by a sensitization of the mesolimbic dopamine system: stimuli associated with reward become cues in the course of the development of addiction. These cues trigger enhanced dopamine release signaling incentive salience and induce 'wanting', which is clinically described as craving. It is assumed that these processes are the consequence of drug-induced changes on neural and molecular level especially in the reward system. This view is supported by animal studies which revealed that drugs induce neuroplasticity in many brain regions including the nucleus accumbens (reward), the dorsal striatum (encoding of habits), the amygdala (emotion), the hippocampus (memory), and the prefrontal cortex (regulation). For review see Kauer and Malenka (2007) and Kourrich et al. (2015). According to this neuroplasticity, the reward-related dopamine response decreases in the course of the development of an addiction resulting in tolerance.

Withdrawal symptoms and negative affect during the withdrawal phase are the consequences of the compensatory processes to maintain homeostasis, which are triggered by the continuous drug intake. These processes are also the reason why natural rewards (e.g., food, sex,…) are experienced less rewarding by addicted subjects than by healthy subjects. These negative aftereffects motivate an addicted subject to further drug taking because the administration of the drug efficiently stops the negative affect (negative reinforcement). The preoccupation and anticipation phase is characterized by thoughts centered on the procurement of the drug and craving. Drug-induced changes in the function of prefrontal regulatory circuits lead to impaired response inhibition and salience attribution (I-RISA, Goldstein and Volkow 2002). It needs to be mentioned, that not all people who are exposed to drugs develop an addiction. Genetic factors (e.g., mediated by personality traits such as impulsivity or novelty seeking) as well as social factors (e.g., poor social and familial support) influence the risk of addiction.

Postulating similar neurobiological mechanisms in behavioral addictions to substance-related addictions, pornography, and pornography addiction should feature at least the following properties:

1. Pornography should—comparable to a drug—activate the dopaminergic reward system in sporadic users.
2. Cue reactivity as a result of conditioning processes should be greater in pornography addicted subjects than in nonaddicted subjects.
3. Tolerance: With increasing consumption intensity, the response of the reward system toward pornography should decrease.
4. Impaired prefrontal control of the reward system: In the course of the development of pornography addiction, the person affected should have more and more problems to control their addictive behavior.
5. Withdrawal: Stopping the consumption of pornography should induce stress symptoms.

7.3 Neurobiological Results

In the following three subchapters, we will review the neurobiological results of three research domains, which are related to the pornography addiction concept. The first chapter summarizes the neural correlates of watching pornography. Here, the question of interest is whether pornography is a potent reward stimulating the reward circuits of the brain. The next chapter is dedicated to cue reactivity and appetitive conditioning. If there is a similarity between pornography addiction and substance-related addictions, then pornographic stimuli should be regarded as unconditioned stimuli. Due to appetitive conditioning, formerly neutral stimuli should be become conditioned stimuli if these stimuli predict the occurrence of pornographic stimuli. In the third chapter, results regarding neurophysiological characteristics of men, who are either excessive pornography users or patients with the diagnosis sexual addiction, are summed up.

7.3.1 Neural Responses Toward Pornography

Pictures or movies containing visual sexual stimuli (VSS) capture attention, a fact that is widely used in the advertising industry. An attention bias toward sexual stimuli could for example be demonstrated by Schimmack (2005), Most et al. (2007), or Prause et al. (2008). A recent review presents several studies indicating that VSS can attract attention similar to threat-related stimuli (Sennwald et al. 2016). Further, among others, Kagerer et al. (2014) found the attentional bias toward sexual stimuli to be related to sexual motivation related traits such as sexual sensation seeking.

As mentioned before, there is an ongoing debate whether sexual stimuli are per se rewarding or whether they serve as conditioned stimuli of sexual activity for example tactile manipulation of the genitals as the de facto rewarding entity. Thus, it is unclear whether sexual stimuli result in *liking* or *wanting*—using the terminology of Robinson and Berridge (1993). Most likely, watching erotic stimuli induces both wanting and liking (Stoléru et al. 2012), and it may depend on the circumstances whether liking or wanting prevails. Before summarizing the studies on the neural correlates of watching pornography, one has to be aware that watching pornography in privacy is often combined with masturbation. Therefore, the rewarding aspect in the experimental situation might be quite different to that in the usual situation, e.g., at home. Despite these difficulties related to validity, several studies on the neural correlates of watching sexual stimuli or pornography were conducted. These used positron emission tomography (PET, e.g., Bocher et al. 2001; Redoute et al. 2000), but mainly functional magnetic resonance imaging (fMRI, e.g., Hamann et al. 2004; Karama et al. 2002; Mouras et al. 2003). Some of the studies used static pictures (Sabatinelli et al. 2007; Stark et al. 2005; Walter et al. 2008) others movie clips (Arnow et al. 2002; Ferretti et al. 2005; Redoute et al. 2000).

Meanwhile, there are first meta-analyses of studies on the neural correlates activated when watching pornography (Georgiadis and Kringelbach 2012; Stoléru et al. 2012). The extended review by Stoléru et al. (2012) included 58 studies (40 fMRI studies, 14 PET studies, 2 MEG studies, 1 SPECT study, and 1 near-infrared spectroscopy study), which were published between 1994 and 2010. In this review,

Table 7.1 Brain structures identified in the meta-analyses by Stoléru et al. (2012) as involved in the processing of visual sexual stimuli (VSS)

Lateral occipital and/or lateral temporal cortex	83.9%
Anterior cingulate cortex	67.6%
Parietal cortex	56.8%
Inferior temporal cortex	54.1%
Dorsal striatum	51.4%
Thalamus	51.4%
Premotor areas	48.6%
Cerebellum	37.8%
Hypothalamus	37.8%
Orbitofrontal cortex	37.8%
Amygdala	35.1%
Claustrum	27.0%
Midbrain	27.0%
Ventral striatum	27.0%
Medial prefrontal cortex	24.3%

The percentage indicates the proportion of studies, which reported a structure as activated during VSS processing

no difference was made between static pictures or film clips or between sexual material, erotic material, and pornographic material. Most of the studies used a passive viewing paradigm meaning that subjects just watch either the sexual pictures or clips or corresponding control stimuli. This meta-analysis therefore summarizes precisely the brain regions activated by the drug *pornography*. Table 7.1 lists the structures found to be activated in several studies.

Stoléru et al. (2012) developed a neurophenomenological model of sexual arousal. As shown in Fig. 7.1, cognitive processes entail motor imagery, appraisal, and attention. Appraisal is further divided into a motivational, emotional, and, autonomic as well as an endocrine component. Involved brain areas are assigned to these functional components. This model also includes inhibitory components, which are activated if sexual arousal must be suppressed. The activation of these structures diminishes with increasing sexual arousal.

Investigating which neural activities toward VSS are stable over time and which are influenced by state factors in one of our own studies, we could demonstrate that activities in nucleus accumbens, anterior cingulate cortex, occipital cortex, and parietal cortex showed the most robust results with respect to temporal stability if subjects are examined a second time one year after the first assessment (Wehrum-Osinsky et al. 2014). Also potential sex effects need to be taken into account: Most studies so far investigated men and because pornography addiction seems to be primarily a male problem, these studies are highly relevant regarding pornography addiction. But nevertheless, results of studies which compare the activation pattern during the processing of pornographic material in men and women should not be neglected: Most of the few studies including both men and women report slightly greater activation in men than in women in some brain areas (e.g., thalamus, hypothalamus, Karama et al. 2002; amygdala, OFC, insula, ACC, Gizewski

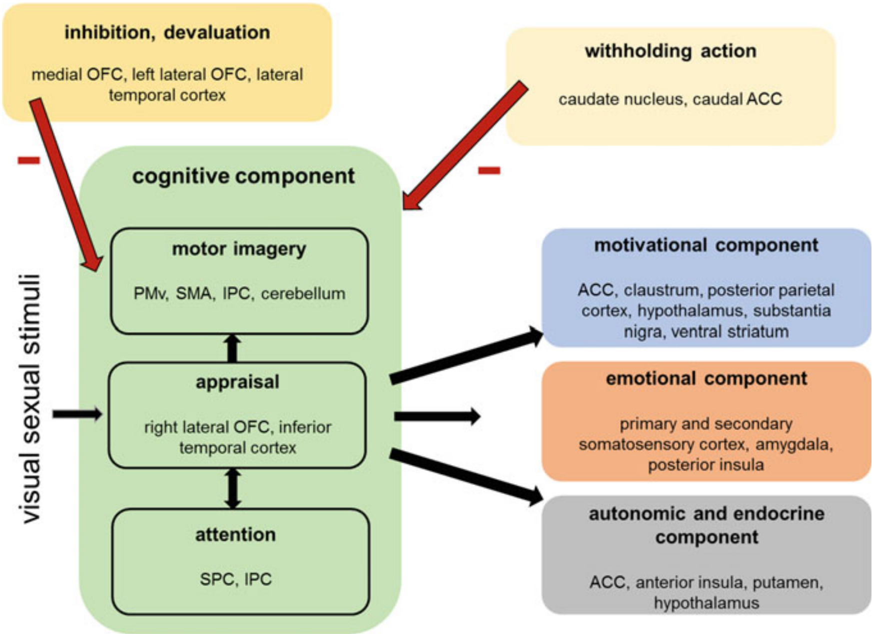

Fig. 7.1 Neurophenomenological model of sexual arousal by Stoléru et al. (2012). Abbreviations: *ACC* anterior cingulate cortex, *IPC/SPC* inferior/superior parietal cortex; *OFC* orbitofrontal cortex; *PMv* ventral premotor area; *SI/SII* primary/secondary somatosensory cortex; *SMA* supplementary motor area

et al. 2006; parital cortex, thalamus, Wehrum et al. 2013). However, often the fact that pornographic material is rated more pleasant and more sexually arousing by men than by women was not taken into account. Therefore, it is not entirely clear whether the observed sex differences are due to male biased stimulus material. A last note: Whereas in some studies there was no difference in subjective ratings, still a greater neural activation was observed in men than in women (e.g., Gizewski et al. 2006). If these results prove to be true by future research then this could be an explanatory factor why men are more prone to develop a pornography addiction.

7.3.2 Cue Reactivity and Appetitive Conditioning

In substance-related addictions, cue reactivity delineates the observation that formerly neutral stimuli which became associated with drug intake trigger craving by dopamine release in the ventral striatum even if the stimuli are backward masked (Childress et al. 2008). The underlying mechanism is appetitive conditioning, a form of classical conditioning (Martin-Soelch et al. 2007). It is assumed that appetitive conditioning is also involved in sexual behavior, e.g., the development of sexual preferences (Akins 2004; Brom et al. 2014; Martin-Soelch et al. 2007; Pfaus et al. 2001) and also plays a major role in sexual addiction (Banca et al. 2016; Klucken et al. 2016). Interestingly, although appetitive conditioning is assumed to be a central mechanism of the development of addiction, only few studies to date have examined the neural correlates of appetitive conditioning, especially in context of sexual addiction.

In case of pornography addiction, one assumes that internal (e.g., arousal, negative mood) or external (e.g., the view of a computer or smartphone) stimuli which were associated with pornography use and masturbation in the past trigger the currently addictive behavior. This hypothesis requires that pornography can indeed serve as unconditioned stimuli in an appetitive conditioning paradigm resulting in a conditioned dopaminergic-driven neural response in the ventral striatum toward the conditioned stimuli.

In typical appetitive conditioning experiments, a neutral stimulus (later the conditioned stimulus, CS+) is paired with a reward (unconditioned stimulus, UCS) like money, pleasant odors, drug, or sexual stimuli, while a second neutral stimulus (CS−) is associated with the absence of the UCS (Martin-Soelch et al. 2007). By testing the differential responses toward CS+ and CS−, differential appetitive conditioning can be proven. There are several studies that have used this experimental design with sexual stimuli as unconditioned stimuli (Both et al. 2008, 2011; Klucken et al. 2009, 2013, 2015). These studies have repeatedly shown that the CS+, which is paired with sexual stimuli (e.g., sexual pictures or genital stimulation), elicits conditioned responses (i.e., increased responses to the CS+ in contrast to the CS−). For instance, increased preference and arousal ratings were found to the CS+ in contrast to the CS− after conditioning but not before (Klucken et al. 2009, 2013). However, while changes in preference ratings have repeatedly been found during appetitive conditioning, conditioned responses in other response systems like peripheral-physiological responses (e.g., skin conductance responses (SCRs) or genital responses) are less clear. For instance, Klucken et al. (2009) found increased subjective ratings and hemodynamic responses to the CS+ compared with the CS−, but no significant differences in SCRs. Moreover, the same subjects reliably differed in SCRs between the UCS (sexual pictures) and the non-UCS (neutral, nonsexual pictures), highlighting that SCRs are able to differ between salient and non-salient stimuli in general. However, other studies using a higher number of subjects could demonstrate increased conditioned SCRs toward the CS+ (Klucken et al. 2013). To interpret these diverging results, it is hypothesized that the conditioned effects in psychophysiological responses are smaller and may also depend more on individual differences (Klucken et al. 2009, 2013, 2015). In a review, Brom et al. (2014) also assume that peripheral-physiological responses may not be a strong marker for appetitive conditioning, especially in context of sexual stimuli.

With respect to the neural correlates of appetitive conditioning with sexual stimuli as UCS, studies have identified a subcortical and cortical network including the amygdala, the ventral striatum, the orbitofrontal cortex (OFC), the anterior cingulate cortex (ACC), and the insula (Martin-Soelch et al. 2007). One of the most important structures for appetitive conditioning is the amygdala, which is crucially involved in the formation of the CS–UCS association (Martin-Soelch et al. 2007). Day and Carelli (2007) emphasize in their review the ventral striatum, or more specifically, the nucleus accumbens as key regions for appetitive conditioning. This important role of the ventral striatum in appetitive conditioning is also supported by findings, showing its involvement in the processing and the anticipation of positive events especially sexual arousal (Oei et al. 2012; Stark et al. 2005). OFC, insula, and ACC activations may reflect conscious evaluation processes of the current CS value and are also important for the awareness of bodily sensations, which seems to be irrespective of sexual stimuli, other emotions like fear and disgust, or other rewarding stimuli (Craig 2009; Domjan 1994; Klucken et al. 2009). Interestingly, studies investigating appetitive conditioning processes in subjects with sexual addiction found small differences to healthy control subjects only. In one of our own studies, Klucken et al. (2016) found increased amygdala activation in sex addicted subjects as well as decreased striatal/prefrontal connectivity during appetitive conditioning even after correcting for individual pleasantness ratings. One explanation for these group differences is the assumption that the increased amygdala activation mirrors facilitated conditioning and craving processes in men with sexual addiction. In addition, the decreased striatal/prefrontal connectivity may reflect impaired emotion-regulation processes like an impeded downregulation of craving in these patients.

In sum, knowledge about appetitive conditioning with sexual stimuli is limited. The few so far published studies showed the same neural network involved in other appetitive conditioning processes with nonsexual rewarding stimuli with the NAcc as one of the most important structures. However, one interesting perspective to explore is the time course of the dopamine activation, because there is some evidence that dopamine in the NAcc plays an important role in the beginning, but less in the sustained sexual behavior (Georgiadis et al. 2012).

7.3.3 Correlates of Pornography Addiction

While Gold and Heffner (1998) described the lack of empirical data on sexual addiction at the end of the last century pointedly in their paper entitled 'Sexual addiction: many conceptions, minimal data', the situation has changed significantly over the last 10 years. Now, there are first published studies focusing on the correlates of excessive consumption of pornography and on pornography addiction.

On a behavioral level, several studies have shown that sexual addiction is accompanied by specific characteristics. Mechelmans et al. (2014) demonstrated an enhanced attentional bias toward sexual cues in subjects with sexual addiction in comparison to subjects without sexual addiction. Banca et al. (2016) could demonstrate that men with pornography addiction showed greater novelty preference for sexual than for control images compared to healthy controls. In the same study, they could also show that men with pornography addiction more strongly prefer stimuli associated with sexual and monetary reward by a conditioning procedure than healthy controls.

In the meantime, several studies were published which address the structural and functional correlates of excessive use of pornography or pornography addiction. In a first neuroimaging study, Miner et al. (2009) expected deficits in structural connectivity in the inferior frontal area measured by diffusion tensor imaging (DTI) in subjects with sexual addiction, but they observed only a negative correlation between the fractional anisotropy (FA) within the inferior frontal area with the scores of questionnaires measuring impulsivity and negative emotionality. In the same paper, the authors reported higher impulsivity in men with sexual addiction in comparison with healthy controls measured by self-report and behavioral data (errors in a go-nogo task).

In a very interesting study, Kuehn and Gallinat (2014) investigated the neural correlates of the habitual use of pornography. They questioned their male participants about their hours of pornography consumption per week and correlated these consumption hours with neural structure, task-related activation, and functional resting-state connectivity. They found a negative correlation between reported pornography consumption hours and the gray matter volume in the right caudate. In an fMRI experiment, they presented blocks with sexual material and nonsexual material and interspersing fixation periods. The values of the contrast *sexual material minus fixation period* were negatively correlated with pornography consumption hours in the putamen. Finally, functional connectivity between the right caudate and the left dorsolateral prefrontal cortex was negatively correlated with pornography consumption hours. This could indicate that the higher the habitual consumption of pornography, the lower the cognitive control of the consumption behavior. However, from these correlative approaches one has to keep in mind that it remains unclear whether these neural correlates are the consequences or the causes for pornography consumption.

In a study by Voon et al. (2014), men with pornography addiction displayed enhanced neural activity toward explicit sexual film clips in the dorsal anterior cingulate cortex, ventral striatum, and amygdala compared to healthy controls. In a similar study, Seok and Sohn (2015) found that men with sexual addiction showed greater activation in caudate nucleus, inferior parietal lobe, dorsal ACC, thalamus, and dorsolateral prefrontal cortex toward explicit sexual pictures than control subjects. Recently, Brand et al. (2016) reported that preferred explicit sexual pictures in contrast to non-preferred sexual pictures resulted in greater ventral striatum activity. Further, this ventral striatum activity increased with increasing symptoms of Internet pornography addiction. Pornography addiction was measured by the short Internet Addiction Test, modified for cybersex (s-IATsex, Pawlikowski et al. 2013).

Summarizing the various studies, pornography addiction seems to be associated with functional and structural brain abnormalities. Interestingly, the results concerning cue reactivity are equivocal: While Voon et al. (2014), Seok and Sohn (2015), and Brand et al. (2016) reported greater neural activation toward sexual material in the reward circuitry in high pornography consuming men, Kuehn and Gallinat (2014) found a negative correlation between cue reactivity toward sexual material and weekly hours of pornography consumption. Since the studies however differ in many aspects (high consumers vs. addicted consumers, pictures vs. films,…) future research must explore the relationship between habitual pornography consumption and cue reactivity in the reward circuits in more detail to explain this inconsistency.

7.4 Conclusions

In the last section, we have reviewed the studies regarding brain responses toward sexual material, cue reactivity, and appetitive conditioning and finally also the neurophysiological correlates of excessive pornography consumption. We could demonstrate that sexual stimuli induce neural activation in the reward circuit (e.g., ACC, ventral striatum, orbitofrontal cortex), probably due to the mesolimbic dopamine reward pathway. Thus, the hypothesis that the consumption of pornography might be appetitive for most men is confirmed. The appetitive value of pornographic material is further underlined by the fact that these stimuli can be used as unconditioned stimuli in appetitive conditioning experiments. Therefore—similar to other addictions—formally neutral stimuli become triggers of the addictive behavior. This is in accordance with reports of men with pornography addiction describing a strong urge/craving to consume pornography if confronted with certain situations, feelings, or stimuli which share similarities with situations, in which pornography is usually consumed. Especially stimuli with sexual aspects, for example a cover of a magazine, but also context information like being-alone-at-home might elicit the urge for addictive behavior.

Finally, we summarized the studies, which investigated the correlates of excessive pornography consumption on a neural level. Despite a lack of longitudinal studies, it is plausible that the observed characteristics in men with sexual addiction are the results not the causes of excessive pornography consumption. Most of the studies report stronger cue reactivity in the reward circuit toward sexual material in excessive pornography users than in control subjects, which mirrors the findings of substance-related addictions (see review by Chase et al. 2011; Garrison and Potenza 2014). The results concerning a reduced prefrontal-striatal-connectivity in subjects with pornography addiction can be interpreted as a sign of an impaired cognitive control over the addictive behavior.

Although all neurobiological insights from these studies support the concept of a pornography addiction, there are still many open questions. To name only a few: Is tolerance a necessary precondition of pornography addiction? Is a change in the preferred sexual material for example toward more deviant material a sign of development of tolerance? Is an increasing time spent on pornography an indicator of tolerance? Are symptoms of withdrawal observable in all subjects considered to be pornography addicted? Are therapeutic interventions known from substance-related addictions successfully transferable to pornography addiction? All these questions must be addressed in future research to further answer the question whether the conceptualization of pornography overuse as an addiction is appropriate or not.

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Chapter 8
Quantitative Behavior Genetics of Internet Addiction

Elisabeth Hahn and Frank M. Spinath

Abstract It is now well established that all human traits are influenced both by genes and the environment. This suggests that most relationships, such as the relationship between personality and Internet addiction, may be due in part to genetic influences. To reach a more complete understanding of the risk factors associated with the initiation and maintenance of Internet addiction, the dynamic interplay of genes and environment over the life course must be investigated to allow for the identification of potential developmental changes linked to genetic vulnerabilities and resilience. In this chapter, we highlight behavior genetic research approaches and findings with respect to Internet addiction (In line with the editors of this book, we use the term Internet addiction as an umbrella term encompassing different conceptualizations and understandings of the phenomenon of problematic Internet use.) and related constructs. We will outline how genetically informative data can provide new and promising insights into the understanding of underlying sources of individual differences in Internet addiction. Future research questions will also be discussed.

8.1 Introduction and Basic Concepts

In the last decade, a growing body of research focused on problematic and addictive behavior patterns related to the use of the Internet to identify contextual as well as individual causes, correlates, and consequences of this relatively new phenomenon. Despite the rapid progress within this research, we are far from understanding all mechanisms involved in the development of Internet addiction. When it was first observed that some people develop a series of symptoms as a result of their inability to control their use of the Internet, research attempts sought to define this newly

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_8

emerging disorder (Young 1998). More than 15 years later, there is broad consensus about key components of Internet addiction, such as excessive use, greater usage than anticipated, cognitive preoccupation with the Internet, unsuccessful attempts to stop or reduce time online, mood disturbances related to reduction or abstinence efforts and endangering employment, education or relationships (Christakis 2010). However, there is still an ongoing debate over how this observed behavior should be labeled and whether it is a unidimensional or multidimensional disorder that needs to be differentiated into subdomains and specific behaviors related to specific activities (Montag et al. 2015). To characterize and classify Internet addiction, a number of studies have focused on investigating the comorbidity of problematic Internet usage behavior with psychopathology (for a review see Carli et al. 2013; Ko et al. 2012) such as alcohol or drug abuse and dependence (Lee et al. 2013), major depression (Ha et al. 2007; Young and Rogers 1998), and attention-deficit hyperactivity disorder (ADHD; Reuter 2015; Yen et al. 2007a, b; Sariyska et al. 2015). Despite, or perhaps even because of, these increasing but ongoing research attempts to define and describe the phenomenon of Internet addition, there is a relative paucity of studies employing behavior genetic models to investigate the origins of individual differences in Internet usage behavior. For most psychiatric diseases, behavior and molecular genetic research have demonstrated the importance of genetic influences (Polderman et al. 2015). The same is true for a variety of personality characteristics, as well as the occurrence, course, and remission from disorders. However, research on genetic involvement in psychiatric disorders is frequently accompanied by tenuous misinterpretations of behavior genetic findings. Therefore, we will initially present an overview of basic concepts in behavior genetics, as well as how findings in this field can be translated into a better understanding of the phenomena under study (for a more detailed illustration see Neale and Maes 2004; Plomin et al. 2013).

Behavior genetic research approaches have been extensively used and developed throughout the last century, focusing on a variety of constructs and behaviors. While molecular genetic studies aim to identify specific genes and genomic regions associated with particular behavior, quantitative behavior genetic studies are invaluable in investigating the relative contribution of *both* nature (i.e., genetic influences) and nurture (i.e., environmental influences) to individual differences in human behavior. Given that Internet usage behavior varies between individuals within and across populations, the goal of behavior genetics is to understand the basis for this phenotypic (observed) variation. On a basic level, behavior genetic methods can be used to address questions such as why some individuals have no problems dealing with the omnipresence of the Internet while others are unable to control their Internet usage behavior. To what extent do environmental influences characterize and trigger this behavior, for example, perceived parenting style, family climate or early, uncontrolled access to the Internet? To what degree is something in our genetic makeup driving us to spend more and more hours online and keeping us from controlling ourselves? Do we have an innate vulnerability to develop problematic Internet use or is a combination of a genetically predisposed vulnerability together with environmental experiences and conditions (or vice versa) at work, and when do these influences occur and produce phenotypic behavior?

Since the mid-nineteenth century (Galton 1869) when evidence for genetic influences on human behavior first emerged, findings from the field of behavior genetics have come a long way in demonstrating that *both* genes and the environment contribute to individual differences, thus replacing the old "nature *versus* nurture" debate with the present understanding of "nature *via* nurture." Consequently, modified and new questions arise. To answer these questions, different behavior genetic research designs—twin, family, and adoption studies—can be used. In the following, we will illustrate the classical twin model as one of the most commonly used techniques in behavior genetics. For a comprehensive introduction to quantitative genetic methodology, the reader is referred to Neale and Maes (2004) as well as Plomin et al. (2013).

8.2 Twin Studies

The rationale behind behavior genetic research designs is simple: If genes are relevant for a specific behavior, then biological relatives should on average resemble one another more than unrelated individuals do, which is reflected in a positive correlation between family members (e.g., parents and offspring, or between siblings). However, relatives also share common environments to a greater degree than nonrelatives do, which would also lead to a positive correlation between family members. To explicitly distinguish genetic from environmental influences, observations of either genetically identical individuals in different environments or genetically dissimilar individuals in equal environments would be ideal. Obviously, this is not such a feasible approach with humans, but from a scientific point of view, twin births are very much like a natural "experiment" along these lines, which allows us to separate nature from nurture. The classical twin design (CTD) is based on comparing the similarity of monozygotic (MZ), or identical twins, and dizygotic (DZ), or fraternal twins. MZ twins are equipped with exactly the same genetic makeup, i.e., 100% shared segregating genes, as they develop from a single fertilized egg that divides in the first days of embryonic development. As they usually grow up together, they also share a large part of their environment (e.g., the lifestyle of the family, peer groups, age cohort). DZ twins are the results of two separately fertilized eggs and therefore share on average 50% of their segregating genes, like non-twin full siblings or parent-offspring dyads. In contrast to normal siblings, DZ twins—like identical twins—share a number of environmental influences because they typically grow up together at exactly the same age. These known degrees of genetic relatedness can be used to disentangle genetic and environmental contributions to dyad similarity and dissimilarity by inspecting patterns of MZ and DZ resemblances (see Table 8.1 for an overview).

Table 8.1 Interpretation of patterns of MZ and DZ twin correlations in the classical twin design

Relation	Interpretation
$r_{MZ} < 1$	Non-shared environmental influences
$r_{MZ} > 2r_{DZ}$	Genetic dominance (or epistasis; shared environment small)
$r_{MZ} > 4r_{DZ}$	Epistasis
$2r_{DZ} > r_{MZ} > r_{DZ}$	Additive genetic and shared environmental influences
$r_{MZ} = r_{DZ} > 0$	No genetic contribution; shared environmental influences (family environment)
$r_{MZ} = r_{DZ} = 0$	No genetic contribution and no familial aggregation; non-shared environmental influences

Notes Derived from Plomin et al. (2013); r_{MZ} = monozygotic intra-pair correlation; r_{DZ} = dizygotic intra-pair correlation

If MZ twins are more alike than DZ twins with respect to the time spent online, this should be attributed to their greater genetic similarity, since both MZ and DZ twin siblings grow up together, i.e., share environment to the same degree. In other words, the greater phenotypic dissimilarity in DZ twins—if one twin spends 10 h per week online while the other spends more than 100 h a week—can be traced back to their greater genetic dissimilarity, which would imply that part of the variation in Internet usage behavior is associated with genetic variation. Less than perfect MZ twin correlations, however, should be attributed to environmental differences between MZ twins because they are genetically identical. Overall, the heritability statistic can be calculated, in principle, by partitioning the observed phenotypic variance of a trait in the following way:

$$V_P = V_G + V_C + V_e$$

where V_P is the total variance in the population, V_G is the variance associated with genetic differences in the population (often abbreviated h^2), V_C is the variance associated with shared environmental variation within the population, and V_e is the residual variance, which includes the variance associated with non-shared (unique) environmental variation, independent epigenetic effects (heritable changes in gene expression) and measurement error or random noise. Using the MZ and DZ twin correlations,[1] heritability, as the proportion of variance in the population due to genetic factors, can be calculated as 2*(rMZ – rDZ). If the correlation between twin1 and twin2 within the MZ twin group for a general Internet addiction score is 0.60, and the correlation within the DZ twin group is 0.30, then h^2 = 2*(0.60 − 0.30) = 0.60 which means that 60% of the observed variation in the Internet addiction score could be explained by a heritable component.

[1]The formula is derived from the respective formulae for the correlations of MZ twins ($r_{MZ} = V_G + V_C$) and DZ twins ($r_{DZ} = ½ V_G + V_C$). Subtracting the second equation from the first gives h^2 = 2*(rMZ – rDZ).

The heritability statistic (V_G, h^2) can be broken down into four parts: additive genetic variance (V_A), non-additive genetic variance, which can again be divided into genetic dominance (V_D) and epistasis effects (V_I), as well as variance due to assortative mating (V_{AM}). While additive genetic influences encompass the sum of all allelic (i.e., different versions of a gene) effects within and across genes, non-additive genetic influences (typically specified as dominance) comprise interactions between genes either at the same loci (dominance) or between loci (epistasis). Assortative mating refers to nonrandom mating, i.e., the phenomenon that individuals with similar characteristics mate with one another more frequently than individuals with dissimilar characteristics. If the mating characteristic itself is to some degree genetically influenced, assortative mating leads to an increase in the genetic variation of a population.

Shared and non-shared environmental influences, on the other hand, may be distinguished from one another through their effect on family members. Shared environmental influences are defined as those influences that serve to increase similarity between family members. Therefore, shared environmental effects are often labeled as "family" effects, which can be misleading. Parenting style is often cited as an example for shared environment, but parenting may also exert an effect on the variation of a trait as a non-shared environmental influence if, for example, parenting is specific to or differentially perceived by individuals in the family, thus increasing dissimilarity among family members. For a variety of psychological constructs, behavior genetic research has come to the conclusion that, with respect to environmental effects, the vast majority reflect non-shared environmental influences which contribute to differences between children in the same family, rather than similarity (for a discussion see, Plomin and Daniels 2011). In this context, the word *environment* includes all influences other than inheritance, for instance, prenatal events and biological events such as illness, family socialization factors as well as climate, geography, and individual experiences.

So far, the presentation has oversimplified the twin method. There are additional possible mechanisms that could be important in explaining variation in human behavior. As a consequence, the formula to calculate heritability can be extended in the following way:

$$V_P = V_G + V_C + V_{GxE} + V_e$$

where V_{GxE} is the variance associated with gene by environment interactions and correlations. The classical twin design is based on the assumption that genetic influences are invariant across different environments. Genotype–environment interactions (GxE) are defined as the moderation of genetic predispositions by environmental experience, such that particular environmental experiences may alter subsequent genetic expression and vice versa. Moreover, genetic influences can contribute to variations in environments that individuals experience via genotype–environment correlation (r_{GE}). Despite these relatively simple definitions, the actual manifestation of GxE and r_{GE} is proving to be more complicated and difficult to detect (Plomin et al. 1977). For example, it is typically assumed that 'bad' environments activate a genetic risk, whereas 'good' environments suppress a genetic risk. However, it is equally likely that deleterious environments may serve to deactivate the expression of otherwise protective genetic influences. Alternatively, it may be that genetic risk is best expressed in the absence of environmental risk (for a discussion of theoretical models see Belsky and Pluess 2009). Therefore, a major question is not simply whether GxE or r_{GE} occurs or is pervasive, but *how* it occurs, in order to derive theoretical frameworks and predictions for behavioral outcomes. Studies investigating gene–environment interactions and correlation using longitudinal genetically informative data that allows for the assessment of developmental trajectories, as well as Mendelian randomization[2] (Smith and Ebrahim 2004) and the identification of endophenotypes[3] (Gottesman and Gould 2003) form the bases for state-of-the-art behavior genetic research that goes way beyond simple heritability estimates.

There are certain prerequisites for the correctness of the conclusions derived from the classical twin model. First, it is assumed that the similarity of the environment has a similar impact in identical and fraternal twins. This prerequisite is known as the "equal environment assumption" (EEA). Only if environmental influences do not act in a differential manner on MZ versus DZ twins, higher similarity in MZ twins can be traced back to their higher genetic similarity. In general, empirical evidence appears to support the EEA. For example, studies have shown that within a sample of MZ twins, those pairs who were treated more similarly (e.g., who were dressed more alike, shared peer groups to a greater degree, etc.) did not show greater similarity in a number of outcomes (e.g., personality; Kendler et al. 1994). A second assumption from the model is that twins are generalizable to the rest of the population. Differences within a population of twins under study build the basis for behavior genetic models and were treated as differences within the population in general. Rutter and Redshaw (1991) argued that "growing up as a twin" leads to differences in the psychological development of twins compared to singletons which would imply that twins may be representative for sibling populations, but not for singletons regarding the environment they grow up in. However, with respect to the variation of psychological variables, research typically shows that twins are no different from the rest of the population (e.g., with regard to personality; Johnson et al. 2002). Further assumptions of the classical twin design include possible additional influences, such as assortative mating, cultural transmission, or genotype–environment interaction and correlation, which cannot be estimated in the model and which are assumed to have zero influence on the variation of the observed trait. If the CTD is extended, for example by including additional groups of genetic or environmental relatedness, these effects can be specified (Keller et al. 2009; Medland and Keller 2009; Keller et al. 2010).

[2]Mendelian randomization is the term applied to the random assortment of alleles at the time of gamete formation.

[3]Endophenotypes are biological or psychological features that mediate the link between genes and complex behaviors.

The basic logic of the CTD can be transferred to the comparison of other dyads of varying genetic and environmental relationships. In the study of identical twins reared apart, the only source of similarity is genetic, because the environments in which the twins live are different. In a similar fashion, we can compare the similarities of adopted siblings, who are genetically unrelated, in the same family environment with the similarity between adopted-away children and their biological parents, who will share genetic influences, but not their environments. Finally, family studies offer another valid and important tool to identify the degree of risk for relatives (with different degrees of genetic relatedness) for developing a specific disorder that other family members suffer from. If increased genetic relatedness is associated with higher risk, it is likely that genetic influences are involved.

To summarize, heritability is a proportion, expressed as a value between 0 and 1, quantifying the relative influence of genes on the variability of the trait under study. It is important to note that the heritability of a particular trait does not relate to how much influence genetics have on the manifestation of the trait itself in an individual; rather, heritability is a population statistic, which is estimated at a given time in a given sample. Moreover, heritability does not directly tell us something about the specific influence of genes on any particular trait or the pathways through which genes influence behavior. Also, heritability estimates depend on the amount of the total variation in a given trait, including the extent of environmental variation. However, knowledge about heritability is essential to quantify and qualify the environment. As soon as we know about genetic factors in etiology and treatment response, and as a consequence know about developmental windows of change, it may enable the individualization of prevention and treatment as well as the identification of new therapeutic targets. To test whether supposed environmental effects play a certain role for the variation and the development of Internet addiction, systematic behavioral genetic studies are needed to control for genetic pathways.

8.3 Nature and Nurture of Internet Addiction

Previous family, adoption and twin studies on a broad range of addictions (e.g., substance use, pathological gambling; for a review see Agrawal et al. 2012) suggest a substantial role for genetic influences on addiction. However, results from studies conducted in different countries and societies also suggest considerable variation in the heritability, both within specific addictions as well as across different addictions. For alcohol dependence, 48–66% of the liability could be attributed to genetic influences (Heath et al. 2001; Heath and Martin 1994; Kendler et al. 1992; Prescott and Kendler 1999), while heritability estimates for cocaine addiction ranged from 42 to 79% (Kendler et al. 2000; Tsuang et al. 2001; Van den Bree et al. 1998). With respect to gambling addiction, twin studies revealed evidence for heritable variation of around 50% (Lobo and Kennedy 2009; Slutske et al. 2010; Slutske et al. 2000). Taken together, heritability estimates of addictions were, on average, about the same size as the heritability of non-pathological personality traits (Johnson et al.

2008). The variation in genetic estimates appears to be caused by differences between the stages of addiction on the one hand and the developmental course of addiction on the other hand. Twin studies have shown that genetic influences increase from early stages of initiation of use to later stages of dependence, which could be explained by a genetic overlap and additional specific genetic factors to problematic and dependent use that contribute to the increase in heritability (Agrawal et al. 2005). Moreover, age (e.g., adolescence compared to adulthood) seems to be an important factor interacting with these stages of addiction (Dick et al. 2007). Besides genetic influences, and in contrast to many phenotypes that have been studied using twin designs, addictive behavior has shown considerable evidence for shared environmental influences, especially during adolescence, including influences such as drug exposure in the family, parental characteristics, parenting style, and peer influences (Dick et al. 2007). Kendler et al. (2008) also found that initiation and early patterns of substance use seemed strongly influenced by social and familial environmental factors while genetic variation played only a minor role. For later levels of use, patterns switched suggesting stronger genetic influences. Although this outline of findings for the heritability of addictive disorders is both selective and brief, it demonstrates that genetic influences are important for different aspects and contexts related to addiction.

To date, only a few studies have investigated Internet addiction using a behavioral genetics research design. Results indicate that both genetics and environmental influences play a role in influencing Internet addiction, but the results across studies show pronounced variation (for an overview see Table 8.2). First, Li et al. (2014) examined generalized Internet addiction in a Chinese sample of adolescent twins aged between 10 and 20 years using a short questionnaire adapted from the Internet addiction test (IAT; Young 1998). They reported heritability estimates of 58% for females and 66% for males. The remaining variance in the total addiction score was explained by non-shared environmental influences, while the shared environmental component was eliminated from the model. Observed twin correlations were consistent with a simple model in which twin resemblance was solely due to additive genetic variation. Deryakulu and Ursavas (2014) investigated not only Internet addiction in general, but also different components of problematic Internet use such as excessive use, social benefit through the Internet compared to real-life interactions, as well as negative consequences associated with Internet use (measured by a Turkish translation of the Problematic Internet Use Scale (PIUS); Ceyhan and Ceyhan 2014). In a sample of Turkish adolescents ranging in age from 10 to 25 years, twin resemblances suggested strong sex effects regarding the etiology of Internet addiction. Heritability estimates were zero for female participants. For males, heritability estimates ranged from 19 up to 86%. For the subcomponents of social benefits and negative consequences, the best-fitting model included additive (21 and 0.1%, respectively) and non-additive genetic influences (34 and 86%, respectively). For the excessive use subscale and the total addiction score, a model including additive genetic, shared, and non-shared

Table 8.2 Behavioral genetic studies on Internet addiction

Author(s) (year)	Sample number of pairs	Age (range)	Country	Instrument	Genetic influences	Notes
Deryakulu and Ursavas (2014)	*N* = 474 80 MZ/157 DZ	*M* = 15.39 (10–25)	Turkey	Problematic Internet Use Scale	42% for males total score; 19–86% for subscales	Gender effects; Genetic models for female twin pairs could not be fitted.
Li et al. (2014)	*N* = 1650 607 MZ/218 DZ	*M* = 15.47 (10–20)	China	Adaption of Young's Internet Addiction Test	66% for males, 58% for females	Effortful control explained part of genetic influences
Vink et al. (2015)	*N* = 5247 730 MZ/1222 DZ	*M* = 15.60 (13–18)	Netherlands	Compulsive Internet Use Scale	48% for total score	No gender effects
Hahn et al. (2017)	*N* = 784 146 MZ/90 DZ/119 SIB	*M* = 30.21 (17–60)	Germany	Internet Addiction Test; Generalized Problematic Internet Use Scale 2	0% for total scores 0–44% for subscales	No gender effects

Notes MZ = Monozygotic twin pairs, DZ = Dizygotic twin pairs, SIB = non-twin full siblings

environmental influences best fit the data. Genetic additivity accounted for 19% of the variance in excessive use, and 42% of the variance for the overall score. With respect to the environment, 19% of the variance in excessive use, and 17% of the variance in the total addiction score was explained by shared environmental influences, while the remaining variance was due to non-shared environmental effects for these scales. Vink et al. (2015) used a large population-based adolescent twin sample from the Netherlands twin register aged between 13 and 18 years. They reported a heritability of 48% for generalized compulsive Internet use measured by the Compulsive Internet Use Scale (CIUS) validated by Meerkerk et al. (2009). They found no gender differences on either the phenotypic or etiological level. Shared environmental influences did not play a role in explaining the variation in general Internet addiction. The study by Hahn et al. (2017) was the first to study a sample of adult twins and non-twin full siblings. Different measures and facets of problematic Internet use were considered. The German version of the Internet Addiction Test (IAT; Young 1998) and the Generalized Problematic Internet Scale 2 (GPIUS; Caplan 2010) were assessed to investigate different components of Internet addiction. Univariate twin models for all components and total scores for both measurements were employed to estimate genetic and environmental influences. In line with the results reported by Deryakulu and Ursavas (2014), considerable variation in the magnitude of genetic influences on Internet addiction subscales was found, indicating different etiologies for specific behavioral components involved in Internet addiction. For generalized IA factors, individual differences could be explained by shared and non-shared environmental influences while genetic influences did not play a role. For specific facets of IA and private Internet use, heritability estimates ranged between 21 and 44%. Overall, heritability estimates were lower in the adult sample compared to previous studies that had investigated adolescent twins, which is in line with findings reported for substance addictions (Kendler et al. 2008).

The findings considered have been consistent with expectations derived from studies of behavior genetics on personality and other addictions, by showing that genetic influences play an important role in explaining the variation in Internet addiction and related behaviors. However, studies also reveal inconsistent findings with respect to the extent of the relative contribution of genetic influences. These different results may be due to a variety of factors that influence heritability estimates (for a discussion of methodological aspects see Johnson et al. 2011). First, cultural differences between European and Asian societies regarding usage behavior of the Internet could be an important factor influencing the total variation of Internet addiction, as well as the environmental variation involved. For example, Li et al. (2014) speculated that gender differences in the relative importance of genetic influences on Internet addiction could be explained by social norms restricting girls' genetic propensities to expression and thus lead to lower estimates of heritability for females in China. Although this may be a valid explanation, it seems to apply not only to Asian civilizations but probably also to the Turkish sample. For the Turkish female twin pairs, both monozygotic and dizygotic twin similarities were of moderate size, indicating that shared environmental influences on the family level were responsible for twin resemblance and that genetic influences were negligible. Furthermore, the studies presented here focused on different age groups from childhood to adolescence and adulthood. As research on substance addiction has shown, heritability estimates differ depending on developmental stages and age (Dick et al. 2007). While differences in the studies on Internet addiction may be confounded by cultural differences, Rose et al. (2001) found the same changes for heritability estimates on adolescent drinking patterns within one cultural context using data from the longitudinal Finnish Twin Study, suggesting a similar developmental pattern may hold for Internet addiction. This is noteworthy, since comparable changes in the importance of heritability across developmental stages have also been documented for major depression (Boomsma et al. 2005).

8.4 Future Directions

Given that so far only a handful of studies have investigated Internet addiction using genetic research designs, further research is needed to replicate and underpin results on the heritability of Internet addiction and its components. As stated above, heritability is the fraction of the variance in a trait that is associated with genetic variation. Consequently, anything that changes either with regard to the total variation associated with the trait, or the fraction of the variance associated with genetic variation, can influence heritability estimates. This could be of crucial importance with respect to Internet addiction because of the immense environmental changes with the invention of the computer and—subsequently—with increasing daily access to the Internet for individuals. Many studies have indicated that access to the Internet is a risk factor for Internet overuse or addiction (Lin and Tsai 2002; Wang 2001; Yang and Tung 2007). If access to the Internet is a fundamental environmental prerequisite to develop problematic Internet use, it is important to systematically investigate whether there is variation in these environmental characteristics for the populations under study. Nowadays, in certain societies there is almost no variation because everyone has or could have online access, while in other areas Internet access still depends on age or characteristics of socio-economic status. But, individuals from different age groups differ with respect to the point in time at which they first accessed the Internet and whether they grew up with Internet access as a shared family environment or without it. At the extreme, Internet addiction may be mildly heritable under 'ordinary' conditions, but highly heritable when environmental variation is reduced. In other words, if the environment does not vary in a relevant way, all phenotypic variation associated with environmental variation will be eliminated, and the only variation left will be associated with genetic differences. This does not mean that the environment is not important, but it would not explain differences between individuals. From a clinical perspective, this means that the etiology of Internet addiction could vary for different generations depending on their exposure to the Internet during certain developmental stages, which could have implications for intervention programs. Future research is needed to investigate the role of genetic influences under different environmental conditions to identify risk groups.

This could be linked to the growing interest in behavior genetics to identify specific environmental factors, which influence behavior, to explain how these environments interact with genetic predispositions. We believe this to be a particularly important area in relation to adolescent Internet use behavior, for which twin models yield substantial evidence for the importance of both genetic influences and for environmental influences. There is a considerable literature on the role of parents, home environment, and peers in adolescent substance use. For example, Kendler et al. (2008) demonstrated that parental use, substance availability, and learned attitudes constitute environmental factors that are important for the use of multiple psychoactive substances. Regarding Internet addiction, family factors such as parent–child relationships (particularly parent–adolescent conflict) and lower family functioning have also been shown to contribute to the risk of problematic Internet use (Koo and Kwon 2014; Liu and Kuo 2007; Yen et al. 2007a, b). Research illustrates how alcohol use patterns of parents and siblings can influence the development of alcohol consumption and dependence in offspring (Kendler et al. 2008). Future generations face a similar predicament with familial patterns of Internet use behavior, which may prove an important source of both genetic and environmental variation. In the context of genetically informative designs, important effects associated with parenting and peers can be investigated while controlling for genetic influences. In addition, the influence of specific environments may vary across life span as the importance of genetic and environmental influences varies with age. Therefore, identifying potential developmental changes (especially with the invention of the Internet and new technologies for its use on a daily basis) should be an important research priority to foster a better understanding of Internet addiction.

To further define and classify Internet addiction, a next step should be to investigate the amount of genetic overlap between Internet addiction and personality traits as well as other psychiatric disorders such as substance addiction, depression, and impulse control disorders based on twin and family studies. In the twin study by Li et al. (2014), a significant overlap between genetic influences on Internet addiction and effortful control (larger in boys than in girls) was found, which provides insights into possible genetic pathways. Li et al. (2014) speculated that the genetic overlap between adolescent problematic Internet behavior and self-regulation capabilities may be partially due to the immature neurobiological system underlying self-regulation and behavioral inhibition. In the same vein, multivariate genetic mediation models can be used to test genetic and environmental correlations with personality-related behavioral components.

In contrast, molecular genetics as well as newly developed polygenetic risk scores (International Schizophrenia Consortium et al. 2009; Wray et al. 2014) can provide information on genetic effects at an individual level. At present, however, these approaches suffer from the fact that they can only explain small fractions of the variance leaving the majority of variance—especially of the genetic variance potentially involved—unexplained. Using genetically informative family data opens the window to explicitly test environmental causation by controlling for all the genetic contribution. Employing mixed effect (regression) models (Turkheimer and Harden 2013) using, for example, MZ twin pairs, it can be tested whether specific characteristics of the environment are responsible for differences within the twin pairs which can only be explained by the environment, given the perfect genetic similarity between twins. Altogether, behavior genetic models provide information on genetic *and* environmental factors and prepare the basis for further research endeavors on both sides.

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Chapter 9
Molecular Genetics, Personality, and Internet Addiction Revisited

Christian Montag and Martin Reuter

Abstract Mounting evidence suggests that personality plays an important role for a better understanding of Internet addiction. As twin studies have shown that both Internet addiction and personality are influenced by genetics, we highlight molecular genetics approaches to Internet addiction in this chapter too.

9.1 Background of the Research Question

Internet addiction has become a global phenomenon. While most of the early studies have been conducted in Asian countries, strong research efforts can increasingly be observed in Western countries. Although prevalence rates strongly differ between countries/cultures (Shaw and Black 2008; Ko et al. 2012), Internet addicts are a strong matter for debate among scientific circles and practitioners around the globe. In Germany, current estimates derived from a representative sample state a prevalence of about 1% (Rumpf et al. 2011).

The inclusion of Internet Gaming Disorder in section III of DSM-5 as an emerging disorder underlines the importance to further characterize Internet addiction by conducting new research in this area. Clearly, the inclusion of Internet Gaming Disorder in DSM-5 represents just a first step towards an acceptance of this rising problem, because Internet Gaming Disorder overlaps only in part with generalized Internet addiction (Montag et al. 2015a), which can best be characterized by addiction to the Internet in more broad terms (spending lots of time

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_9

online in chats, checking e-mails excessively, procrastinating over every day work by spending too much time on the Internet). Moreover, it needs to be mentioned that the empirical evidence on the nature of Internet addiction, as it stands, is currently multifaceted (Ko et al. 2012). Although researchers do not agree on standard symptoms for an Internet addiction diagnosis, a 2 + 1 rule has been put forward by Tao et al. (2010). Based on empirical data, Tao et al. suggested that both 'withdrawal symptoms when not being online' and 'preoccupation with the Internet' are prerequisite for Internet addiction and must be accompanied by at least one further symptom, such as development of tolerance (see Chap. 13 for more details). Besides a large body of classic psychological studies dealing with questions on how personality (e.g., Ko et al. 2006; Chak and Leung 2004; Cao et al. 2007; Montag et al. 2010, 2011; Sariyska et al. 2014) or sociodemographic factors (in particular gender, age) are linked to Internet addiction (e.g., Hur 2006; Tsai et al. 2009), more and more studies are incorporating neuroscientific tools, including functional and structural magnetic resonance imaging, to shed light on the actual nature of Internet addiction (e.g., Dong et al. 2010; Yuan et al. 2011; Zhou et al. 2011).

The present chapter aims to provide a short review of two important related aspects, which may be considered vulnerability factors for Internet addiction—namely personality traits and molecular genetic factors. As most studies in these two fields used cross-sectional designs, clearly no causality can be derived from the majority of findings. Nevertheless, conceptualization of the term 'personality' and of genetic factors suggests that these research targets represent a cause for—rather than an effect of—Internet addiction (see also the new I-PACE model on Internet addiction in Chap. 2 or Brand et al. 2016; I-PACE: Interaction of Person-Affect-Cognition-Execution). This will be further explained in the next sections, followed by a summary of the empirical evidence on personality/genetics and Internet addiction.

9.2 What Is Personality?

Definitions for personality are numerous and these definitions differ across personality theories. For an introduction to several important (in particular biological) personality theories, two of our own review studies are particularly recommended (see Montag et al. 2012a, 2013). Despite the numerous approaches to personality, the term needs to be briefly defined to enable a better understanding of the present chapter.

In our opinion, the most important common denominator in defining personality across theories can be found in the term *trait*. A personality *trait* represents an enduring disposition of a person to behave with certain behavioral, cognitive, and emotional tendencies to heterogeneous demands across a large number of situations. For example, individual differences in personality traits can manifest in being overtly anxious or socially outgoing when dealing with diverse problems/situations in everyday life. As a counterpart to the term *trait*, we also want to briefly introduce the term *state*. The current *state* of a person refers to the individual's mood in a specific situation. To clarify this idea, imagine an individual losing a beloved person. Independent of one's own personality traits, clearly suffering from a broken heart will induce a sad condition in (nearly) all humans.

This said, it is also clear that *traits* and *states* interact. It is not as easy to disentangle these terms as it appears in the previous section, because a person who is extraverted (socially outgoing, more positive) is more likely to feel happy at any given time. It has been demonstrated that traits and the means of single state measures over a longer time period correlate between 0.39 and 0.64 (Augustine and Larsen 2012). These numbers suggest some overlap of the constructs *traits* and *states*, but also leave enough room for differences. As personality is thought to be stable over time (personality traits change only subtly after the age of 30; McCrae and Costa 1994), it is likely that personality traits represent a vulnerability factor for Internet addiction, rather than that large personality changes are observed after becoming addicted to the Internet. However, given that most studies on Internet addiction deal with younger participants (i.e., below the age of 30), it cannot be ruled out that personality changes may occur due to becoming Internet addicted (for a deeper discussion on stability of personality, please see Montag 2016).

9.3 Is Internet Addiction Heritable? Are Personality and Genetics Related?

By definition genetics can also be viewed as a causal factor for Internet addiction, because genes coding for bodily products clearly represent the starting point for a long cascade of biochemical events, via neurotransmitters, brain structure, and functionality, to human behavior, such as being addicted to the Internet. In the following sections we briefly try to answer the question of whether Internet addiction is heritable, and also try to shed some light on the question of how the independent variables of interest in the present chapter—personality and genetics—relate to each other.

The broad topics of the present chapter—personality and genetics—are closely entwined, because personality traits, such as being high/low on anxiety or cooperativeness, are strongly influenced by genetics. Twin studies reported that individual differences in personality show heritability estimates about 0.50 (Jang et al. 1996; Polderman et al. 2015). This means that about half of the variation in personality traits between individuals is due to genetic influences. Clearly this represents an oversimplification, because the emerging field of epigenetics demonstrates how environmental influences shape genetic activity (Berger et al. 2009; Nestler 2012). As a consequence, nature and nurture are strongly entwined in shaping psychological phenotypes such as personality traits.

Of note, not only individual differences in personality, but also in the susceptibility to non-substance related addictions, are influenced by genetics, e.g., a review study on pathological gambling by Lobo and Kennedy (2009) illustrates this point nicely showing heritability estimates of 0.50–0.60. Unfortunately, no twin studies on Internet addiction have yet been conducted to allow for estimation of the

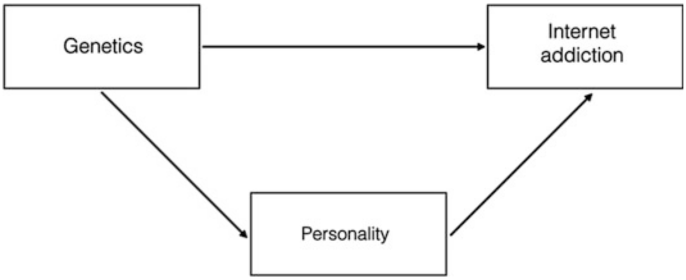

Fig. 9.1 Genetics could influence Internet addiction either directly or mediated via personality traits or other variables

influence of genetics on the disposition of Internet addiction. Given both the evidence from twin studies on pathological gambling and the findings from molecular genetics and Internet addiction (see below), it is likely that twin studies in this area will also come up with substantial heritability estimates.[1]

Investigating both molecular genetics and personality in the context of Internet addiction could reflect two sides of the same coin, because genes may exert their influence on Internet addition via personality (e.g., a mediation effect). Clearly it is also imaginable that genetic variations may exert their influence via the non-shared variance of the correlations (e.g., a direct influence) between personality and Internet addiction. This is depicted in Fig. 9.1 and will be discussed later on in this review (note that a new work by Hahn et al. (2017) using a twin design demonstrates that the genetic effects on individual differences in Internet addiction can indeed be explained by genetic effects on interindividual differences in personality).

9.4 Personality and Internet Addiction

Before summarizing the large body of studies dealing with Internet addiction and personality, several major issues hindering the generalization of results need to be highlighted.

9.4.1 Problems in Reviewing the 'Personality—Internet Addiction' Findings

First of all, the reviewed studies vary strongly with respect to the personality questionnaires administered. Although personality dimensions can be measured

[1]In the meanwhile, four twin studies on Internet addiction have been published showing that individual differences in Internet addiction may indeed be accounted for by a genetic component (Deryakulu and Ursavas 2014; Hahn et al. 2017; Li et al. 2014; Vink et al. 2015). These are highlighted in Chap. 8.

Table 9.1 A simplified overview on the investigated personality dimensions in the context of Internet addiction

Personality dimension	Explanation
Extraversion (vs. Introversion); can be measured with many questionnaires—e.g., NEO-FFI or NEO-PI-R or EPQ-R	Socially outgoing, optimistic, sometimes impulsive, risk-taking
Neuroticism (vs. Emotional stability); can be measured with many questionnaires—e.g., NEO-FFI or NEO-PI-R or EPQ-R	Emotional instable, anxious, having guilt feeling
Psychoticism can be measured with many questionnaires—e.g., EPQ-R	Cold-hearted, creative, antisocial, egocentric
Novelty Seeking (as measured by the Tridimensional Personality Questionnaire or the Temperament and Character Inventory)	Temperament dimension with the subscales exploratory excitability, impulsiveness, extravagance, and disorderliness (see also Kose 2003)
Harm Avoidance (as measured by the Tridimensional Personality Questionnaire or the Temperament and Character Inventory)	Temperament dimension with the subscales anticipatory worry, fear of uncertainty, shyness, and fatigability (see also Kose 2003)
Reward Dependence (as measured by the Tridimensional Personality Questionnaire or the Temperament and Character Inventory)	Temperament dimension with the subscales sentimentality, attachment, and dependence (see also Kose 2003)
Self-Directedness (the Temperament and Character Inventory)	Character dimension with the subscales responsibility, purposefulness, resourcefulness and congruent second nature (see also Kose 2003)
Impulsivity (as measured by the Barratt Impulsiveness Scale-11)	Impulsivity can be measured with three subscales named attentional, motor, and non-planning impulsivity (see also Stanford et al. 2009)

with different questionnaires, the intercorrelations of the different scales are far from perfect. For example, about 75% of non-shared variance can be observed when correlating personality traits linked to positive emotionality, such as *Extraversion* and *Novelty Seeking* (Montag et al. 2012a). Extraverts can be described as socially outgoing, sometimes impulsive and optimistic. Novelty Seeking is associated with being impulsive, extravagant, and loving to explore the world (Cloninger et al. 1993; Kose 2003). For a short overview on the most important personality dimensions in Internet addiction research, please see Table 9.1.

More problems arise when considering further characteristics of the reviewed studies. Some studies clearly only recruited very small samples (e.g., Armstrong et al. 2000, n = 50) and most studies focused on young participants, thereby lacking representativeness. In addition, one needs to consider the different cultural backgrounds of the conducted research. Different environments across the globe may have profound influences on human personality (and potentially also on disposition for Internet addiction). Another crucial point when comparing the results of the studies reviewed here concerns the dependent variable of interest, namely Internet addiction. Internet addiction has been measured very differently across all studies, ranging from the inclusion of psychiatrists' assessments, to a range of self-report questionnaires (e.g., Tao et al. 2010; Young 1998a, b). In this context the reader is referred to the important new field of *Psychoinformatics* (Markowetz et al. 2014; Montag et al. 2016a), which will aid the diagnostic process and treatment of Internet addiction. Please see also chapter 13 on this newly emerging topic in this book.

Last but not least, one of the reviewed studies investigated a specific form of Internet addiction—namely online gaming Internet addiction/Internet Gaming Disorder—in the context of personality (Kim et al. 2008). As recently reported by our own work group only generalized Internet addiction and online social network addiction show a large overlap in terms of their intercorrelations (Montag et al. 2015a). In contrast, online gaming addiction/Internet gaming disorder only shows small correlations with generalized Internet addiction and will therefore be largely excluded from this summary. Having observed the caveats, the next section will deal with the results of a large number of studies.

9.4.2 Neuroticism, Harm Avoidance, Psychoticism, and Internet Addiction

The reviewed studies are all presented in Table 9.2. Summarizing, it becomes obvious that several studies observed higher scores either for the personality trait *Neuroticism* or *Harm Avoidance* in Internet addicts as compared to non-afflicted controls (e.g., Tsai et al. 2009; Hardie and Tee 2007; Cao and Su 2007). *Neuroticism*

Table 9.2 Studies on personality and Internet addiction (some of the studies focussed also on other aspects besides personality, which are not summarized in the present review)

Authors	Participants	Internet addiction and personality inventories, etc.	Results
Armstrong et al. (2000)	N = 50 participants	Coopersmith Self-Esteem Inventory, Sensation Seeking Scale, MMPI-2 Addiction Potential Scale, Internet-Related Problem Scale	Low *Self-Esteem* was associated with Internet addiction. No association between *Impulsivity* (measured via the disinhibition scale of *Sensation Seeking*) could be observed with Internet addiction
Cao et al. (2007)	N = 2620 high school students from which a case–control study was conducted (with 64 Internet addicts and 64 control persons)	Eysenck Personality Questionnaire (edition for children), diagnostic questionnaire for Internet addiction	Internet addicts were associated with higher *Neuroticism*, higher *Psychoticism,* and *Lie scores*

(continued)

Table 9.2 (continued)

Authors	Participants	Internet addiction and personality inventories, etc.	Results
Cao et al. (2007)	N = 50 Internet addicts were contrasted with N = 50 healthy Internet users	Barratt Impulsivity Scale; diagnostic questionnaire for Internet addiction	Internet addicts showed higher *Impulsivity* scores than controls
Ha et al. (2007)	N = 452 Korean adolescents	Temperament and Character Inventory, Internet Addiction Test	Internet addiction was associated with high *Harm Avoidance*, low *Self-Directedness*, low *Cooperativeness,* and high *Self-Transcendence*
Han et al. (2007)	N = 154 participants (79 Internet addicts and 75 healthy controls)	Temperament and Character Inventory and Internet Addiction Test	Higher *Reward Dependence* in Internet addicts compared to healthy control persons
Hardie and Tee (2007)	N = 96 participants	International Personality Item Pool, Internet Addiction Test	*Neuroticism* is associated with Internet addiction
Kim et al. (2008)	N = 1471 online game users	Buss-Perry Aggression Questionnaire, Self-Control Scale, Narcissistic Personality Disorder Scale, Online Game Addiction Scale (modified from Young's Internet Addiction Test)	*Aggression* and *narcissistic* personality was positively associated with online game addiction. Moreover, a negative association with self-control turned up.
Ko et al. (2010)	N = 216 college students	Symptom criteria were used for diagnosing Internet addiction, Tridimensional Personality Questionnaire (TPQ)	Lower *Reward Dependence* and higher *Harm Avoidance* scores for Internet addicts
Ko et al. (2006)	N = 3662 students	Chen Internet Addiction scale, TPQ	High *Novelty Seeking*, high *Harm Avoidance,* and low *Reward Dependence* predicted Internet addiction
Lee et al. (2012)	N = 27 Internet addicts; N = 27 patients with pathological gambling, N = 27 healthy controls	Barratt Impulsiveness Scale, Young's Internet Addiction Test	Internet addicts show significantly higher *Impulsivity* scores than control persons (and comparable scores to the group of pathological gamblers)

(continued)

Table 9.2 (continued)

Authors	Participants	Internet addiction and personality inventories, etc.	Results
Montag et al. (2010)	N = 201 participants	Eysenck's Personality Inventory (-R), Revised, Temperament and Character Inventory, Internet Addiction Test	Low *Self-Directedness* is a better predictor for Internet addiction than *Neuroticism* or *Harm Avoidance*
Montag et al. (2011)	N = 610 participants	Among others NEO-FFI, Self-Directedness of the Temperament and Character Inventory and Internet Addiction Test	Low *Conscientiousness* and low *Self-Directedness* are associated with higher Internet addiction
Mottram and Fleming (2009)	N = 272 undergraduate students	UPPS Impulsive Behavior Scale, Extraversion from the Big Five Inventor	With respect to personality 'lack of perseverance' (a facet of impulsivity) was a predictor for Internet addiction
Sariyska et al. (2014)	N = 989 participants from seven countries	Self-Directedness of the Temperament and Character Inventory and Internet addiction test	In all countries under investigation (China, Taiwan, Germany, Bulgaria, Spain, Sweden, and Colombia) a negative association between high *Self-Directedness* and low Internet addiction could be observed
Tsai et al. (2009)	N = 1360 freshman in Taiwan	Chinese Internet Addiction Scale (-R), Chinese Health Questionnaire, Maudsley Personality Inventory	Male gender, *Neuroticism* and higher probability for psychiatric disorders are associated with Internet addiction
Yan et al. (2014)	N = 892 college students	Eysenck's Personality Questionnaire, Chen Internet Addiction Scale	Among others Internet addicts were characterized by higher *Neuroticism*, lower *Extraversion*, and higher *Psychoticism*
Yen et al. (2009)	N = 1992 college students	Behavioral Inhibition/Activation Scale (BIS/BAS), Chen Internet Addiction Scale	Higher scores of *BIS* and the *BAS Fun Seeking* subscale in Internet addicts

(continued)

Table 9.2 (continued)

Authors	Participants	Internet addiction and personality inventories, etc.	Results
Xiuqin et al. (2010)	N = 204 Internet addicts and N = 100 controls	Eysenck Personality Questionnaire Revised, Symptom Checklist 90 Revision, My Memories of Upbringing Scale, Internet addiction diagnosed via symptoms	Internet addicts are associated with lower *Extraversion* and higher *Psychoticism* scores. Moreover, Internet addicts reported more symptoms on the symptom checklist 90 and less parental support

itself (and also *Harm Avoidance*) is a well-known vulnerability factor for depression and more generally, a public health hazard (Lahey 2009). This also fits with the observation that Internet addicts or at least a subgroup of patients suffering from Internet addiction show high comorbidity with affective disorders (e.g., Kim et al. 2006; Sariyska et al. 2015). It is not clear, however, whether depression may cause Internet addiction, or if it represents an outcome of Internet addiction (ultimately, both ways are imaginable and likely). For a deeper discussion we refer to the works by Davis et al. (2001) and Brand et al. (2016). Please, see also Chaps. 1 and 2.

How can the anxiety–Internet-overuse link be explained? High neurotics/harm avoidant individuals are characterized by constant worrying about the future, and emotional instability. In the context of Internet addiction, being too anxious to interact with others, particularly, in face-to-face interactions, may represent the trigger to overuse the Internet (Shepherd and Edelmann 2005). The online world offers a more anonymous and distant way to fulfill the human need for social interaction, which may be accompanied by social withdrawal from the offline, real world. Clearly, these findings demonstrate that negative emotionality is closely linked to Internet addiction.

Adding to these findings, some studies report an association between *Psychoticism* and Internet addiction (Cao and Su 2007; Xiuqin et al. 2010). Thus, personality characteristics such as cold-heartedness underlying in extreme forms “psychotic and sociopathic behavior” (McCrae and Costa 1985, p. 588) have been linked to excessive Internet use. A look at the findings by Amiel and Sargent (2004) may explain this *Psychoticism* finding from a motivational perspective. Here, persons scoring high on the personality trait of *Psychoticism* showed a higher motivation to use “deviant, defiant, and sophisticated Internet Applications” (p. 711). This includes content such as illegal file sharing and use of pornography. Following this, *Psychoticism* may be of special and greater relevance when investigating specific forms of IA, such as online pornography addiction, rather than generalized Internet addiction. Finally, it has recently been suggested that high

Psychoticism together with high life stress may represent a unique vulnerability constellation for Internet addiction (Yan et al. 2014). Of note, personality traits such as *Psychoticism* need to be seen in the context of a continuum model. This means that humans can be characterized by lower or higher scores on such a personality dimension, but not in terms of distinct categories such as being a psychopath or not. As a consequence psychotic behavior is not per se psychopathological.

Of note, further studies have tried to link Cloninger's character dimension *Reward Dependence* (Han et al. 2007; Ko et al. 2006), as well as individual differences in *Impulsivity* (Armstrong et al. 2000; Cao et al. 2007; Lee et al. 2012), to Internet addiction. As described in Table 9.1, humans scoring high on *Reward Dependence* are sentimental, attach easily to others, and give a lot of attention to what others think about them. Impulsivity can be viewed as "swift action without forethought or conscious judgment" (Moeller et al. 2001, p. 1783). Impulsive behavior can be measured by the Disinhibition scale of the construct *Sensation Seeking* by Zuckerman (1990) or the Barratt Impulsiveness Scale (e.g., Stanford et al. 2009).

The studies dealing with *Reward Dependence* are inconsistent, as the results of the studies by Ko et al. (2006) and Han et al. (2007) point in opposite directions. The results on impulsive behavior are a bit more coherent (in particular those using the Barratt Impulsivity Scale), linking high impulsivity to Internet addiction. This link is also supported by academic discussions in favor of characterizing Internet addiction as an impulse control disorder (Shapira et al. 2003). Moreover, an association between the attention deficit and hyperactivity disorder (ADHD) and Internet addiction has been already established, which is particularly interesting as ADHD is also accompanied by impulsive behavior (Yen et al. 2007; Sariyska et al. 2015).

9.4.3 Individual Differences in Self-Directedness as a Core Feature of Internet Addiction?

The question arises, if traits related to negative emotionality and *Psychoticism* represent the best predictors for (generalized) Internet addiction. Our own data suggest that this might only partially be the case. Rather, a series of our own studies (Montag et al. 2010, 2011; Sariyska et al. 2014) showed that individual differences in the character dimension *Self-Directedness* may be a better predictor for Internet addiction. People scoring high on *Self-Directedness* are satisfied with their personality, accept themselves as they are, and handle their everyday life successfully. Clearly, these persons are also characterized by high self-esteem and high willpower.

In an initial study, we demonstrated that low *Self-Directedness* represents a better predictor for Internet addiction than high *Neuroticism*/*Harm Avoidance* (and *Psychoticism*, which played no role). In detail, the variables *hours of leisure Internet use each week* together with (low) *Self-Directedness* explained 25% of the variance in Internet addiction (Montag et al. 2010). *Harm Avoidance* and *Neuroticism* did not explain any additional variance in Internet addiction, when the two aforementioned variables were included in the regression model.

As this study was conducted with a student sample not at high risk for Internet addiction, we tried to replicate the link between low *Self-Directedness* and high Internet addiction in more than 600 participants, who were characterized by being online video gamers of first-person shooter video games (Montag et al. 2011). Although online video gamers focus on online games and are more prone to become addicted to this specific form of Internet addiction, they are also characterized by higher generalized Internet addiction (Montag et al. 2011). The association between *Self-Directedness* and Internet addiction was even stronger in this follow-up study [compare $r = -0.48$, $p < 001$ in the Montag et al. (2011) study to $r = -0.35$, $p < 0.001$ in the above-mentioned Montag et al. (2010) study], thereby giving support for a continuum model to explain the ‘Self-Directedness Internet addiction link’ from healthy to psychopathological use of the Internet. In addition, high *Conscientiousness* was negatively correlated with Internet addiction in this study.

Strongest support for the relevance of *Self-Directedness* in the context of Internet addiction came recently from a cross-cultural study including samples from China, Taiwan, Bulgaria, Spain, Sweden, Germany and Colombia (Sariyska et al. 2014). Despite differences in sociodemographic variables such as age and gender, and of course in cultural background across samples, low *Self-Directedness* was robustly associated with high Internet addiction scores in every sample under investigation. The importance of *Self-Directedness* has also been outlined in broader clinical terms by Cloninger et al. (1993), who state that *Self-Directedness* “is the major determinant of the presence or absence of personality disorder” (p. 979). Although we are not dealing with personality disorders in the present chapter, Cloninger et al. hint towards the tremendous clinical relevance of *Self-Directedness*, which is reflected by our present Internet addiction studies, too.

In sum, we believe that the character dimension *Self-Directedness*, of Cloninger’s Temperament and Character Inventory, represents a valuable tool in the treatment and research of Internet addiction. Deriving from our *Self-Directedness* results, therapeutic treatment of Internet addicts should aim at restructuring the patients’ lives. Moreover, the therapy should focus on the acceptance of one’s own strength and weaknesses, self-regulation/will power abilities and on the related area of self-esteem.

9.4.4 New Advances in the Study of Personality and Internet Addiction

For the second edition of the Internet addiction book, we decided to update the present chapter with this section presenting new advances in the field of personality and Internet addiction. Many new studies have been published since the initial release of this chapter supporting the importance of the already described associations between individual differences in personality and Internet addiction. Among others Yan et al. (2014) and Wu et al. (2015) provided additional evidence for a role of high *Neuroticism* to understand tendencies toward Internet addiction. Ying et al. (2015) published data also stressing the role of *Neuroticism* (and *Psychoticism*) for Internet addiction when investigating urban left-behind children. Besides the robustness of this association, earlier research by Kuss et al. (2013) demonstrated that the *Neuroticism*/personality–Internet addiction link is more complicated than "just" being strictly linear across all possible investigated populations, because distinct domains of online (over-)usage have to be taken into account. Kuss et al. even reported that "A combination of online shopping and neuroticism *decreased* the risk for Internet addiction, whereas a combination of online gaming and openness to experience increased it" (p. 959). In the meanwhile, also other personality constructs have been revisited in the context of Internet addiction in the literature. Here, Burnay et al. (2015) and Floros et al. (2015) gave additional support for the importance of the trait *Impulsivity*.

Clearly, many more studies have been published on the link between personality and Internet addiction since the initial release of this chapter, but we refrain from adding all relevant studies to the already high number of studies presented in Table 9.2 (given also some redundancies). Instead we now want to present a short additional overview on studies going beyond classic personality–Internet addiction associations.

In our opinion the study by Ko et al. (2015) is in particular noteworthy, because researchers asked students to fill in questionnaire inventories after having evoked different mind sets. In detail, the participants of the study were asked how they see their personalities when being online vs. offline (in detail individual differences in the *Behavioral Activation System* (BAS) and *Behavioral Inhibition System* (BIS) were assessed). The methodological approach used by Ko et al. fits with the classic idea put forward by Mischel and Shoda (1995) demonstrating that stability of individual differences in personality foremost can be observed when taking into account the different kinds of nature of a given situation. Imagine a person being shy: this person might always be shy in the offline world, but less shy in the online world. Therefore, context matters a lot to understand the stability of personality. Coming back to the study by Ko et al. (2015), they observed a smaller decrease in BIS and BAS when Internet addicted students got online.

Further approaches in the study of Internet addiction take into account that personality associations with digital addictive tendencies might be influenced by the diverse domains of possible Internet overusage. Here, Wang et al. (2015) observed that lower *Conscientiousness* and lower *Openness* to *Experiences* were associated with online gaming addiction. In contrast higher *Neuroticism* and higher *Extraversion* were associated with higher online social network addiction. Another unique pattern could be observed for generalized Internet addiction in this study (lower *Conscientiousness* and higher *Neuroticism*). This again shows the importance to disentangle different kinds of online activities when dealing with Internet addiction.

Finally, a study by Montag et al. (2016b) tested Hofestede's construct of *Power Distance* in the context of Internet addiction: It has often been reported that Western and Eastern cultures differ in terms of *Power Distance* (with higher acceptance of *Power Distance* in Asia compared to Europe). The concept of *Power Distance* describes the psychological distance between persons such as father to son or teacher to student. In our study, we were able to show that higher acceptance of *Power Distance* was associated with higher tendencies towards Internet addiction in two samples (one from China and one from Germany). Future research clearly will need to address more the influence of cross-cultural contexts on the development of Internet addiction interacting with personality traits. In addition, new important interpersonal constructs such as individual differences in empathy need to be considered as relevant variables. Melchers et al. (2015) reported in a German and Chinese sample that lower empathy is associated with higher Internet addiction. Here, it will be interesting to understand if lower empathy is a consequence or a cause for higher Internet addiction (for a deeper discussion on the link between empathy and smartphone/Internet addiction see Montag and Walla 2016).

9.5 Molecular Genetics and Internet Addiction

As mentioned in the introduction, the present chapter also deals with molecular genetics and Internet addiction. To date, three studies have investigated—by means of a candidate gene approach—the molecular genetics of Internet addiction.

The first study was published by Han et al. (2007), and investigated two prominent dopaminergic genetic variations in the context of Internet addiction. A role for dopamine in Internet addiction is very probable, because reduced dopamine transporters have been observed in striatal regions of the human (Internet addicted) brain (Hou et al. 2012; Kim et al. 2011) and Internet gaming addicts show stronger striatal responses to gaming cues compared with controls (Ko et al. 2009). In general, dopamine represents the classic neurotransmitter in the investigation of addiction because it is discussed to be the final common pathway of reward (Pierce and Kumaresan 2006). The molecular genetic findings by Han et al. (2007) provide support for a role for dopamine in Internet addiction, as the catechol-o-methyltransferase (COMT) Val158Met polymorphism, which crucially influences the dopamine catabolism, was associated with Internet addiction. The COMT 158Met allele variant, associated with a 3–4-fold lower activity of the COMT enzyme (Lachman et al. 1996), occurred significantly more often in Internet addicts compared to controls. In addition to this dopaminergic target, the authors also investigated the ANKK1/DRD2 Taq Ia polymorphism, which is associated with individual differences in D_2 receptor density in striatal regions (Pohjalainen et al. 1998). Here, Internet addicts were linked to a higher occurrence of the A1+ variant (carrying at least one A1 allele) compared to controls. Of note the A1+ variant is associated with a 30–40% reduction in D_2 receptors (Pohjalainen et al. 1998), and has previously been associated with alcoholism (Munafo et al. 2007). Other addictive forms including opioids or smoking have been also associated with this genetic variant (e.g., De Ruyck et al. 2010; Wang et al. 2013). Deriving from this, similar biochemical processes could underlie substance- and non-substance-related addictions.

The Han et al. (2007) study also reported that Internet addicts are associated with higher *Reward Dependence* scores. In addition, among Internet addicts, carriers of the A1+ variant showed significantly higher scores in *Reward Dependence* compared to control persons. This provides support for the earlier suggestion, depicted in Fig. 9.1, that genetic variations may target personality traits and thereby indirectly influence vulnerability to Internet addiction. Although this was not tested directly in the Han et al. study, the results do point in this direction (please see the twin study by Hahn et al. (2017) and Chap. 8 demonstrating that this kind of explanation is convincing).

Further indirect support for a role of dopamine in Internet addiction comes from a study investigating the CHRNA4 gene coding for the subunit alpha 4 of the nicotinic acetylcholine receptor gene (Montag et al. 2012b). Of special note for the dopamine link is the observation that the administration of nicotine, such as by smoking a cigarette, triggers the dopaminergic system (Corrigall et al. 1992). In the context of the investigated CHRNA4 gene, carriers of the CC variant of the single-nucleotide polymorphism rs1044396 on this gene were associated with Internet addiction, because this genetic variation occurred significantly more often in the Internet addict group compared to the control group. Interestingly, this same CC variant associated with Internet addiction has previously also been associated with smoking (Feng et al. 2004).

A further statistical analysis of the CHRNA4–Internet addiction link revealed that this effect was mainly observed in female Internet addicts. This could be explained by the potentially higher use of social networking sites in females (Thelwall 2008; see also social network usage on smartphones in Montag et al. 2015b), although this statistical effect could be rather small, and may depend on the site(s) used (Hargittai 2007). Data on the gender–social network link could not be provided in the Montag et al. (2012b) study, because activities in special domains of the Internet use were not collected.

Besides dopamine, mounting evidence from psychopharmacology and molecular genetics suggests that serotonin may also play a crucial role in the biochemistry of Internet addiction. First evidence from the psychopharmacological treatment of Internet addicts shows some success in treating Internet addicts with selective serotonin reuptake inhibitors (e.g., Atmaca 2007; Camardese et al. 2012, see Chap. 14). Moreover, Lee et al. (2008) demonstrated that a genetic variation of the gene SLC6A4 coding for the serotonin transporter could be associated with Internet addiction. In detail, the s-variant of the so-called serotonin transporter polymorphism 5-HTTLPR occurred more often in Internet addicts compared to control persons. Of note, the s-variant has been associated with lower mRNA expression of the serotonin transporter gene and therefore, putatively, also with a lower number of presynaptic transporters (Lesch et al. 1996). It has to be pointed out that 5-HTTLPR has meanwhile qualified as a super-vulnerability-factor for psychopathological disorders. Since Lesch et al. demonstrated for the first time in 1996 an association between 5-HTTLPR and the personality factor of neuroticism, countless studies have reported associations between this polymorphism and all sorts of disorders, among these also drug addiction (for a review see Kenna et al. 2012). Finally, we hint to new developments implicating oxytocin as a potent neuropeptide for a better understanding of the molecular basis of Internet addiction as outlined in a conference presentation by Sariyska et al. (2015) and a new theoretical framework by Montag et al. (2016c).

9.6 General Internet Usage and Personality

The present chapter focused explicitly on a review of studies dealing with Internet addiction, molecular genetics, and personality. There are several studies dealing also with a description of the link between normal/healthy use of the Internet and personality, which has not been considered in the present chapter, e.g., Hamburger and Ben-Artzi (2000) reported that male extraverts use the Internet for leisure activities, whereas extraversion was negatively correlated with (online) leisure activities in females. Moreover, female neurotics more often used online social services. Interestingly, Hills and Argyle (2003) could not find a strong link between the use of 16 different services and individual differences in personality when age and gender were controlled for. This is not surprising, because Hamburger and Ben-Artzi (2000) provided evidence for gender-dependent differences in Internet usage. An interesting observation has been made by Amiel and Sargent (2004) while researching motives for Internet usage. Neurotics used the Internet to fulfill a need for belonging and being informed. Extraverts used the Internet in very goal oriented manners (e.g., research or music sharing) but not for reasons of meeting people online. Finally, users scoring high on *Psychoticism* showed interest in more extreme Internet usage (as mentioned above).

9.7 Conclusions

The present review showed that genetic variations of the dopaminergic, serotonergic, and cholinergic system are associated with Internet addiction. Preliminary evidence suggests that the neuropeptide oxytocin might be also a new interesting candidate for a better understanding of the molecular basis of Internet addiction. From classic personality psychology comes evidence that personality traits linked to negative emotionality, but perhaps more important to self-regulation and self-esteem, are strongly linked to Internet addiction. As both the genetic variations and personality traits discussed here are known to play a role in other addictions (e.g., Basiaux et al. 2001; Guo et al. 2007), it is likely that same (bio)psychological mechanisms underlie Internet addiction as other addictions.

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Chapter 10
Autonomic Nervous System and Brain Circuitry for Internet Addiction

Andrew Chih Wei Huang

Abstract The autonomic nervous system can be divided into sympathetic and parasympathetic divisions. The activation of the sympathetic and parasympathetic autonomic nervous systems in Internet addiction is similar to that in drug addiction. The sympathetic division is more strongly reactive, with responses in internal glands and bodily organs and acceleration of heart rate (or blood volume pulse) and respiratory response rate as well as a reduction of temperature, while surfing the Internet. However, contradictory data have also been obtained. Decelerations of skin conductance have also been observed in Internet addiction, showing activity of the parasympathetic division, but not the sympathetic division. Drug addiction produces greater activation of the sympathetic nervous system, but less activation of the parasympathetic system. The autonomic nervous system reciprocally connects to neural circuitry in the brain to modulate both systems, reflecting specific features of Internet addiction. Moreover, Internet addiction induces numerous behavioral and psychopathological symptoms related to pathogenesis, including depression, anxiety, hostility, psychoticism, interpersonal sensitivity, attention-deficit/hyperactivity disorder, obsessive-compulsive disorder, novelty seeking, and social anxiety disorder. Therapeutic interventions for Internet addiction, including pharmacological and non-pharmacological treatments, need to be linked to psychopathological symptoms. The autonomic nervous system, brain circuitry pathogenesis, and specific interventions targeting Internet addiction are discussed in the present review article.

10.1 Introduction

Internet addiction is a newly emerging and increasing prevalent addictive disorder. In contrast to drug addiction, Internet addiction does not directly act via substance consumption on receptors of neural substrates to induce compulsive and impulsive behavior. Thus, while Internet addiction may partially share neural substrates with

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_10

Table 10.1 The neural mechanisms, pathogenesis, and interventions of Internet addiction

Internet addiction		
Neural mechanisms	Pathogenesis	Interventions
1. Central nervous system: neural substrates	Psychopathological behaviors/symptoms	1. Pharmacological treatments
2. Peripheral nervous system: autonomic nervous system (1) Sympathetic nervous system (2) Parasympathetic nervous system	1. Before Internet addiction: Obsessive-compulsive disorder 2. After Internet addiction: Depression, anxiety, hostility, interpersonal sensitivity, and psychoticism	2. Non-pharmacological treatments

drug addiction, it also involves some different brain mechanisms to drug addiction. Comparisons of neural substrates in the peripheral autonomic and central nervous systems of the brain between Internet addiction and drug addiction allows a better understanding of the behavioral and neural mechanisms of Internet addiction.

Internet addiction has been linked to many psychopathological and behavioral symptoms, such as depression, anxiety, hostility, psychoticism, interpersonal sensitivity, attention-deficit/hyperactivity disorder, obsessive-compulsive disorder, novelty seeking, and social anxiety disorder. The pathogenesis of Internet addiction is discussed in the present article, and the current discussion may provide some novel viewpoints into therapeutic interventions for Internet addiction.

To enable a better understanding of Internet addiction, it is important to combine our knowledge of the activity of the autonomic nervous system and neural circuitry in the brain, as the pathogenesis of Internet addiction presumably results from behavioral and neural activity arising from these systems. Accordingly, interventions for Internet addiction may be based on the pathogenesis of Internet addiction. Therefore, three components of Internet addition—pathogenesis, neural mechanisms, and interventions—are interconnected, and their relationship is shown in Table 10.1. The present review article discusses these three aspects of Internet addiction.

10.2 Internet Addiction and the Peripheral Nervous System

10.2.1 Internet Addiction Impacts the Autonomic Nervous System

To our knowledge, little research has investigated how Internet addiction affects the autonomic nervous system with regard to the sympathetic and parasympathetic divisions. Our 2010 study was the first to delve into this interesting issue. The study

Table 10.2 Spearman correlations among BVP, SC, TEMP, RESPR, and CIAS score

	BVP	SC	TEMP	RESPR	CIAS score
BVP (%) (Mean = 0.024, SE = 0.011)	1.000	–	–	–	–
SC (%) (Mean = 0.649, SE = 0.223)	−0.101 0.239	**1.000**	–	–	–
TEMP (%) (Mean = 0.002, SE = 0.009)	−0.056 0.346	**−0.461**[a] **0.000**	1.000	–	–
RESPR (%) (Mean = 0.202, SE = 0.039)	−0.044 0.379	**−0.238**[b] **0.045**	0.001 0.497	1.000	–
CIAS score (Mean = 56.221, SE = 1.605)	0.188 0.091	**−0.065** **0.323**	−0.312[b] 0.012	0.336[a] 0.007	1.000

[a]$p < 0.01$
[b]$p < 0.05$, significant α value of Spearman correlation

used the Chen Internet Addiction Scale (CIAS) to assess the magnitude of Internet addiction and to screen participants for allocation into low- and high-risk Internet abuse groups. Four psychophysiological assessments of autonomic nervous activity, including blood volume pulse (BVP), skin conductance (SC), peripheral temperature (TEMP), and respiratory response (RESPR), were recorded while the participants spent 6 min browsing the Internet. Some important findings were obtained in this study. First, RESPR and TEMP were sensitive psychophysiological indices of Internet addiction that were positively and negatively correlated with CIAS score, respectively. Blood volume pulse and SC were unrelated to CIAS score (Table 10.2). Blood volume pulse and RESPR in high-risk Internet abusers were significantly increased compared with low-risk Internet abusers. Skin conductance and TEMP were lower in high-risk abusers compared with low-risk abusers (Figs. 10.1, 10.2, 10.3 and 10.4). This means that greater activation of the sympathetic nervous system, reflected in the increased BVP and RESPR together with decreased TEMP, was observed in the high-risk Internet abusers. However, the SC results showed paradoxical responses in comparison to the other psychophysiological indices. Lower skin conductance activation was observed among high-risk abusers, suggesting that the parasympathetic nervous system was simultaneously activated in this group. Based on these observations, the autonomic activity hypothesis of Internet addiction is suggested to explain how the sympathetic and parasympathetic divisions of the autonomic nervous system are activated in Internet abusers.

The autonomic nervous system is composed of sympathetic and parasympathetic divisions (Fig. 10.5). With regard to structure, the sympathetic and parasympathetic nervous systems can be divided into preganglionic and postganglionic neurons. The dissociation between the sympathetic and parasympathetic divisions involves preganglionic fibers in the sympathetic nervous system that are shorter than those in the parasympathetic nervous system. Similarly, preganglionic fibers in the parasympathetic nervous system are longer than those in the sympathetic nervous

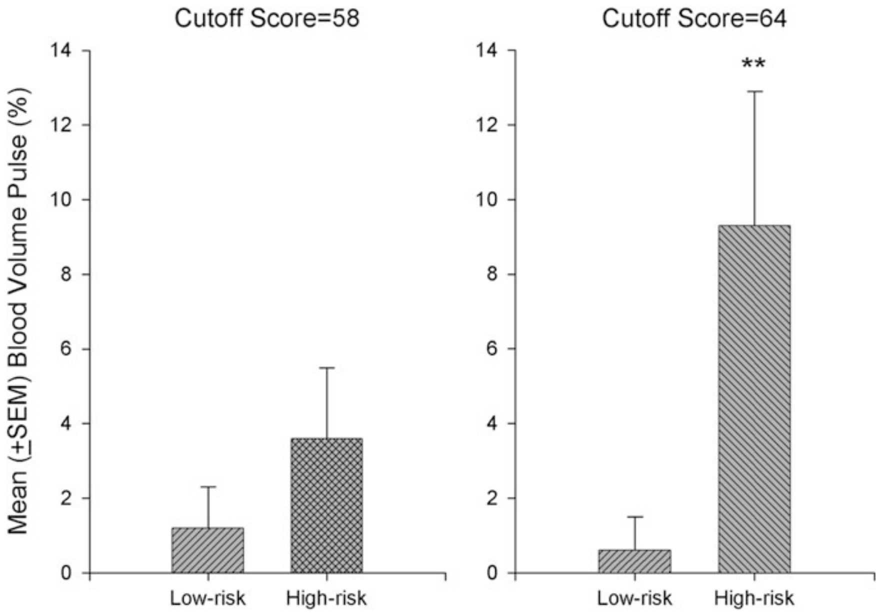

Fig. 10.1 Mean (±SEM) BVP (%) in high- and low-risk Internet abusers, with cutoff scores of 58 or 64 in the CIAS screening of Internet addiction. $^{**}p < 0.01$, versus low-risk group with the same cutoff score

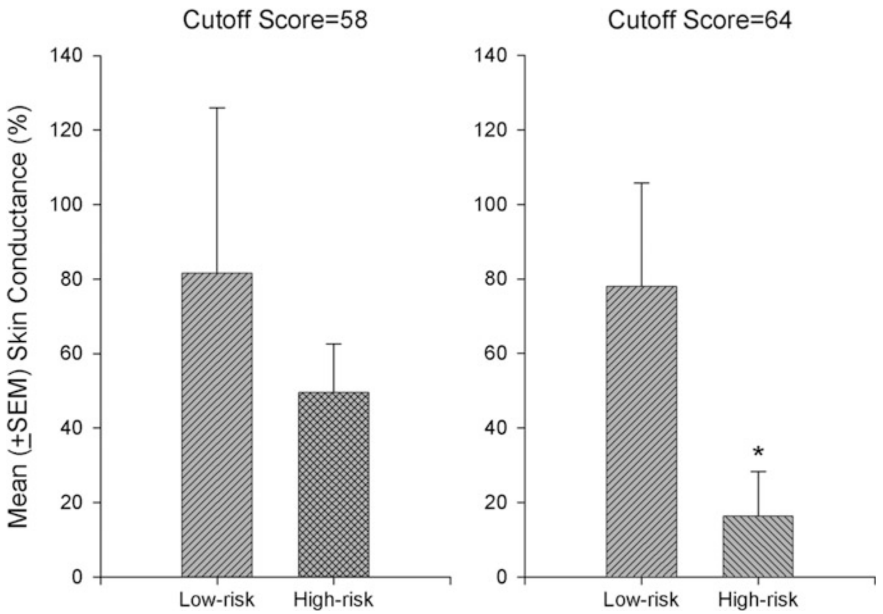

Fig. 10.2 Mean (±SEM) SC (%) in high- and low-risk Internet abusers, with cutoff scores of 58 or 64 in the CIAS screening of Internet addiction. $^{*}p < 0.05$, versus low-risk group with the same cutoff score

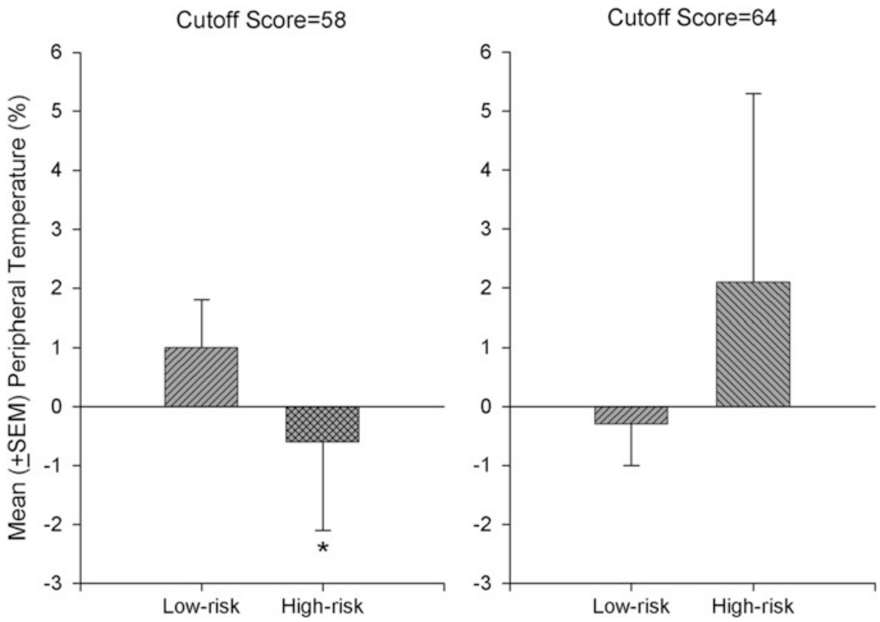

Fig. 10.3 Mean (±SEM) TEMP (%) in high- and low-risk Internet abusers, with cutoff scores of 58 or 64 in the CIAS screening of Internet addiction. *$p < 0.05$, versus low-risk group with the same cutoff score

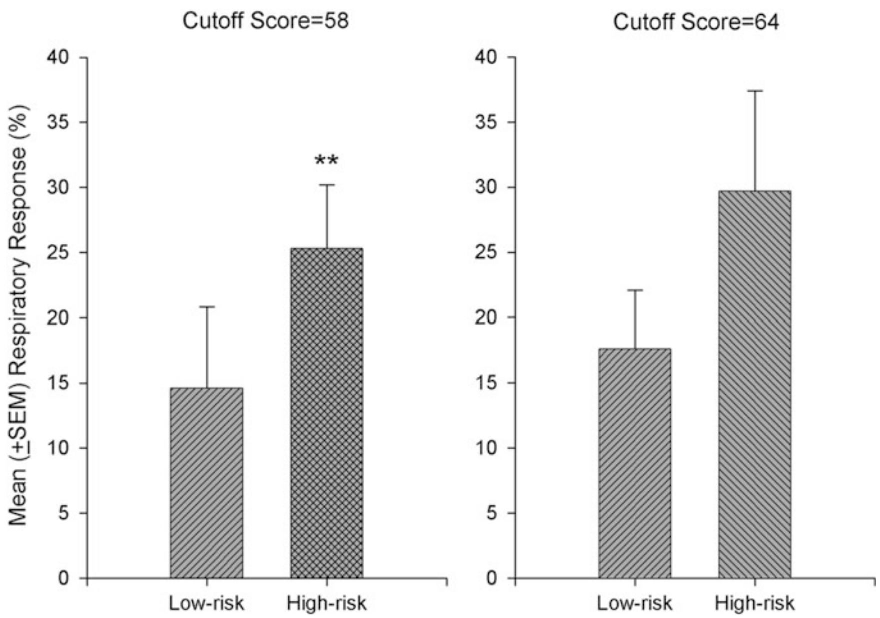

Fig. 10.4 Mean (±SEM) RESPR (%) in high- and low-risk Internet abusers, with cutoff scores of 58 or 64 in the CIAS screening of Internet addiction. **$p < 0.01$, versus low-risk group with the same cutoff score

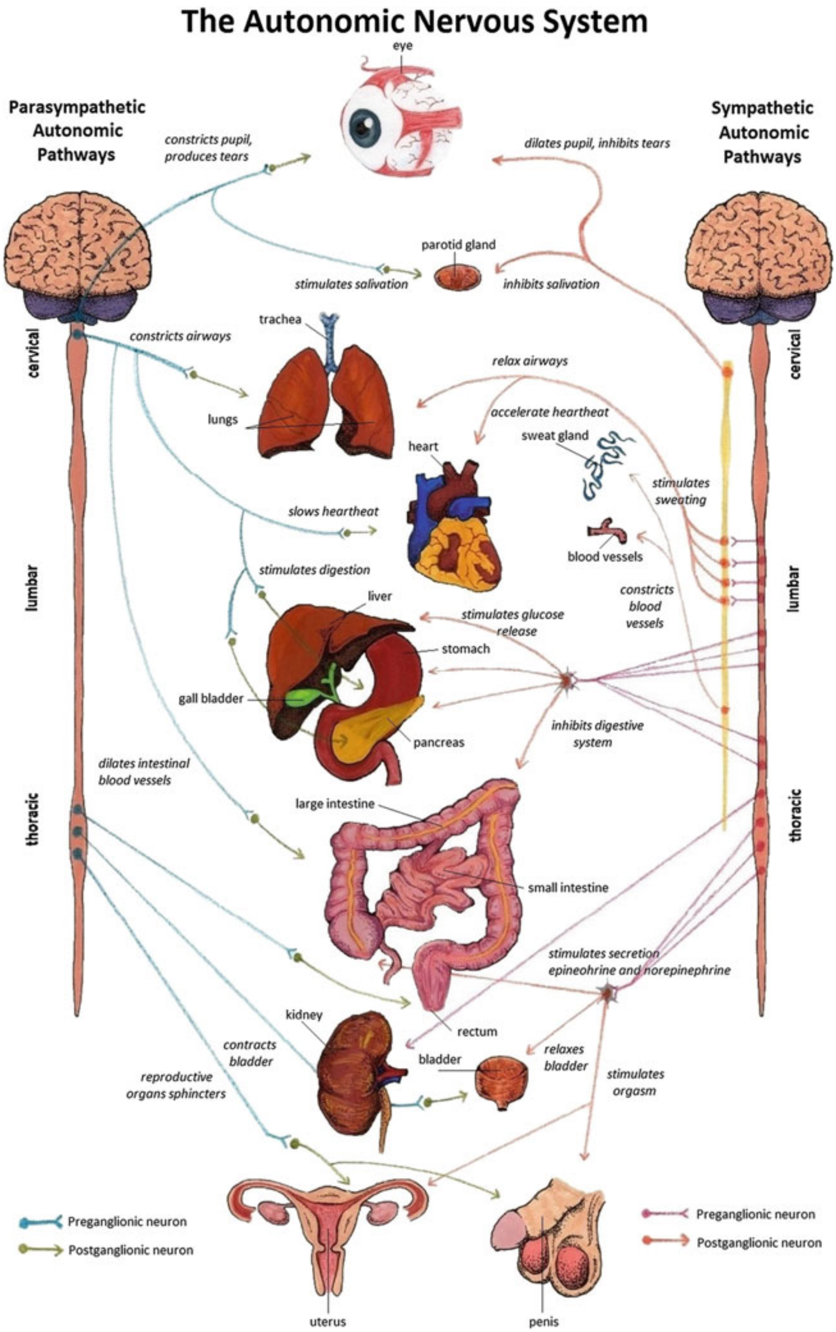

Fig. 10.5 The autonomic nervous system. The schematic figure depicts the target organs and functions served by the sympathetic and parasympathetic fibers of the autonomic nervous system

system. With regard to functional aspects, the sympathetic nervous system has been shown to govern and enhance the activation of internal glands and bodily organs. The parasympathetic nervous system plays an inhibitory role to attenuate the activity of glands and organs. The sympathetic/parasympathetic divisions are activated within the same internal glands and bodily organs in a complementary way. When the sympathetic division is activated, the parasympathetic division is antagonized, and vice versa. This is referred to as sympathetic-parasympathetic antagonism (Carlson 2007). However, our previous data seemingly contradict the notion of sympathetic-parasympathetic antagonism. One question is why the sympathetic division is activated with regard to BVP, TEMP, and RESPR, and the parasympathetic division responds with changes in SC at the same time. This issue warrants further investigations.

Similarly paradoxical findings related to sympathetic-parasympathetic antagonism have been reported in a number of studies. For example, a study of voluntary control of physiological feedback affecting autonomic activity, found that heart rate feedback training reduced heart rate, and the deceleration in heart rate was linked to an increase in SC magnitude. The results showed a contradiction between the sympathetic division (i.e., SC responses) and parasympathetic division (i.e., heart rate activity; Gatchel 1976). Another study investigated how pathological worry affects heart rate variability arising from the sympathetic-parasympathetic nervous system. Their results indicated that threat stimuli (e.g., worrisome events) inhibited heart rate variability, and this effect was likely attributable to the inhibition of parasympathetic activity and simultaneous suppression of the sympathetic response (Weng and Teng 2005). A critical review reported that the activity arising from the sympathetic-parasympathetic divisions of the autonomic nervous system cannot be understood in terms of an antagonism of sympathetic and parasympathetic nervous activities on the level of each single internal gland or bodily organ, because some glands and organs are controlled by the single sympathetic or the single parasympathetic division of autonomic nervous system activity (Meyers 1959). For illustrative purposes; sympathetic but not parasympathetic nerves innervate nictitating membranes, most blood vessels, and sweat glands. On the other hand, the lacrimal gland, ciliary body, and iridal muscle are controlled by parasympathetic nerves, but not sympathetic nerves. Vascular smooth muscles are governed by alterations of activity in parasympathetic fibers. Although salivary glands are mediated by the sympathetic-parasympathetic divisions, two different types of cells within the salivary gland receive either sympathetic or parasympathetic innervations. In conclusion, internal glands and bodily organs may synergize but not antagonize each other through the sympathetic-parasympathetic divisions (Meyers 1959). Therefore, our previous contradictory data showing sympathetic and parasympathetic activity with regard to BV, TEMP, RESPR, and SC, are consistent with the idea that sympathetic and parasympathetic nervous system do not necessarily antagonize each other.

10.2.2 Explanations for Contradictory Data in Four Psychophysiological Measurements in Internet Addiction: Rewarding and Aversive Properties of Addiction

Our contradictory findings indicate that the observed differences in BV, TEMP, and RESPR in Internet addicts may be attributable to reactivation of the sympathetic division, and that alterations in SC in Internet addicts may result from parasympathetic activity. The hypothesis of the rewarding and aversive properties of addiction may help to explain this contradictory data.

According to this hypothesis, addictive stimuli and their associated cues result in both rewarding and aversive effects, which influence the sympathetic-parasympathetic divisions of autonomic nervous system activity. Two lines of research have elucidated the activity of the sympathetic-parasympathetic divisions of the autonomic nervous system in humans and animals when individuals are confronted with rewarding and aversive events (Bradley et al. 2008; Ettenberg and McFarland 2003; Firestone and Douglas 1975; Inagaki et al. 2005). For example, a recent animal study investigated the relationship between reward conditioning and activity of the autonomic nervous system. This study showed that both conditioned stimuli (i.e., cue) and unconditioned stimuli (i.e., reward) significantly increased heart rates (Inagaki et al. 2005). Additionally, a previous animal study examined the effect of the dopamine D2 receptor antagonist haloperidol on heroin consumption-related automatic activity and behavioral performance (in terms of reward and motivation). This study found that haloperidol attenuated heart rate and running speed following heroin injections. These results demonstrate that the blocking of the dopamine D2 receptor decreased the rewarding effect of heroin and reduced heart rate (Ettenberg and McFarland 2003). A prior human study assessed SC and heart rate under reward, punishment, and reward + punishment conditions. The results indicated that SC was not significantly different between these three groups, but the heart rate response was stronger in the reward condition than in the other two conditions (Firestone and Douglas 1975). Another human study examined how arousal in response to pleasant, unpleasant, and neutral pictures influenced autonomic activation. The subjects' pupil diameters and SC responses were increased when encountering pleasant and unpleasant pictures, but heart rate was decreased in relation to the occurrence of the unpleasant picture (Bradley et al. 2008).

On the other hand, the way in which aversive stimuli induce sympathetic-parasympathetic activity of the autonomic nervous system remains unclear (Campbell and Ampuero 1985; Ditto et al. 1987; Marsh et al. 2008; Miller and Ditto 1988, 1989, 1991; Olafsdottir et al. 2001; Palomba et al. 2000; Sirota and Schwartz 1976; Weng and Teng 2005). One study tested cardiac performance while watching an unpleasant film and showed that sympathetic nervous system activity was enhanced when subjects encountered the unpleasant film, including an increase in heart rate and electrodermal activation (Palomba et al. 2000). A facial expression study demonstrated that sad facial expressions (i.e., aversive stimuli) facilitated parasympathetic activity and reduced sympathetic responses, with lower SC (Marsh et al. 2008). An animal study examined how conditioned heart rate was activated in response to aversive classical conditioning with conditioned stimuli (e.g., light or tone) and unconditioned stimuli (e.g., electric shock). The authors reported that the presentation of the conditioned stimulus, which was associated with an aversive unconditioned stimulus, produced a prolonged deceleration in heart rate (Campbell and Ampuero 1985). The team of Miller and Ditto has found that subjects who were exposed to an aversive stimulus in a video-game avoidance task exhibited an increase in heart rate and peripheral vascular responses (Miller and Ditto 1988, 1989). Moreover, they have also shown that aversive psychological stress could elicit strong sympathetic activity, such as an increase in cardiovascular responses (Miller and Ditto 1991). A previous human study trained female subjects to voluntarily control their heart rate under aversive conditions using a biofeedback device, and reported that all of the subjects could voluntarily decelerate their heart rate to relieve anxiety and fear reactions (Sirota and Schwartz 1976). Their evidence suggests that aversive stimuli increase the activity of the sympathetic nervous system through enhanced heart rate.

An old hypothesis developed by Silvestrini (1990) to explain how aversive stress activates the autonomic nervous system suggests that a stress-related stimulus may elicit both orthodox and paradoxical stress reactions. These two stress reactions are reflected in the response of the sympathetic system when individuals encounter emergency situations. The orthodox responses consist of pupil dilation, increased blood pressure or heart rate, the concentration of blood flow at specific organs (e.g., the heart and muscles), the facilitation of blood coagulation, an increase in the metabolism of glycogen to glucose, the inhibition of some instinctual drives (e.g., hunger and sex), increases in alertness, mental activity, and muscle strength. These orthodox responses result in the effects of analgesia in physical and mental conditions. On the other hand, paradoxical stress responses are thought to be a common basis for some abnormal conditions including depression, panic attack, obesity, sexual deviation, alcoholism, and drug addiction. The paradoxical stress response produces an effect opposite to the orthodox response. For example, the orthodox stress response is speculated to decrease hunger and sex, but the paradoxical stress response excessively increases hunger and sex drives, eventually resulting in obesity and impotence. Silverstrini explained the paradoxical stress responses induced by some abnormal conditions and said, “On the basis of my empirical clinical experience, I have proposed that depression is associated with a state in which stress produces mental pain, rather than analgesia” (Silvestrini 1990, p. 7). Internet addiction also involves these abnormal and psychopathological domains (e.g., depression, obesity, alcoholism, and drug addiction) and therefore is expected to induce a paradoxical stress response, resulting in the effect of mental pain but not analgesia.

Based on the prior data, we suggest that a rewarding event (or the anticipation) may trigger sympathetic nervous system activity (e.g., an increase in heart rate and SC), whereas an aversive event may elicit parasympathetic nervous system activity (e.g., a decrease in heart rate and SC). Nevertheless, it is of importance to remember some of the aforementioned inconsistencies of sympathetic-parasympathetic divisions of the autonomic nervous system, in the context of rewarding and aversive events.

In summary, individuals with Internet addiction are suggested to expose to these two contradictory rewarding and aversive processes. When surfing the Internet, Internet abusers may encounter a rewarding process. However, when they do not use the Internet, Internet abusers may experience aversive feelings that may be related to withdrawal symptoms (Young 1996). The autonomic activity hypothesis of Internet addiction is proposed in this regard; suggesting that the sympathetic nervous system is activated by the rewarding properties of Internet addiction. However, we found that SC did not follow this viewpoint because Internet abusers exhibited lower SC than normal subjects. Therefore, the SC response is likely related to parasympathetic activity.

10.2.3 Drug Addiction Reflected in the Autonomic Nervous System: Comparison with Internet Addiction

In contrast to Internet addiction, most addictive drugs exert their effects in the sympathetic-parasympathetic divisions of the autonomic nervous system with apparent consistency, indicating that the sympathetic nervous system, but not parasympathetic activity, is more active in drug addiction (Table 10.3; Brunelle et al. 2006; Fishbein et al. 2005; Henry et al. 2012). For example, some addiction studies related to betel chewing found that consumption of a small amount of a betel nut can induce more cardiovascular responses, suggesting that it results from sympathetic nervous activity, whereas large amounts of consumption cause hyperactivity of the parasympathetic nervous system (Chu 1995, 2001, 2002). Abusers with methamphetamine dependence have been shown to have decreased heart rate variability, reduced parasympathetic activity, and attenuated heartbeat variability, while they also show increased sympathetic activity with heart rate facilitation (Henry et al. 2012). A comparative investigation of drug addiction among psychostimulant, marijuana, and hallucinogen abusers that assessed the activity of the autonomic nervous system found that psychostimulants abusers had significantly higher ethanol-induced heart rate increases than non-abusers. However, alcohol-induced heart rate in marijuana abusers and hallucinogen abusers was not significantly different compared to controls. This suggests that psychostimulant addiction can elicit hyperactivity of the sympathetic nervous system (Brunelle et al. 2006). A recent study of polydrug abuse, including cocaine, heroin, alcohol, marijuana, and amphetamine, indicated that drug abusers had a stronger SC response and worse performance on Gambling and Rogers Decision Making Tasks, suggestive of hyperactivity of the sympathetic nervous system in drug addiction (Fishbein et al. 2005). A review article related to alcohol addiction suggested that animals with alcohol withdrawal symptoms had increased heart rate and RESPR

Table 10.3 Comparisons of heart rate/blood volume pulse, skin conductance, finger temperature, and respiratory rate of the autonomic nervous system for Internet addiction and drug addiction

Autonomic nervous system activity					
Type	Characteristic				Note
	HR/BVP	SC	TEMP	RESPR	
Internet addiction	+(S)	−(Para)	−(S)	+(S)	
Betel chewing	+(S)	+(S)	N/A	N/A	Small amount →Sympathetic activity (↑) Large amount →Parasympathetic activity (↑)
Methamphetamine	+(S)	N/A	N/A	N/A	
Stimulant user (alcohol challenge)	+(S)	N/A	N/A	N/A	
Marijuana user	None	N/A	N/A	N/A	
Hallucinogen user	None	N/A	N/A	N/A	
Polydrug abuse (cocaine, heroin, alcohol, marijuana, and methamphetamine)	N/A	+(S)	N/A	N/A	
Alcohol (withdrawal state)	+(S)	N/A	N/A	+(S)	
Alcohol user	+(S)	N/A	−(S)	N/A	
Opiate user (heroin, morphine)	−(Para)	N/A	N/A	−(Para)	
Naltrexone therapy (+) or Methadone therapy (−)	+(S)	N/A	N/A	N/A	

HR heart rate; *BVP* blood volume pulse; *TEMP* peripheral temperature; *RESPR* respiratory response; *S* sympathetic nervous system; *Para* parasympathetic nervous system; *N/A* not applicable

(Becker 2000). However, acute and chronic alcohol administration has been shown to enhance heart rate and inhibit TEMP (Boschloo et al. 2011; Johnson et al. 1986), indicating sympathetic nervous system activity, regardless of withdrawal and administration phases.

Opiate addiction exerts effects on the sympathetic-parasympathetic divisions of the autonomic nervous system through different means. Some studies of opiate abusers, such as heroin and morphine, demonstrate that dogs that receive chronic injections of morphine exhibit decreased heart rate and RESPR, indicative of parasympathetic nervous system activity (Napier et al. 1998). The opioid receptor antagonist naltrexone has been used for opiate detoxification and was shown to have an inverse effect, in which subjects had increased heart rate (Hoffman et al. 1998). Methadone, an opioid receptor agonist, activated sympathetic activity, with heart rate acceleration (Chang et al. 2012; Huang et al. 2012). Altogether, opiate abusers exhibit activation of the parasympathetic system rather than the sympathetic system. This is very different from other drug addictions (Table 10.3).

Internet addiction studies have reported contradictory data, in which the sympathetic nervous system is more highly active, with increases in heart rate and RESPR and a decrease in TEMP. Simultaneously, the parasympathetic nervous system is active, with a decrease in SC. These autonomic activity data are slightly different from those on drug addiction.

10.3 The Connections: Autonomic Nervous System and the Brain

To our knowledge, few studies have investigated how neural activity in the brain connects and governs the activity of the sympathetic-parasympathetic divisions of the autonomic nervous system (Hosoya et al. 1991; Leone et al. 2006; McAllen and May 1996; Montenegro et al. 2011; Okano et al. 2013). For example, a recent study used transcranial direct-current stimulation to assess the relationship between the temporal and insular cortices and autonomic nervous system, reflected by exercise performance. These authors suggested that stimulation of the temporal and insular cortices by transcranial direct-current stimulation modulated the activity of the autonomic nervous system and the perception of exertion and performance during maximal exercise (Okano et al. 2013). Moreover, another study showed that the application of transcranial direct-current stimulation in the left temporal lobe in athletes modulated heart rate variability. Additionally, it increased parasympathetic activity but decreased sympathetic activity and sympatho-vagal balance (Montenegro et al. 2011). Furthermore, an electrical recording study in an animal model found that the activity of medullary premotor neurons in the brainstem was correlated with the contraction of cutaneous vasoconstrictor postganglionic fibers. This suggests that brainstem neurons govern postganglionic sympathetic nerves (McAllen and May 1996). A previous review of neuroimaging and pain in humans reported that many of the brain areas related to pain functions directly mediate the activity of the sympathetic-parasympathetic divisions of the autonomic nervous system. A neuroanatomical study showed that the brain pain system is highly associated with the autonomic nervous system, and lamina 1 neurons in the brain receive pain and visceral information from relevant visceral organs that is then transmitted to the spinothalamocortical pathway in central brain structures. Interoceptive visceral messages project to the viscerosensory cortex, including the right anterior insula and orbitofrontal cortices and nociception structures, such as the anterior cingulate cortex (Leone et al. 2006). Alternatively, an afferent axon tracing study investigated the neural pathways between the hypothalamic paraventricular nucleus and peripheral sympathetic preganglionic neurons. The results indicated that the hypothalamic paraventricular nucleus projects descending inputs to sympathetic preganglionic neurons, indicated by the labeling of the anterograde transport of *Phaseolus vulgaris* leukoagglutinin (i.e., a protein derived from kidney beans and used as an anterograde tracer). Sympathetic preganglionic neurons retrogradely project ascending fibers to the hypothalamic paraventricular nucleus, revealed by cholera toxin subunit B (i.e., a retrograde tracer). Therefore, the hypothalamus paraventricular nucleus interacts with peripheral sympathetic preganglionic neurons in the autonomic nervous system (Hosoya et al. 1991).

In summary, some neural substrates of the brain indeed connect to the autonomic nervous system. The hypothalamic paraventricular nucleus reciprocally projects to sympathetic preganglionic neurons. Medullary premotor neurons in the brainstem might control the activity of postganglionic sympathetic nerves. Numerous neural substrates of pain in the brain, including the right anterior insula, orbitofrontal cortex, and anterior cingulate cortex, govern autonomic nervous activity. The temporal and insular cortices can modulate autonomic nervous system cardiac activity and the perception of exertion and performance during strenuous exercise. How central brain substrates control the peripheral sympathetic-parasympathetic divisions of the autonomic nervous system remains uncertain and needs to be scrutinized in future studies.

10.4 Internet Addiction and the Neural Circuits of Brain Reward

The neural circuitry of reward has long been demonstrated in animal models, indicating the existence of dopamine reward systems, including the mesolimbic and mesocortical dopamine systems (Di Chiara 1998; Wise 1988, 2008; Wise and Rompre 1989). The mesolimbic dopamine system is defined as the neural projection from the ventral tegmental area to many brain areas of the limbic system, such as the amygdala, nucleus accumbens, hippocampus, and olfactory cortex. The mesocortical dopamine system projects from the ventral tegmental area to the prefrontal cortex (Oades and Halliday 1987). The function of the mesolimbic dopamine system is proposed as the governance of rewarding and hedonic effects (Koob and Swerdlow 1988). However, the mesocortical dopamine system plays a crucial role in high-level cognitive functions, such as logical thinking, reasoning, and planning, although some reports have shown that its function may also incorporate rewarding and hedonic effects, similar to the mesolimbic dopamine system (Fibiger and Phillips 1988). To review the literature of Internet addiction related to neural circuitry in the brain, evidence of Internet addiction in humans has been inconsistent with drug addiction data in animals (Dong et al. 2012a, b; Han et al. 2010; Ko et al. 2009; Liu et al. 2010; Lin et al. 2012; Lorenz et al. 2013; Sun et al. 2012; Weng et al. 2013). For example, a diffusion tensor imaging study indicated that subjects with Internet gaming addiction showed greater fractional anisotropy (i.e., a value that is calculated from a marker of diffusion along the axon and diffusion perpendicular to the axon) due to an increase in white matter integrity in the thalamus and left posterior cingulate cortex compared with normal subjects. Moreover, greater volume of white matter in the thalamus was associated with the severity of Internet addiction (Dong et al. 2012a). A similar study that used a diffusion tensor imaging approach related to Internet addiction showed that subjects with Internet addiction had significantly decreased fractional anisotropy in orbitofrontal white matter, corpus callosum, cingulum, inferior fronto-occipital fasciculus, and corona radiation internal and external capsules (Lin et al. 2012). A recent study of online gaming addiction suggested that abnormal gray matter and white matter volumes may be related to online gaming abuse. These abnormal brain areas included the right orbitofrontal cortex, insular cortex, and right supplementary motor cortex. Furthermore, white matter volume was decreased in the right genus of the corpus callosum, frontal cortex, and right external capsule, whereas gray matter volume increases were correlated with the right orbitofrontal cortex, insular cortex, and right external capsule in Internet gaming abusers (Weng et al. 2013). A recent functional magnetic resonance imaging (fMRI) study of Internet addiction to the online game World of Warcraft provided supporting evidence implicating similar brain regions, suggesting that some common neural substrates may mediate online game craving behaviors in Internet addiction (Ko et al. 2009). The common neural substrates of the brain comprise the right orbitofrontal cortex and bilateral anterior cingulate cortex. Moreover, the right nucleus accumbens, medial frontal cortex, dorsolateral prefrontal cortex, and right caudate nucleus may also be involved in craving behavior in Internet addiction (Ko et al. 2009). Thus, reward-related brain areas may mediate the specific form of Internet addiction, such as the online game Word of Warcraft; however, another study with the online game, Counter Strike, has not implicated neural reward mechanisms in this category of Internet gaming addiction (Montag et al. 2012). This raises questions as to whether neural reward pathways are selectively implicated in internet (gaming) addiction dependent on game-specific characteristics (e.g., role-player, point of view, the accumulation of "point", story narrative etc.).

With regard to craving behavior and cue-induced Internet addiction, a brain mapping study of Internet video game play showed that the anterior cingulate cortex and orbitofrontal cortex were significantly activated when subjects encountered Internet video game cues (Han et al. 2010). Another study found greater brain activity in a cue/picture exposure condition, including in the dorsolateral prefrontal cortex, bilateral temporal lobe, cerebellum, right inferior parietal lobe, right cuneus, right hippocampus, parahippocampus, parahippocampal gyrus, and left caudate nucleus (Sun et al. 2012). These results suggest that these brain areas may be involved in cue-induced Internet addiction or craving behavior.

A recent study that used resting-state fMRI brain mapping found that Internet gaming addicts exhibited higher brain activity in the brainstem, inferior parietal lobule, left posterior cerebellum, and left middle frontal gyrus. Additionally, regional homogeneity measures of the temporal, occipital, and parietal lobes were significantly decreased in Internet gaming abusers. The authors suggest that these brain areas may be involved in sensory and motor coordination or visual and auditory function, but the data did not suggest the involvement of these areas in reward and hedonic effects (Dong et al. 2012b). Another study indicated that Internet gaming abusers had significantly greater increases in regional homogeneity in the cerebellum, brainstem, right cingulate gyrus, bilateral parahippocampus, right frontal lobe, left superior frontal gyrus, left precuneus, right postcentral gyrus, right middle occipital gyrus, right inferior temporal gyrus, left superior temporal gyrus, and middle temporal gyrus. The results suggested that the neural networks among the cerebellum, limbic cortex, brainstem, and frontal cortex might be correlated with the rewarding and hedonic effects of Internet addiction (Liu et al. 2010).

In summary, the results of human Internet addiction studies are more complex than the findings from animal drug addiction research. The mesolimbic and mesocortical dopamine systems may comprise the framework for Internet addiction. Unfortunately, the dopamine hypothesis, which was developed using evidence from animal studies, is not fully consistent with Internet addiction findings related to the neural circuitry of the brain. This suggests a need for the development of a novel hypothesis of Internet addiction in the future.

10.5 Internet Addiction: Pathogenesis and Interventions

A growing body of evidence has shown that Internet addiction can induce depression or that the pathogenesis of Internet addiction is induced by uncontrolled Internet use; moreover, Internet abusers often show numerous psychopathological symptoms and behaviors related to Internet addiction (Karim and Chaudhri 2012; Carli et al. 2013). For example, Internet abusers can exhibit uncontrollable use of the Internet, distressing feelings, and time-consuming habits that result in social and occupational difficulties (Shapira et al. 2000). Some Internet abusers suffer from depression and guilty feelings. They may also exhibit an increase in the probability of aggressive behavior when exposed to long-term use of the Internet (Treuer et al. 2001). Therefore, many Internet abusers state that they encounter relational, academic, familial, and occupational impairments (Young 2007).

Internet addition was not defined as a mental disorder by the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV), but the current version, the DSM-5, includes Internet gaming addiction (American Psychiatric Association 2013). Internet addiction was first proposed as a psychological or psychopathological disorder by Ivan Goldberg in 1995 (Eppright et al. 1999; Garrison and Long 1995). He adapted the psychopathological symptoms of pathological gambling to describe the compulsive symptoms of Internet addiction, such as pathological Internet use and uncontrolled Internet use that results in physical, social, psychological, and occupational dysfunction (Young 1998). Moreover, the characteristics of Internet addiction may be associated with symptoms of substance dependence that involve mood alterations, tolerance, abstinence, and withdrawal symptoms (Griffiths 1995). Internet addiction is also correlated with some psychopathological behaviors, such as depression, anxiety, hostility, psychoticism, interpersonal sensitivity, attention-deficit/hyperactivity disorder, obsessive-compulsive disorder, novelty seeking, and social anxiety disorder (Carli et al. 2013; Cho et al. 2013). However, all of these psychopathological behaviors are not required simultaneously to define an Internet abuser. Rather, some number of characteristics may present in one Internet addict, while additional and/or different characteristics may typify another Internet addict. Similar to many psychological disorders, e.g., substance addiction and depression, the presentation of symptoms can be heterogenous across patients. The symptoms and psychopathological behaviors associated with Internet addiction are very diverse. Thus, therapeutic interventions for Internet addiction may be complicated.

Recently, some studies have examined the relationship between Internet addiction and psychopathology. For example, Cho et al. (2013) found that withdrawal and anxiety/depression symptoms during childhood could predict the occurrence of Internet addiction. These authors suggested that clinicians should consider withdrawal and anxiety/depression behaviors during childhood to protect humans with an increased vulnerability for Internet addiction (Cho et al. 2013). The psychopathological compulsive behavior associated with Internet addiction is similar to that in alcohol use, resulting from implicit cognition to the exclusion of explicit cognition to control substance abuse (Yen et al. 2011). Xiuqin et al. (2010) investigated pathological symptoms, personality, and parental rearing styles in adolescents with Internet addiction, suggesting that Internet abusers might have higher obsessive-compulsive behavior, interpersonal sensitivity, depression, anxiety, hostility, and paranoid ideation. Additionally, the personality traits of Internet abusers trend toward a lower magnitude of extraversion and a higher degree of psychoticism, while parental rearing styles often lean toward being over-intrusive, punitive, and lacking in responses during parent–child interactions (Xiuqin et al. 2010). A recent study of Internet addiction suggested that obsessive-compulsive symptoms develop before Internet abusers become addicted to the Internet. Depression, anxiety, hostility, interpersonal sensitivity, and psychoticism are present after Internet addiction develops (Dong et al. 2011). Our recent study further showed that Internet addiction is associated with depressive states but not depressive traits (Huang et al. 2013). This suggests that the psychopathological depression associated with Internet addiction is not related to a depressive personality trait. Instead, psychopathological depressive symptoms are a temporary depressive state. Therefore, interventions for psychopathological depression should target temporary depressive states rather than permanent depressive traits. Interestingly, the notion that depressive state is more important than personality trait as a vulnerability factors for depression has been challenged by recent findings (Mehroof and Griffiths 2010; Tsai et al. 2009). This requires further scrutiny in future studies.

In conclusion, some crucial points are the following. Obsessive-compulsive symptoms disorder, depression, anxiety, hostility, and interpersonal sensitivity may be common psychopathological symptoms of Internet addiction. Obsessive-compulsive behavior can also effectively predict the occurrence of Internet addiction. Moreover, obsessive-compulsive behavior is a critical precursor for Internet addiction. Depression, anxiety, hostility, and interpersonal sensitivity are psychopathological symptoms of Internet addiction; thus, these symptoms and behaviors are the sequelae that appear after Internet addiction develops. Dissociations between depressive states and depressive traits with regard to psychopathological depressive behavior are important considerations for interventions. Finally, the occurrence of Internet addiction may involve many factors in addition to psychopathological symptoms, including personality traits and parental rearing styles.

10.6 Conclusions

Interventions for Internet addiction should include pharmacological and non-pharmacological approaches. The pathogenesis of Internet addiction involves complicated and multiple psychopathological and behavioral symptoms. The role of the autonomic nervous system and the neural circuitry involved in the multiple psychopathological symptoms of Internet addiction require elucidation to enable development of novel and effective interventions. The development of new drugs that focus on the sympathetic-parasympathetic divisions of the peripheral autonomic nervous system is also a crucial line of research. With regard to interventions associated with the peripheral autonomic nervous system, the antagonism of sympathetic nervous system activity may be a key way to prevent against Internet addiction. Thus, research in this basic area requires replication and verification in the future studies.

Acknowledgements This work was supported by grants NSC 101-2413-H-431-007 and NSC 102-2410-H-431-005-MY3 from the National Research Council of the Republic of China. I would like to thank my students, Mr. Cai N Cheng and Mr. Alan Bo Han He, for drawing Fig. 10.5.

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Chapter 11
Psychometric Assessment of Internet Gaming Disorder in Neuroimaging Studies: A Systematic Review

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Abstract ***Background***: Little attention has been paid to research on Internet Gaming Disorder (IGD) using neuroimaging techniques even though this type of research is of key importance for the formal recognition of IGD as an independent disorder. ***Aims***: The aim of the present study was to conduct a systematic review of some of the methodological and assessment characteristics in neuroimaging studies that have been published from May 2013 to January 2016 and that have assessed IGD whilst also having used a neuroimaging technique to gather neurobiological evidence of this potential disorder. ***Methods***: Systematic electronic searches using strict inclusion and exclusion criteria were conducted on ProQuest (in the following scholarly databases: ProQuest Psychology Journals, PsycARTICLES, PsycINFO, Applied Social Sciences Index and Abstracts, and ERIC) and on MEDLINE to identify potential eligible studies. ***Results***: A total of 853 studies were screened and after a careful systematic selection process, 14 studies were found to meet the inclusion criteria. Based on the findings, it was concluded that research on IGD using neuroimaging techniques is on the rise. Additionally, this systematic review offers ten practical recommendations to authors based on the methodological and assessment shortcomings of extant empirical studies on IGD using neuroimaging techniques. ***Conclusions***: It is envisaged that the results of this study will help improve the overall quality of research on IGD using neuroimaging techniques.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_11

11.1 Introduction

Since the introduction of the concept of **Internet Gaming Disorder** (IGD) as a tentative disorder in the latest (fifth) edition of the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association 2013), research into IGD using neuroimaging techniques has steadily increased. Neuroimaging studies appear to offer several advantages over traditional self-report and clinical research by highlighting specific areas of the brain involved in the development and maintenance processes of addiction (Kuss and Griffiths 2012a). More recently, the APA (2013) defined IGD as a behavior that refers to "persistent and recurrent engagement in video games, often with other players, leading to clinically significant impairments or distress as indicated by five (or more) of the following nine criteria in a 12-month period: (1) preoccupation with games; (2) withdrawal symptoms when gaming is taken away; (3) tolerance, resulting in the need to spend increasing amounts of time engaged in games; (4) unsuccessful attempts to control participation in games; (5) loss of interest in previous hobbies and entertainment as a result of, and with the exception of, games; (6) continued excessive use of games despite knowledge of psychosocial problems; (7) deceiving family members, therapists, or others regarding the amount of gaming; (8) use of games to escape or relieve negative moods; and (9) jeopardizing or losing a significant relationship, job, or education or career opportunity because of participation in games (p. 795)."

Numerous studies have systematically reported numerous harmful effects games can have on human health because of their potentially addictive features (Eichenbaum et al. 2015; Lehenbauer-Baum et al. 2015; Schmitt and Livingston 2015) and overall detrimental effects (Brunborg et al. 2014; Haghbin et al. 2013; Hull et al. 2013; Kuss and Griffiths 2012b) both from a psychosocial and neuroscientific standpoint. From a psychosocial viewpoint, such harmful effects related to addiction to gaming can include decreased levels of exercise and sports (Henchoz et al. 2014), sacrificing work, education, hobbies, socializing, time with partner/family, and sleep (Griffiths et al. 2004), impaired decision-making (Yao et al. 2015), poorer psychosomatic health (Wittek et al. 2015), decreased emotional and behavioral functioning (Baer et al. 2012), increased stress (Snodgrass et al. 2014), greater incidence of psychiatric symptoms (Király et al. 2015a, b; Vukosavljevic-Gvozden et al. 2015), lower expected college engagement and grades in adolescent students (Schmitt and Livingston 2015), decreased academic performance (Brunborg et al. 2014), lower levels of sociability, self-efficacy and satisfaction with life (Festl et al. 2013), in addition to other psychiatric disorders and abnormal behaviors (see Griffiths et al. 2012, 2015, 2016; Kuss and Griffiths 2012b).

On the other hand, from a neuroscientific perspective, a systematic review of neuroimaging studies of Internet and gaming addiction (Kuss and Griffiths 2012a) found that excessive Internet use and gaming is associated with changes on the behavioral, as well as molecular and neural circuitry levels, providing objective evidence of the biological similarity between Internet and gaming addiction and more traditional substance-related addictions. Previous studies (e.g., Dong et al.

2012, 2013; Dong and Potenza 2014; Liu et al. 2015) have found that IGD is associated with abnormal activations in frontal, insular, temporal, and parietal cortices when affected individuals perform tasks related to impulse control. Additionally, previous structural studies have found that IGD was associated with structural abnormalities in gray matter, such as decreased lower gray matter density in the bilateral inferior frontal gyrus, left cingulate gyrus, insula, right precuneus, and right hippocampus (Lin et al. 2015a, b). In addition, IGD has also found to be associated with lower white matter density in the inferior frontal gyrus, insula, amygdala, and anterior cingulate, brain regions that are involved in decision-making, behavioral inhibition, and emotional regulation (Lin et al. 2015a, b).

11.1.1 Objectives

Since IGD may be related to a wide range of health and psychiatric disorders as reported by previous studies, it has become vital to understand and evaluate the potential methodological shortcomings of research on IGD using neuroimaging techniques in order to refine future research. For this reason, and given the ongoing debates surrounding the issue of assessment of IGD and the need for unification in the way assessment of this disorder is carried out (Griffiths et al. 2014, 2015, 2016; Petry and O'Brien 2013; Petry et al. 2015, 2014; Pontes and Griffiths 2015b), the present chapter systematically reviews the extant neurobiological evidence of studies that have adopted commonly used types of neuroimaging techniques to investigate the psychobiology of IGD. More specifically, the main aim of this chapter is to investigate what are (if any) the caveats and potential biases and limitations stemming from an assessment of IGD during participant recruitment in such studies. The secondary objective of this chapter is to ascertain the publication rates of IGD studies using neuroimaging techniques as of May 2013 and briefly summarize the main findings of these studies. To the best of the authors' knowledge, no previous review has attempted to summarize and critique the existing evidence regarding the assessment of IGD in neuroimaging studies (as opposed to describing neuroimaging evidence for Internet and gaming addiction; Kuss and Griffiths 2012b). This chapter contributes a critical discussion of current practices in the assessment of IGD and may pave the way for new methodologically robust research.

11.2 Method

11.2.1 Eligibility Criteria

To be eligible for inclusion in this systematic review, only original studies investigating IGD and its associated neurological correlates were included. Additionally, eligible studies had to: (i) assess IGD or direct effects of gaming on neurological functioning, (ii) be an empirical study, (iii) use neuroimaging techniques, (iv) be published in a scholarly peer-reviewed journal, and (v) be written in English, Spanish, German, Polish, or Portuguese language. Searches were limited to articles published from May 2013 to January 2016, because IGD was officially defined and conceptualized by the APA in May 2013, which followed the publication of psychometric tools using this framework to assess IGD. Studies were excluded from review if they were (i) unpublished dissertation and thesis studies, (ii) single-case reports ($N = 1$), and (iii) review studies.

11.2.2 Information Sources and Search

The identification of studies was carried out by performing electronic searches on *ProQuest,* which included the following databases: *Applied Social Sciences Index and Abstracts (ASSIA), ERIC, ProQuest Psychology Journals, PsycARTICLES,* and *PsycINFO*. An additional independent search was carried out on *MEDLINE* to enhance the accuracy of the results regarding the systematic search of relevant studies. The search strategy adopted to identify relevant papers in the aforementioned databases sought to include and be able to retrieve the most common types of neuroimaging techniques employed in research on IGD (i.e., electroencephalogram [EEG], positron emission tomography [PET], single-photon emission computed tomography [SPECT], functional magnetic resonance imaging [fMRI], structural magnetic resonance imaging [sMRI], diffusion-tensor imaging [DTI]) as reported in a previous systematic review (i.e., Kuss and Griffiths 2012a). As a result, the following search strategy was used:

(patholog* OR problem* OR addict* OR compulsive OR dependen* OR disorder*) AND (video OR computer OR internet) gam* AND (neuroimaging OR eeg OR pet OR spect or fmri OR smri OR dti).

11.2.3 Study Selection and Data Collection Processes

Following the initial literature searches, each study's title and abstract were screened for eligibility. Full texts of all potentially relevant studies were then retrieved and further examined for eligibility. The flow diagram in Fig. 11.1 details the selection process. Information from the included studies was recorded in an electronic spreadsheet after in-depth analysis. The overall data extracted from the studies reviewed subdivided into two larger overarching groups: (i) methodological

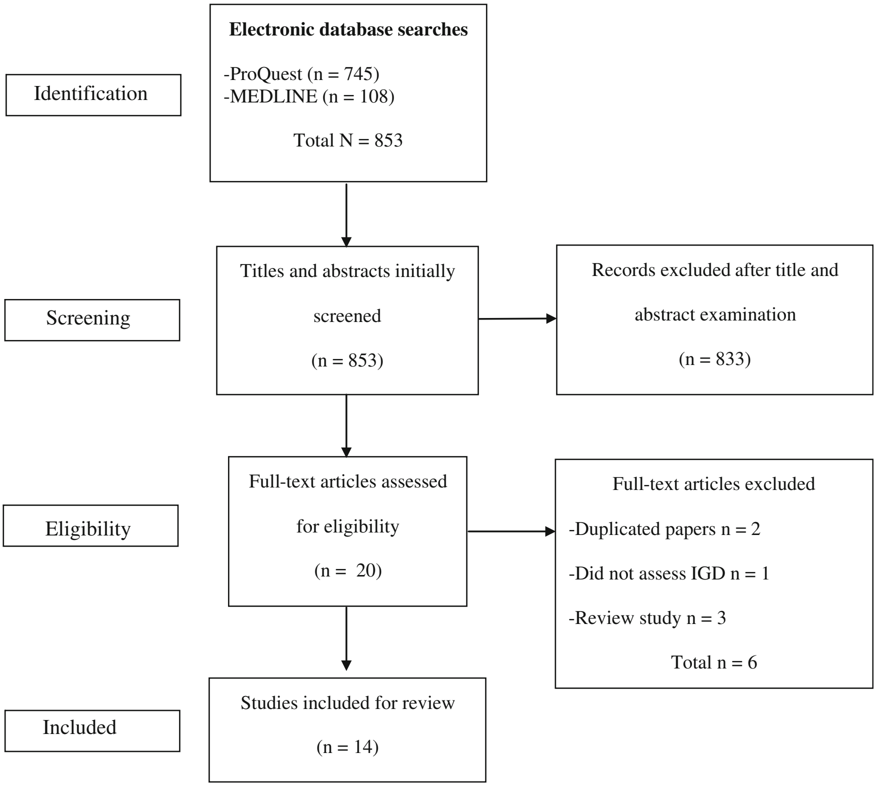

Fig. 11.1 Flow diagram of the study selection process

characteristics and (ii) instrument characteristics. The information extracted concerning the studies' methodological characteristics included: provenience of the sample recruited (i.e., country), sample size, gender distribution, age range (and mean age), sample characteristics, neuroimaging technique used, study aims, and main findings. The information extracted regarding the features of the instruments used to diagnose IGD included: instrument utilized, item sensitivity, criteria included, time scale, theoretical framework, suitability to assess IGD, alignment with the nine IGD criteria, and missing IGD criteria.

11.3 Results

11.3.1 Study Selection

After performing the aforementioned electronic searches, a total of 853 studies (*ProQuest* n = 745; *MEDLINE* n = 108) were initially identified, with the search performed on the *ProQuest* website yielding the following results: *ProQuest Psychology Journals* $n = 524$; *PsycARTICLES* $n = 115$; *PsycINFO* $n = 106$; *Applied Social Sciences Index and Abstracts* $n = 0$; and *ERIC* $n = 0$. All 853 papers had their titles and abstracts screened, resulting in the exclusion of 833 papers that were of no relevance for the present review. Consequently, a total of 20 studies were eligible for further review. Of these, six papers had to be further excluded because they were either duplicated ($n = 2$), did not assess IGD ($n = 1$), or were review papers ($n = 3$). Following this study selection process, 14 studies were eligible for further analysis as they fully endorsed all inclusion criteria (see Fig. 11.1).

11.3.2 Publication Rate of Peer-Reviewed Neuroimaging Studies on IGD

One of the conditions set by the APA in the DSM-5 was that if IGD is to be recognized as an independent disorder in the future, more studies should be carried out to help ascertain the prevalence rates of IGD across the globe, its clinical course and possible genetic influences, and potential biological factors, based on, for instance, brain imaging data (APA 2013). For this reason, research on IGD employing neuroimaging techniques is of utmost importance not only because of its methodological capabilities, but also because the apparent weight it may carry towards the formal recognition of IGD as an independent disorder in the future [as neurobiological empirical evidence appears to be given more weight than psychological empirical evidence when considering the inclusion of behavioral addictions—such as IGD and sex addiction—in the DSM (Griffiths 2016)]. In light of this, Fig. 11.2 shows a clear trend toward an increase of published peer-reviewed studies on IGD using neuroimaging techniques. This increased trend is most obvious from the period of 2014–2015 because the official diagnosis of IGD only appeared in the scientific literature in May 2013 with the publication of the DSM-5, and because the systematic searches performed for this review were conducted in January 2016.

11.3.3 Neuroimaging of IGD

In order to present some of the latest neuroimaging research on IGD, this section briefly summarizes the main findings of the studies that fully met the inclusion criteria of this review as previously outlined. Ding et al. (2014) found that the prefrontal cortex may be involved in the circuit modulating impulsivity, while its impaired function may be related to high impulsivity in adolescents with IGD, which in turn, may contribute to the IGD process. Sun et al. (2014) concluded that

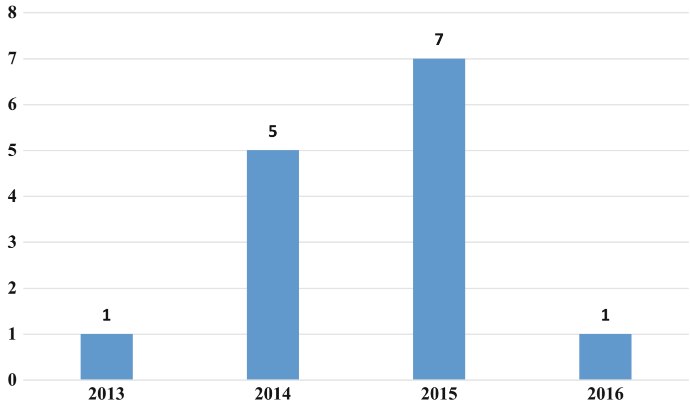

Fig. 11.2 Publication rate of peer-reviewed neuroimaging studies on Internet Gaming Disorder from May 2013 to January 2016. *Note*. This figure only includes studies that met all inclusion criteria of the present systematic review

diffusional kurtosis imaging (DKI) can detect subtle differences in gray matter microstructure between IGD and healthy individuals, and that DKI can provide sensitive imaging biomarkers for assessing the severity of IGD. In the study conducted by Dieter et al. (2015), the authors found that disordered gamers tend to identify significantly more with their avatar in comparison to nondisordered gamers. The authors also noted that the avatar might increasingly replace gamers' ideal self as gaming addiction progresses. Wang et al. (2015a) found that individuals with IGD presented with significant gray matter volume reduction in the bilateral anterior cingulated cortex and other brain regions when compared to healthy individuals. Additionally, IGD was also found to compromise both behavioral and neural structure in adolescents with IGD. Xing et al. (2014) found that the abnormal structural connectivity in the right salience network was associated with impaired executive function in adolescents with IGD, with structural connectivity differences found between IGD adolescents and healthy controls. Yuan et al. (2016) found that differences between individuals with IGD and healthy controls in the striatum volume and frontostriatal circuits resting-state functional connectivity (RSFC) emerged. Additionally, cognitive control deficits detected in IGD were associated with reduced frontostriatal RSFC strength. In addition to these findings, Hahn et al. (2014) concluded that converging evidence for a general reward system deficiency in frequent online gamers exists as frequent players displayed significantly decreased neural activation when anticipating both small and large monetary rewards in the ventral striatum. Luijten et al. (2015) found reduced inhibitory control amongst individuals with IGD but no evidence was found for reduced error processing. Furthermore, attentional control and error processing were mostly intact in IGD individuals. At the molecular level, Tian et al. (2014) found that the D_2 receptor level is significantly associated with glucose metabolism in disordered gamers, indicating that D_2/5-HT_{2A} receptor-mediated dysregulation of the orbitofrontal cortex could underlie a mechanism for loss of control and compulsive behavior in individuals with IGD. Duven et al. (2015) reported that tolerance effects are present in patients with IGD and noted that the initial orienting toward the gaming reward is suggested to consume more capacity for patients with IGD when compared to healthy controls. Lin et al. (2015b) found that individuals with IGD demonstrated lower low-frequency fluctuation (fALFF) values in superior temporal gyrus and higher fALFF values in the cerebellum. Wang et al. (2015b) found that adolescents with IGD exhibited decreased voxel-mirrored homotopic connectivity (VMHC) between the left and right superior frontal gyrus (orbital part), inferior frontal gyrus (orbital part), middle frontal gyrus and superior frontal gyrus. Son et al. (2015) found that lower absolute beta power can be used as a potential trait marker of IGD. Finally, Yuan et al. (2013) found that adolescents with IGD presented with abnormal amplitude of low-frequency fluctuations in comparison to controls.

In summary, with regard to the functional and structural changes found in IGD individuals when compared to healthy controls, these are often observed within specific brain areas in the frontal lobe (i.e., dorsolateral prefrontal cortex, orbitofrontal cortex, prefrontal gyrus, and the middle frontal gyrus), parietal and temporal lobes (i.e., parahippocampal gyrus), basal ganglia, thalamus, insula and the cerebellum. A finding that mirrors those recently report in similar review studies (Lemos et al. 2014). Furthermore, regardless of the neuroimaging technique utilized, these studies provide preliminary evidence that illustrate converging points and similarities between substance use disorders and IGD, especially during craving processes, a finding that has been previously reported (Smith et al. 2015) and that warrants further investigation as at this point, it may be premature to draw definite conclusions regarding the similarities between IGD and substance use disorders as the definition of IGD currently includes many features present in the definition and diagnostic framework of substance use disorders. Taken together, the main findings reported across all reviewed studies do not provide a complete picture of neuroimaging studies on IGD as other potentially useful findings from similar studies may be missing due to strict inclusion criteria employed in this review.

11.3.4 Methodological Characteristics of Studies

In order to assess some of the methodological features of existing neuroimaging studies examining IGD, key variables were analyzed among the reviewed studies, such as: geographical location of the sample recruited (i.e., country), sample size, gender distribution, age range and mean, sample characteristics, neuroimaging technique used, study aims, and main findings (see Table 11.1).

Regarding the cultural context of the samples recruited, nine studies out of fourteen recruited Chinese samples (Ding et al. 2014; Lin et al. 2015a, b; Sun et al. 2014; Tian et al. 2014; Wang et al. 2015a, b; Xing et al. 2014; Yuan et al. 2013, 2016), three studies used German samples (Dieter et al. 2015; Duven et al. 2015;

Hahn et al. 2014), one study used a Dutch sample (Luijten et al. 2015), and one study used a South Korean sample (Son et al. 2015). As for the sample sizes, studies recruited from a minimum of 26 disordered gamers in one study (Tian et al. 2014) to a maximum of 87 disordered gamers in another study (Yuan et al. 2016). The mean number of disordered gamers recruited across all 14 studies was 43 (SD = 18.3). In terms of gender distribution across all studies, only one study had an even split between genders (Ding et al. 2014) while six studies recruited male-only samples (Duven et al. 2015; Hahn et al. 2014; Lin et al. 2015a, b; Luijten et al. 2015; Son et al. 2015; Tian et al. 2014). Although Table 11.1 summarizes the age of gamers recruited, little information was available in the reviewed studies regarding the overall age range of all gamers as the studies usually reported this information only for each group of participants (e.g., experimental and control groups). Despite this limitation, the data gathered suggests that most IGD-affected gamers recruited were in their mid- to late adolescence given the characteristics of the samples recruited across all studies. Almost half of all reviewed studies included gamers that were either addicted to *World of Warcraft* (*WoW*) (i.e., Hahn et al. 2014; Tian et al. 2014; Yuan et al. 2013) or *League of Legends* (*LoL*) (i.e., Xing et al. 2014; Yuan et al. 2016) or included both types of gamers (i.e., participants addicted to *WoW* and participants addicted to *LoL*) (i.e., Dieter et al. 2015) only. The procedure of recruiting participants having problems with only a particular game or specific game genre is questionable because it clearly limits the external validity of the findings reported in such studies as it is unclear to what extent these findings can be replicated across all disordered gamers. Interestingly, all studies provided some form of control group, as well as inclusion, and exclusion criteria in the recruitment of participants, which certainly helped mitigate some of the potential threats to the internal validity of the studies in question.

Finally, as to the neuroimaging techniques used, six studies employed resting-state functional magnetic resonance imaging (rsfMRI) (Hahn et al. 2014; Lin et al. 2015a, b; Wang et al. 2015b; Xing et al. 2014; Yuan et al. 2013, 2016), four studies used functional magnetic resonance imaging (fMRI) (Dieter et al. 2015; Ding et al. 2014; Luijten et al. 2015; Sun et al. 2014), one study used positron emission tomography (PET) (Tian et al. 2014), one study used electroencephalography (EEG) (Duven et al. 2015), one study used resting-state electroencephalography (rsEEG) (Son et al. 2015), and one study used voxel-based morphometry (VBM) (Wang et al. 2015a).

11.3.5 Methodological Characteristics of the Instruments Used to Assess IGD

Table 11.2 provides an overview regarding the preferred methods for diagnosing IGD among the reviewed studies and the features of these instruments and/or diagnostic approaches utilized. Even though the main construct under investigation

Table 11.1 Main methodological characteristics of the studies that met the inclusion criteria

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
Ding et al. (2014)	China	34	50% male	NR;16.41 (3.20)[1]	Adolescents recruited from a mental health center[1]	fMRI	To investigate if different facets of trait impulsivity may be specifically linked to the brain regions characteristic of impaired impulse inhibition in IGD subjects	The prefrontal cortex may be involved in the circuit modulating impulsivity, while its impaired function may relate to high impulsivity in adolescents with IGD, which may contribute directly to the IGD process
Sun et al. (2014)	China	39	83% male[1]	NR; 20.50 (3.55)[1]	Adolescents recruited from a mental health center (i.e., IGD group) and advertisements (i.e., healthy controls)	fMRI	To investigate the utility of diffusional kurtosis imaging (DKI) in the detection of gray matter alterations in people suffering from IGD	DKI can detect subtle differences in gray matter microstructure between IGD and healthy individuals. Additionally, DKI model can provide sensitive imaging biomarkers for assessing the severity of IGD
Dieter et al. (2015)	Germany	32	91% male	NR; 26.72 (6.30)	Adults with IGD recruited through a mental health center and healthy controls	fMRI	To investigate the psychological and neurobiological correlates reflecting the relation of the avatar to	Disordered gamers identify significantly more with their avatar than non-disordered gamers. Additionally,

(continued)

Table 11.1 (continued)

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
					recruited from advertisements		disordered gamers' concepts of their self and ideal self	the avatar might increasingly replace gamers' ideal self as the addiction progresses
Wang et al. (2015a)	China	56	67% male	NR; 18.80 (1.33)[1]	Late adolescent college students	VBM	To investigate the relationship between alteration of gray matter volume and cognitive control feature in adolescents with IGD	Gray matter volume reduction was found in the bilateral anterior cingulate cortex and other brain regions. Additionally, IGD compromised both behavioral activity and neural structure in adolescents with IGD
Xing et al. (2014)	China	34	61% male	NR; 19.10 (0.70)[1]	Adolescents	rsfMRI	To investigate the relationship between the connections within salience network and cognitive control in IGD adolescents	The abnormal structural connectivity in the right salience network was associated with impaired executive function in IGD adolescents. Additionally, structural connectivity differences were found between IGD adolescents and healthy controls

(continued)

Table 11.1 (continued)

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
Yuan et al. (2016)	China	87	75% male	15-23; 19 (1.40)[1]	Adolescent and young adult university students	rsfMRI	To investigate the differences of striatum volume and resting-state functional connectivity (RSFC) networks in IGD and healthy individuals	Overall findings consistent with the literature on substance use disorders as differences between IGD and healthy controls in the striatum volume and frontostriatal circuits RSFC emerged. Moreover, cognitive control deficits detected in IGD were correlated with reduced frontostriatal RSFC strength
Hahn et al. (2014)	Germany	33	100% male	18-34; 25.50 (4.18)[1]	Adolescent and adult gamers and non-gamers	rsfMRI	To investigate if players of the Massively Multiplayer Online Role-Playing Game World of Warcraft show a generally deficient reward system as in substance use disorders	Converging evidence for a general reward system deficiency in frequent online gamers was found. Frequent players displayed significantly decreased neural activation during the anticipation of both small and large

(continued)

Table 11.1 (continued)

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
								monetary rewards in the ventral striatum
Luijten et al. (2015)	Netherlands	34	100% male	NR; 20.83 (3.05)[1]	Adolescent and adult gamers and non-gamers	fMRI	To investigate if IGD players are characterized by deficits in various aspects of cognitive control (i.e., inhibitory control, error processing, attentional control)	Reduced inhibitory control amongst IGD players was found while no evidence was found for reduced error processing in IGD players. Furthermore, attentional control and error processing were mostly intact
Tian et al. (2014)	China	26	100% male	NR; 23.50 (2.60)[1]	Adolescent and adult gamers and non-gamers	PET	To examine the post synaptic D_2 receptors and regional brain glucose metabolism in IGD	The D_2 receptor level is significantly associated with glucose metabolism in disordered gamers, indicating that D_2/ 5-HT_{2A} receptor-mediated dysregulation of the orbitofrontal cortex could underlie a mechanism for loss of control and compulsive behavior in IGD individuals

(continued)

Table 11.1 (continued)

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
Duven et al. (2015)	Germany	27	100% male	NR; 24.29 (5.84)[1]	Adults with IGD recruited through a mental health center and healthy controls recruited from advertisements	EEG	To investigate whether enhanced motivational attention or tolerance effects are present in patients with IGD	Tolerance effects are present in patients with IGD. Furthermore, the initial orienting toward the gaming reward is suggested to consume more capacity for patients with IGD
Lin et al. (2015a, b)	China	52	100% male	NR; 22.20 (3.13)[1]	Late adolescent and adult college students	rsfMRI	To investigate the abnormal spontaneous brain activity in IGD with the low-frequency fluctuation (fALFF) at different frequency bands	IGD individuals demonstrated lower fALFF values in superior temporal gyrus and higher fALFF values in cerebellum
Wang et al. (2015b)	China	41	76% male	14-17; 16.94 (2.73)[1]	Adolescents with IGD recruited from a mental health center and healthy controls	rsfMRI	To investigate the interhemispheric resting state functional connectivity of the whole brain of adolescents with IGD using a new voxel-mirrored homotopic connectivity (VMHC) method	Adolescents with IGD exhibited decreased VMHC between the left and right superior frontal gyrus (orbital part), inferior frontal gyrus (orbital part), middle frontal gyrus and superior frontal gyrus

(continued)

Table 11.1 (continued)

Author	Country	Sample size	Gender distribution (%)	Age range (years) and Mean age (SD)	Sample characteristics	Neuroimaging technique used	Study aims	Main findings
Son et al. (2015)	South Korea	76	100% male	NR; 22.71 (5.47)	Young males diagnosed with IGD (N = 34), alcohol use disorder (N = 17) and 25 healthy controls	rsEEG	To identify the unique neurophysiological characteristics that can be used as biomarkers of IGD	Lower absolute beta power can be used as a potential trait marker of IGD
Yuan et al. (2013)	China	36	66% male	NR; 19.40 (3.10)[1]	Adolescent college students	rsfMRI	To investigate the local features of spontaneous brain activity in adolescents with IGD and healthy controls during resting-state	IGD adolescents presented with abnormal amplitude of low frequency fluctuations in comparison to controls

Superscripts [1]Information concerning the experimental (i.e., disordered gamers) group
Abbreviations fMRI functional magnetic resonance imaging; *VBM* voxel-based morphometry; *rsFMRI* resting-state functional magnetic resonance imaging; *PET* positron emission tomography; *EEG* electroencephalography. *rsEEG* resting-state electroencephalography

of the studies reviewed was IGD, the diagnosis of this disorder was carried out most of the time using measures that were either (i) designed to assess generalized Internet addiction (IA) or (ii) measures that had their theoretical framework based on the concept of IA or non-validated diagnostic criteria. More specifically, in terms of diagnosis of IGD, five studies (i.e., Ding et al. 2014; Sun et al. 2014; Wang et al. 2015a, b; Yuan et al. 2013) used Young's Diagnostic Questionnaire (YDQ) (Young 1998b) with Beard and Wolf's (2001) suggested criteria for IA, two studies (i.e., Lin et al. 2015a, b; Xing et al. 2014) used the Internet Addiction Test (IAT) (Young 1998a), one study (i.e., Luijten et al. 2015) used the Videogame Addiction Test (VAT)[1] (Van Rooij et al. 2012), one study (i.e., Tian et al. 2014) used Tao et al. (2010) diagnostic criteria for IA, one study (i.e., Dieter et al. 2015) used the Checklist for the Assessment of Internet and Computer Game Addiction (AICA-C) (Wölfling et al. 2012), another study (i.e., Duven et al. 2015) used the Scale for the Assessment of Internet and Computer Game Addiction (AICA-S, CSV-S) (Wölfling et al. 2011), and one study (i.e., Hahn et al. 2014) adopted a frequency criterion based on time spent gaming (i.e., playing at least four times per week for one hour or more for at least 1 year). Finally, only two studies (i.e., Son et al. 2015; Yuan et al. 2016) used the DSM-5 criteria for IGD (APA 2013) to diagnose IGD.

Although most studies relied on only one instrument or criterion to diagnose and assess the severity of IGD, five studies, including the two studies that used the IGD criteria to diagnose IGD, adopted two different instruments to diagnose and assess the severity of IGD (Ding et al. 2014; Son et al. 2015; Sun et al. 2014; Wang et al. 2015b; Yuan et al. 2016), with these instruments either being the Chen Internet Addiction Scale (CIAS) (i.e., Ding et al. 2014; Sun et al. 2014; Wang et al. 2015b) or the IAT (i.e., Son et al. 2015; Yuan et al. 2016).

11.4 Discussion

The present chapter sought to systematically review and evaluate some of the methodological and instrument characteristics of the most recent IGD studies that have employed commonly used neuroimaging techniques. In regard to the methodological features assessed in the reviewed studies, data were collected and analyzed concerning the studies' methodological characteristics such as: geographical location of the sample recruited (i.e., country), sample size, gender distribution, age range and mean, sample characteristics, neuroimaging technique used, study aims, and main findings. Additionally, the quality of assessment of IGD amongst neuroimaging studies published after the formulation of the nine IGD criteria in the DSM-5 (APA 2013) was also assessed by examining the following

[1]Although this test presents with some degree of validity to assess gaming addiction, the theoretical framework of this test was based on Compulsive Internet Use theory derived from the DSM-IV criteria for dependence and obsessive-compulsive disorder and the components model of addiction see van Rooij et al. (2012).

Table 11.2 Main features of the instruments used to assess Internet Gaming Disorder (IGD) in neuroimaging studies

Author	Instrument	Item sensitivity	Criteria covered	Time scale	Theoretical framework	Suitability to assess IGD[1]	Alignment with IGD criteria	Missing IGD criteria
Ding et al. (2014)	Young's Diagnostic Questionnaire (YDQ) modified to reflect Beard and Wolf's (2001) criteria for Internet addiction[2]	Yes/no	Preoccupation; tolerance; inability to control use; withdrawal; salience; jeopardy of opportunities; deception; mood modification	NR	Pathological gambling (DSM-IV)	No	Partial	3, 5, and 6
Sun et al. (2014)	Young's Diagnostic Questionnaire (YDQ) modified to reflect Beard and Wolf's (2001) criteria for Internet addiction[2]	Yes/no	Preoccupation; tolerance; inability to control use; withdrawal; salience; jeopardy of opportunities; deception; mood modification	NR	Pathological gambling (DSM-IV)	No	Partial	3, 5, and 6
Dieter et al. (2015)	Checklist for the Assessment of Internet and Computer game Addiction (AICA-C)	6-point	Craving; tolerance; withdrawal; loss of control; preoccupation; negative consequences	1 month	Internet addiction as a generalized problem including specific usages (e.g., video gaming)	Yes	Partial	5, 6, 7, and 8
Wang et al. (2015a)	Young's Diagnostic Questionnaire (YDQ) modified to reflect Beard and Wolf's (2001) criteria for Internet addiction	Yes/no	Preoccupation; tolerance; inability to control use; withdrawal; salience; jeopardy of opportunities; deception; mood modification	NR	Pathological gambling (DSM-IV)	No	Partial	3, 5, and 6

(continued)

Table 11.2 (continued)

Author	Instrument	Item sensitivity	Criteria covered	Time scale	Theoretical framework	Suitability to assess IGD[1]	Alignment with IGD criteria	Missing IGD criteria
Xing et al. (2014)	Internet Addiction Test (IAT)	6-point	Salience; excessive use; neglect work; anticipation; lack of control; neglect social life	1 month	Pathological gambling (DSM-IV)	No	Partial	2, 5, 6, and 8
Yuan et al. (2016)	IGD criteria (DSM-5)[3]	Yes/no	Preoccupation; withdrawal; tolerance; inability to control use; loss of interest in activities; continued excessive use despite knowledge of problems; deception; escape/mood modification; jeopardy or loss of relationships and opportunities	1 month	Internet Gaming Disorder (DSM-5)	Yes	Total	None
Hahn et al. (2014)	Frequency criteria (i.e., playing at least four times per week for 1 h or more for at least 1 year)	–	Salience	12 months	Excessive playing time is likely to reflect IGD	No	Partial	2, 3, 4, 5, 6, 7, 8, and 9
Luijten et al. (2015)	Videogame Addiction Test (VAT)	5-point	Loss of control, conflict, preoccupation/salience, coping/mood modification, withdrawal	NR	Compulsive internet use theory derived from the DSM-IV criteria for dependence and obsessive-compulsive disorder and the components model of addiction	Yes	Partial	3, 5, 6, 7, and 9

(continued)

Table 11.2 (continued)

Author	Instrument	Item sensitivity	Criteria covered	Time scale	Theoretical framework	Suitability to assess IGD[1]	Alignment with IGD criteria	Missing IGD criteria
Tian et al. (2014)	Diagnostic criteria for Internet addiction by Tao et al. (2010)	NR	Preoccupation; withdrawal; tolerance; lack of control; excessive use despite problems; loss of interests; mood modification	3 month	Impulsive control disorder; pathological gambling (DSM-IV); components model of addiction and substance use disorder	No	Partial	7 and 9
Duven et al. (2015)	Scale for the Assessment of Internet and Computer Game Addiction (AICA-S, CSV-S)	5-point	Excessive use; preoccupation; compulsive use; tolerance; withdrawal; craving; escape; inability to control use; negative consequences	NR	Substance dependence (DSM-IV-TR and ICD-10)	Yes	Partial	2, 5, 6, 7, and 9
Lin et al. (2015a, b)	Internet Addiction Test (IAT)	6-point	Salience; excessive use; neglect work; anticipation; lack of control; neglect social life	1 month	Pathological gambling (DSM-IV)	No	Partial	2, 5, 6, and 8
Wang et al. (2015b)	Young's Diagnostic Questionnaire (YDQ) modified to reflect Beard and Wolf's (2001) criteria for internet addiction[2]	Yes/no	Preoccupation; tolerance; inability to control use; withdrawal; salience; jeopardy of opportunities; deception; mood modification	NR	Pathological gambling (DSM-IV)	No	Partial	3, 5, and 6
Son et al. (2015)	IGD criteria (DSM-5)[3]	Yes/no	Preoccupation; withdrawal; tolerance; inability to control use; loss of interest in	1 month	Internet Gaming Disorder (DSM-5)	Yes	Total	None

(continued)

Table 11.2 (continued)

Author	Instrument	Item sensitivity	Criteria covered	Time scale	Theoretical framework	Suitability to assess IGD[1]	Alignment with IGD criteria	Missing IGD criteria
			activities; continued excessive use despite knowledge of problems; deception; escape/mood modification; jeopardy or loss of relationships and opportunities					
Yuan et al. (2013)	Young's Diagnostic Questionnaire (YDQ) modified to reflect Beard and Wolf's (2001) criteria for Internet addiction	Yes/no	Preoccupation; tolerance; inability to control use; withdrawal; salience; jeopardy of opportunities; deception; mood modification	NR	Pathological gambling (DSM-IV)	No	Partial	3, 5, and 6

Superscript [1]Suitability was evaluated by verification of published peer-reviewed psychometric validation studies investigating the validity and reliability of the instrument to assess IGD. [2]The severity of IGD was assessed with the Chen Internet Addiction Scale (CIAS). [3]The severity of IGD was assessed with the IAT

Abbreviation NR Not reported

Note **IGD criteria (DSM-5; APA 2013)**: (1) preoccupation with games; (2) withdrawal symptoms when gaming is taken away; (3) tolerance, resulting in the need to spend increasing amounts of time engaged in games; (4) unsuccessful attempts to control participation in games; (5) loss of interest in previous hobbies and entertainment as a result of, and with the exception of, games; (6) continued excessive use of games despite knowledge of psychosocial problems; (7) deceiving family members, therapists, or others regarding the amount of gaming; (8) use of games to escape or relieve negative moods; and (9) jeopardizing or losing a significant relationship, job, or education or career opportunity because of participation in games indicators across all reviewed studies: instrument utilized, item sensitivity, criteria covered, time scale, theoretical framework, suitability to assess IGD, alignment with the nine IGD criteria, and missing IGD criteria.

Overall, this chapter provides objective data concerning a trend suggesting an increase in the publication rates of IGD studies using neuroimaging techniques since the publication of the DSM-5 (APA 2013). As shown in Fig. 11.2, the number of such studies is increasing and this may be beneficial to the process of formal recognition of IGD in future editions of the DSM (and other diagnostic manuals). This is because the APA suggested neurobiological evidence for IGD is of utmost importance. However, quantity does not necessarily equate to quality because there are a series of methodological issues that appear to hinder the progress of this type of research. Based on the results found in this review, the following recommendations are made to help improve the overall quality of future studies on IGD using neuroimaging techniques. Some of these recommendations apply to other types of IGD research (e.g., self-report surveys, focus group interviews, experiments, etc.), so implementing such recommendations is advised whenever possible as it may help strengthen the quality of future research into IGD.

Methodological Recommendations

1. Recruitment of gamers (cultural background): Since most of the reviewed studies were carried out in Asian countries, mostly in China, and only few studies were conducted in Western countries, it is recommend that future studies recruit participants from both Western and Eastern regions of the world where both online and offline games are played. This procedure is crucial to improving the quality of research on IGD as replicability of findings across all cultures where gaming is prevalent is important if research is to progress.
2. Recruitment of gamers (gender and age groups): Based on the findings collated in this review, it is also recommended that researchers recruit samples that are balanced in terms of gender and age. It is paramount to recruit gamers from diversified cultural backgrounds, otherwise findings may (potentially) be gender/culture biased or gender/culture-specific, and therefore, less likely to be replicated across different cultural settings.
3. Recruitment of gamers (clinical vs. experimental groups): Although it is common practice to recruit participants seemingly addicted to specific types of games (e.g., *WoW, LoL*, etc.) or game genres (e.g., Massively Multiplayer Online Role Playing Games), as suggested by the findings of this review, this procedure should be avoided as it has been largely adopted in past gaming addiction research from the early 2000s (see Pontes and Griffiths 2014) and is known for being problematic because IGD can occur in any type of gaming (e.g., online and/or offline) and therefore is not limited to a specific type of game and/or genre. Ultimately, limiting the recruitment of IGD-affected individuals to specific games may lead to biased results as other disordered gamers who play other games and genres may be overlooked.
4. Neuroimaging data (use of eclectic techniques): One noticeable finding in this review was that a large number of studies employed rsFMRI in order to collect

imaging data from gamers. Although this may not be problematic in and of itself, authors are advised to adopt an eclectic approach to imaging data collection by using more heterogeneous and other cutting-edge techniques so more information regarding the neurobiological etiology and course of IGD may be acquired. For instance, the combination of fMRI techniques with insights from PET research provides more direct insights into the biochemical mechanism of human behaviors, including IGD (Ko et al. 2015). The adoption of such approaches is likely to lead to quicker recognition of IGD by the psychiatric community as an independent disorder because greater and more diversified data will be available.

5. The inherent potential of using fMRI (refining the diagnostic features of IGD): Due to the need for differentiating chemical and nonchemical addictions coupled with the need to refine the diagnostic features of IGD, studies using fMRI techniques are welcome due to their inherent potential for investigating the specific mechanisms of addiction, including response to a substance, vulnerability for addiction, characteristics or symptoms of addictive behavior, and consequences of addiction (Fowler et al. 2007; Ko et al. 2015). For this reason, neurobiological research into IGD should formulate clear hypotheses derived from previous evidence from brain imaging studies as they might help clarify the utility and appropriateness of having specific diagnostic criteria within the diagnostic framework of IGD. Consequently, this type of research may provide robust evidence to either confirm or disconfirm claims that IGD may arise without associated withdrawal symptoms (Kaptsis et al. 2016) or that the tolerance criterion of IGD might be a prominent characteristic of passionate gaming rather than a criterion indicative of *bona fide* gaming addiction (Kardefelt-Winther 2015).
6. Impacts of IGD on cognition (avoiding premature conclusions): According to Ko et al. (2015), any conclusions regarding cognitive function in IGD would still be premature as the overall effect of IGD on cognitive functioning remains controversial. Contrary to most controlled substances that are known to have damaging effects on the brain, a reasonable assumption is that they impair cognitive function. However, it is known that gaming can exercise and enhance many specific cognitive functions (e.g., Stroud and Whitbourne 2015; Toril et al. 2014). For this reason, the hypothesis that gaming in and of itself produces a deficit in cognitive function is questionable because perfect performance in gaming requires good cognitive function (Ko et al. 2015). Thus, studies reporting potentially negative impacts of IGD on cognition should take into account the fact that gaming may also produce positive cognitive effects on gamers.

Assessment of IGD recommendations

7. Assessment of IGD (key assessment issues): As shown in Table 11.2, although all studies reviewed concerned the phenomenon of IGD, the diagnosis of this potential disorder was largely conducted by employing assessment instruments

that were either (i) designed to assess generalized IA or (ii) had their theoretical framework based on the concept of IA or (iii) nonvalidated diagnostic criteria. This is perhaps one of the most troublesome findings of this review because the use of different, nonspecific, and/or psychometrically weak tools to assess IGD not only represents a threat to the call for unification in the assessment of IGD (Griffiths et al. 2015, 2016), but also hinders the progress of research in this field as cross-cultural comparisons between studies are virtually impossible to be achieved under such circumstances (Kuss et al. 2014). Moreover, researchers in the field are discouraged to adopt such procedures because they severely compromise the overall validity of neuroimaging studies on IGD since the main construct under investigation is not being properly assessed but instead, other related (and yet different) constructs are being assessed (i.e., generalized IA rather than IGD).

8. Assessment of IGD (frequency of gameplay and IGD): Although it is not common practice to assess IGD based on frequency of gameplay (i.e., time spent gaming), there are still studies using the frequency criterion as a way to diagnosing IGD cases. It has now been long established in the field that excessive gaming does not necessarily equate to addiction (Griffiths 2010; Kuss et al. 2012) and that there is a difference between engaged and addicted gamers (see Charlton and Danforth 2007; Fuster et al. 2015; Pontes et al. 2014). Therefore, we encourage authors to assess and diagnose IGD based on newly developed standardized instruments available that were devised using the updated framework to assess IGD (i.e., the APA's nine criteria) and that have been shown to possess acceptable levels of validity and reliability (such as: Király et al. 2015a, b; Lemmens et al. 2015; Pontes and Griffiths 2015a; Pontes et al. 2014). By adopting such a recommendation, the goal of unification in the assessment of IGD will be more tangible and less difficult to achieve.
9. Assessment of IGD (heterogeneity issues): A systematic review conducted by King and colleagues (2013) assessing a total of 18 problematic gaming instruments across 63 empirical studies, demonstrated that most tools presented similar limitations including: (i) inconsistent coverage of core addiction indicators, (ii) use of varying cut-off scores to indicate clinical status, (iii) lack of a temporal dimension, (iv) untested or inconsistent dimensionality, and (v) inadequate data on predictive validity and inter-rater reliability. Similarly, the findings of the present chapter mirrored those found by King and colleagues (King et al. 2013). More specifically, the present review found that the included studies used eight different methods for diagnosing IGD, which suggests great disparity and heterogeneity between the preferred methods for assessing IGD in this new era of research. As noted above, there are valid and reliable psychometric tools designed to assess IGD based on the APA's suggested framework and these should be used. Because of the inherent difficulties in obtaining a gold standard for IGD across studies, authors can mitigate the possible biases stemming from the assessment of this disorder by adopting commonly used tools that assess IGD using APA criteria and possess some degree of validity and reliability. This is an important aspect of research into IGD more generally

(as shown in Table 11.2) because most instruments used to assess IGD are based on theoretical frameworks of IA that lack content validity to assess IGD because many important aspects of the IGD construct are not fully covered.

10. Assessment of IGD (diagnosis vs. severity): Findings in this chapter also found that most of the studies reviewed relied on one instrument or criterion to diagnose IGD and another one to assess the severity of IGD. More specifically, five studies, including the two studies that have used the IGD criteria to diagnose IGD, adopted two different instruments to diagnose and assess the severity of IGD (Ding et al. 2014; Son et al. 2015; Sun et al. 2014; Wang et al. 2015b; Yuan et al. 2016), with these instruments either being the CIAS (i.e., Ding et al. 2014; Sun et al. 2014; Wang et al. 2015b) or the IAT (i.e., Son et al. 2015; Yuan et al. 2016). Although it is not entirely clear as to why two different instruments were used to diagnose and assess the severity of IGD, this certainly does not facilitate a sound assessment of IGD as more noise is introduced into such studies with the use of different assessment tools. Additionally, and perhaps more worryingly, assessing the severity of IGD with generalized IA is not the way forward as issues of construct validity may emerge. Hence, it is recommended to use one of the newly standardized psychometric tools to assess the severity of IGD as well as an initial structured interview to diagnose IGD based on the nine IGD criteria if necessary as they appear to have clinical validity (Ko et al. 2014).

Based on the findings raised and highlighted in this chapter (and the recommendations generated upon them), it is hoped that future IGD studies, especially those using neuroimaging techniques, may improve their methodological and instrumentation features as there are several different ways to overcome such shortcomings that most of the extant studies on IGD using neuroimaging techniques present with.

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Chapter 12
A Short Summary of Neuroscientific Findings on Internet Addiction

Christian Montag, Éilish Duke and Martin Reuter

Abstract Neuroscientific approaches to the understanding of Internet addiction have broadened our knowledge on the biological basis related to the overuse of the Internet. The present chapter lends a short introduction to this area. Moreover, it integrates and summarizes the most important findings of this research field.

12.1 Background of the Present Section

The present chapter closes the section on neuroscientific findings on Internet addiction. In total, ten chapters of this book give the reader detailed insights into different approaches to investigating Internet addiction through use of neuroscientific techniques. While structuring the book and inviting authors to contribute, we became aware that it would be meaningful to ask internationally renowned researchers to summarize the findings on the nature of Internet addiction from distinct perspectives such as structural/functional MRI, PET, and molecular genetics, and also by investigating the peripheral autonomous activity using classic biopsychological tools such as recording electrodermal activity and heart rate. Clearly all these techniques have unique advantages and disadvantages, thus different approaches to Internet addiction illuminate different facets of this new potential psychopathological disorder. As only a small number of studies used EEG, we refrained from including a

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_12

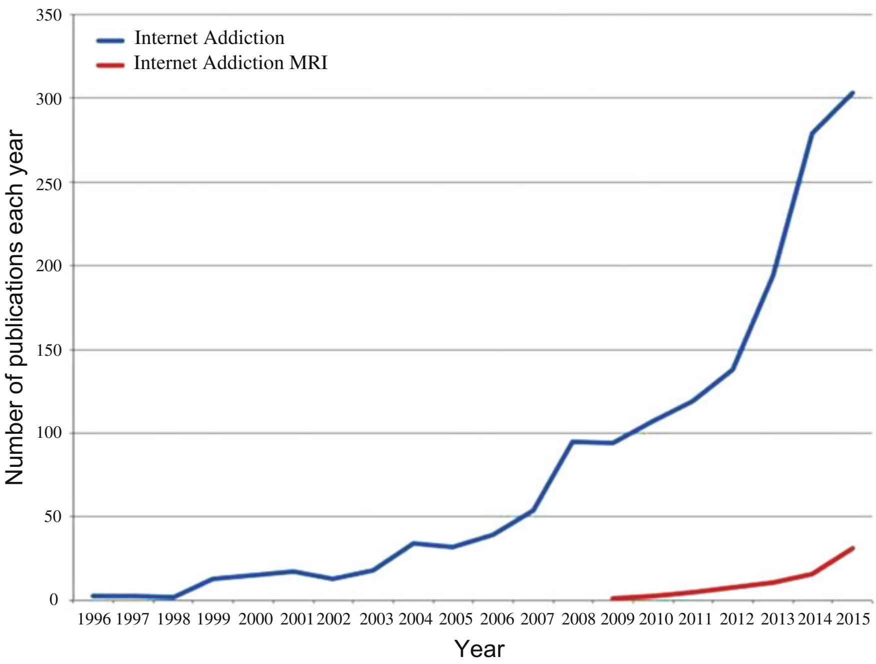

Fig. 12.1 Number of publications dealing with Internet addiction each year since 1996 split into all papers (*blue*) and those only dealing with MRI (*red*) found on pubmed.com

further chapter on EEG research (although this was initially planned). Nevertheless, we will briefly outline the EEG findings on Internet addiction in this synopsis. For readers not familiar with the background of the neuroscientific techniques, we refer in addition to the chapters in this book, to the extensive Appendix of the volume "Neuroeconomics," also appearing in the present series "Studies in Neuroscience, Psychology and Behavioral Economics," giving scholarly insights into a wide range of important methods (Reuter and Montag 2016).

In the following, we would like to outline some general thoughts on the question of whether Internet addiction actually qualifies as a distinct psychopathological disorder. Before we aim to find a preliminary answer to this question, we first would like to underline the importance of publishing a compendium on the status quo of Internet addiction research. In this context, we produced Fig. 12.1, which is discussed in the next section.

12.2 Some Numbers on Published Internet Addiction Papers

On July 24, 2016 we searched pubmed.com for papers dealing either with the keyword "Internet addiction" or a combination of the keywords "Internet addiction" and "MRI." Without doubt MRI represents the most frequently used neuroscientific technique in the study of Internet addiction. While general research dealing with Internet addiction started in the year 1996, the first studies using MRI to gain insights into the biological underpinnings of MRI appeared 13 years later, in the year 2009. Clearly the numbers of published Internet addiction papers continue to rise dramatically each year. In the last year N = 303 papers were published on Internet addiction, totaling up to N = 1572 papers since 1996. Since the year 2009, N = 87 papers have been published on Internet addiction utilizing MRI. The popularity of MRI studies in the field of neuroscientific Internet addiction research is also reflected by the inclusion of several chapters in the present book dealing with structural/functional MRI and Internet addiction. In general, the tremendous research efforts in this new field clearly mirrors the need to better understand how the Internet challenges our society and how our brains react to an increasingly complex (digital) world.

12.3 Cue Reactivity Paradigms, the Striatum and Internet Addiction

Although it is too early to answer the question of whether Internet addiction qualifies as a distinct behavioral addiction or otherwise, several similarities between Internet addiction and other well-known forms of addiction are striking. In the following, we will summarize some of the most important overlaps.

One classic approach to the study of addiction by means of functional MRI is the use of cue reactivity experiments. Here, the drug stimulus (e.g., a computer screen with a browser) is shown to the (Internet) addict via special goggles or a mirror system while lying in the MRI scanner. By recording the brain activity in this setting, the researcher hopes to gain insights into the biological mechanisms underlying addictive tendencies. This approach to the study of addiction in humans has been adapted from 'classic' psychological research. Here, Carter and Tiffany (1999) observed in their meta-analyses that typical reaction patterns in different groups of addicts towards the exposure of their preferred drug cue can be observed in the periphery of the human body. These include elevated heart rate, higher electrodermal activity, and lower skin temperature. In line with this, Huang describes in Chap. 10 in the present volume, that Internet addicts are also characterized by higher blood volume pulse and lower skin temperature, while surfing the web. Conflicting findings were observed with respect to skin conductance, which was lower in Internet addicts compared to healthy Internet users. Despite the latter finding, similarities between the bodily responses of Internet addicts compared to other types of addicts can be observed. This all naturally hints towards the idea to include cue reactivity experiments in an MRI setting, too.

The adoption of cue reactivity experiments in MRI paradigms suggests that the striatal brain region represents a key to understanding the psychological processes of wanting and consuming a drug, such as the Internet. Ko et al. (2009) observed stronger neuronal activity in this brain area while processing World of Warcraft stimuli in excessive gamers versus healthy controls. Sun et al. (2012) observed a similar activity in the nucleus caudatus in an identical design.[1] It is noteworthy that this kind of brain activation can also be observed in the processing of alcohol stimuli while scanning alcoholics (Vollstädt-Klein et al. 2010), smoking-related stimuli while scanning smokers (Franklin et al. 2007) or heroin-related stimuli while scanning heroin addicts (Li et al. 2012). Deriving from this, different kinds of addictions seem to share common biological underpinnings in the processing of drug cues. The fact that some of the aforementioned studies deal more with online video game addiction/Internet Gaming Disorder (instead of generalized Internet addiction) is mentioned as a limitation in the summary of findings below.

12.4 Dopamine, the Striatum and Internet Addiction

Functional MRI studies help to describe which brain areas play an important role in the processing of drug cues, craving, or being intoxicated (e.g., by consuming too much alcohol). Besides giving these valuable insights, functional MRI clearly also possesses limitations, such as having a relatively low temporal resolution. In contrast, EEG is able to record brain processes within a more accurate time window, but is unable to sufficiently image subcortical processes. Both fMRI and EEG are unable to give direct insights into the active transmitter systems of a given brain area when recording brain activity. To close this gap, other approaches from brain imaging, such as PET or molecular genetics, need to be taken into account for a better understanding of the biochemical processes underlying Internet addiction.

It is common knowledge that the striatum, in particular the nucleus accumbens, as central brain region for the processing of and craving for rewards, is strongly innervated by the neurotransmitter dopamine, which represents a classic target to understand addiction and reward (Berke and Hyman 2000; Wise and Rompré 1989). Thereby it might not come as a surprise that one of the previous chapters dealing with the imaging technique PET revealed strong evidence for a link between dopamine and Internet addiction. Park and Kim observe in Chap. 5 (see also Kim et al. 2011) that Internet addicts are characterized by a lower D_2 receptor density (something which is typical for additive tendencies in general; e.g., Blum et al. 1996). This is also in line with one of the earliest PET findings in this research field, which showed that the dopaminergic neurotransmission is triggered while playing a video game (Koepp et al. 1998).

To explain these noteworthy dopamine findings a bit more, the role of dopamine in addiction needs to be better defined. A seminal review by Volkow et al. (2003) summarized that strong dopaminergic bursts accompany the consumption of or craving for a drug. The over-activity of the dopaminergic system when being

[1]The above mentioned studies by Ko et al. (2009) and Sun et al. (2012) reported a wide range of further brain areas of interest, which are not discussed at this point for the sake of brevity.

confronted with or anticipating a drug makes it hard for the addict to fight against the actual consumption, and to focus instead on potential negative long-term consequences of the drug abuse. Here, we will also need to discuss the findings on Internet addiction and the anterior cingulate cortex (ACC), reflecting top–down processes to control the dopaminergic bursts in subcortical areas when being confronted with a drug. This is done in the next section.

Coming back to the observation that lower D_2 receptor density can be observed in Internet addicts; it is of importance to note that a lower number of these receptors could result in a higher threshold required for drug stimulation, thereby increasing the amount of drug intake necessary to achieve a similar threshold. Thanos et al. (2001) revealed that the artificial upregulation of D_2 receptors in rats led to less alcohol consumption, whereas the downregulation of these receptors was associated with even higher consumption of alcohol. In humans (as in other mammals), the D_2 receptor density of the striatum itself is in parts determined by genetics disposing a person more or less to become addicted. As summarized in our chapter on molecular genetics and Internet addiction (see Chap. 9), the first evidence has been provided that Internet addicts more often carry the A1+ variant of the DRD2/ANKK1 Taq Ia polymorphism (Han et al. 2007), which is linked to a 30–40% reduction of the D_2 receptor density in striatal regions (e.g., review by Noble 2000). Moreover, the A1+ variant also seems to be associated with a lower binding capacity of dopamine at the D_2 receptor (Thompson et al. 1997). As mentioned above, carrying the A1+ variant reflects not a tendency to become Internet addicted per se but rather represents a general vulnerability factor for addictive behavior, as the A1+ variant has also been associated with a wide range of addictions including alcoholism (Munafo et al. 2007), heroin addiction (Teh et al. 2012), and smoking (De Ruyck et al. 2010).

12.5 Conflict Monitoring, Anterior Cingulate Cortex, and Internet Addiction

Another key region in addiction research is the ACC. This brain area is crucially involved in conflict monitoring (Kerns et al. 2004). Conflicting situations or dilemmas play an important role in addiction research, because drug addicts are usually confronted with the lure of immediate drug consumption/reward and thereby taking into account long-term negative consequences such as bad health or social repercussions.

In the context of addiction research, it has been demonstrated that, for example, opiate addicts show an attenuated error-related activity of the rostral ACC, when performing a Go/NoGo task in an fMRI setting (Forman et al. 2004). In a Go/NoGo task, participants of a study need to suppress a learned dominant behavior, such as pushing a button, when not appropriate. The poorer performance of addicts compared to healthy participants on such a task, supports the idea that monitoring functions of the ACC seem not to work properly in addicts (Lubman et al. 2004).

This also potentially explains why addicts are prone to weigh the short-term rewards higher than the long-term negative consequences of drug misuse. In addition, cocaine addicts have been associated with lower gray matter volume of the cingulate area (Franklin et al. 2002). Although studies bridging structural with functional brain imaging are scarce, it is imaginable that a reduction of brain volume in a given brain area such as the ACC goes along with a higher chance of dysfunctionality.

The findings on the ACC-addiction link can also be transferred in part to Internet addiction research. In line with the study by Franklin et al. (2002), Internet addicts have been associated with lower gray matter density of the ACC (Zhou et al. 2011; see also Chap. 3). Moreover, a recent EEG study by Dong et al. (2010) provides further data for a dysfunction of the ACC in Internet addiction, because Internet addicts "had lower activation in the conflict detection stage than the normal group" in their Go/NoGo experiment (p. 138). A follow-up study by Dong et al. (2011a) extended these findings in the same direction using a color word Stroop experiment. The group of Internet addicts was associated with a reduced medial frontal negativity of the EEG signal going along with more errors made in the incongruent condition[2] of the experiment and longer reaction times compared to healthy controls. Finally Dong et al. (2011b) showed that Internet addicts respond with lower activity in the ACC to losses in a guessing task.

Taken together, these findings point towards an impairment among Internet addicts in resolving conflicts and problems in following a long-term health strategy. The low inhibitory control from the prefrontal cortex, including the ACC, over the strong dopaminergic bursts from subcortical areas when being confronted with a drug, seem to represent an essential part of the biology of Internet addiction. This simplified model is also depicted in Fig. 12.2 (note that we also included the dorsolateral (dl) prefrontal cortex as important brain area for top-down control in the figure).

12.6 Summary of the Present Overview

These two examples focusing on the striatum and the anterior cingulate demonstrate that indeed several findings from Internet addiction research integrate well into findings from general addiction research. Nevertheless, it is too early to state that Internet addiction represents a distinct behavioral addiction.

First of all, an own study recently outlined that it is problematic to compare all kinds of specific and generalized Internet addictions, because the overlap in terms of comorbidity between these different forms of Internet addiction is not large (Montag et al. 2015). Besides this, longitudinal studies describing the effects of excessive Internet usage on the brain are largely missing. In contrast to smoking,

[2]In the color word Stroop experiment, words describing colors are presented in two conditions. The congruent condition e.g. consists of the word blue presented in blue color, whereas in the incongruent condition the word blue is presented in red color. Participants are required to name the color of the shown words (i.e. not the word printed).

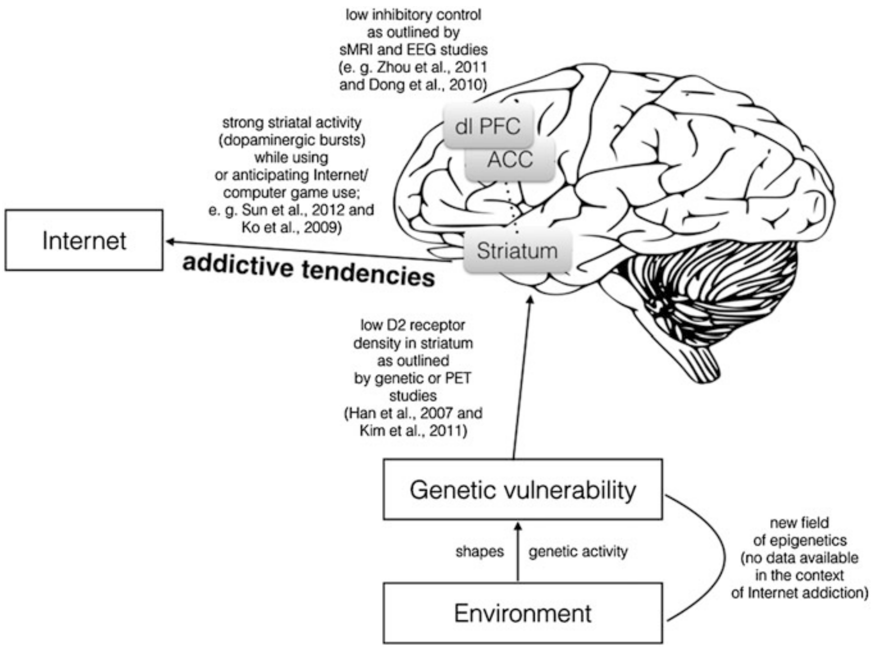

Fig. 12.2 A simplified psychobiological model of Internet addiction including key findings from Internet addiction research (for a more detailed model on Internet addiction and brain functions including limbic brain areas we refer to the work by Brand et al. (2014))

alcohol, cocaine, or heroin, no substance is directly inserted into the human body. Therefore, brain changes due to Internet addiction may ultimately prove more reparable than those arising from the substance-related addictions, although empirical evidence is lacking for this hypothesis. In particular, neuroscientific studies are needed to directly contrast Internet addicts with substance dependent addicts in longitudinal designs.

From a therapeutic viewpoint, a large difference exists between Internet addiction and other forms of addiction. While typically a 'zero tolerance' strategy is taken toward future drug use with substance-abusing addicts, full abstinence from the Internet cannot be the aim in treating Internet addicts. Otherwise, most jobs and communication forms of the twenty-first century are out of reach for the afflicted patients. Interestingly, empirical data also suggests that only private but not business use of the Internet is associated with Internet addiction (Montag et al. 2010; Sariyska et al. 2014). On the other hand, it has been demonstrated that Internet addicts have already been successfully treated with classic psychopharmaceuticals, such as SSRIs (see review by Camardese et al. 2012, see also Chap. 14), showing that Internet addiction might not that different to treat, compared with other psychopathological disorders. Moreover, successfully treated Internet addicts have been associated with a downregulation of activity in the dorsolateral PFC, potentially reflecting lower rumination about craving (Han et al. 2010; see also the Chap. 6). In sum, therapy seems to leave its mark on the activity of the brain as demonstrated with fMRI here.

12.7 Limitations of the Present Short Synopsis

Last but not least, some limitations of this very brief overview need to be mentioned. First of all, for reasons of clarity and to give an "easy to read" overview on the neuroscientific findings related to Internet addiction, we focused on two major brain regions in addiction research—namely the ACC and the striatum. Of course, a large number of other brain areas stemming from the limbic system and further prefrontal regions have been not included here (for example please see Chaps. 3 and 4 for additional insights on prefrontal cortex and executive functions; moreover see Brand et al. 2014). Second, the present overview followed not the aim to review all existing neuroscience studies on Internet addiction, because this has been done much better by the authors of each chapter and their special approach to Internet addition. Third, some new approaches are arising in neuroscience, which have not yet been implemented in Internet addiction research. As depicted in Fig. 12.2, epigenetics will be of interest to better understand how environmental influences changes genetic activity into the direction of becoming vulnerable or resilient for becoming addicted to the Internet. In order to provide researchers with a new roadmap to better understand which molecules might underlie the molecular foundations of Internet addiction, finally we like to refer to a new publication using Panksepp's Affective Neuroscience theory as a guide (Montag et al. 2016).

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Part III
Therapeutical Interventions in Internet Addiction and Governmental Policies

Chapter 13
The Impact of Psychoinformatics on Internet Addiction Including New Evidence

Christian Montag, Martin Reuter and Alexander Markowetz

Abstract *Psychoinformatics* refers to the new collaboration between the disciplines computer science and psychology to study psychological phenotypes by means of data mining. This chapter gives an overview of how *Psychoinformatics* can aid research and therapy in the context of Internet addiction. In particular, applications on smartphones are highlighted, which track the online behavior of humans on their digital devices.

13.1 Introduction

Psychoinformatics, the fusion of psychology with computer science, will be of great importance in the treatment, diagnostics, and research of Internet addiction. In a recent paper, Markowetz et al. (2014) outline the potential of *Psychoinformatics*, as a new interdisciplinary research endeavor, for the study of mental health. This approach applies methods from computer science to psychological research, in order to obtain deeper insights into the mental states of individuals or other psychological variables such as personality (for an example for empirical research in this field see Montag et al. 2014, 2015b; a new overview is presented in Montag et al. 2016a, but see also an overview using the term *digital phenotyping* by Onnela and Rauch 2016). To date, the most frequently used methods in psychology for the assessment,

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_13

understanding and prediction of human behavior, have been (i) the classic laboratory experiment, (ii) the administration of self-report questionnaires, and (iii) particularly in psychotherapeutic and work psychology settings, the interview. Although these techniques have several advantages, they also have some drawbacks.

First, we briefly summarize the advantages and limitations of traditional methods in psychological research. Subsequently, we outline techniques from computer science that can address these issues. Finally, we outline the impact of *Psychoinformatics* on the research and therapy of Internet addiction.

13.2 Traditional Methods in Psychology

The interview poses one of the leading tools to obtain insights into the attitudes and character of a person (e.g., Potter and Hepburn 2005; Schmidt and Hunter 1998). It is not only used widely in psychotherapy, but in many other areas such as work and organizational psychology. The information gathered is used to hire a person for a job or to help a person in overcoming biased cognitions such as being always responsible for a negative outcome while treating depression (Wright and Beck 1983; Beck 2002).

Significant research effort has been directed into the development of structured interviews, to enable a fair hiring process (Campion et al. 1988) or to form guidelines for a psychiatric diagnosis, such as depression (Riskind et al. 1987). Structured interviews follow a clear "structure," with the same items/questions being administered in the same order. In contrast unstructured interviews follow no clear line of questioning. The push toward standardized interviews has led to improved outcomes with respect to their validity, e.g., in work psychology (Wiesner and Cronshaw 1988) and clinical psychology (Miller et al. 2001). The enduring prevalence of interviews in many areas of psychology can be attributed to the fact that direct communication with a person is, in many ways, an indispensable tool (especially in therapy), in taking into account the unique perspective of a person. This subjective perspective can be supplemented with information derived from other (more objective) sources. Imagine a salesperson who pretends to be outstanding at selling cars. In reality, it turns out that, despite the self-report, he/she has never sold a car. The discrepancy between the information derived from the interview and the exact figures from a company's paperwork on sold cars, gives insights into biased cognitions. In the context of the main topic of the present chapter it is noteworthy that Tao et al. (2010) investigated the prevalence of different diagnostic criteria for Internet addiction; which represents a significant step toward a structured interview (as questions can be built based on these findings). Notable is their proposal of a "2 + 1 rule." As a first step, the symptoms "preoccupation with the Internet" and "withdrawal" must be observed. Adding to this, at least one out of several optional symptoms, e.g., development of tolerance, must also be present, in order to justify a diagnosis of Internet addiction. Finally, Tao et al. argue that clinical impairments such as problems in private or job areas and course criteria (excessive Internet use of three month with a minimum private Internet usage of 6 h each day) need to be fulfilled/observed (p. 563).

Besides the mentioned advantages of interviews, this method also has several shortcomings. First, the method is time consuming and expensive, requiring the psychologist as well as the interviewee to invest a significant amount of time in data collection. Second, it is unclear whether the interviewee provides an accurate description of his/her mental world. Social desirability may play a particularly important role, especially where individuals are asked about stigmatizing psychopathological conditions (Edwards 1957; Sugarman and Hotaling 1997). Social desirability describes the tendency to present one's own character and attitudes according to what is thought to be acceptable in terms of social norms. Usually the person describes him- or herself as "better" than he/she actually is. However, the opposite, so-called "self-handicapping," is also observed. Here, individuals "handicap" themselves to protect their self-esteem, e.g., if a goal could not be achieved. It is important to note that cross-cultural differences in tendencies toward social desirability also exist (Johnson and van de Vijver 2003).

The second dominant method in the social sciences is the use of self-report questionnaires. Here, a person fills in items on a given topic of interest—e.g., in this instance, Internet addiction. Although questionnaires are relatively easy to handle, they also need to be analyzed (i.e., through use of statistical tests) and they too are subject to the problem of social desirability. This is especially true if the information provided on the questionnaire is not anonymized, but needs to be used further, e.g., in a therapeutic or employment context. Besides this, classic forms of self-report-inventories, such as paper-pencil questionnaires, constitute extra work for the researcher, as the information must be transferred to a digital form (to enable statistical analysis) and the hard copy questionnaires must then be stored for a longer time. This is especially true where paper-pencil questionnaires have been part of a research endeavor, employment scenario, etc. Of course, this can be circumvented through use of electronic versions of questionnaires, whereby some of the aforementioned problems can be diminished. Yet, the major drawback of self-report methods and interviews remain; the reliance upon the ability of the participant to recognize, recollect, and present the subject matter accurately.

Last but not least, social scientists rely on experiments, in which strict experimental laboratory settings provide the possibility of controlling potential confounding factors, e.g., if a researcher aims to assess the influence of Internet addiction on cognitive function. Although experiments provide a high scientific standard, they are vulnerable to several problems. Due to the artificial environment of the laboratory, it is not clear whether results derived from laboratory experiments can be generalized to the "real world." In other words, laboratory experiments often lack ecological validity, especially when only a small aspect of a broad phenotype is assessed in the lab. For example, shorter fixation times to threatening stimuli (a marker for anxiety) do not imply that a participant has difficulties in giving a talk in front of a broad audience (social phobia). Besides this, and in-keeping with the other methods, participants' motivational factors play an important role. If a participant in a study is not motivated to follow the instructions of the experiment, the quality of the data will be poor. Moreover, conducting experiments is very expensive, because a room for the experiment needs to be rented and highly trained specialists are needed to carry out the experiment properly.

Methods from computer science can help to overcome some of the above-mentioned problems encountered by interviews, self-report-measures and experiments. They can be of particular value to research efforts in Internet addiction.

13.3 Psychoinformatics and Internet Addiction

Methods from computer science have been used in psychological research for several decades. The use of computers and the Internet, such as online surveys and computer-based psychological experiments, illustrate this point nicely. Such, rather obvious, methods will not be discussed in the present chapter. Instead, we focus on new developments in the assessment of human behavior, via mobile devices but also by monitoring the human–machine interaction in everyday life, e.g., the use of the computer in a workplace situation.

Most humans in industrialized societies possess and use a smartphone on a daily basis. These powerful little machines provide access to the Internet, entertainment, including computer games, and of course the classic functions of mobile phones, such as telephone and short text message features. Furthermore, the new generation of smartphones includes intelligent sensors, which are able to track the location of a person (via the global positioning system, GPS) and their bodily movements. Of note, the smartphone is usually carried on the body of a person, thereby accompanying humans in nearly all daily activities. Many smartphone users even carry their smartphone when going for a run to track the speed and distance of the workout. This being said, smartphones and the data recorded from the human–machine interaction, provide genuine insights into the life and even mental states of a person. Most importantly, data derived from this source can be collected on a longitudinal basis, whereas the traditional methods discussed above usually do not go beyond one or two measures. Anyway, traditional methods do not provide a fine grained monitoring of a person's behavior over a long time.

In the context of assessing and treating Internet addiction, an exact recording of the length of online sessions over a longer time window provides a significantly more accurate picture of a person's Internet usage than numbers derived via self-report. Direct monitoring of the smartphone also provides insight into the most important addictive behaviors in the context of computer or smartphone use. The need to distinguish between different forms of online addiction has been demonstrated recently by Montag et al. (2015a).[1] Figure 13.1 depicts our recently self-developed app for monitoring smartphone behavior.

[1]Of note, smartphone addiction (and the broader category mobile phone addiction) and Internet addiction are not the exact same constructs, as questionnaires measuring both forms of addiction correlate only moderately with each other (see Jenaro et al. 2007; Kwon et al. 2013a, b; Montag et al. 2016b). But: As a rising number of smartphone users surf the Internet via these devices, it is very likely that correlations will be higher in the future (see also Chap. 21).

Fig. 13.1 *Left side* of the figure shows the recording of actual time spent on the smartphone each day and the *right side* shows the most often used application of a user. The figure depicts *screenshots* from the app “Menthal”

By tracking Internet activity directly on a smartphone or computer, classic symptoms from addiction research can be examined (Andrews et al. 2015; Lin et al. 2015; Montag et al. 2015c). If one thinks of development of tolerance in the context of Internet consumption, this symptom should be reflected in increasing hours spent online over a given time window (for methodological issues see Chap. 20, please). Of course, here a patient’s wellbeing will also need to be considered, and will play an important role in diagnosing Internet addiction. The therapist’s impression of a patient completes the assessment of this potential new behavioral addiction. Besides asking a person about his/her wellbeing, it will be also possible to assess wellbeing via *textmining* in the future. Here, the content of E-Mails, messages of online social network channels (e.g. Kern et al. 2014; Schwartz et al. 2013), etc., can be analyzed in terms of the number of positive and negative words used by the patient. This will give indirect insights into the individual’s mental state. This topic will prove less intrusive than anticipated, as the text can be analyzed on the phone and only the derived quantitative assessment is transmitted to a server (not the content of an individual’s messages).

In the following section, we outline a short example demonstrating how a distinct pattern of different variables from smartphone use, could help to monitor and diagnose affective disorders such as depression. Depression is of interest in the context of Internet addiction as a subgroup of Internet addicts concurrently experience a form of this affective disorder (Kim et al. 2006; Sariyska et al. 2015). Imagine that a person usually phones ten different contacts a day; this person is very active in terms of recorded GPS locations, and shows signs of positive emotionality reflected in the large number of positive words used in communication channels (including lots of smiley emoticons). Suddenly a different data pattern occurs: The same person calls no one for several weeks, seems to stay at home (no GPS activity) and the use of negative words (and a lower number of messages) prevails. The shift in the data pattern recorded on the smartphone could represent a sign of social withdrawal accompanied by negative emotionality, possibly indicating a depressive state. In line with this, new studies demonstrated that variables such as loneliness, shyness (Bian and Leung 2015) and also depression can be linked to smartphone usage patterns (Saeb et al. 2015).

Psychoinformatics can also aid in the therapy of Internet addicts. Traditional settings such as Cognitive Behavioral Therapy (CBT) usually encounter longer time windows between therapy sessions. Here, the therapist often sees his/her patient not more than once a week. In addition, in some psychotherapeutic approaches (see also the Chaps. 15, 16 and 17), patients are required to write a daily diary monitoring their Internet usage and/or their mental states. The inclusion of the above-mentioned techniques from *Psychoinformatics* aids and simplifies the therapeutic process, because events in the everyday life of a patient can be better included in therapy, without the problem of distorted memory. For example, if the therapist verbally asks the patient "How often have you used the Internet over the last week in hours?", this question can only be answered with a vague number. It might even be trickier if the patient is required to recall the use of last Monday. In contrast to this, direct measurement of time spent using the device will provide accurate numbers and facilitate more direct therapeutic interventions. If an Internet addict uses a certain function of the Internet, such as Facebook, for more than one hour, a virtual "red flag" could be raised alerting the user to quit the session. It is even possible that after excessively long online sessions a notification will be send directly to the therapist. In the context of psychodiagnostics, it is noteworthy that recorded behavior on the smartphone is stronger linked to self-reported addictive tendencies on the smartphone compared to the associations with self-assessed hours and other relevant variables on the phone (Montag et al. 2015c).

Last but not least, *Psychoinformatics* can help to assess the development of cognitive function in Internet addicts. Among others, Park et al. (2011) provided evidence that Internet addiction is associated with lower cognitive functions in the domain of attentional processes. As this data stems from a cross-sectional study, longitudinal evidence is needed to obtain insights into the cause–effect principles. Again, the smartphone may be of help. Instead of "swiping" the log-in-screen to gain access to the functions of a smartphone, cognitive games can be incorporated at log-in (e.g., instead of swiping, the patient participates in a short cognitive test). Thousands of data points on cognitive functions could thus be collected by the therapist or the researcher, giving valuable insights into the development of cognition in light of Internet and smartphone use. Naturally, it is not practical to include a 5 min experiment at log-in, but this may be viable for shorter trials (such as a ten second game when logging in). Longer experiments would possibly serve to demotivate participants' smartphone usage (albeit arguably show some therapeutic effects), but also could demotivate participants' participation in the experiment. Although no data yet exist on the validity and reliability of cognitive data collected via a smartphone log-in-screen, clearly the collection of thousands of data points should drastically diminish the standard error of the mean in the registered data and therefore provides a more precise picture of the user's smartphone usage cognitive functions.

13.4 Psychoinformatics, Multiple Testing, and Data Privacy

The use of *Psychoinformatics* also presents several problems. First of all, we would like to consider the important issue of data protection/privacy. The recording of data from smartphones or from other digital devices bears the great danger of data misuse. Therefore, it is of importance to explain in detail which data will be recorded, and what kind of data will *not* be recorded. In the above-mentioned "Menthal Balance" app (Fig. 13.1), users are informed prior to installation, that no calls or message content will be recorded. Furthermore, in this research scenario, each smartphone is used as a small computer to conduct the statistical analyses. Only numbers, i.e., no direct content, from the smartphone is sent to the server of the researchers. Nevertheless, for many areas, such as therapy, direct content from mails could be a valuable data source. Again, we wish to note the difference between categorizing words into positive or negative categories and sending numerical data on the use of these positive/negative words to a server, compared with sending the complete content. Of note, the long recognized system of confidentiality between medical/psychological practitioners and patients provides a valuable guideline on how to use the data derived from *Psychoinformatics*.

A second problem of *Psychoinformatics* applies primarily to research related areas. Correlating thousands of variables from Big Data[2] will inevitably lead to some false positive results. Therefore, strong correction procedures, such as those applied in genetics and brain imaging research areas need to be adapted in this kind of research approach. Results derived from exploratory data analyses will also need to be replicated (and tested in strict laboratory experiment).

[2]In our context, Big Data refers to the enormous amount of information being collected on devices such as a smartphone.

13.5 Conclusions

Psychoinformatics, the introduction of methods from computer science to the area of psychology, can aid the diagnostics process, therapy, and also research in the field of Internet addiction. To date, there is a dearth of empirical data in support of the above-mentioned hypotheses. The future will show how these methods can be included in the various areas dealing with Internet addiction.

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Chapter 14
Pharmacological Treatment of Internet Addiction

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Abstract The increasing number of Internet users has resulted in an increased population percentage affected by the negative effects of problematic Internet usage. To date, the management of psychopathological Internet use is not supported by extensive empirical research. No standard clinical treatment protocols for pharmacological treatment exist, and as a result, empirical or anecdotal assessments based on case studies are mainly consulted. A relevant problem in performing clinical trials is the evolving nosology, which encompasses ambiguous definitions of Internet addiction and a diversity of diagnostic, prognostic, and therapeutic criteria. The aim of this chapter is to review the current literature, to assess the extent to which specific pharmacological interventions (e.g., using antidepressants, mood stabilizers, opioid receptor antagonists, or antipsychotics) can alleviate the symptomatic burden in patients with "Internet addiction." We also explore pharmacological interventions that target patterns of comorbidity and underlying psychopathological dimensions (e.g., addiction, impulsivity, obsessive-compulsive spectrum, bipolar spectrum, dissociation, etc.) shared with other behavioral or substance addictions.

Keywords Internet addiction · Comorbidity · Pharmacological treatment

14.1 Introduction

The Internet represents one of the most important products of culture and industry in society and has become an integral part of daily life for many people. Worldwide, more than one billion computers are connected to the Internet (Reuter et al. 2005)

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience,
Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_14

and the increasing number of Internet users has, in fact, resulted in an increased percentage of users being afflicted by problematic Internet use. This phenomenon is growing, both in terms of prevalence and within the public consciousness, as a pathological condition. This societal development together with an increase in clinical observations, raise issues concerning the management of the condition. To date, there is no consensus in the literature with respect to the definition of problematic Internet use, though most authors refer to it as “Internet Addiction” (IA) (Tao et al. 2010).

The study of IA is currently hampered by ambiguous definitions of the phenomenon and a diversity of diagnostic, prognostic and therapeutic criteria. Internet use can lead to a state that appears to meet the Diagnostic and Statistical Manual of Mental Disorders (DSM) definition for a mental disorder, described as “a clinically significant behavioral or psychological syndrome associated with present distress or with a significantly increased risk of suffering death, pain, disability or an important loss of freedom” (APA 2013). No clinical conditions related to problematic Internet use have been part of any diagnostic system, until now. Considerable effort has been made to include “Internet addiction,” “pathological Internet use,” “problematic Internet use” (Shapira et al. 2000) or any of its derivatives in the 2013 update of the Diagnostic and Statistical Manual of Mental Disorders, the Fifth Edition (DSM-5), but no official criteria exist in either the DSM-5 or in the International Classification of Diseases, Tenth Revision (WHO 2010). To date, only “Internet gaming disorder” has been included in Sect. 14.3 of DSM-5 (American Psychiatric Association 2013), and the core feature of this disorder is the persistent and recurrent participation in computer gaming, typically massively multiplayer online role play games, for many hours. This condition is included to reflect the scientific literature (most of which comes from studies in Asian countries) on persistent and recurrent use of Internet games, and preoccupation with these, which can result in clinically significant distress and functional impairment of general life, such as social interaction, academic performance, occupational interest, and behavioral problems (Petry and O’Brien 2013). As a syndrome listed in Sect. 14.3 of DSM-5, “Internet gaming disorder” requires further research before it can be formally considered as a disorder in its own right.

Although the diagnostic criteria and assessment questionnaires used for diagnosis may vary between countries, surveys in the United States and Europe indicated that IA may affect between 1.5 and 8.2% of the general population (Weinstein and Lejoyeux 2010). To date, clinicians have only empirical or anecdotal reports at their disposal, concerning pharmacological treatment options for the management of the large number of patients suffering from IA. For this reason, in our chapter we review the role of pharmacotherapy in the treatment of IA to guide clinical decisions according to the most recent data. We also provide a psychopathological framework for this particular form of behavioral addiction, with the intention of proposing a guided approach to aid clinicians in choosing between available drugs.

14.1.1 Is Pharmacological Treatment a Valid Therapeutic Option for IA?

In order to provide an answer to this question, an overview of the empirical data on functional changes occurring in the brains of patients suffering from non-substance related addictions is of relevance. The identification of specific neurophysiological dysfunction in behavioral addictions would establish a biological rationale for intervention. Data to this effect are scarce in the literature.

The potential phenomenological overlap between IA, substance addiction and, in particular, gambling suggests that a common neurobiological substrate involving an impairment of the "reward system" underlies these disorders. The mesolimbic dopaminergic pathway represents the final common pathway for reinforcement/reward induced by physiological stimuli or psychotropic drugs. It follows that dopamine is considered the neurotransmitter responsible for mediating "pleasure" (Di Chiara and Bassareo 2007). The intake of certain substances or the execution of certain behaviors, induces a very intense and fast feeling of pleasure (consummatory pleasure) caused by the rapid increase of dopamine in the mesolimbic system (Di Chiara and North 1992). Moreover, dopamine is also elevated when anticipating the substance use or behavioral execution (anticipatory pleasure) and this also drives motivational processes that promote goal-directed behaviors aimed at achieving desired rewards. Addiction disrupts the normal activity of these dopaminergic circuits, thus redefining the hierarchy of motivational priorities.

In this regard, the literature provides small, but convincing evidence for a link between biological brain abnormalities in patients addicted to substances and similar brain abnormalities in patients with IA. Blum et al. (2012) persuasively linked a reward-deficient aberrant behavior (RDAB) to abnormal dopaminergic function in the nucleus accumbens, and argued that RDABs can be observed both in conventional substance-use disorders, and also in excessive internet gaming and related activities that stimulate excessive dopamine release, such as gambling.

Several fMRI studies in pathological gamblers have reported blunted neural responses to appetitive cues, primarily in ventral striatum and orbital/lateral prefrontal cortex (Reuter et al. 2005; de Ruiter et al. 2009; Balodis et al. 2012) and these observations have been interpreted in terms of the reward deficiency hypothesis of addiction.

Furthermore, a neuroimaging study conducted by Ko et al. (2009) suggested that both the strong desire to play online video games[1] and craving, e.g., for nicotine/alcohol in substance dependent addictions could be explained by a single neurobiological mechanism. The right orbitofrontal cortex, the medial frontal cortex, the anterior cingulate cortex bilaterally, the right dorsolateral prefrontal cortex, the caudate nucleus and the right nucleus accumbens were activated when patients were stimulated with images of "online gaming" in contrast to a neutral picture

[1]Characterizing a particular form of IA, namely "online game addiction".

condition. These imaging results suggest that "online gaming addiction" indeed shares biological substrates with substance addiction. For instance, the urge to smoke cigarettes while watching a videotape showing smoking scenes in current smokers was associated with increased metabolic activity in the ventral striatum, anterior cingulate, orbitofrontal cortex, middle temporal lobe, hippocampus, insula, midbrain and thalamus (Weinstein et al. 2010).

From this it could be intuitively derived that IA might be treatable in the same way as other addictions. In 2010, Liu et al. (2010) carried out a functional magnetic resonance imaging (fMRI) experiment, by using the regional homogeneity (ReHo) method to analyze cerebral function characteristic of IAD college students under resting state. In adolescents with IAD, compared to healthy controls, they found that the increased ReHo brain regions (representing the increase in cerebral metabolic rate) were distributed over the cerebellum, brainstem, limbic lobe and frontal cortex, indicating a possible involvement of the "reward" system.

Summing up the evidence, to date the knowledge on the neurobiological underpinnings of IA is extremely limited and is insufficient as a basis for pharmacological intervention. Nevertheless, if we assume that a malfunction of the reward system underlies IA, one might conclude that pharmacological interventions of use in treating other forms of addiction may be eligible as a starting point for psychopharmaceutical research in the area of IA.

14.2 Clinical Evidence on Pharmacotherapy for IA

To date, case studies of IA treatment are rather scarce and several key limitations have been highlighted, including inconsistencies in definition and diagnosis, a lack of randomization and blinding techniques, a lack of adequate controls or other comparison groups, and insufficient information concerning recruitment dates, sample characteristics, and treatment effect sizes (King et al. 2011).

First, we reviewed the current literature on pharmacotherapy specifically for "Internet addicted" patients. However, considering the lack of adequately large, rigorous studies, we also focused, in a second step, on the underlying psychopathological dimensions of IA (i.e., impulsivity, compulsivity, craving, obsessive-compulsive spectrum) as well as on the high prevalence of comorbid conditions to address the issue of dual diagnosis.

We discuss the clinical evidence available for different classes of psychotropic drugs, according to our recent article (see Camardese et al. 2012).

14.2.1 Antidepressants

Antidepressants are psychotropic drugs mainly used in depression, dysthymia and anxiety. They include: monoamine oxidase inhibitors, tricyclics, selective serotonin reuptake inhibitors (SSRIs), serotonin-norepinephrine reuptake inhibitors and melatonergic agents. The onset of the antidepressant effect is delayed (4–8 weeks) and treatment typically lasts for months or years. They determine mood enhancement, alertness and attention, increased appetite, regularization of sleep and reduction of the hypochondriac attitude. Moreover, serotonergic antidepressants have been proven to be helpful to alcoholics in maintaining abstinence and decreasing craving for alcohol in detoxified alcohol dependent subjects (Janiri et al. 1998). Bupropion (a dopamine/norepinephrine reuptake inhibitor) is also effective for smoking cessation (Hughes et al. 2007).

The use of antidepressants for IA, in particular SSRIs may be endorsed mostly by evidence of the aminergic systems' role in the suppression of inhibitory control (i.e., "resisting" the urge) and the control of compulsive repetition, as well as data indicating a high lifetime prevalence of major depression in "internet addicts" (Shapira et al. 2003; Yen et al. 2007; Lee et al. 2008). Clinical studies have also suggested a close relationship between serotonergic dysregulation, impulsivity, and symptoms of the obsessive-compulsive spectrum, for which serotonergic drugs are known to be effective (Goddard et al. 2008). However, while definitely effective in treating obsessive-compulsive disorder, SSRIs have shown mixed results in some impulse control disorders, namely pathological gambling, kleptomania and compulsive shopping (Kim et al. 2002; Koran et al. 2002, 2007; Grant et al. 2009).

The first experience reported in the literature on IA concerns treatment with escitalopram (a SSRI) in an "internet gaming addicted" patient (30 mg/day for 3 months). An improvement in mood and a significant reduction of the strong urge to perform online gaming were observed, leading to a complete functional recovery (Sattar and Ramaswamy 2004). Another study investigated the effectiveness of escitalopram (20 mg/day for 10 weeks) on 19 "Internet addicts" (Dell'Osso et al. 2008). During the 10 week open-label phase,[2] 11 patients (64.7% of the sample) showed significant decreases in weekly hours spent online and improvements in global functioning. At the end of the 10 weeks, subjects were blindly randomized to either continued escitalopram treatment or to placebo. The abovementioned improvement persisted in the second phase of the study, but no significant differences were observed between those who continued taking the drug and those who were switched to placebo. The authors speculate that 9 weeks may not have been sufficient for the effect to be lost in the placebo group, or for additional gains to be made in the escitalopram group, but also do not rule out the possibility that the improvements seen in the open-label phase may have been a placebo response.

A study on 11 "Internet game addicted" patients and 8 healthy controls, assessing brain activity in response to a game stimulus using functional magnetic resonance imaging (fMRI), explored the possible effectiveness of bupropion, a norepinephrine/dopamine reuptake inhibitor. Patients showed higher activation in the left occipital lobe, left dorsolateral prefrontal cortex and left parahippocampal gyrus before treatment. After 6 weeks of treatment, craving for Internet video game

[2]A clinical trial where both physician and patient know about the administered drug.

play, total game play time, and cue-induced brain activity in the dorsolateral prefrontal cortex were decreased (Han et al. 2010). This allowed the authors to presume that the drug was effective but, given the small sample size, further studies are needed to support this assumption.

A study conducted on Internet addicts with comorbid major depressive disorder and excessive online game play, further investigated the role of bupropion in reducing the severity of online game play as well as depressive symptoms (Han and Renshaw 2011). The study consisted of a 12-week, randomized, double-blind clinical trial, including an 8-week active treatment phase and a 4-week post-treatment follow-up period. Significant bupropion-associated reductions in online gaming and depressive mood were observed, though the latter improvement did not persist during the post-treatment follow-up period.

The anti-craving properties of antidepressants still need to be evaluated with respect to long-term outcomes and in controlled studies. Regarding observations on anti-craving properties made in other addiction research, evidence for short-term effects seems to exist in the main. Long-term exposure to antidepressants may also facilitate mood swings toward the manic pole, to which subjects with pathological addictions seem more prone (Goldberg and Whiteside 2002). This could imply a greater risk of relapse of impulsive behavior, which is characteristic of manic mood.

14.2.2 Opioid Receptor Antagonists

Opioid receptor antagonists such as naltrexone and nalmefene block the reinforcing effects of opioids and reduce substance consumption and craving. Generally, they have no abuse potential, mild and transient side effects, and appear to be a suitable treatment for addiction in combination with psychosocial support. Opioid receptor antagonists are mainly prescribed in alcoholism and heroin dependence.

Various studies have found a high comorbidity rate between IA and other forms of addiction (such as a substance use disorder) as well as impulse control disorders (Bernardi and Pallanti 2009). In this regard, Griffiths (2000) suggested that the Internet merely represents a different context in which gamblers, shopping addicts and sex addicts develop their pathological behavior. In particular, Davis (2001) distinguished a “specific pathological Internet use” and a “generalized pathological Internet use.” The first includes online sexual material/services, online auction services, online stock trading and online gambling. These dependencies are content-specific and they would exist in the absence of the Internet and in a manner independent of multiple Internet functions. The second involves a general, multidimensional overuse of the Internet and it may be related to the social aspect of the Internet. Individuals with general pathological Internet use are considerably more problematic, in that their pathology would likely not even exist in the absence of the Internet (Davis 2001).

In our opinion, the mounting evidence on pathological gambling considered by the authors could equally be applied to some IA patients, given that gambling shares, as previously mentioned, the conceptual and phenomenological bases of a behavioral addiction. The psychopathological (e.g., impulsivity, compulsive repetition, etc.) overlap between IA, substance addiction and pathological gambling suggests a common neurobiological substrate, involving a dopamine dysfunction of the neural "reward systems." Opioid receptor antagonists inhibit dopamine release in the nucleus accumbens and ventral pallidum and have been considered for use in some behavioral addictions. Literature is currently limited to a single case report in the treatment of IA with opioid receptor antagonists (see Bostwick and Bucci 2008). This case study reported successful treatment with naltrexone, which has also proven effective in the treatment of other impulse control disorders, such as pathological gambling and kleptomania (Grant et al. 2008, 2009). The patient in this study was a 31-year-old male with compulsive cybersexual behavior (chatting online, masturbating for hours, and occasionally, sex with Internet contacts). A stable dose of sertraline was ineffective in treating his "Internet addiction". Naltrexone (150 mg/day) was gradually administered and helped to induce a 3-year remission. The authors hypothesize that by blocking the capacity of endogenous opioids to trigger dopamine release in response to reward, naltrexone may block the reinforcing nature of compulsive Internet sexual activity.

14.2.3 Mood Stabilizers

Mood stabilizers are drugs that have the property of acting on mood. They affect long-term mood stability and typically lead to an improvement of the initial condition (e.g., depression, anxiety, agitation, etc.). Mood stabilizers, such as lithium or anticonvulsants (e.g., valproic acid, carbamazepine and lamotrigine), are primarily used to treat bipolar disorder (BD). On the other hand, non-mood stabilizing anticonvulsants (e.g., gabapentin and pregabalin) are also increasingly used to treat alcoholism and substance abuse disorders. Generally, they show a safe side-effect profile and are well tolerated by patients (Guglielmo et al. 2012).

A potential use for mood stabilizers in the treatment of IA may be substantiated by similarities between mood disorders belonging to the bipolar spectrum and IA. Both conditions are characterized by impulsive behaviors (mainly during manic episodes in bipolar patients) and often coexist. In particular, a high lifetime prevalence (up to 70%) of bipolar disorder has been found in Internet addicted patients. (Shapira et al. 2003; Di Nicola et al. 2010b).

A specific anti-compulsive property of some mood stabilizers has been hypothesized. Lithium and anticonvulsants have, in fact, been successfully used in the treatment of various impulse control disorders (Roncero et al. 2009). Likewise, in patients with substance use disorders, valproate appears to be a potentially fruitful medication due to its anti-craving property (Maremmani et al. 2010). Furthermore, there is data pointing to the considerable utility of mood stabilizers (particularly lithium and valproate) in the treatment of pathological gambling (Pallanti et al. 2002). At present, the effectiveness of mood stabilizers in the treatment of IA has not been investigated, though consideration of this drug class in future studies is certainly promising.

14.2.4 Antipsychotics

Antipsychotics include drugs used for the treatment of psychotic diseases, such as schizophrenia or bipolar disorder, mainly acting on neurotransmitter systems of dopaminergic and serotonergic pathways. Antipsychotics can be divided in first-generation antipsychotics (typical antipsychotics or neuroleptics) and second-generation antipsychotics (atypical). The main difference is that typical antipsychotics have a highly selective affinity for D2 receptors while atypical antipsychotics can modulate both dopaminergic and serotonergic systems in different ways. Due to their relevant action on dopamine receptors of the nigrostriatal pathway, neuroleptics increase the risk of extrapyramidal effects, unlike atypical antipsychotics, which are more tolerable in terms of neurological side effects. On the other hand, due to their particular pharmacodynamic properties, atypical antipsychotics are also frequently used in other clinical conditions like mood disorders, anxiety, and autism spectrum disorders.

With respect to these drugs, possible models for their use in patients with addiction are linked with antipsychotics' effectiveness in the treatment of resistant obsessive-compulsive disorder (Choi 2009). Given their serotonergic properties, atypical antipsychotics have been most investigated. Prescription of atypical antipsychotics seems to be a highly helpful strategy for treatment-resistant obsessive-compulsive disorder, with benefits most evident for risperidone (Bloch et al. 2006). Authors of several placebo-controlled clinical trials have found evidence to support psychopharmaceutical treatment with olanzapine (Bystritsky et al. 2004), risperidone (Hollander et al. 2003) and quetiapine (Denys et al. 2004). Head-to-head comparisons involving these agents have also been conducted: Maina et al. (2008) compared olanzapine and risperidone augmentation in subjects resistant to SSRIs and found that both were equally effective at reducing obsessive-compulsive symptoms. In particular, medication augmentation refers to the addition of a second drug to an initial, ineffective pre-existing therapy. A single pilot trial of atypical antipsychotic monotherapy using aripiprazole has also been published (Connor et al. 2005), with significant improvement observed, particularly in compulsive symptoms. Moreover, preliminary data also support a possible efficacy of aripiprazole in reducing alcohol craving (Martinotti et al. 2007, 2009).

The use of antipsychotics in treating impulse control disorders has also been investigated, given that the central features "impulsivity" and "compulsive repetition" are possible targets for antipsychotic medication. In particular, preliminary studies have shown that olanzapine, targeting both dopaminergic and serotonergic functioning, effectively reduces impulsivity. Olanzapine has shown preliminary effectiveness in several disorders in which a lack of impulse control is a key feature, such as trichotillomania, skin picking, and borderline personality disorder

(Garnis-Jones et al. 2000; Stewart and Nejtek 2003; Christensen 2004; Shoja-Shafti 2006). Each of the clinical conditions that responded to olanzapine share phenomenological features with pathological gambling, in that patients are unable to resist impulses, and act without thinking about the consequences. Olanzapine has, thus, been tested in the treatment of pathological gambling, though it did not show significant effectiveness (McElroy et al. 2008). Quetiapine has also been tested as a treatment of pathological gambling and, in addition, it has been used as an add-on treatment for the management of bipolar I disorder with comorbid compulsive shopping and physical exercise addiction (Di Nicola et al. 2010a).

Given the overlap between impulsivity/compulsivity symptoms of IA and the abovementioned psychiatric conditions, it has been hypothesized that antipsychotic treatment could benefit "Internet addicted" patients. A promising case study reported the successful use of quetiapine (200 mg/day), gradually added to citalopram, in a 23-year-old subject with IA (Atmaca 2007). The improvement was maintained at a 4-month follow-up.

14.2.5 Other Drugs

Future research on the pharmacological treatment of IA should also consider focusing on further drug categories, namely psychostimulants, alpha-2-adrenergic agonists (commonly referred to as alpha 2 agonists) and glutamatergic drugs.

Among these, psychostimulants (i.e., methylphenidate) are the only class for which anecdotal data is available in relation to a possible use in "internet addicted" patients. Methylphenidate (MPH) is a stimulant molecule, indicated for the treatment of attention deficit hyperactivity disorder (ADHD) in children and adults. It can also be used to treat chronic fatigue syndrome or symptoms of traumatic brain injury and daytime symptoms of fatigue induced by narcolepsy.

Recently, one trial tested methylphenidate in 62 attention deficit/hyperactivity disorder (ADHD) subjects with "Internet video game addiction," reporting a significant improvement both in attentional capacity and in Internet usage after 8 weeks of treatment (30.5 mg/day) (Han et al. 2009). The authors cautiously suggest that methylphenidate may be beneficial as a treatment for IA, especially where it co-occurs with ADHD. In fact, many clinical studies provided evidence for a link between ADHD and "Internet addiction," with comorbidity rates reaching up to 33% (Yoo et al. 2004). This comorbidity suggests that other drugs used to treat ADHD patients could also be considered as avenues for possible treatment, at least for the subgroup of "Internet addicts" also suffering from ADHD. For instance, alpha 2 agonists, recently approved in controlled release formulations for ADHD, have anecdotally been found to act on impulsive behavior. In fact, among alpha 2 agonists, Guanfacine extended-release has demonstrated effectiveness in reducing impulsivity, hyperactivity and inattention in children and adolescents suffering from ADHD (Muir and Perry 2010). Likewise, there is evidence supporting the use of clonidine extended-release (another alpha 2 agonist) in the treatment of ADHD youth with inadequate response to stimulants. It appears that if clonidine is used in combination with psychostimulants, it provides incremental effectiveness in improving ADHD symptoms (Kollins et al. 2011). These preliminary clinical findings demonstrating that alpha 2 agonists have beneficial effects on ADHD symptoms that overlap with those of patients suffering from IA (namely impulsive behavior), suggest they should be studied in the context as IA as well.

Finally, the rationale for glutamatergic drugs' possible use in "Internet addicted" patients is linked to the fact that, along with dopaminergic dysfunction, glutamatergic system alterations have also been implicated in the pathophysiology of behavioral and substance addictions. There are several clinical reports that support the possible effectiveness of glutamatergic modulators in treating these conditions (Krystal et al. 2003). Among glutamatergic drugs, memantine (a NMDA receptor antagonist) and riluzole (an inhibitor of glutamate synaptic release) have been mostly investigated. Preclinical and clinical observations suggest that glutamatergic modulators target obsessive-compulsive symptoms and impulsivity. Memantine appears to diminish gambling and reduce impulsive decision making in patients with pathological gambling (Grant et al. 2010a). Of note, memantine was not more effective than placebo in reducing alcohol use (Evans et al. 2007). Riluzole has been found to have beneficial effects on patients with obsessive-compulsive disorder (Grant et al. 2010b) and in the treatment of self-injurious behavior associated with borderline personality disorder (Pittenger et al. 2005). Also, riluzole has been successfully used in cases of compulsive skin picking (Sasso et al. 2006) and in a patient with severe, chronic trichotillomania (Coric et al. 2007). Though promising, most of these results are reported in small studies and case studies and, thus, their generalizability is limited. Further examination of glutamate-modulating agents in the treatment of disorders associated with impulse control dysregulation and obsessive-compulsive symptoms, including IA, would certainly be of value.

14.3 Clinical Suggestions for a Psychopathologically Guided Approach

Case studies on IA treatment are rather limited, the quality of the current literature in this emerging field is not optimal, and no standard clinical treatment protocols or approved medications yet exist.

We summarize the reported evidence in Table 14.1.

The limited existing empirical evidence does not allow for definite conclusions to be drawn. We are not yet able to determine to what extent pharmacological treatment of approved psychopathological disorders may also help in the treatment of IA. But a clinically significant beneficial effect is easily discerned and has commonly been observed in daily clinical practice.

A recent meta-analysis of psychological and pharmacological interventions for IA suggests that both forms of therapy are highly effective for improving addictive behavior, time spent online, depression and anxiety after treatment (Winkler et al. 2013).

Table 14.1 Overview of clinical evidence on pharmacotherapy for IA

Class	Drug	Dosage	Patients	Outcome	References
Antidepressants	Escitalopram	30 mg/day for 3 months	1 Internet gaming addict	Mood improvement, reduction in online gaming drive and complete recovery of functioning	Sattar and Ramaswamy (2004)
		20 mg/day for 10 weeks	19 Internet addicts	Significant decrease in weekly hours spent online	Dell'Osso et al. (2008)
	Bupoprion	300 mg/day for 6 weeks	11 Internet gaming addicts	Decrease in craving and total time spent gaming online	Han et al. (2010)
		300 mg/day for 8 weeks	50 Patients with major depressive disorder and problematic online gaming	Reduction in online gaming and depressive symptoms	Han and Renshaw (2011)
Opioid receptor antagonists	Naltrexone	150 mg/day for >3 years (in addition to sertraline 100 mg/day)	1 Patient with compulsive cybersexual behavior	Perceived control over sexual urges	Bostwick and Bucci (2008)
Antipsychotics	Quetiapine	200 mg/day for 4 months (in addition to citalopram 40 mg/day)	1 Patient with internet addiction	Lower obsessive-compulsive features and decrease in 'nonessential' internet use	Atmaca (2007)
Other	Methylphenidate	30.5 mg/day for 8 weeks	62 ADHD patients with video game addiction	Lower young internet addiction Scale scores and decrease in internet use	Han et al. (2009)

With respect to pharmacological treatment, this analysis pooled 49 subjects of three different trials using escitalopram, bupropion, and methylphenidate. Interestingly, when comparing psychological versus pharmacological interventions, the authors did not find any significant differences in the efficacy of improving status and reducing time spent online. This finding supports the hypothesis that, in the future, pharmacotherapy could significantly contribute to the management of "Internet addicted" patients, with a particularly favorable cost-benefit profile.

In order to define the actual role of pharmacotherapy in the treatment of IA, we draw primarily on the evidence obtainable from clinical practice, to consider patterns of comorbidity and to propose some considerations from a psychopathological view. The latter are mere suggestions that may contribute to the complex clinical management of many "Internet addicted" patients, who are referred to clinicians, possibly alleviating their psychic distress and encouraging supporting their adhesion to treatment and rehabilitation programs.

If the patient exhibits high levels of discomfort and craving that interfere with the treatment strategy, and substance addiction coexists, the use of an opioid antagonist could be considered.

Patients with clinically significant anxiety levels or depressive symptoms, and specifically in case of comorbidity with anxiety disorders or depression, the use of a serotonergic drug could be helpful. In the case of a comorbidity with major depression, bupropion should be considered a good option. If the patient has manic or hypomanic symptoms, or in some cases of sub-syndromic excitement, the clinician could also consider the use of mood stabilizers, taking into account that their effectiveness in "internet addiction" has not yet been investigated.

To date, the research on IA is mainly focused on diagnostic criteria and assessment instruments (there is a significant need for consensus concerning clinical definitions and possible sub-forms relating to particular internet applications and/or activities). Future studies are needed to explore valid and reliable outcome measures and, certainly, further randomized controlled trials encompassing long-term follow-up data will be required to evaluate the treatment effects in large samples of "Internet addicted" patients. Research is also needed into whether addicts who use a particular medium/specific form of the Internet require different types of intervention.

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Chapter 15
Therapeutic Interventions for Treatment of Adolescent Internet Addiction—Experiences from South Korea

Eunsuk Cho

Abstract This chapter introduces several intervention programs that have been developed and implemented for adolescents and younger Internet addicts. A few individual and group counseling programs currently operating in Korea will be outlined, and residential camps and integrative long-term therapy programs will also be introduced. The author also includes a summary of the characteristics of Internet-addicted youth in Korea.

The problem of Internet overuse has emerged in many countries over the past several years. With one of the most advanced IT infrastructures and almost universal access to the Internet, Korea has been particularly concerned with problems of Internet overuse since 2000. The Korean government and academia have made substantial efforts to prevent and treat the problem of Internet addiction. Many counseling and therapy services have been established, many of which have been government initiatives. Researchers and clinicians have worked together to develop and implement effective intervention models for those individuals experiencing Internet addiction.

The effects of Internet addiction on children and adolescents has been the source of much attention, due to the potential developmental implications. This chapter introduces many intervention programs that have been developed and implemented for adolescents and younger Internet addicts. The characteristics of Internet-addicted youth in Korea will briefly be reviewed, and examples of individual and group counseling programs will be outlined, as well as residential camps and integrative long-term therapy programs which are now being operated in Korea.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_15

15.1 Characteristics of Internet Addicts of Korean Adolescents

According to the annual national survey of Internet addiction (NIA[1] 2013), the rate of Internet addiction among Korean children and adolescents ranged between 9.4 and 11.7% in 2012.[2] In other words, approximately 3–4 people per classroom require special monitoring of their Internet use. Work by Korean researchers and clinicians aimed at clarifying the characteristics of Internet addicts.

15.1.1 Internet Use Behaviors and the Observed Problems

According to NIA's 2012 survey (NIA 2013), online games were the most frequently used type of computer program by the addicted group, whereas mobile instant messenger applications were most frequently used among the non-addicted group. Daily average Internet use time for the Internet-addicted group was longer (3.2 h per day for the high-risk group; 2.5 h for the potential risk group) than that of those in the normal group, which averaged 2.1 h per day. The majority of the problems arising from Internet addiction encompassed mental and physical health problems, parent–child relationship problems, and problems with school coursework.

Clinicians working in frontline centers observed that many Internet-addicted adolescents faced problems such as failing to keep up with schoolwork, lying, poor peer relationships, stealing, being victims of cyber-crime, being tardy and coming home late, sleep deprivation, and irregular eating habits. Internet addicts are also likely to experience physical problems commonly related with computer overuse, such as eyestrain, neck pain, chronic fatigue, and weight gain. It is because of such problems that the clients and their families call for Internet addiction intervention services (Ahn 2012).

15.1.2 Psychological Traits

Irrational beliefs about Internet usage are unique characteristic of Internet addicts (Davis 2001). They think that the Internet will free them from stress and fatigue and

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[1]Korea National Information Society Agency (NIA) is one of the focal institutions of Korean government which was devoted to Internet addiction-related research and the public response.

[2]Internet addiction was measured by KS Scale (Kim et al. 2008). Percentage of high risk group: 1.8(elementary), 3.3(middle), 1.7(high school students) % of addicts (% of high risk and potential risk group): 9.4(elementary), 11.7(middle), 9.6(high school students).

connect them to other people and the world. This erroneous thinking is the focus of interventions using a cognitive behavioral approach (Young 2011).

High impulsiveness and low self-control are the most influential psychological traits of Internet addicts. Because of these aspects, Internet addiction maybe considered as a form of impulse control disorder (Lee et al. 2012). Comorbid symptoms such as ADHD (Yen et al. 2007) can be understood in the same context. For this reason, clinicians frequently include the learning of self-regulation skills in their approach to Internet addiction counseling.

Internet addicts' lack of problem-solving skills often leads them to unhealthy coping styles such as "avoidance." Instead of confronting and coping with difficulties, they cling to the Internet to avoid their problems, thereby adding further to such problems (Whang et al. 2003). Stress management and coping techniques have been incorporated into counseling protocols to help address these issues.

In many cases, Internet addicts experience depression as a comorbid symptom (Ha et al. 2007; Kim et al. 2006). They feel isolated and their self-esteem appears to be lower on average compared to non-addicts (Kim and Davis 2009). They feel safe in the Internet world where anonymity seems to be guaranteed. For these depressive clients, finding and dealing the exact causes of their depression is necessary, in addition to treating their symptoms of IA.

15.1.3 Family and Peer Relationship

Oftentimes, parents of Internet-addicted adolescents struggle to develop the proper parenting skills to deal with the issues their children face. Extreme permissiveness (i.e., through a lack of rules and boundaries) or extreme coercive control over their children's behavior becomes an important factor in their children's Internet overuse (Song and Park 2008). When this is the case, psychological education and counseling for the parents is also important and necessary.

Lack of family resources is another characteristic of Internet addicts. This is observed in children who have "nothing to do after school" and resort to the Internet. Parents of children suffering from Internet addiction commonly work long hours, coming home late in the evenings, and have no extra resources to supplement parental care at home (Choi et al. 2009). In such instances, it is helpful to connect the family to community resources, provide a mentoring service to the children, and organize afterschool programs as this provides a safe, Internet-free environment.

In some cases, it is observed that there are serious family conflicts such as parental separation, divorce, or violence. In other cases, there may be severe conflict in the parent–child relationship due to Internet use problems (Choi et al. 2009; Song and Park 2008). In both cases, family counseling is suggested for disentangling family issues.

In many cases, addicted adolescents do not have satisfying peer relationships. They have a tendency to withdraw from their peer groups and isolate themselves from the real world (Bae et al. 2012c). This is sometimes caused by a lack of social skills. Social skills training and group counseling are effective in promoting positive peer interactions for such clients.

15.1.4 Implications of Counseling Interventions

We suggest several implications for counseling interventions from the above review of the characteristics of Internet-addicted adolescents. First, an accurate initial assessment of the addicts is necessary for effective intervention. While the manifest behavior of addictive use of the Internet may seem similar, the addiction arises from various roots (Douglas et al. 2008) including temperamental, cognitive, psychological, and familial factors. Also, comorbid symptoms need to be screened for proper psychiatric treatment and counseling. For the initial assessment, the counseling office needs to prepare an interview sheet to check the client's Internet use behavior, addiction level, and psychological assessment tools.

Second, as with other forms of addiction counseling, the counselor must first approach the client using motivational interviewing techniques (Miller and Rollnick 2002). This is particularly important when the client is a child or an adolescent, as their participation in counseling is typically involuntary and they often prefer to ignore their problem. Showing genuine interest in the client's life (including the client's favorite Internet game) is important. It is also important to foster good rapport in group counseling programs, e.g., through the provision of snacks and the facilitation of interesting activities.

Third, counseling needs to tackle the immediate and practical issues first and deal with deeper concerns later (Bae et al. 2012a). Many Internet addicts who come in for treatment suffer from various life problems, such as failure in school, irregular eating and sleeping patterns, etc. Counselors should first facilitate a return to everyday basics in the client's life, before approaching behavioral and cognitive issues like time management, planning, communication skills, study methods, irrational beliefs, stress coping skills, and other activities. If there are family conflicts or issues with the client's inner-self, the counselors can then go further and deeper to help resolve these issues.

Finally, relapse management is important. Preparing skills to cope with relapse and risky situations for the clients and their family is an essential goal in the final phase of counseling. Mentoring services, club activities, and support groups can be provided to the clients or their families after the counseling or intervention has finished.

15.2 Individual Counseling

15.2.1 Counseling Service System

This section introduces the Internet addiction counseling service system for children and adolescents in Korea. Korea has implemented a thorough nationwide screening system, which in turn has increased demand for more intervention services and more research to be done in the field of Internet addiction.

Enumeration survey of Internet addiction: Since 2009, Korean government has implemented an annual enumeration survey of Internet addiction for the target grades of 4, 7, and 10. This is a very thorough screening system designed to detect those at risk of developing an Internet addiction. Based upon the survey results, counselors select students in the high-risk group and then assess their comorbid symptoms using Child Behavior Check List (CBCL by parental report for grade 4) or Youth Self Report (YSR for grade 7 and 10) (Achenbach and Rescorla 2001). They refer those students who show clinical psychiatric symptoms to hospitals for more professional psychiatric assessment and treatments. For high-risk students who do not have comorbid symptoms, they provide individual or group counseling service throughout the year. The counseling service is mostly offered at the school by the school counselors or by counselors from local counseling centers.

Central dissemination of the expertise of the Internet addiction counseling: To meet the vast amount of counseling requests after the survey, the government offered professional training in Internet addiction counseling through the government institution, the Korea Youth Counseling and Welfare Institute (KYCI), and the National Information Society Agency (NIA). These two institutions are developing individual counseling protocols and group counseling programs for each age group, and disseminate the program manual for frontline counselors to use and to improve the quality of services.

Home Visit Counseling service: Home Visit Counseling (HVC) services, in which counselors visit clients in their own homes, are provided for clients who are socially withdrawn or disconnected from social services due to disadvantaged home environments. The visiting counselors offer the initial assessment and initiate a short-term counseling intervention (i.e., 3–4 sessions). Actually, the goal of HVC services is not to complete the treatment in the home setting, but to motivate these clients come to the counseling office for further counseling and treatment (Choi et al. 2009).

15.2.2 Counseling Protocol

To guide the quality of Internet addiction counseling in the local youth counseling centers, KYCI initiated the development of an individual counseling protocol (Bae et al. 2012c). This protocol is now disseminated through the regular in-depth counselor training offered by KYCI.

For the more effective interventions, the researchers (Bae et al. 2012c) developed different protocols based on subtypes of the addicts. For this purpose, they categorized Internet addicts into three groups according to clients' temperament, affect, and relationship dimensions: "the stimulus seeking type," "the depressive type," and "the weak peer relationship type." A different protocol was designed for each type to effectively target the individual root causes of addiction, which is likely to differ between individuals, despite similar surface presentation of symptoms. The protocols are summarized in Table 15.1.

Based on experimental trials of the protocol in 12 cases, the intra-group change indicated this counseling protocol helped to decrease the duration of Internet use and the level of Internet addiction of the clients. Additionally, positive changes were observed in peer and in parent–child relationships, self-regulation and depressive symptoms of the clients, and/or the parent(s) (Bae et al. 2012c).

Table 15.1 KYCI's Internet addiction individual counseling protocol (Bae et al. 2012c)

Internet addiction counseling protocol (Bae et al. 2012c)	
• *Adolescent counseling*	
Initial phase (Session 1–3)	Building rapport, assessment, motivational interview
	Recognizing the problem, goal setting
Middle phase (Session 4–10)	*Stimulus seeking type*: self-regulation training
	Depressive type: CBT approach to treat depression
	Weak peer relationship type: social skills training
	Common for all types: changing irrational thoughts on Internet use, time planning, finding alternative activities to replace the internet, coping skills, career plans, etc.
Final phase (Session 11–12)	Creating a supportive environment, planning for relapse, evaluation
• *Parent counseling*	
Initial phase (Session 1–2)	Building rapport, motivational interview
	Parental assessment, sharing the child's assessment results with the parents
	Therapeutic goal setting for the parent and the adolescent
Middle phase (Session 3–5)	*Stimulus seeking type*: supportive parenting for the child's self-regulation
	Depressive type: encouraging and supporting the depressive child
	Weak peer relationship type: supportive parenting for the child's better peer relationship
	Common for all types: Dealing with parent–child conflict, Parenting skills in guiding Internet use for the child
Final phase (Session 6)	Planning for relapse, evaluation

15.2.3 Hospital Treatment Model

Compared to psychological counseling services, hospital services are often specialized in accurate diagnosis of the psychiatric symptoms and proper medications to relieve the symptoms. Hospitalization is, sometimes, the last choice for very serious addiction clients.

One hospital-run center is the "On-Line Game Clinic and Research Center," operated by Chung-Ang University Hospital. In addition to regular psychiatric treatment, they provide individual and group counseling, family counseling, and sports therapy in an integrative mode for Internet addiction patients. Known for their active neuro-scientific research on Internet addiction, the "On-Line Game Clinic and Research Center" is continuously developing effective treatment methods. A recent publication highlighted the efficacy of CBT individual therapy combined with medication (bupropion) for treatment of problematic on-line game play (Kim et al. 2012).[3] The clinic has also developed an applied sports therapy treatment, which has proven an effective method in improving attention, cognitive symptoms and social skills in ADHD children (Kang et al. 2011), and Internet addicts, who suffer from similar symptoms.

15.3 Group Counseling

Group counseling has a unique effect on Internet-addicted adolescents in two ways. First, the counseling group can be both a reference group and a support group for the individual client. Their unstable and fragile self-identity needs and wants approval from peer groups. A perceived lack of peer approval is one of the main contributors to adolescents' Internet (gaming) addiction and is often the underlying reason for their resistance to quit Internet overuse. Peers in counseling groups provide healthy peer pressure and approval, facilitating change in addicts' lifestyles. In this way, they work as a support group to help each other overcome their Internet addiction. When one or two leading figures change and overcome their addictions, it creates a large positive impact on the other resistant group members, an effect that cannot be achieved through individual counseling.

Second, the clients are able to build relationships in group counseling. Many clients have not been satisfied with their peer relationships, partly because of their poor social skills. The safe and accepting atmosphere of the group encourages group members to be active and to have social interactions with other members, which, in turn, creates positive relationship experiences for them. For these reasons, group counseling is a popular treatment for children and adolescents.

[3]The 'CBT and medication' group showed the reduction of internet addiction score more compared to the 'medication only' group (Kim et al. 2012).

Group counseling programs are implemented in schools following administration of the enumeration survey, and are facilitated by counselors dispatched from local counseling centers. To motivate client participation, most of the programs have activities such as games, drawing, crafts, and cooking, in addition to psychoeducation about Internet addiction interventions. They aim to facilitate "learning through activities" while taking the clients' developmental characteristics into consideration.

According to Park (2009)'s meta-analysis of 41 Internet addiction group counseling programs in Korea, the main theoretical approaches of the group counseling programs are "integrative" (mixture of effective interventions from different approaches), cognitive behavioral therapy (CBT), motivational enhancement therapy (MET: Miller 1999), reality therapy (Kim 2008), solution-focused therapy (Moon et al. 2011), and expressive art therapy (Chung 2008). Park (2009) concludes that Internet addiction group counseling programs in Korea are effective in reducing addiction level. Of these therapies, the integrative approach, reality therapy, and CBT show the greatest efficacy.[4]

One example of a group counseling program is presented in Table 15.2. This program is based on a combination of the trans-theoretical model (Prochaska and DiClemente 2005) and the CBT model. It is targeted for Internet game addicted middle school students (7–8 participants). The post-test result indicates this program is effective in significantly reducing Internet addiction scores (Hyun et al. 2006).

15.4 Residential Therapy Program

Residential therapy programs such as intensive "school" or "camp" to help clients recover from Internet addiction are also popular in Korea. A variety of programs are available according to the clients' situations, such as "one day family camp," "daycamp (for 2–3 days)," "12 day intensive treatment," or "long-term (a couple of months) residential treatment."[5] The content of residential programs comprise individual and group counseling, sports or outdoor activities, artistic or play activities, family activities, and parental education. Regular eating, sleeping, walking, social interaction, and full abstinence from the Internet are the "unique" benefits of the residential program. In fact, these "regular" daily-life practices play important role in the recovery of Internet addicts.

KYCI's "Internet RESCUE School" is known as the most successful residential program in Korea (Koo et al. 2011). It has been operated and modified since 2007, and the operation manual was published in 2010 (Hwang et al. 2010). Now, this

[4]Park (2009) evaluated the 195 effect sizes of the 41 group counseling programs and got 1.04 mean effect size which means quite high effectiveness.

[5]For now, there is only one residential treatment center in Korea, which is funded by a Christian church. Another one will be opened soon, which is operated by government.

Table 15.2 Example of internet game addiction group counseling program for middle school students (Hyun et al. 2006)

Session	Goal		Stage
1	• Building rapport	• Exploring the pros and the cons of the change	Precontemplation
	• Recognizing the risks of game addiction	• Motivating for change	
2	• Recognizing the underlying motives of Internet game use	• Weighing the pros and the cons of the Internet game and the change	Contemplation
	• Dealing with the ambivalence toward change		
3	• Finding my strength	• Finding alternative activities	Contemplation
	• Reflecting my successful experience	• Exploring the benefits of the change	
4	• Understanding the parents' mind	• Parental pledge of supporting the child's alternative activities	Preparation
	• A pledge of abstinence (control) of Internet game		
5	• Finding the reasons of clinging to the Internet game	• Finding the coping strategies to overcome the temptation of Internet game	Action
6	• Checking the high-risk situation related to peer pressure	• Role play of saying "No"	Action
	• How to say "No" to the temptation		
7	• Exploring my dream	• Consolidate the dream to bridge it to reality	Action
8	• Sharing my change	• Tamping my resolution	Maintenance
	• Coping skills training for relapse and risky situation	• Evaluation	

12-day residential program is disseminated by KYCI's special workshop for local treatment centers and is expanding rapidly beyond metropolitan areas to the entire country with the support of the government. The target group of this "RESCUE School" is high-risk Internet-addicted adolescents. The goals of this program are reducing (controlling) Internet use, improving parent–child relationship, learning stress coping strategies, and career planning of the participants. It employs and combines the ecological perspective integrating bio-psycho-social aspects, motivational enhancement therapy, behavioral therapy, CBT, and solution-focused approach. The summary of the program is presented in Table 15.3.

A 2–3 months' screening process is implemented before the main program starts. Clients with serious comorbid symptoms that would hinder program participation or trouble group dynamics are screened out. Three parental visits to the "School" during the 12 days are mandatory. Because the program is usually offered in the countryside surrounded by an abundance of natural environments and

Table 15.3 The summary of the "RESCUE school" of KYCI (Hwang et al. 2010)

Screening	• **Inclusion criteria**:
	– Internet addiction high-risk group (KS-scale[a] and Intake interview)
	• **Exclusion criteria:**
	– Serious psychiatric symptoms hindering the "School" participation
	– Parents cannot participate in the three parental sessions (for 5 days) during the "School" days
Phase I	• Group counseling: sessions 1–3
	• Individual counseling: "recognizing my addiction"
	• Parental education: understanding the child's psycho-emotive status
	• Therapeutic activities for relationship building
	• Other therapeutic activities: strolling, meditation, sports
Phase II	• Group counseling: sessions 4–6
	• Individual counseling: solution-focused approach to the issues related to Internet addiction
	• Parental intervention: family camping, parent counseling, family therapy
	• Therapeutic activities for energizing the clients: wall-climbing, skin scuba diving, etc.
	• Other therapeutic activities: Meaningful experiences (i.e., volunteering at the neighborhood) added to the above activities
Phase III	• Group counseling: session 7
	• Individual counseling: family relationship, coping strategies
	• Parental intervention: "recognizing the change of the child"
	• Therapeutic activities for recovery of positivity: pottery, craft, etc.
	• Other therapeutic activities: strolling, meditation, sports
Follow-up	Parental education and support group
	Mentoring for sustaining the change (1:1 mentoring service)
	Alternative activities (sport, hobby, etc.)

[a]KS scale is an Internet addiction scale developed by Kim et al. (2008). This is the most popular measurement of Internet addiction in Korea, used for national survey as well as many Internet addictions counseling assessment

facilities for youth activities, it is hard for some families to come to the "School" during weekdays. Throughout the "School" days, individual and group counselings are provided. Parental counseling and family therapy are also provided during family visitation days. A regular day at the "School" starts with a walk in the forest and closes with meditation. Sports activities such as soccer are enjoyed during the day. Therapeutic activities such as group projects, energizing activities, and artistic works are also provided. There is also a "Two-day family camping" program at a tent site which consists of family recreation, cooking, and experiences that facilitate positive interactions among family members.

A mentor is matched to each participant during the whole 12 days. Mentors support and encourage the clients' successful participation in the program. At the beginning of the "School," most clients are very resistant and terrified by the fact that they will be disconnected from the Internet. However, they become gradually accustomed to “the School life” and build up their new lifestyle. Of course, a few members fail to overcome their addiction and leave the “School” during the program. After graduation from the “School,” participants undertake 3 months of follow-up programs, such as mentoring services and regular parental education sessions to help parents sustain the change in their children.

The intra-group changes show that participants’ Internet usage times significantly decrease and show positive changes in Internet-use-related aspects of the adolescents and their parents (e.g., thoughts about using the Internet, career development, parenting style, parent–child communication, wellbeing, self-control). Furthermore, the change was sustained at a 2-month follow-up after the program finished (Hwang and Du 2011).

Because KYCI’s “Internet RESCUE School” is available only to adolescents whose parents can cooperate, an alternative residential camp was developed by KYCI in 2012 for adolescents whose parents cannot visit during the camp. For elementary school students who have problems with usage of the Internet, two- or three-day family camp programs are usually offered. In these programs, the focus is more on parental education and parent–child communication (Bae et al. 2012b).

15.5 Long-Term Therapy Program

Long-term integrative programs have been implemented by “I WILL” centers.[6] These programs were developed in answer to the question, “Why do adolescents who seem to have overcome addiction relapse so easily?” They found that the origin of the problem was the “fragile self” of the clients. And thus they designed a program in order to tackle this problem. The program aims to build up a balanced, healthy life through a year-long period of therapy. The program focuses not just on reducing Internet usage, but also on strengthening the “root” of the addicts; this includes things such as their self-image, self-confidence, and future dreams. “Gwang-Jin I WILL Center” began the first long-term program in 2009. Through several iterations, this program has come to have its present shape, displayed in Table 15.4. The 4-1-4 months’ module of the main program and the 1-year follow-up is designed to fit the Korean school calendar.

The program is intended for high-risk Internet-addicted middle school students, upon recommendation of school teachers. Priority is given to clients from disadvantaged home environments. About 15 members are included in each cohort. In many cases, participants are found deprived of various cultural experiences, sports activities, and achievements in their life. Internet gaming is their only respite and amusement. Phase I consists of mostly counseling programs. Once it finishes,

[6]“I WILL Center” is the Internet addiction prevention and intervention center run by Seoul Metropolitan Government, Korea.

Table 15.4 Long-term integrative program "Dream Tree" of Gwang-Jin I WILL Center (Ahn 2012)

Long-term integrative therapy program "Dream Tree"				
	Title	Client's status	Goal	Therapy/activities
Phase I (4 months)	Recovery of my "self"	• Psychological weaknesses • Lack of self-control • Family conflicts	• Recognizing the problem and starting to change Internet use habit	• Psychological assessment • Individualcounseling • Group counseling • Parent counseling • Family activity
Phase II (1 month)	Exploring myself	• Lacks diverse experiences • Lacks ability to deal with stress • Passive attitude • Lethargic	• Discovering my interest • Experiencing joy	• Outdoor camping • Cultural activities • Group counseling
Phase III (4 months)	Self-expression	• Lacks success experience • Lacks self-confidence • Lacks life satisfaction	• Experiencing a sense of achievement	• Alternative activities • Performance/exhibition • Graduation ceremony
Phase IV (12 months)	Follow-up maintenance	• Relapse possibility • Limited resources • Lacks initiative and future plan	• Maintaining self-control and the changed habit of Internet usage	• 1:1 mentoring • Youth self-help group, (club) activities

Phases II and III are focused on providing various experiences (e.g., music, acting and performing, outdoor camping, family activities, etc.) to offer opportunities "to learn through activities." A follow-up program is offered to maintain the change and to facilitate further growth through mentoring and club activities (e.g., sports, hobbies, etc.).

Because of high costs and other operational difficulties, such as retaining the participants during the 1+ year duration of the program, practitioners debate the long-term efficacy of this program versus its cost–benefit ratio (Cho and Kim 2011). However, the impressive results observed in clients—even several years after completing the program—and the relationship experiences between clients and group leaders, motivate practitioners to contribute their passion to this program. According to the program evaluation summary (Ahn 2012), the changes in Internet addiction scores of the participants reflect the effectiveness of this program. Qualitative materials such as letters from school teachers and families or participants' evaluations show a profound change in the participants' lifestyle. Further efforts are needed to modify and to develop the operation manual of this program as well as to provide scientific research on the effectiveness of this program.

15.6 Conclusion

In the midst of its IT prosperity, Korea is suffering from the affliction of Internet addiction. However, with the active response of the Korean government, scholars and practitioners have continuously developed and implemented better treatments for Internet addiction. From Korea's various intervention experiences, we can draw several implications for the future of Internet addiction treatment for children and adolescents.

First, Internet addiction treatment for children and adolescents cannot be separated from parental or family counseling. Parents sometimes cannot play their parental role of supervising and guiding their children's Internet usage for various reasons. It can be due to serious marital conflict, economic difficulties, lack of time, or lack of effective parenting skills. Whatever the reason, tackling the risk factors on the parental side is one important key to resolving the child's addiction problem. Consequentially, a substantial number of counseling programs in Korea use the multi-modal approach, providing treatment for children/adolescents as well as parental/family counseling in parallel (Bae et al. 2012c; Hwang et al. 2010; Song and Park 2008).

Second, clinicians and scholars need to pay more attention to non-traditional counseling methods in treating children and adolescents' Internet addiction problems. That is, the effect of positive experiences and therapeutic activities in the treatment of the addiction cannot be ignored. Of course, the need for counseling and psychiatric treatment is indisputable. However, the experience of being together with peers, being deeply involved in other hobbies, and developing emotional closeness with their parents brings out their potential growth. For better treatment of children and adolescents' Internet addiction, more creative intervention programs are expected in the future that integrate positive experiences, therapeutic activities as well as counseling services.

Third, clinicians need to have close relationships with the clients' school teachers and parents. This is crucial in detecting addictive problems early and treating them successfully. We cannot expect voluntary participation of younger clients in treatment, especially during the early stage of the program. In fact, teachers and parents play key roles in maintaining the treatment of younger clients. For this reason, in Korea, many educational workshops are offered to parents and teachers.

Finally, we see Internet overuse as the beginning signs of an addiction that needs to be treated in the early stage. If interventions do not occur properly and in a timely manner, it gradually undermines the daily life of affected children and adolescents up to an irrevocable level. Therefore, the importance of the regular assessment of Internet addiction and the preventive education about the risk of the addiction for every children and youths needs to be addressed.

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Chapter 16
Therapeutic Interventions for Treatment of Adolescent Internet Addiction—Experiences from Germany

Wolfgang Dau, J.D.G. Hoffmann and Markus Banger

A journey of a thousand sites begins with a single click
(Author Unknown).

Abstract In this chapter, the Internet usage behaviour of the general population and the prevalence of problematic Internet use will be discussed and a variety of treatment options are introduced. Theoretically and practically, through use of a case study, the brief intervention, "Compass", is described. The last section considers research on the efficacy of existing approaches to the treatment of problematic Internet use. To contextualize the prevalence of Internet use, the underlying concepts and the therapy, this chapter opens with a brief consideration of television and the debate about TV dependency, which took place during the 1990s. Before taking a closer look at the prevalence of Internet use, the underlying concepts and the therapy, this chapter begins with a brief recourse on television and the debate about TV dependency, which took place during the nineties of the last century. For the triumph of the Internet will possibly go hand in hand with the "death" of another medium: television, in any case, in its "classical" form (Katz and Scannell, The end of television? Its impact on the world (so far), 2009). At least with youngsters, television seems to have become less important compared with the Internet. For instance, among 12–19-year-olds, as far as frequency of media activity went, television came in third place in 2011, after the mobile phone and the Internet. Among boys, 89% considered personal use of the Internet very important/important, while only 58% made this statement about television. Among girls, the Internet came after "listening to music" and "mobile phone use", in third place with 86%, and television was in sixth place with 54% (Medienpädagogischer Forschungsverbund Südwest (MPFS), Jugend, Information, (Multi-)Media. Basisstudie zum Medienumgang 12- bis 19-Jähriger in Deutschland, 2012). In 2009, Internet and television were of equal importance to this age group; television may even have had a slight edge (MPFS, Jugend, Information, Multimedia. Basisstudie zum Medienumgang 12- bis 19-Jähriger in Deutschland, 2010). A note on terminology is necessary here. A key

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_16

problem in looking at the phenomenon of Internet use is the veritable flood of terminology—much of which may also be used differentially; the concept "problematic Internet use (PIG)" will be consistently used in this chapter, except in the reproduction of results from studies that explicitly use a different terminology.

16.1 Media Socialization and Moral Panic: "Digital Immigrants" and "Digital Natives"

Hurrelmann and Quenzel (2012) refer to adolescents who naturally grew up with digital new media, as "digital natives", while the parents, being representative of the older generation, can be seen as "digital immigrants". In the wake of World War 2, television began its slow but inexorable ascent in popularity, which socialized the generation of "digital immigrants" in media terms. Consequently, this generation is characterized and/or is influenced by the earlier discussions about the negative consequences of television use (Livingstone 2009). The resurgent discussion, particularly in Germany, that accompanied the introduction of private television in 1984 is still in the memory of the "digital immigrant" generation and seems to assume certain aspects of "moral panic". A moral panic is an intense feeling expressed within a population over an issue that appears to threaten the social order (Jones and Jones 1999). A well-known media critic primarily associated with television was the communication scientist Neil Postman who made the criticism "television is in the process of transforming our culture into a gigantic arena for show business" (Postman 1988, p. 102). In this context (Livingstone 2009) pointed out that

> [the] moral panics associated with the arrival of each new medium, which demand that research address the same questions over and again – about displacement of reading, exercise, and conversation; about social isolation and addiction; about violent and consumerist content […]–have a long history (p. 152).

Accordingly, the discussion about television dependence that occurred during the nineties closely resembles to the debate on Internet dependence. At that time researchers had already begun to debate the definition and/or existence of substance-related and non substance-related addictions, about possible addiction-generating features of the medium, specific characteristics of those people susceptible to addiction and over the difficulties regarding exact diagnostic criteria, as well as problems of comorbidity (Horvath 2004; McIlWaraith et al. 1991). TV dependence has so far not been included in diagnostic manuals and whether inclusion will be extended to the question of Internet dependence remains to be seen.

16.1.1 Compulsion? Addiction? Impulse Control Disorder? Search for a Usable Definition for Therapy

Attempts to define "Internet addiction" or "media dependence" present particular difficulties in that, very often, multiple phenomena may be included in these terms, e.g. the excessive use of pornographic content, games, general surfing of the Internet and excessive use of social networks (Winkler et al. 2013). It has been recently pointed out, in fact, that separate forms of generalized and specific Internet addiction must be distinguished (Montag et al. 2015).

Nevertheless, clear definitions and concepts of disorders are very important for the planning of treatment and therapy. Furthermore, it is not always clear whether the individuals concerned are dependent *in* or *on* the Internet (Griffiths 2000). Classification of the research findings to date has been further complicated by the absence of uniform diagnostic criteria and measurement instruments (Winkler et al. 2013). At the moment, such classification is largely dependent on the criteria of substance-related addictions or pathological gambling (Rehbein et al. 2013). At least for the so-called "Internet Gaming Disorder", the American Psychiatric Association has decided to include nine criteria (see Table 16.1) in the Appendix of DSM-V as a research diagnosis (American Psychiatric Association 2013). These criteria are not intended for clinical use, but to encourage future research.

The diagnosis should be given if at least five of these criteria are fulfilled. These criteria are to be separated expressly from the use of professional and other private Internet use. Rehbein et al. (2013) point out that thus far these criteria have not been empirically verified, but express hope that this specification of criteria could be a starting point for further research into the development of appropriate diagnostic instruments.

It is thus clear that many different perspectives are accommodated within the research on (problematic) Internet use. Indeed, general sociological factors (Livingstone 2009) seem to play just as much a role as generation processes concerning the different media socialization of "digital natives" and "digital

Table 16.1 DSM-V criteria of the Internet gaming disorder

1.	Preoccupation with internet games
2.	Withdrawal symptoms when internet gaming is taken away (irritability, anxiety, sadness)
3.	Tolerance—the need to spend an increasing amount of time engaged in Internet games
4.	Unsuccessful attempts to control participation in Internet games
5.	Loss of interest in previous hobbies and entertainment
6.	Continued excessive use of Internet games despite knowledge of psychosocial problems
7.	Has deceived family members, therapists, or others regarding the amount of Internet gaming
8.	Use of Internet games to escape or relieve a negative mood
9.	Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of participation in Internet games

immigrants" (Shell Deutschland Holding 2011). There is also some debate regarding the correct diagnostic classification of the behaviours related to PIU, i.e. either as an addiction or other Axis I disorder, as in the case of pathological gambling and other behavioural addictions (Mann et al. 2013). As important as this debate may be, it contributes rather little to improving understanding of the very different profiles of use and application that the Internet offers. The position of the therapist, a possible "digital immigrant" himself, offers a unique challenge. The task consists, after all, in providing adequate therapeutic access for the clients without lapsing into "moral panic" or playing things down.

In addition to the DSM-V criteria, which possibly will facilitate more comparable research findings, the cognitive-behavioural model (Davis 2001) also seems to be helpful in classifying the disparate phenomena related to problematic Internet use.

16.1.2 The Cognitive-Behavioural Model of Davis: Specific and Generalized Problematic Use of the Internet

Davis (2001) suggested the need to make a distinction between a ***specific*** and ***generalized*** form of Internet abuse within his cognitive-behavioural model of PIU. For people with a generalized Internet abuse problem, the medium of the Internet is proposed as a stressor that ultimately leads to the exacerbation of particular behaviours. On the other hand, people with a specific Internet abuse problem, use the Internet merely as another medium through which the addicted behaviour is shown. As a consequence this kind of addiction would also be observed in the absence of the Internet (e.g. addiction to online and offline pornography). Another example of this constitutes a person suffering from a pathological gambling addiction, who gambles both on slot machines as well as online. This model is illustrated in Fig. 16.1. The criteria identified in this model of problematic Internet use closely resemble those for "Internet Gaming Disorder" discussed above, but with a stronger focus on cognitive symptoms. Of particular importance is the belief that the Internet is the only place where one feels good.

Another advantage of the model is that the author tries to incorporate healthy use of the Internet. A continuum between a healthy and a pathological use of the Internet is suggested. The distinction between functional and dysfunctional Internet use can only be made on a case-by-case basis, taking the model into account (see Fig. 16.1; Davis 2001). This model has received empirical support (Caplan 2010; Montag et al. 2015), however, the role of Internet-related cognitions still requires clarification (Li et al. 2010).

The cognitive-behavioural model is very helpful since it provides a theoretical framework for research as well as therapy (Davis 2001). Further research is needed to determine the extent to which the specific and generalized forms of pathological Internet use necessitate different therapeutic approaches.

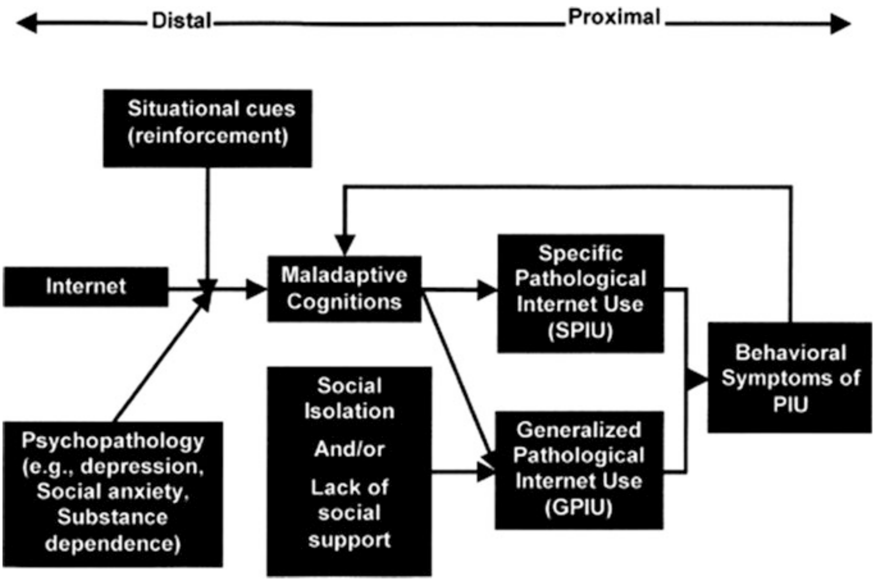


Fig. 16.1 Cognitive-behavioural model of problematic internet use (Davis 2001, p. 190)

Figures on Internet usage for the general population and the prevalence of problematic Internet use are presented below. Following this, treatment alternatives are introduced. In the context of a case study, the short intervention, "Compass", will be detailed, before a final discussion of the empirical research on the efficacy of existing approaches to the treatment of problematic Internet use.

16.1.3 General Use of the Internet

16.1.3.1 Adolescents and Young Adults

According to surveys by the Statistisches Bundesamt (official statistics office; 2011), 77% of households in Germany had Internet access in (2011), of which 98% had a broadband Internet connection. Among adolescents, 87% said they had Internet access in their own room (MPFS 2013). The everyday importance of the Internet is reflected in the fact that 68% of 12–19-year-olds reported that they surfed the Internet daily, and 91% at least several times per week. The sociodemographic variables, gender and educational background, were not significant. In contrast, the frequency of Internet usage increases with age: among 12–13-year-olds only 48% use the Internet daily, while this true of 69% of 14–15-year-olds. Adolescents estimated their total daily usage to be 131 min per day. While no gender differences were observed, educational differences did emerge: adolescents who attended

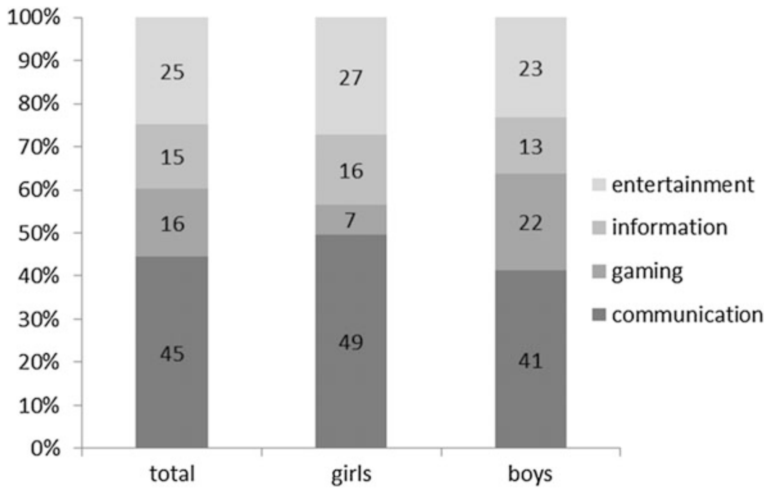


Fig. 16.2 Frequency of Internet usage depending on gender (MFPS 2013)

Elementary school, spent more time on average on the Internet than pupils of Grammar Schools (157 min versus 124 min) with Technical school pupils being in the middle of the observed usage (134 min).[1]

The use of the Internet on mobile phones or Smartphones increased 20% from 2011, up to 50% in 2012, with no observed gender differences. Figure 16.2 provides information on the types of use and related gender differences.

Girls use the Internet more for electronic communication and less for gaming compared with boys. Similar results are observed in other representative surveys on Internet use (Czaika 2011; Shell Deutschland Holding 2011). Evaluations using factor and cluster analyses (Leven et al. 2011) classified adolescent users into so-called "Gamers" (25%), "Function Users" (17%), "Multi-users" (34%) and "Digital Networkers" (24%). In addition to game-play, the "Gamer" group is also unique in having a markedly lower use of digital communication forms (email, social networks). "Digital Networkers" showed the opposite pattern: they used all forms of digital communication, especially social networks, and spent the most time on the Internet (14.6 h per week). This group also often surfs the Internet at random and more than half (53%) of them never play online games. The "Function Users" use the Internet very specifically, e.g. for shopping and information searches, while the "Multi-users" are varied and non-specific in their Internet usage; however, it is worth noting that this group also seldom plays online games (Leven et al. 2011). Besides this, the groups also differ in terms of other features. The "Gamers" are

[1]In Germany four kinds of secondary schooling exist: (1) Grammar school (Gymnasium) until grade 12, qualifying for university. (2) Technical school (Realschule) until grade ten. (3) The least academic Elementary school (Hauptschule) until grade nine or ten, and (4) the Comprehensive school (Gesamtschule), which is not included in the statistic.

younger, mostly male, often have lower socio-economic backgrounds and are more likely to live in conurbations. The "Multi-users" are also mostly male, often come from higher socio-economic backgrounds and often live in cities. Women form the majority of the "Function Users" and the "Digital Networkers", the latter coming primarily from more rural areas. After the "Gamers", the (majority female) "Digital Networkers", represent the second-youngest group. Given these clear age delimitations, Leven et al. (2011) propose a model for the development of Internet usage from online gaming, through "network use", up to a purely functional use. However, the authors concede that further research is needed on this. However, the growing popularity and importance of the Internet among adolescents and young adults cannot be denied.

16.1.3.2 Usage in the General Population and Generation Differences

Both in terms of media usage and expertise, significant generational differences have been observed, with younger users being more advanced and possessing a "pioneering role" (Hurrelmann and Quenzel 2012, p. 197). Furthermore, Hurrelmann and Quenzel (2012) show that adolescents have a more confident and more natural handling of the Internet and smart phones. While differences in usage traced to socio-economic background have nearly levelled out (Christakis 2010; MFPS 2013; Ridder and Engel 2010), this is not true for age differences. Internet usage is increasing among older people in Germany. While the proportion of over 60 s using the Internet, the so-called "silver surfers", was 28.2% in 2010, this proportion has increased to 42.9% in 2013 (van Eimeren and Frees 2013). Of note, the average duration of daily Internet use decreases with increasing age (see Table 16.2).

All user groups show longer duration of Internet use from Monday to Friday (185 min) than on the weekend (130 min). Older users are less varied and explorative in their usage of the Internet than their younger contemporaries. Users over the age of 50, typically restrict themselves to email communication and targeted information searches (van Eimeren and Frees 2013).

In contrast, usage of the Internet for communication (email, social networking) ***and*** for entertainment is more common among younger groups. In view of how common Internet usage has become among the general population, one can ask whether a division between the "real" and virtual/digital world still makes sense. At least for the younger age groups, such a separation seems increasingly artificial. The importance of both quantitative and qualitative differences in Internet use is

Table 16.2 Average of minutes per day spent online (according to van Eimeren and Frees 2013)

Age group (years)	Minutes per day online-time (average)
14–29	237
30–49	168
Over 50	116
Total	169

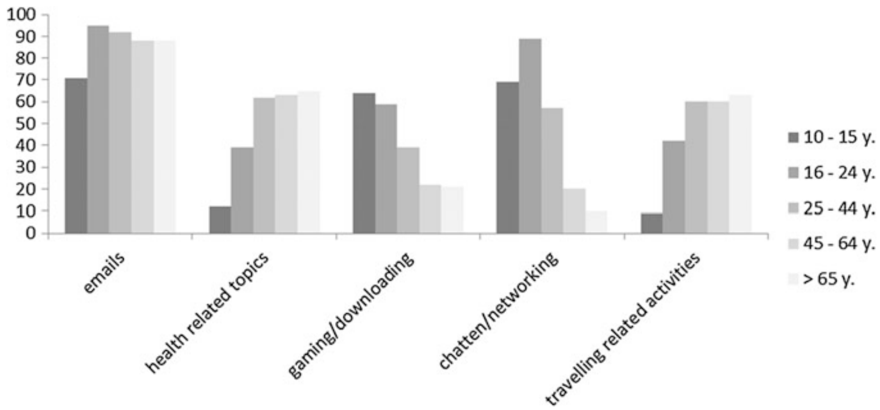


Fig. 16.3 Internet usage depending on age groups (Czaika 2011)

illustrated by generational differences in how personal data is handled online. Younger people show a much greater willingness to reveal personal data, for instance on social networks, than older people (Leven et al. 2011). This may of course be interpreted as an expression of greater carelessness in the handling of personal information, however, it may also be reflective of a fundamentally different relationship towards new media (Leven et al. 2011). Although a substantially higher number of younger users report having been "bullied" on the Internet, fears and concerns about negative consequences of Internet use, like data abuse, are more common among older people (Czaika 2011). Further research will show whether these trends will be confirmed and/or reinforced (Fig. 16.3).

16.1.3.3 Use of the Internet in Austria and in Switzerland

In Austria, 79% of households had Internet access in 2012 and 85% reported the possibility, in principle, of having a connection with the Internet (e.g. through workplace, school, university, etc.) and repeated use of the Internet was nearly equally frequent for men and women: 54% versus 46%. Specifications on the age structure of the use are reproduced in Table 16.3 (Integral Markt- und Meinungsforschungsges. m. b. H. (INTEGRAL) 2012).

In Switzerland 85% of households had Internet access in 2012, but otherwise hardly any differences in usage behaviour exist between the countries (Bundesamt für Statistik and Schweiz 2010; Czaika 2011; INTEGRAL 2012).

Table 16.3 Age structure of internet users using the internet several times per week in Austria and Switzerland (Bundesamt für Statistik Schweiz 2010; INTEGRAL 2012)

Age (years)	Percentage of regular internet users	
	Austria	Switzerland
14–19	97	94.9
20–29	95	94.5
30–39	94	90.6
40–49	89	83.9
50–59	83	77.7
60–69	66	62.2
>70	34	32.2

16.1.3.4 Summary

The Internet has become a part of everyday life in Germany and this is also true for Austria and Switzerland. Depending on age, the usage and subjective importance of the Internet apparently seem to differ. While rather specific applications and functions of the Internet seem most interesting for older people, for younger people the Internet has become an important component of experience and behaviour. Young people more commonly share private information on the Internet and demonstrate a rather carefree attitude towards the Internet as a medium. Just as everyone in school knows that a student is single or a member of a sports team, this is similarly communicated to the web community, with little concern for data protection. In addition, the proportion of adolescents with personal access to the Internet is on the rise and, correspondingly, uncontrolled Internet access is increasing. In this regard, the existing evidence suggests that absent parental control increases the risk for problematic Internet use (Lin et al. 2009).

16.2 Prevalence of Problematic Internet Use

In Germany, two representative population studies of the prevalence of problematic Internet use are of particular relevance. In a representative study by the University Hospital of Mainz, the prevalence of Internet-dependent people was found to be 2.1% (Müller et al. 2013).

However, the study carried out by order of the federal health ministry, “Prevalence of Internet dependence (PINTA)” (Rumpf et al. 2011), identified 1% of the whole population as Internet-dependent. The results of the PINTA study fit well with the findings from international studies. For instance, prevalence rates between 0.3 and 0.7% arose for the USA (Aboujaoude et al. 2006) and of 1% for Norway (Bakken et al. 2009). For Switzerland, the prevalence is estimated at 2.7% (Eidenbenz 2011) and for Austria, 2.4% (the estimates for Austria vary between 1.95 and 2.81%; Batthyány and Pritz 2009).

In summary, the prevalence for computer game dependence in Germany is taken to be between 0.9 and 1.7% (Rehbein et al. 2013). For cybersex addiction, defined as the excessive use of sexual material, the prevalence estimates vary as a function of the investigation methods used, between 1 and 8.6% (Eichenberg and Blokus 2010).

Furthermore, the PINTA study shows that the prevalence of Internet dependence is negatively correlated with age; the prevalence is higher among younger users. Furthermore, females are more often affected and significantly more often use social networks (Rumpf et al. 2011). If you compare these results to the findings from Leven et al. (2011), a more fine-grained picture emerges. Here, the problem of an excessive or dependent use of the Internet seems to concern mostly the groups of "Gamers" and "Social Networkers". With computer game dependence and cybersex addiction, problem users are most often male, while female users more often have difficulties controlling their use of social networks (Eichenberg and Blokus 2010; Rehbein et al. 2013; Rumpf et al. 2011).

Rehbein et al. (2013) point to the high degree of comorbidity observed when investigating problematic Internet use. In particular depressive disorders, anxiety disorders and attention–deficit disorder appear comorbid with problematic Internet use. This high degree of comorbidity is one reason why the stand-alone diagnosis "Internet addiction" is viewed critically by some researchers (e.g. Kratzer and Hegerl 2008). According to Rehbein et al. (2013), the spectrum of comorbid disorders present in Internet addiction, bear resemblance to those comorbid in people suffering from substance-related addictions and also pathological gambling.

Longitudinal studies on the course of Internet Addiction or problematic Internet use is still rare. For dependent online video game players, Van Rooij et al. (2011) found that after one year 50% of the random sample still fulfilled the criteria for addictive gaming, while Gentile et al. (2011) showed symptoms can continue to exist for years later. For this, further research is urgently needed.

In sum, it can be ascertained that the prevailing majority of Internet users show no pathological patterns of use. However, it seems that female users of social networks have an increased risk of developing an problematic Internet use. Furthermore, it can be stated that both healthy Internet users and those with problematic Internet use represent rather heterogeneous population groups with different issues and problems. This needs to be kept in mind when offering treatment and consultation.

It should also be taken into account that, particularly for younger people, the Internet forms a natural and integral component of their social environment. Differences between the generations and lessons gleaned from the debate on television should be considered in the design of treatment and counselling services for Internet Addiction. On one hand this is needed to counteract preventable reactance from the target group, which presumably will consist primarily of younger people. On the other hand, it is necessary, as stereotypes about young people and their supposed usage of the Internet can lead to other more important problems being overlooked, e.g. depression and/or social anxiety. The distinction between "real" and "virtual" in this case seems of little help. Empirical findings suggest that an essential function of social network usage is the intensification and maintenance of offline friendships/relationships (Ellison et al. 2007; Kraut et al. 2002). However, socially nervous adolescent users, in-keeping with the model of Davis (2001), seem to have other expectations of online communication; socially anxious adolescents value the importance of online communication on intimate topics significantly higher than their non-anxious peers (Valkenburg and Peter 2007).

16.3 Treatment Programmes in Germany

In Germany, it is predominantly the addiction help system that provides and further develops prevention, counselling and treatment for Internet Addiction (Petersen and Thomasius 2010). On the relevant websites in the field of addiction support, in addition to information, there are self-tests to assess one's own Internet use, consultation chats, email contact details, as well as brief interventions or tools to facilitate autonomous change. University institutions are also engaged in research on problematic Internet use (te Wildt 2011). In addition to this professional orientation, homepages of people and their families who are affected by Internet Addiction promote the issue and its accompanying problems, provide information and recommend contact with therapists, e.g. www.rollenspielsucht.de or also www.onlinesucht.de. A professional association has also been developed ("Media addiction association"/"Fachverband Medienabhängigkeit e.V.") and the German Association for Psychiatry, Psychotherapy and Psychosomatics [Deutsche Gesellschaft für Psychiatrie, Psychosomatik und Nervenheilkunde (DGPPN)] has founded a group for the investigation and nosological classification of Internet addiction.

Besides offers of consultation from outpatient addiction specialist agencies, which also do preventive work on media competence in schools, the outpatient clinics of psychiatric hospitals, psychosomatic hospitals and rehabilitation clinics (addiction and psychosomatics) predominantly offer treatment (te Wildt 2011).

Research of online manuals and treatment concepts in Germany suggests that there currently exist cognitive-behavioural therapy-oriented concepts, attachment theory- and depth psychology based- approaches. The latter also integrate behavioural therapy-oriented technologies and interventions (Petersen and Thomasius 2010).

The website of the trade association for media addiction lists numerous support services in Germany, Austria, Switzerland and Luxembourg: http://www.fv-medienabhaengigkeit.de. It is beyond the scope of the present chapter to review these services in detail. Based on their pioneering nature and/or reputation, three services have been selected for discussion below.

16.4 Lost in Space/Café Beispiellos Berlin

Since 1987, the Café Beispiellos has existed in Berlin as a consultation service for addicted gamblers and their relatives, with sponsorship from The German Caritas Association Berlin (Caritasverband des Erzbistums Berlin e.V.) As of October 2006, an additional service specifically for Internet and computer addicts has been provided, called "Lost in Space". The objective of "Lost in Space" is to compile alternatives to computer use and/or to develop better time management thereof. The service offers various activities to facilitate these aims. Furthermore the consultation service offers counselling for individuals, couples and families. This service can be accessed via: http://www.computersucht-berlin.de.

16.5 Schwerin Media Addiction Counselling

The counselling centre for excessive media use and media addiction emerged in November 2006 as a cooperation project between the Mecklenburg-Vorpommern Evangelical Addiction Help and the Schwerin Helios medical centres. The offer is directed at all age groups and can be used by telephone, in writing, or in person. The objectives are to find ways out of addiction and to understand the underlying causes. The teaching of media literacy to relatives is seen as an integral part of the offer. The website is available at http://suchthilfe-mv.de/vermittlung/vermittlung3/allgemeines.php.

16.6 Computer Game Addiction Outpatient Clinic of the University Hospital in Mainz

"Sabine M. Grüsser-Sinopoli Ambulanz für Spielsucht" of the University Hospital of Mainz was opened in 2008. Initially created as a 12-month pilot project, computer game- and Internet-addicted people are treated on an outpatient basis, as well as pathological gamblers. The offer includes free telephone consultation for concerned friends and relatives, as well as elements of behavioural therapy talks. In addition to individual meetings, group therapy takes place over 20 sessions (Wölfling 2009). There also exists a cognitive-behavioural treatment manual for computer game- and Internet-addiction (Wölfling et al. 2013).

In a little more detail, we will now look at the treatment and counselling services of the LVR Clinic of Bonn. The short intervention, "Compass", used at the LVR clinic will be described inter alia.

16.7 Treatment and Consultation Services for Media Dependence at the LVR Clinic in Bonn

In 2004, the LVR Clinic in Bonn, in cooperation with the specialist agency for addiction prevention, *update,* started the special treatment service "Bonn model—young addiction", with financial support from the city of Bonn, in view of rapidly increasing prevalence and treatment demands (Dau et al. 2008). First, this outpatient–inpatient treatment service was directed at young cannabis and party drug users over the age of 18. The cognitive-behavioural therapy approach includes content based on a developmental-psychology model for the development of addiction. Moreover, learning to adequately handle alcohol and drugs can be understood within the context of age-specific developmental tasks (Havighurst 1972). A failure to accomplish these developmental tasks bears an increased risk of later dependence (Hurrelmann and Quenzel 2012). Therefore, this treatment approach orientates itself more in-line with psychosocial development, than substance consumption. Based on this approach, an independent consulting and treatment service for media dependency was established in 2009 in the outpatient clinic of the Department of Addictions and Psychotherapy, at the LVR Clinic in Bonn. This treatment service also encompasses the diagnosis and treatment of comorbid disorders. The service is directed at all age groups. It must be noted that the development of identity and autonomy are central issues in adolescence, and that the Internet, with its information and communication possibilities, offers various opportunities for the fulfilment of these needs (Lei and Wu 2007). For some individuals, the risk of failure or non- age appropriate coping with developmental tasks may lead to an increased risk of developing a problematic Internet usage, e.g. if autonomy and/or demarcation demands are acted out too excessively on the Internet.

16.8 Is Abstinence a Sensible Therapy Objective?

A complete abstinence from the Internet may only prove a realistic—or even useful therapeutic aim in very exceptional cases. The Internet is too pervasive in important areas of life for this aim to be broadly feasible. The treatment approach of the department outpatient clinic is thus characterized by one principal goal: openness. Depending on the patient's planning and goal setting, the entire renunciation of a specific application or a reduction in the use thereof may be agreed upon as potential objectives. The patient's motivation for this goal setting needs to be taken seriously. The importance given to Internet activities in the life of the patient, both currently and in the post-treatment future, requires discussion. The definition of very concrete contingents of Internet use and early warning signs for relapse into older, problematic online behaviour patterns, also appear to be essential.

The role of self-esteem problems, stressful life events and family conflicts in relation to problematic Internet use has been highlighted by many studies (e.g. Rehbein et al. 2010). This also needs to be considered in diagnosis, case-planning and treatment. If necessary, inclusion of relatives or family members in the treatment process may be useful. Clinicians should be mindful, however, that the patient's possible need for increased autonomy may result in a potential conflict endangering positive treatment outcomes.

In addition to outpatient services, there also exists the possibility of acute inpatient treatment for those strongly affected by Internet addiction and, where applicable, comorbid mental disorders, e.g. heavy depressive disorders. There is also the possibility of establishing email contact via www.mediensucht-bonn.lvr.de.

There were 75 accepted requests for access to this service at the time of going to press. In about 35 cases, continuous treatment was recorded, with more than five single-therapeutic sessions. In three cases, inpatient treatment was necessary due to the presence of an acute depressive disorder. In this context, Teske et al. (2013) note that many Internet abuse services record significantly fewer help-seekers than would be expected based on prevalence estimates. In the opinion of the authors, this may be explained by the low awareness of the disorder and those problems connected with excessive use of the Internet. The extent to which demand for treatment is consistent with the prevalence identified so far, however, remains to be seen. In the following sections, the treatment approach as implemented in the LVR Clinic in Bonn, as well as the theoretical considerations thereof, are outlined in more detail.

16.9 Internet-Related Procrastination Meets Developmental Tasks

Helpful to the analysis of Internet Addiction is the consideration of motivational-psychological approaches (e.g. the research field of procrastination (Steel 2007), in which postponing behaviour is explored). Such approaches can facilitate a better understanding and treatment of problematic Internet use. The relationship between procrastination and problematic Internet use is empirically based (e.g. Lim 2002; Thatcher et al. 2008). Lavoie and Pychyl (2001) found a strong relationship between trait procrastination, negative emotions and Internet procrastination: 51% of their study participants stated that they frequently surfed the Internet at work, instead of beginning the execution of tasks, and spent 47% of their whole time online procrastinating, although trait procrastination was not increased among this sample. For the usage of social networks and online gaming via the Internet, an association between usage time, procrastination and life satisfaction can be shown: heavy users showed increased procrastination and lowered life satisfaction (Hinsch and Sheldon 2013). Another study showed that more than 3 h at work each week are spent on the Internet performing non-work-related assignments (Zanna 1996). Such procrastination behaviour via the Internet is associated with negative feelings, stress, lapses in productivity, and negative self-evaluation (Davis et al. 2002). It seems that some individuals use the Internet as an avoidance activity in order to be distracted from a stressful event, task or stream of thought. In an online study of 1,399 participants, a strong connection between procrastination, problematic Internet usage and the flow experience was found (Thatcher et al. 2008). The flow experience (Csikszentmihalyi 1997) describes an intrinsically motivated state occurring when task difficulty and the self-perceived abilities of a person to successfully work on this task are almost identical. The flow experience is also characterized by a clear objective control over the activity, immediate feedback, concentration and focusing, loss of conscious self-experience, loss of sense of time and is experienced predominantly as pleasant (Csikszentmihalyi 1997). Many activities that are carried out with—and on—the Internet have the potential to convey a flow experience (Thatcher et al. 2008). Accordingly it can be expected that an individual who avoids a stressful task using Internet activities, e.g. online gaming, could get caught up in the pleasant "flow" of this avoidance activity. As a consequence the gaming session, begun as an avoidance behaviour, will probably last much longer than originally planned. Indeed, this vicious circle is supported by research findings (Thatcher et al. 2008; Wan and Chiou 2006).

To further illustrate this, we outline the following case study: A 25-year-old man with a depressive disorder and problematic Internet use sought therapy. He had failed to successfully apply for a job upon completion of his education. Moreover, he failed to sustain a long-term relationship. The patient's mother accompanied him to seek help. He stressed the importance of being head of an online role-player guild. This game-related success, in which the patient had invested a lot of time, money and commitment, were ultimately more important to him than the game experience itself. On the other hand, he failed to deal with his everyday mail, and had failed to report to the unemployment office, with the consequence that he had lost his home shortly before coming into our clinic. Due to the belief that he could only be truly successful in his online game (Davis 2001), the patient had used Internet games to avoid confronting important job-related tasks, which he experienced as aversive (Steel 2007). Instead he satisfied his need for achievement through his role as head of the online guild. The actual playing of the online game was rather of secondary importance, here.

This Internet-based procrastination fits within Davis' (2001) cognitive-behavioural model for problematic Internet use, and gains therapeutic relevance through an improved understanding of the mechanisms underlying problematic Internet use. In the following section we will address how problematic Internet behaviour mirrors the attempt of the patients afflicted to treat their problems by using the Internet.

In addition to the short therapeutic intervention "Compass", outlined in more detail below, interventions for the treatment of procrastination, as developed, e.g. by Höcker et al. (2013) may also be useful. This notion is supported by the findings of Montag et al. (2010). They reported that low self-directedness, as defined by the Temperament and Character Inventory (Cloninger et al. 1993) is a better predictor than neuroticism for problematic Internet use. Self-directedness accompanies the feeling of having control over one's own life, an active coping strategy in solving everyday problems, and self-acceptance of one's own personality. Procrastinators typically lack these personality characteristics. Of note the association between problematic Internet use and low self-directedness has also been replicated in a large group of "*Counterstrike*" Gamers (Montag et al. 2010) and also cross-culturally in seven countries, including the continents Europe, Asia and South America (Sariyska et al. 2014).

16.10 Goals Against "Clicks": The "Compass" Short Intervention for the Treatment of Problematic Internet Use

> The tragedy of life doesn't lie in not reaching your goal. The tragedy lies in having no goals to reach.
> (R. H. Smith)

The following sections outline the development of the "Compass" program, which has originated from the results and experiences of the "Bonn model—young addiction" treatment program. We also outline how this program relates to a cognitive-behavioural approach to the treatment of problematic Internet use, as described by Davis (2001).

16.11 Development of the "Compass"

In the context of research dealing with cannabis patients (Aden et al. 2011), it was observed that patients sought treatment more because of massive external pressure, rather than an intrinsic motivation. This raised the question of how patients could be better supported to comply with the therapy. The basic idea was to integrate the positive effects of therapeutic homework (Kazantzis et al. 2005) as effectively as possible in the inpatient treatment and to associate it with experiences of short interventions (Haug et al. 2010).

16.12 Background: Self-regulatory Theoretical Underpinning

In the development process of "Compass" several theories including self-management therapy (Kanfer et al. 2000), expected self-efficacy (Bandura 1977), reactance research (Brehm 1966), Motivational Interviewing (Miller and Rollnick 2002) and solution-focused therapy (DeShazer 1989) were considered.

Box 1: The four basic principles of the "Compass"

(a) Motivation is assumed in the patient; its catalyst is the task of the therapist,
(b) the reduction of demoralization through the mediation of experiences of success is crucial for the development of expected self-efficacy,
(c) a reduction of reactance is achieved through acceptance, transparency and freedom of choice, and
(d) the mediation of problem-solving knowledge to improve the self-management skills.

One of the basic assumptions in self-management therapy is to support people in creating an *active* lifestyle. In order to maximize *personal freedom,* decision-making authority and freedom of action should be attained in place of habits and stereotyped behaviour patterns (Kanfer et al. 2000). Instead of using the Internet for procrastination behaviour, e.g. in avoidance of more stressful challenges, self-management therapy aims to enable people with alternative behaviour strategies. If the therapy is successful, the individual can then choose between procrastination and task-solving behaviour, which provides an increased level of personal freedom due to more accessible behaviour strategies. Self-regulation and self-control represent the central approaches of self-management therapy for the "Compass" program. Self-management refers to the overall ability of a person to control and/or change their own behaviour under explicit or implicit use of specific strategies (Kanfer et al. 2000). The processes involved in this control are described in the concept of self-regulation, which comprises the steps of "introspection", "self-assessment" and "self-reinforcement". Insofar as problematic Internet use is defined as "an individual's inability to control his or her use of the Internet, causing marked distress and/or functional impairment" (Shapira et al. 2000, p. 267), a key focus in therapy is the strengthening of self-control. In the self-management approach, and therefore also in the "Compass" intervention, self-control is understood as a special case of self-regulation. A person displays self-control if, when experiencing a conflict, that person exhibits a behaviour that would not be expected from the perspective of short-term contingencies (Kanfer et al. 2000). These conflicts typically arise when short-term contingencies suggest avoidant behaviour, e.g. not learning for an exam (short-term contingencies: relief, spare time), but the long-term contingencies (failing the exam, receiving poor marks, not getting a degree) demand task-solving behaviour. In such a case, the individual is forced to decrease negative emotions, like fear, anger, or boredom, and to increase or activate problem-solving behaviour. Two basic types of self-control can be distinguished and are depicted in Box 2.

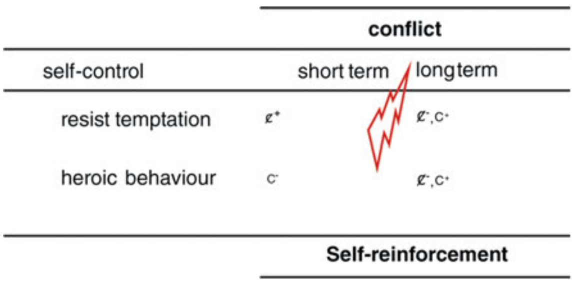


Fig. 16.4 Self-control as a special case of self-regulation with notation of the SORCK-model (Kanfer et al. 2000)

Box 2: Two basic types of self-control (Kanfer et al. 2000)

1. **Resisting a temptation**:
   An enjoyable activity, like playing online games on the Internet is forfeit in order to achieve other goals, like getting a degree or fulfilling obligations.
2. **Heroic behaviour (enduring an aversive situation)**:
   Short-term negative consequences will be tolerated to cause long-term positive results, e.g. going to the dentist, learning for an exam, enduring craving to regain control over the Internet usage, etc.

Here, self-control is understood as actions of people in conflict situations, without referring to individual differences or personality traits. In addiction, self-control is distinguished into decisional or protracted self-control. The former can be described as a conflict which is ended through a decision by the individual themselves (decisional self-control), the latter describes an aversive condition that has to be endured, or a temptation resisted, for a longer period (protracted self-control) (Kanfer and Gealick 1986). As a rule, protracted self-control is particularly difficult for most people, but is especially important in the treatment of problematic Internet use, as total abstinence from the Internet is seldom a realistic goal. The way in which “Compass” supports clients’ self-regulation is outlined below. From a theoretical point of view, we will next consider the importance of self-relevant objectives in achieving self-regulation (Fig. 16.4).

16.13 Background: Underpinnings from Goal-Setting Theory and Motivation Psychology

In goal-setting theory, objectives are defined as an object or objective of an action and can be identified by content and intensity (Latham and Locke 2013; Locke and Latham 2002). Here, the content of an objective refers to the target object or the

Fig. 16.5 Moderators and mediators between goal setting and performance according to Locke and Latham (2002)

state to be achieved, e.g. get up on time. The objective intensity consists of the effort, the position of the target in the personal hierarchy of objectives and the degree of commitment of the individual to achieve their objectives (Latham and Locke 2013). Specific objectives typically and more successfully reached compared to unspecific or summary objectives. In terms of percentage, the performance improves through specific formulation in ranges from 8 up to 16% (Wood et al. 1987). So, the formulation of a specific objective such as "get up at 06:30 h" is more favourable than the more vague "get up on time". Furthermore, important variables include freedom of choice, task difficulty, effort, perseverance, and solution strategies (Locke and Latham 2013). Simplified and schematically, the relationship is shown in Fig. 16.5.

These findings from goal-setting theory can be easily reconciled with the self-management approach. Also, according to Kanfer et al. (2000), therapy objectives have to be (a) specific, (b) realistic, (c) attainment must, in principle, be subject to client control and (d) include self-reward in case of reaching the goal. These principles of goal formulation are incorporated in the "Compass" program. In general terms, objectives take on a directive, attention-controlling function for behaviour. Under the aforementioned conditions, objectives increase motivation, as well as perseverance, and they encourage the acquisition of task-relevant knowledge (Locke and Latham 2002). The benefit for psychotherapy, therefore, is clear, especially if the determining parts of the definition of "flow experience" are considered (Csikszentmihalyi 1997). Hence, during goal formulation in the "Compass" program, it is important to use cognitive methods to teach patients both to gain a realistic perception of their own abilities, as well as to set goals at a reasonable level of difficulty.

16.14 Background: Motivational Underpinnings in a Nutshell

At first it seems difficult to understand that people with problematic Internet use are willing to accept negative consequences in order to spend more time on the Internet. Over the course of this development, it may be possible to observe that Internet use becomes increasingly important for the person, while other activities/objectives become steadily more repressed. From classical operant conditioning research it is known that immediate positive reinforcements have a profound behaviour-controlling effect. When an individual spends a lot of time on the Internet and takes a lot of joy and/or relaxation from it, s/he will increasingly carry out this behaviour. Moreover, the individual will probably feel very good due to the Internet and may connect the unspecific objective "to feel good" with Internet use. Internet use then becomes instrumental to the objective "to feel good", and so a strong association will originate between "Internet" and "good mood" (Fishbach et al. 2004). Thus, the motivational value of the objective "to feel good" is transferred onto the means for goal achievement, in this case Internet use. This process, called "means valuation", is well supported empirically (Brendl et al. 2003; Ferguson and Bargh 2004; Fishbach et al. 2004). In the long term, this effect can have the result that the original means for goal achievement (Internet use) becomes an objective in itself (Köpetz et al. 2013).

Furthermore, it is known from research that goal pursuit is dependent on resources and that intra-psychological resources for self-regulation can at times be exhausted (Baumeister et al. 1998; Hagger et al. 2010). This can be illustrated as a muscle being trained and strengthened through use, but which can also be temporarily exhausted. It can be assumed that such resource exhaustion occurs over time, especially when a person is practicing self-monitoring techniques, in particular with "protracted self-control". Clearly, relapses and setbacks can be explained by such a lack of resources. People react to resource limitation by using their resources strategically, depending on the individual significance and importance of objectives (Kruglanski et al. 2012). If several objectives are active at the same time, e.g. desire for Internet use and learning for an exam, people protect the currently most important goals through highly automated inhibition of competing goals (Köpetz et al. 2011). The most important current goal is followed, in spite of competing goals, and hence also in spite of possible negative consequences. Such tendencies may generally play an important role in behaviour related to addiction (Köpetz et al. 2011, 2013). Over time an original means of goal achievement can become in itself a goal that, if the positive emotion is strong enough, has the potential to increasingly dominate other goals. Under certain conditions afflicted persons cannot get out of this vicious cycle without help, even if they want to do so.

If we follow the assumptions made above, two main approaches should be pursued in therapy: on one hand, self-regulation resources should be maximized to prevent exhaustion. On the other hand, the person should have as many specific, moderately difficult and problem-behaviour-related competitive objectives as possible, and the means to achieve them. It is described how such objectives can be established and how self-regulation resources can be protected.

16.15 Cure for Problematic Internet Use: How the "Compass" Helps Beating Clicking

First, implementation of the "Compass" is described in its original form, as conceived for an inpatient setting. Second, other possible applications are outlined for an outpatient service. Of note, in inpatient therapy the patients receive an additional daily therapeutic contact of maximum 5 min duration. During the "Compass" session, a short behaviour-related assignment (one goal) is formulated daily by the patient himself. In the "Compass" discussion the next day, monitoring of the performance and achievement of the assignment is carried out, based on a scale rating (scale 0–100), as well as the establishment of a new goal. Through this, the "TOTE" scheme (Test-Operate-Test-Exit) should be taught as a simple problem-solving algorithm (Miller et al. 1960).[2] As the patient is responsible for setting the objective, the therapist provides support only in shaping and operationalising the specific goal. In doing so, the therapist works to promote motivation and to reduce reactance as far as possible. As a general instruction, the patient is told that the goal must be achievable within a day or a weekend and the implementation must also be measurable. The goal is written down, read to the patient again and the patient is positively reinforced, i.e. praised, for the formulation. After that the therapist asks whether the patient requires assistance to achieve the goal and briefly intervenes if necessary.

16.16 Goal Openness and Instruction for the Patient

Goal openness on the part of both the therapist *and* the patient should provide the greatest possible acceptance of the client's potential, should increase compliance with—and therefore decrease reactance to—therapy and behavioural change. The patient is given the suggestion to formulate the goal very positively and specifically (positive rule; e.g. "get up at 6.30 am" instead of "do not oversleep"). In giving this instruction, the therapist also orientates himself towards the resource-oriented approach (Haug et al. 2010). If no goal can be formulated, it is suggested that the goal should be to find a goal for the next session. A time limit is imposed in such a situation to avoid excessive problem orientation. This saves both the resources of therapist and patient and provides a feeling of "Less can be more".

[2]The TOTE scheme is especially useful in the early stages of therapy due to its simplicity, although it does not do full justice to the complexity of the underlying process.

16.17 Intervention During the "Compass"

In a way, "Compass" may be considered a special form of the well-established therapeutic 'homework' as known from behavioural therapy. Issues that arise in individual or group sessions can be integrated into the "Compass" and vice versa. "Compass" intervenes if the patient sets himself inaccessible or unspecific goals, or if he proceeds with attainment scaling too strictly. In such a case, the therapist will use cognitive techniques (socratic dialogue) to dispute the strict judgement of the patient, trying to enable the patient to notice and to reward himself even for small progress. The program also targets high self-demands as a central theme, encouraging the patient to set himself smaller goals and teaching him self-reflection and positive self-reinforcement. In this context, the "Compass" is also suitable for use as a diagnostic instrument. In Fig. 16.6 the "Compass" course for a patient over seven sessions is displayed. Here, the goals partially build on each other, something that can be a very useful side effect; the patient thus creates a structure for task accomplishment. In this case, the therapist gives support only insofar as giving assistance with implementation.

Experience shows that over the course of treatment, the patients usually bring their own ideas for very specific goals to the "Compass" session. The task of the therapist is then focused on substantiating the goals or observing adherence to the "Compass" rules (One goal/Positive rule), as well as to positively support the patient in goal achievement and/or the attempt. According to clinical experience, goals such as "remain abstinent" are selected if the patients particularly suffer from craving, e.g. for cannabis, Internet gaming, etc., and therefore want to confirm their abstinence goal.

16.18 Effectiveness of the "Compass" in the Treatment of Cannabis and Party Drug Users

In the LVR Clinic's own study, carried out with 104 cannabis and party drug patients within the scope of the "Bonn model—young addiction" treatment program, there were clear indications of an improvement in the effectiveness of inpatient treatment through the use of the "Compass" (Dau et al. 2011). In comparison to the treatment-as-usual control group, significant improvements of medium effect sizes ($d = 0.56–0.70$) were shown for the "Compass" patients in the following areas: interpersonal problems, depression, trait anxiety and general psychological distress. The "Compass" group also demonstrated better clinical outcomes: more improvements above chance were shown in the "Compass" group on the Reliable Change Index (RCI). The RCI equals the difference between pre- and post-test scores, divided by the standard error of the difference. Cut-off scores are established, assigning patients to one of the following categories; recovered, improved, unchanged or deteriorated (Jacobson and Truax 1991). In terms of


Kompass

Patient: Anonymus

Date: 20.07.12

Goal: get welfare claim form **Goal attainment:** 100%

Date: 21.07.12

Goal: fill in claim form **Goal attainment:** 100%

Date: 22.07.12

Goal: get up at 06:30 **Goal attainment:** 100%

Date: 23.07.12

Goal: go to sleep no later than 23.30 hrs **Goal attainment:** 80%

Date: 24.07.12

Goal: stay clean **Goal attainment:** 100%

Date: 27.07.12

Goal: stay clean **Goal attainment:** 100%

Date: 28.07.12

Goal: exhaust yourself through sport **Goal attainment:** 100%

Fig. 16.6 Example of a "compass" over seven units

general psychological distress, more "Compass" patients improved from clinically increased to normal values (Kendall et al. 2004). Moreover, less relapses with cannabis occurred in the "Compass" group than in the group of patients without "Compass", which is a further indication that the "Compass" intervention facilitates self-management abilities.

Despite limitations due to the quasi-experimental and naturalistic study design, these results are encouraging. Based on patient feedback, the clinical experience was perceived positively and the short intervention was well accepted. Here, the overall impression was that the “Compass” program significantly contributed to improving therapy motivation and the compliance with the inpatient setting more generally, among the young (23 years) target group of cannabis and amphetamine consumers. Difficulties, like low motivation, reactance, and dropping out of treatment, that often occur in non-specific therapeutic interventions for this target group, were avoided, and thus the risk of untimely termination of therapy was limited (Aden et al. 2011). This last point was particularly instrumental in adapting the “compass” intervention to outpatient and inpatient treatment of problematic Internet use.

16.18.1 Using the “Compass” Intervention in the Treatment of Problematic Internet Use

16.18.1.1 Acute Inpatient Treatment of Patients with PIU

Previous treatment demands in the outpatient department of the LVR Clinic of Bonn referred to all spectra of problematic use of computers and the Internet. In cases where a comorbid severe and pronounced mental health problem, e.g. severe depression, made acute inpatient treatment unavoidable, the inpatient treatment was undertaken within the scope of the “Bonn model—young addiction” treatment offer. Here, experience so far suggests that the integration of patients with problematic Internet or computer use into the group of young cannabis and party drug patients is possible. Joint treatment within the framework of the psycho-educational group, the motivational group based on the concept of Motivational Interviewing (Miller and Rollnick 2002), and the competence group, in which rejection skills, assertive skills and strategies for relapse prevention are practiced, seem sensible from a clinical perspective, for both patient groups. In this case, the developmental-psychology approach of the “Bonn model—young addiction” (Dau et al. 2008) proved very helpful for the integrative treatment of both patient groups. Although the case numbers are insufficient for systematic statistical evaluation, the clinical impression suggests that both patient groups seem to profit from the exchange of similarities and differences in their respective issues. Within the scope of the inpatient treatment, the patients with PIU also participated in “Compass” and no differences between them and the cannabis and party drug patients became apparent. Patients with PIU accepted the “Compass” and benefitted from the Intervention in terms of therapy outcome.

16.18.1.2 Outpatient Counselling and Treatment of Patients with PIU Undergoing the "Compass" Program

The demand for outpatient interventions far exceeds that for inpatient treatment. In addition to the therapeutic interventions already described, some first steps have been made in adapting the "Compass" intervention to outpatient treatment. Unlike the inpatient practice, discussion of the goals and results is not part of daily therapy in outpatient treatment; rather, this is conducted on a weekly basis. Thus, the "Compass" program takes on the character of a therapeutic "homework" task (Kazantzis et al. 2005). The principle of breaking one goal down into smaller steps remains central to the intervention. These smaller sub-steps of goals are easier to achieve and it is also easier to train patients to reflect on themselves, to formulate positive and realistic targets and to reaffirm themselves, even for partial successes. Although the literature on effective treatments for procrastination behaviour is scarce (Klingsieck 2013), early studies show that, at least for random student samples, the four elements embodied in the "Compass" (see Box 3), have a favourable effect on procrastination behaviour (Pychyl and Binder 2004).

Box 3: The four therapeutic core elements of the "Compass"

1. Self-observation.
2. Segmentation of tasks into small steps.
3. Formulating of positive approach goals.
4. Training of self-rewarding behaviour.

Clinical experience suggests the "Compass" program is both useful and effective in the treatment of problematic Internet use. Acceptance of the intervention among outpatient clients is good and allows for easy dovetailing of the content of individual therapy sessions through continuous work on self-set and self-relevant goals. Patients quickly see tangible progress, which in turn increases motivation for treatment. Besides this, the "Compass" can be used over and over again to practice the formulation of realistic goals and to discuss goal-oriented problem-solving strategies (D'Zurilla and Nezu 2010). Usually, within "Compass", selected goals focus directly on the problematic Internet use and address related problem areas, such as the development of hobbies, improvement of social skills, etc. It should be noted that "Compass" is not a stand-alone intervention, but a program that supplements an overall cognitive-behavioural therapeutic approach. Below, a case study will be presented that specifically illustrates the significance of the "Compass".

16.18.2 Case Study

Initial Interview:
Mr. B virtually burst into the room, where he finally got rid of his complaints with vigorous urgency and restlessness. In his case, recording of a structured medical history was not possible. Mr. B reported multiple symptoms including stomach and digestive problems, headaches, tremors, dizziness, aggressive impulses, feelings of tension, insomnia with nightmares, and feelings of inferiority. He reported that everything around him became sort of unreal. In subsequent conversations, drive reduction (lack of motivation) and social withdrawal could also be observed. Concentration and memory problems were also reported by the patient, but these could not be objectively established, neither through conversation with the therapist nor by neuropsychological tests. Mr. B worried about a lack of job opportunities and his upcoming change of residence, difficulties in making friends and stressful family situations. He rarely had suicidal thoughts. Sometimes he felt hopeless and developed thoughts of meaninglessness of life.

Mr. B stated that he considered himself to be addicted to computer games. He stated that he had a strong desire to play these games and described unsuccessful attempts to control his own behaviour. A neglect of leisure activities, friends and own health due to an unbalanced and irregular diet and lack of sleep were furthermore reported.

16.18.2.1 Diagnostic Assessment and the Role of Cognitions

Following a structured clinical interview (SKID-I; Wittchen et al. 1997), the symptoms reported were assigned to a generalized anxiety disorder. Furthermore, at the start of treatment, both depressive tendencies and PC gaming addiction were encoded as control variables. These additional symptoms, as assessed by the structured interview, come under both the classifications of depression and impulse control disorder, in accordance with the guidelines of the International Classification of Diseases 10 (ICD-10; Dilling et al. 2011).

The depressive and anxiety symptoms named in the initial interview increased over time and crystallized as the main stress factors. In addition to this, the unsuccessful attempts at reducing computer usage also became a therapeutic focus. "*Feeling bad*", something that Mr. B stated over and over again, and the experience of helplessness was compensated through use of computer games. Mr. B stated that his experience while using the computer took his mind off things. He stated that the above-mentioned symptoms returned upon termination of the gaming session and in particular when leaving his flat. Dysfunctional cognitions manifested in statements such as: "If I play, I am safe. As soon as I leave the computer, the bad experience returns and I have to return to the computer".

16.18.2.2 Construction of Change Motivation and Development of Therapy Goals

In order to promote change motivation, the advantages and disadvantages of the online gaming were discussed as well as other problems linked with it.

Box 4: Initiation of motivation for change
Therapist: "You have named several symptoms at the beginning, from which you are suffering, and other problems that may be associated with the PC gaming. In your view, what should be changed in your life in addition to this?"
Mr. B: "I cannot get myself to choose a profession, I am also unsure as to how I can manage to move to another place. I cannot stay in the present apartment. I would like to find more friends and establish contacts with others again."

It can be assumed that the client had conversations about his problems before he turned to the outpatient clinic. The younger clients are, the more likely it is that these talks have taken place with parents or legal guardians. Therefore, such conservations may have assumed the form of reproaches, and were probably perceived as damaging to self-esteem (Miller and Rollnick 2002). Notably, the afflicted patients are often placed in a defensive position forcing them to justify their behaviour and speak in the interest of self-protection.

These problems can be avoided if the therapist shows a value-neutral, interested and open outcome attitude. The therapist asks open questions on the problems and goals for change of the client. The question about the benefits and the advantages the patient got from his computer use is also essential

Box 5: Analyzing the advantages and disadvantages of the problematic behaviours
Therapist: "You have already mentioned various problems related to PC games. What are the benefits the games had for you?"
Mr. B: "I'm really good at" League of Legends, "they are talking about me in the forums and I am being admired! I also play together with others. Without the other players I would be all alone. When I'm not playing, I'm lonely and I see that I have failed professionally and I am getting nothing done. Then I feel dizzy and I get uneasy."

Upon determining the problems and goals that are important for change motivation, the behavioural patterns leading to the problematic behaviour were identified. Here, the patient quickly names the computer gaming itself. In doing so, he enters a voluntary commitment and can give up justifying his game-play, as may have been necessary previously in conversations with parents, teachers or friends. It is useful here not to immediately judge the behaviour as "bad", "wrong" or "clumsy", but to look at it as a means of preserving self-worth. In other words, it is important to be open and to explore the function the behaviour serves for the client. Mr. B had independently come to recognize how his gaming served the function of fear regulation, but additional reasons soon became clear; in addition to anxiety regulation, Mr. B's gaming served to fulfil a need for admiration, self-esteem and belonging (see Box 5).

Here, basic motives become clear, such as the need for approval, closeness, and self-preservation. Once these have been identified, the convictions and beliefs held in relation to the problematic computer usage could be approached.

16.18.2.3 Modification of Dysfunctional Cognitions and Activation of Resources

Dysfunctional cognitions are often observed in Internet addiction. These manifest in statements such as, "without success in the game I would be a complete loser. The only possibility to have regular contact with others is through the game. Being average is not enough, one must belong to the best." In cognitive therapy such dysfunctional beliefs are modified, by arguing against them (Beck et al. 2001). For example, both therapist and patient examine what reasons speak in favour of—and against—these convictions. Through the therapeutic process, Mr. B became aware that some statements are indeed changeable (see Box 6).

Box 6: Example of the modification of dysfunctional beliefs

Mr. B	"I would be a total loser if it were not for my success in gaming."
Therapist	"Okay, you have success in gaming. Can you imagine any other reasons that would suggest that you could also succeed in other things besides gaming?"
Mr. B	"Well, I've already finished school and in earlier days I was good at football, but that was only in earlier times."
Therapist	"Does that mean you cannot play football anymore and you now have no school graduation certificate?"
Mr. B	"Sure I could still do that, but I am not doing anything."
Therapist	"Hmm. How could your sentence "I would be a total loser if it were not for my success in gaming" be reworded into something else?"
Mr. B	"I could play football and I have a college degree, but I am not doing anything with it, and so how should I say this?"
Therapist	"How could you rephrase it so that the sentence becomes more coherent for you?"

Mr. B	"I am currently leaving much undone, but I managed my high-school diploma."
Therapist	"How are you doing with this sentence?"
Mr. B	"Of course, it already feels better than the loser sentence. This way, it already becomes easier to do something. I can notice something here after all."

Mr. B identified a desire to be active as a football co-trainer as an approach goal (Grosse Holtforth and Grawe 2004). He had played a lot of football during his youth and he enjoyed working with adolescents. He already helped out in his home club as a co-trainer. It became apparent that he already possessed the skills needed to be a co-trainer, for example, sporting skills gained during sports lessons at school, and organizational skills gleaned from the planning of Internet games. Interestingly, Mr. B was now able to use the skills he had learnt while playing computer games both in therapy and in his "real" life.

On one hand a realistic view of present behaviours and skills can be developed through Socratic debate as depicted above in Box 6, and on the other hand the value-neutral therapeutic stance towards computer gaming can be vividly demonstrated. Mr. B perceived the appreciation of those skills he had acquired as an appreciation of himself as an individual, as a result of which the therapeutic relationship and change motivation was additionally reinforced.

16.18.2.4 The Role of Comorbidity—Integration of Fear Treatment

The patient's history strongly suggested that the anxiety disorder had developed prior the problematic Internet use, and had facilitated the development of the gaming problem. To counter the patient's anxiety, extensive psycho-education on anxiety disorder was provided. Behaviour therapy interventions targeting anxiety disorders were incorporated into the intervention (Schneider and Margraf 1998). The "Compass" program was used to facilitate positive reinforcement. Mr. B set for himself small goals to cope with his anxiety, and further increased his expected self-efficacy and motivation to change through the sense of achievement he experienced.

16.18.2.5 Formulation of "Compass" Goals in the Therapy Process

Box 7: Example dialogue on a "Compass" evaluation

Therapist	"What were you working on in the past week?"

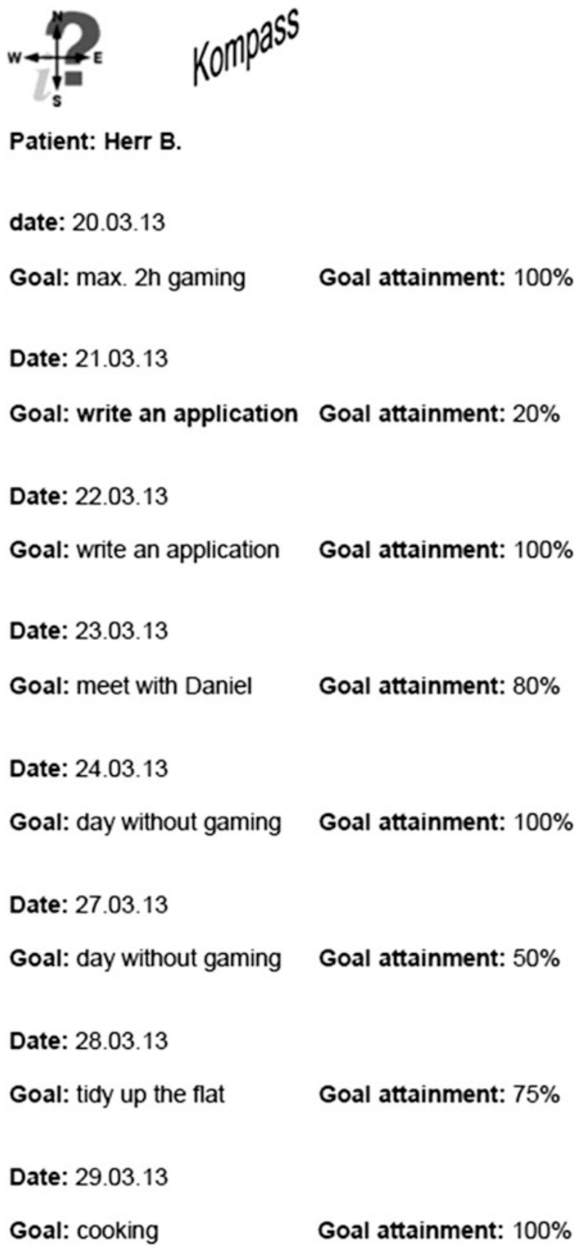
Mr. B	"It is important to me to improve social contacts again. On Tuesday I formulated the goal *to write emails to friends at school*."
Therapist	"And how well did it go?"
Mr. B	"I wrote to 6 people and two answered at once, on the same day. On Friday, Jens from secondary school has also written back. That made me happy. I evaluated my goal achievement with 100% in the "Compass". I also set myself the goal after football on Saturday to watch the sports show with the others in the club. This has also worked!"

As shown in Box 7, it was possible to work on changes continuously so that the patient soon set himself daily goals like "view flats (for moving to another apartment)", "meet my school friend Daniel" and "go to the cinema with Jessica" among other things. A shift of priorities resulted, moving away from Internet-related behaviour towards social activities and other important goals. In this example, it can be illustrated that focussing too early on the obviously dysfunctional computer use may not be necessary and may even endanger the client's progress in therapy. On the other hand, a plan of treatment that is aligned to one's own values and goals, taking into account any comorbid disorders, seems to better facilitate treatment.

In conclusion, thanks to this treatment protocol, Mr. B was able to leave the house and go to football training. Through continuous work on small daily tasks, partly related to coping with anxieties, partly related to goal formulation (i.e. through use of "Compass"), Mr. B developed more functional cognitions. He recognized the changeability and controllability of his thoughts, feelings and behaviour.

16.18.2.6 Summary

In the illustrated case, reactance was avoided through a planned and transparent approach (Brehm 1966). Change motivation was created. Early concentration on change can generate fear and can create a danger of not being understood. These aspects seem to be of particular importance when working with younger clients. Here, in addition to building a stable working relationship, the aspect of self-observation needs to be taught. In each case, the therapist must be careful that self-observation is directed towards own behaviour and behaviour change, particularly with younger adolescents. The self-reflection typical for this development phase is often orientated towards one's own perceived deficits, leading to depressive symptoms (Nurmi and Salmeda-Aro 2002). This should not be further reinforced in building up symptom diaries during therapy. Instead, the patient needs to recognize and focus on positive change and how this change can occur. In this example, a sense of control was encouraged, which promoted feelings of



Kompass

Patient: Herr B.

date: 20.03.13

Goal: max. 2h gaming **Goal attainment:** 100%

Date: 21.03.13

Goal: write an application **Goal attainment:** 20%

Date: 22.03.13

Goal: write an application **Goal attainment:** 100%

Date: 23.03.13

Goal: meet with Daniel **Goal attainment:** 80%

Date: 24.03.13

Goal: day without gaming **Goal attainment:** 100%

Date: 27.03.13

Goal: day without gaming **Goal attainment:** 50%

Date: 28.03.13

Goal: tidy up the flat **Goal attainment:** 75%

Date: 29.03.13

Goal: cooking **Goal attainment:** 100%

Fig. 16.7 Example of an outpatient "compass" run

self-efficacy. Mr. B was very proud when he understood that his symptoms were closely associated with his anxious thoughts and his fear of failure. This insight helped him to apply for a temporary job. He experienced relief and confidence at his ability to change something. The therapeutic plan was then extended by the patient himself, and the goals of the patient became part of the Compass program (Fig. 16.7).

In outpatient treatment, the “Compass” program leads to better cooperation and improves the effectiveness of the behavioural homework. Systematic investigations of the efficacy of the “Compass” for the treatment of problematic Internet use need to be implemented. Hence, in the LVR clinic, a pilot project for online use of the “Compass” is being planned.

16.19 Effective Therapy Approaches to Problematic Internet and Media Use in General

A review by Petersen et al. (2009) states that an evidence-based recommendation of treatment for Internet addiction is not possible, because studies are largely lacking. Wdiyanto and Griffiths (2006) summarized that most treatment approaches comprised cognitive-behavioural paradigms (regardless of their effectiveness). Peukert et al. (2010) recommend cognitive-behavioural and pharmacological treatment approaches as most likely to be successful. The authors suggest that the inclusion of relatives and family members in the intervention may also be helpful. In a meta-analysis of 16 studies, comprising a total of 670 participants, Winkler et al. (2013) confirmed the effectiveness of psychological/pharmacological treatment. Here, the effect strengths of cognitive-behavioural approaches outperformed other therapy approaches in the reduction of time spent online and depressive symptoms, but the number of studies of pharmacological treatments was very low (n = 3). Individual therapeutic approaches proved more effective than group therapy, something the authors explain through increased social anxiety and increased social isolation, as well as the shortage of social competence, which could be an obstacle for group-therapeutic approaches with this patient group (Winkler et al. 2013, p. 326). Higher effect sizes were found for clients who were female, older, and of North American origin. The latter may be explained by unique characteristics of Asian countries. For example, South Korea has the most developed broadband network of the world, three professional online gaming leagues, and online individuality in the context of social structures is of increasingly high importance. Young people, “who have been brought up within a hierarchical, family focused society find that they are able to act out individualism and socialize independently through the Internet for the first time. Therefore, engaging in psychotherapy for IA might mean losing their individual (online) identity” (Winkler et al. 2013, p. 326).

Further research into this area is necessary. To sum up, it can be stated that Internet addiction seems to be treatable. Cognitive-behavioural approaches could be particularly effective. Further research must elucidate what role pharmacological and a combination of psychotherapeutic therapies play. Also the question of whether group therapy settings or individual therapy settings are more helpful in dealing with Internet addiction needs further investigation, because this could prove very significant. A temporary combination of the two settings might be advisable here, where initially one begins with individual therapy and progresses to a group setting later in the treatment.

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Chapter 17
Psychotherapeutic Approaches to the Treatment of Internet Addicts: Scientific Evidence and Clinical Experience in Germany

Bert te Wildt and Klaus Wölfling

Abstract Treatment of Internet addiction within the German healthcare system is performed by two main clinical disciplines, "Psychiatry and Psychotherapy" on the one hand and "Psychosomatic medicine and Psychotherapy" on the other. Acute states of addiction and withdrawal are usually treated in psychiatric hospitals, which can deal with any medical implications that arise and which offer expertise in psychopharmacology. Long-term rehabilitation treatment is traditionally offered by psychosomatic hospitals, which boast expertise in inpatient psychotherapy. However, the majority of Internet addicted patients are treated as outpatients. The chapter presents an overview of the two different psychotherapeutic approaches to the treatment of Internet addiction from a scientific and a clinical angle. As in the case of addiction medicine more generally, cognitive behavioural approaches have shown the greatest efficacy in the initial treatment of Internet addiction. A growing body of evidence supports this approach. However, far less is known about the effectiveness of psychodynamic psychotherapy. It most likely has a place in the long-term treatment and management of Internet Addiction and in the treatment of underlying co-morbid disorders, such as depression or anxiety. We will outline the current state of play in both psychotherapeutic schools, before concluding with a more holistic, integrative view of how an ideal integrated treatment scenario could work.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_17

17.1 Introduction

Germany boasts a history of around 15 years of clinical experience and scientific research on Internet addiction. With approximately 80 Million inhabitants and a striving global economy, computers and the Internet have readily become ubiquitous in the everyday lives of most Germans. Correspondingly, Germany, alongside the North American countries, South Korea and other modern Asian countries, has been relatively quick to detect, diagnose and treat Internet addiction.

Treatment of Internet addiction in Germany is influenced by two major trends. Firstly, the application of evidence-based therapeutic principles is an important feature of the dynamic German health care system. However, clinical research aimed at developing therapeutic interventions for Internet addicts has traditionally been a slow process. Secondly, the particulars of the health care system in Germany also influence treatment of those experiencing Internet addiction. Within this healthcare system, patients suffering from mental health disorders are treated by two main clinical disciplines. The treatment of addiction, particularly behavioural addiction, is especially influenced by this therapeutic landscape.

These two clinical disciplines comprise "Psychiatry and Psychotherapy" on the one hand and "Psychosomatic medicine and Psychotherapy" on the other. Acute states of addiction and withdrawal are usually treated in psychiatric hospitals, which can deal with any medical implications that arise and which offer expertise in psychopharmacology. Long-term rehabilitation treatment is traditionally offered by psychosomatic hospitals, which boast expertise in inpatient psychotherapy. However, since somatic complications are not typically a feature of behavioural addictions, acute treatment interventions in psychiatric hospitals are rarely necessary. Since psychotherapy is usually the therapeutic approach of choice for behavioural addictions, German psychosomatic facilities play a greater role in the management of Internet addiction.

In the meantime, Internet addiction is fastly becoming the most common behavioural addiction in Germany (Bischof et al. 2013). Quite a few urban university hospitals already offer outpatient services dedicated to general behavioural addictions and often have specific clinics for Internet addiction. However, for most patients, their first experience with the health care system is with medical doctors such as general practitioners or specialists for psychiatry or psychosomatic medicine and psychotherapy in private practices. Alternatively, "first aid" for Internet addicts is offered by social workers in addiction counselling centres run by federal, charitable and church-based providers. A similar organisational structure applies to paediatric health care systems. Aside from general paediatricians, there is only one medical specialty targeted toward children with mental health disorders—"Child and Adolescent Psychiatry and Psychotherapy". Irrespective of age, psychotherapeutic interventions, either on an individual or a group basis, are the treatment of choice for Internet addiction and are provided in all the aforementioned facilities, be it outpatient clinics, counselling facilities or private practices.

Generally, psychotherapeutic approaches are offered and supported by the health care system. The majority of people in Germany have health insurance and such medical insurance usually subsidizes both psychodynamic psychotherapy and cognitive behavioural psychotherapy. Professional psychotherapy is performed either by medical or psychological psychotherapists. Traditionally, medical doctors are more commonly trained in psychodynamic psychotherapy, whereas psychologists tend toward cognitive behavioural psychotherapy. Yet, there are signs of a shift in this division, as increasing numbers of physicians are also trained in cognitive behavioural psychotherapy. More generally, clinical facilities and individual psychotherapists are increasingly adopting therapeutic methods that integrate both psychodynamic and cognitive behavioural approaches.

This chapter presents an overview of the two different psychotherapeutic approaches to the treatment of Internet addiction from a scientific and a clinical angle. As in the case of addiction medicine more generally, cognitive behavioural approaches have shown the greatest efficacy in the initial treatment of Internet addiction. A growing body of evidence supports this approach. However, far less is known about the effectiveness of psychodynamic psychotherapy. It most likely has a place in the long-term treatment and management of Internet Addiction and in the treatment of underlying co-morbid disorders, such as depression or anxiety. We will outline the current state of play in both psychotherapeutic schools, before concluding with a more holistic, integrative view of how an ideal integrated treatment scenario could work.

17.2 Cognitive Behavioural Psychotherapy for Internet Addiction

International research focusing on the treatment of Internet addiction and especially on Internet Gaming Disorder indicates that approaches using cognitive behavioural therapy (CBT) are highly effective interventions. A recent meta-analysis by Winkler et al. (2013) suggests that CBT interventions are particularly effective in reducing the depressive symptoms accompanying Internet addiction, compared with other intervention programmes.

In Germany, a cognitive behavioural manual for the treatment of Internet addiction and Internet gaming disorder has been introduced to the therapeutic community in 2013 (Wölfling et al. 2013). Results of a pilot study on the efficacy of the program showed that subjects suffering from Internet addiction significantly benefited from this CBT treatment. Both the amount of time patients spent online, as well as their general levels of psychosocial distress, were significantly reduced after completion of the intervention (Wölfling et al. 2014). The diagnostic process for patients seeking assistance for Internet addiction is necessarily elaborate to ensure the appropriate treatment setting is identified for each individual. This process includes aspects of the Internet addiction itself (e.g. type of addiction, severity, negative consequences) as well as the exploration of possible differential diagnoses. Since IA is related to high rates of co-morbid disorders, e.g. anxiety and depression, it is crucial to address this issue thoroughly in the patient's medical history. Depressive symptoms require particular consideration, as they can worsen during the intervention (e.g. as a result of reduced time spent online) and thus may lead to a decompensation of the patient. Psychosocial functioning, motivation to change and biographical information (e.g. phases of Internet abstinence) should also be assessed during the diagnostic process. Patients of at least 17 years of age who meet the criteria of Internet addiction/Internet gaming disorder can be treated with the aforementioned short-term cognitive behavioural-therapy manual, which outlines an outpatient therapy program consisting of 15 once weekly sessions of group therapy (duration: 100 min each) and ideally eight accompanying sessions of individual therapy (duration: 50 min each). Table 17.1 outlines the content of the therapeutic program.

Each group session follows an identical format, with the exception of the initial group session, which serves to introduce the patients and to explore their motivations for therapy. In each group session the previous session is reviewed and is followed by an abstinence round. If patients report relapses, priority is given to that issue by discussing the preconditions of and reactions to the relapse in depth. Otherwise, the focus should revolve around positive changes, which are reinforced and existing resources, which should be clarified and activated. In the group sessions new ideas leading to changed behavioural patterns are discussed. Afterwards, the specific topic of the session is addressed. In the early phase (Sessions 1–3) psychoeducation and the agreement on therapeutic goals are established. These are essential preconditions for the later stages of the program. Individual models of the development and maintenance of addictive behaviour, as well as individual therapeutic goals are elaborated. As therapy progresses (Sessions 4–12), psychotherapeutic interventions, including the functional analysis of the addictive behaviour

Table 17.1 Content of therapeutic program to treat internet addiction

Session and topic	Content
1. Introduction, therapy contract and goals (Sessions 1–3)	• Outline of the therapeutic program • Introduction round (getting to know each other) • Discussion of an initial attempt to abstain from Internet use over the upcoming week • Identification of individual therapeutic goals and development of a therapy contract for each patient • Self-observation using week protocols
2. Triggers and maintenance factors of addictive behaviour (Sessions 4–12)	• Abstinence round: evaluation of abstinence attempt • Analysis of week protocols • Vicious circle model: Identifying individual factors contributing to the vicious circle of addiction
3. Resources and alternative strategies (Sessions 13–15)	• Abstinence round • Discussion of alternatives to abstinence • Search for and documentation of resources using the flip chart (model learning)

(i.e. through diary keeping), skills training (e.g. coping strategies, social skills) and promotion of social interaction and communication are cultivated. Beyond that, exposition training is applied as a kind of core intervention. After a period of abstinence (usually 6 weeks), the patient will be confronted with an electronic device, on which his favourite application runs. The main aim of the session is learn how to cope with the irresistible urge for addictive behaviour. The patient has to withstand symptoms of craving, shivering and inner psychological pressure. Before the therapeutic program comes to an end, the final sessions (sessions 13–15) will discuss relapse prevention. Within this final phase of treatment, the real-life application of strategies and skills acquired during the intervention is central. Moreover, functional computer and Internet use is facilitated and tools for relapse prevention are developed.

The intervention presented here operates on the assumption that learning processes are crucial for the development and maintenance of addictive behaviours. Thus, Internet Addiction and Internet Gaming Disorder can be perceived as dysfunctional behaviours, which are consolidated by learning processes. The implication here is that core features of the disorder can be reversed through cognitive restructuring. The main therapeutic goal is abstinence from Internet-based content that is used problematically—initially (sessions 3–10) this constitutes a complete abstinence from any online behaviour (i.e. patients are not allowed to use any kind of new electronic media privately). Moreover, the program aims to facilitate patients' understanding of the underlying psychological concepts of addiction (psycho-educative components) and the triggers initiating addictive behaviour. Based on this, useful alternative strategies (to abstinence) should be developed (i.e. specific change-oriented strategies) and patients' self-esteem and self-regulating skills are cultivated and increased. Taken together, this program, as well as similar approaches based on cognitive behavioural therapy, demonstrate impressive efficacy in evaluative studies. While most research has considered outpatient interventions, there is also some evidence for the efficacy of inpatient treatment.

17.3 Psychodynamic Psychotherapy for Internet Addiction

To date, Internet addiction mainly presents clinically as Internet gaming disorder, i.e. as an addiction to complex video games played with other users via Internet. This predominantly affects young male users, who experience major difficulties completing the tasks necessary to enter adulthood and become a fully autonomous human being. By seeking refuge in Cyberspace they end up far behind their peers in terms of psychosocial and psychosexual development. It can be quite difficult to differentiate whether their regression to the playful parts of the digital world stems from primary relationship difficulties and attachment insecurity, or if their inabilities to fully mature derive from the excessive time spent engaging with Cyberspace at the sacrifice of human interaction, thus resulting in a poor grasp of the necessary developmental steps to reach adulthood (Bilke-Hentsch et al. 2013). From a psychodynamic perspective, these developmental deficits are less a feature of what Internet addicts *have* experienced within the Internet's parallel universe, and more a result of what they *have not* experienced in the real, physical world. From a psychodynamic perspective, this is quite important, since both physical and mental development are dependent on lived experience, both in terms of one's own bodily existence and in terms of direct contact with other people, such as parents, siblings and friends. Meanwhile, digital communication cannot adequately replace such real-life experiences.

However, some of the Internet's applications can become an object substitute, i.e. a replacement for a meaningful personal bond. Referring to substance abuse, Wurmser (1997) postulated a phobic core structure of the addicted individual, who is striving for narcissistically charged objects. From this point of view, addiction goes back to the idea of an object having powerful impact on its user. Thus, excessive online gaming—which is often accompanied by an uninhibited submission to the rules of the game—can be understood as a subconscious neurotic conflict resolution strategy. Online gaming addicts can thus emerge from the virtual battles in Cyberspace in a narcissistically gratifying manner as shining heroes, a status they cannot satisfactorily achieve in real life. This may explain, why a strong sense of self-efficacy in terms of computer usage (Jeong et Kim 2011) and deficits in self-esteem or self-confidence (Ceyahan et Ceyahan 2008) are viewed as predictors for the development of Internet addiction. Taking this into account, it is not surprising, that depression and socio-phobia are typical co-morbid disorders accompanying Internet addiction (te Wildt et al. 2010; Carli et al. 2012). For young Internet addicts, the real world, particularly the adult sphere, is perceived as narcissistically demeaning and social contacts are viewed as overly intimidating. Thus, depressive and anxious psychodynamics often pave the way for a retreat into Cyberspace.

For patients who withdraw themselves from the real world or who remain in the virtual world as a result of time spent there during childhood and adolescence, their addictive behaviour may be interpreted as a denial or even a rebellion against adulthood and its demands. This particularly applies to educational and professional achievements. Similar to parents, teachers, trainers and therapists are also perceived as representatives of the adult sphere. When taken to the extreme, the refusal of adulthood and the rejection of the outer world can turn into an existential refutation of being human in the full sense of the word.

In such cases an intensive psychotherapeutic approach is optimal, as it affords the patient an unmediated therapeutic relationship within the here and now. Such a psychotherapeutic encounter can facilitate experiences of attachment independently from the struggle for success. Psychodynamic therapies are very helpful in this respect, since they place an emphasis on working within the therapeutic relationship between patient and therapist. A more secure therapeutic object relation is often necessary for patients in the long term, when transitioning back to the real world.

Within the current German framework, psychodynamic approaches are not typically the first choice of psychotherapy for Internet addiction, but they do have a complementary function during distinct phases of treatment and under special circumstances. First of all, in adolescent and child psychotherapy in Germany psychodynamic therapeutic approaches play a greater role than in adult psychotherapy, though cognitive behavioural and pedagogical approaches are also used (Petersen et al. 2010). Second, when treating adults, the individual co-morbidity profile may lend itself to a psychodynamic approach, especially, when a depressive or anxiety disorder forms the main diagnosis. Moreover, when dealing with structural deficiencies, i.e. personality disorders, psychoanalytical approaches may be of help (Albertini and te Wildt 2014). In general, the psychodynamic approach allows for etiological aspects of Internet addiction to be explored and treated in depth. In the instance of Internet gaming disorder particularly, the symbolic meaning of excessively used Internet content, such as archetypical avatars—in analogy to the interpretation of dreams—can be examined. This may help to obtain a better and deeper understanding of the patient's motives. However, as in addiction medicine in general, psychodynamic approaches are helpful only when being administered after the acute stages of Internet addiction have been mastered by cognitive behavioural and psychopharmacological approaches. Psychodynamic psychotherapy may best be utilised once the patient has overcome acute withdrawal and their social situation has been stabilized, but the impact of craving and underlying co-morbidity remains strong. At such points, psychodynamic psychotherapy may be the optimal treatment to facilitate a long-term recovery with abstinence from the online-applications that have been responsible for the Internet addiction in the first place. Optimally, Internet addicts will learn to view themselves as heroes in their own right by (re)conquering and mastering real life.

17.4 The Future of Psychotherapy for Internet Addiction

In the long run, psychotherapeutic interventions integrating both cognitive behavioural and psychodynamic approaches, as well as other schools of psychotherapy, are likely to become the gold standard of psychotherapy for Internet addicts.

For example, within their psychotherapeutic manual for the cognitive behavioural treatment of video game and Internet addicts, Woelfling et al. (2013) have reserved a couple of sessions for interpersonal topics, leaving also space for psychodynamic interactions and interventions. In Germany, the general trend towards more integrative approaches (Senf et al. 2013) most likely will be extended to the relatively new field of behavioural addictions as well. Since the quality of the patient-therapist relationship is the most decisive factor in terms of therapeutic progress and success, the continuity of the interpersonal relationship may be as important as the specifics of the intervention in predicting recovery. Therefore, it may be optimal to train physicians and psychologists in different schools of psychotherapy, so that full treatment may be facilitated by a single individual, rather than establishing a fragmented system in which different aspects and stages of mental illness are treated by ever more different specialists of different disciplines. An integrative approach would not only help to overcome the long standing divide between psychodynamic and cognitive behavioural therapy, but would incorporate other approaches as well. For instance, when it comes to treating Internet addicts, providing systemic counselling of the patients' families and partners can sometimes be a helpful addition to the patients' individual treatment (Eidenbenz 2015). This may indeed be the only option in cases where the affected person lacks the motivation to seek or pursue treatment of their own volition.

Moreover, from a German perspective an integrated approach would optimally include overarching inpatient, day-clinic and outpatient facilities. The vast majority of the German population live within easy access of mental health providers. This allows for community-based services to incorporate within the therapeutic process, the lived social circumstances of Internet addicts. Depending on the level of Internet addiction and the severity of co-morbid difficulties, patients could be treated within inpatient or day-hospital settings in order to be supported towards a fresh start in their everyday lives at home. In the long run, further outpatient treatment, either in groups or individually, could provide continuing therapeutic support and monitoring of recovery processes. Hence, for Internet addicts, living in the vicinity of a specialised clinical facility could provide both the necessary continuity in the therapeutic bond and consideration of their social reality, optimally contributing to a long-term recovery.

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Chapter 18
Opinion: Real-Time fMRI Neurofeedback and the Application of the Neuropeptide Oxytocin as Promising New Treatment Approaches in Internet Addiction?

Benjamin Becker and Christian Montag

Abstract This chapter provides insights into two innovative treatment approaches for psychiatric disorders that have gained increasing attention in the neurosciences: real-time fMRI-based neurofeedback training and the neuropeptide oxytocin. Progress in neuroimaging technology during the last years has enabled the ultra-fast analysis (near real-time) of brain activity patterns. Combined with neurofeedback approaches, this technology enables subjects to learn the volitional control of regional brain activity. On the background of the neuroimaging literature on Internet addiction, the present chapter discusses potential targets for the application of these training methods, with a focus on the prefrontal-limbic-striatal circuitry. In addition, the intranasal application of the neuropeptide oxytocin as potential innovative treatment approach for psychiatric disorders has received increasing interest during the last years. Initial studies in patient populations revealed promising effects in psychopathological conditions such as autism, depression, and social phobia. Given links between the underlying pathology of these conditions and Internet addiction, the present chapter outlines which subtype of Internet addicted patients might potentially benefit from the intranasal application of the neuropeptide oxytocin.

Internet addiction has become a rapidly emerging global health issue. Recent and upcoming developments in the international classification systems for mental disorders take account of Internet addiction as an emerging health issue and either

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_18

included Internet Gaming Disorder (IGD) (as an emerging disorder and therefore working term in the DSM-5 appendix) or discuss to include computer and Internet addiction (ICD-11) to emphasize the need for further research and the development of new treatment approaches. To date, little is known about specialized treatment approaches for Internet addiction and their efficacy. An initial meta-analysis covering more than 650 patients revealed that psychological and pharmacological interventions, particularly cognitive behavioral therapy and antidepressive pharmacological agents, are effective for improving symptoms of Internet addiction, including time spent online and depressive symptoms (Winkler et al. 2013). However, the lack of established diagnostic criteria and the unsatisfactory compliance with international randomized clinical trial guidelines of several of the covered studies (King et al. 2011), limited the conclusions regarding treatment efficacy. Moreover, long-term efficacy of treatment has only rarely been assessed. During the last decades, increasing efforts have been made to establish and evaluate specific treatment approaches for related disorders, such as substance use disorders and pathological gambling (see e.g., Nutt et al. 2015; van den Brink 2012).

Although current qualitative and quantitative reviews support the efficacy of these treatment approaches in reducing symptoms of substance-use disorders and pathological gambling immediately following therapy (e.g., Cowlishaw et al. 2012; Jonas et al. 2014), long-term success rates are low and relapse to excessive patterns of use is the normative clinical course rather than the exception (Cowlishaw et al. 2012; Denis et al. 2006; Nutt and Lingford-Hughes 2008). The currently available pharmacological therapies are additionally hampered by negative side effects limiting the compliance of the patients and further contributing to the high-relapse rates. Certainly, there remains room for improvement.

Against this background, the current chapter explores the therapeutic potential of two innovative treatment approaches that have received increasing attention as promising treatment strategies in related disorders, including substance use disorders and obsessive compulsive disorders: real-time functional MRI neurofeedback and oxytocin challenge approaches (Bakermans-Kranenburg and van Jzendoorn 2013; Striepens et al. 2011; Stoeckel et al. 2014; Kim and Birbaumer 2014).

18.1 Real-Time Neurofeedback as Innovative and Noninvasive Brain Modulatory Strategy

Progress in neuroimaging technology during the last years has opened new opportunities for the noninvasive modulation of brain activity. During the last 20 years, the development of functional magnetic resonance imaging (fMRI) methodologies enabled tremendous progress in the basic neuroscience of human cognition and affect (Smith 2012; Poldrack 2012). In the psychiatric domain, fMRI studies revealed brain functional and structural abnormalities in psychiatric populations and fMRI has made major contributions to the current conceptualization that psychiatric disorders are brain-based disorders (for an overview on addiction see, e.g., Suckling and Nestor 2016; for Internet addiction see, e.g., Brand et al. 2014). However, despite the invaluable knowledge that neuroimaging studies have provided regarding the neurobiological basis for psychiatric disorders, including Internet addiction and related disorders, their clinical impact remains limited. In line with these observations, a recent consensus report of the American Psychiatric Association (APA) concluded that neuroimaging approaches have a highly promising potential to significantly impact the diagnosis and treatment in psychiatry and that future research should aim to promote the translation of these approaches from basic scientific research to clinical application (First et al. 2010).

The development of ultra-fast (near real-time) fMRI analyses allowed the implementation of real-time fMRI-based neurofeedback (rt-fMRI NF) strategies (Weiskopf 2012), which have the potential to open up radically innovative paths to translation. The fMRI-based neurofeedback follows similar principles as other neurofeedback approaches, such as evaluated treatment strategies combining electroencephalography (EEG) with biofeedback trainings that have become widely available treatment strategies for psychiatric disorders such as attention-deficit/hyperactivity disorder (Holtmann et al. 2014; Cortese et al. 2016). Briefly, during fMRI-based NF trainings, participants receive real-time feedback on their regional brain activity and are instructed to change the activation (see schematic presentation of a real-time neurofeedback platform in Fig. 1). Previous proof-of-concept studies have shown that healthy subjects can learn to volitionally control their brain activity in training sessions as short as 20 min (for an overview see Sulzer et al. 2013) and that these abilities can be maintained in the absence of feedback and for a period of up to 3 days (Yao et al. 2016).

Importantly, previous studies have shown that healthy subjects can gain volitional control over key hubs of the emotional and cognitive brain networks that have been found to show altered functioning in Internet addicted populations (Brand et al. 2014; Ko et al. 2015; Han et al. 2015), including emotion processing hubs such as the amygdala (Paret et al. 2016; Marxen et al. 2016), striatal regions (MacInnes et al. 2016; Greer et al. 2014), and the anterior insula (Yao et al. 2016; Caria et al. 2007) as well as regulatory hubs including anterior cingulate and prefrontal regions (Rance et al. 2014; Sherwood et al. 2016). Initial studies have begun to explore the utility of real-time fMRI-guided feedback in psychiatric populations and provided evidence that patients with depression (see Linden 2014 for an overview), schizophrenia (Ruiz et al. 2013; McCarthy-Jones 2012) and alcohol addiction (Karch et al. 2015) can learn the volitional control of regional brain activity. With initial evidence from proof-of-concept studies in psychiatric patient populations that real-time fMRI neurofeedback training has the potential to improve symptoms of depression (Linden et al. 2012) and schizophrenia (Dyck et al. 2016), it is conceivable that real-time NF training might also represent a potential treatment strategy to treat Internet addiction or alleviate symptoms of comorbid conditions such as depression in Internet addicts (e.g., see overlap between depression and Internet addiction as shown by Sariyska et al. 2015). Importantly, a large quantitative review that covered data from over 600

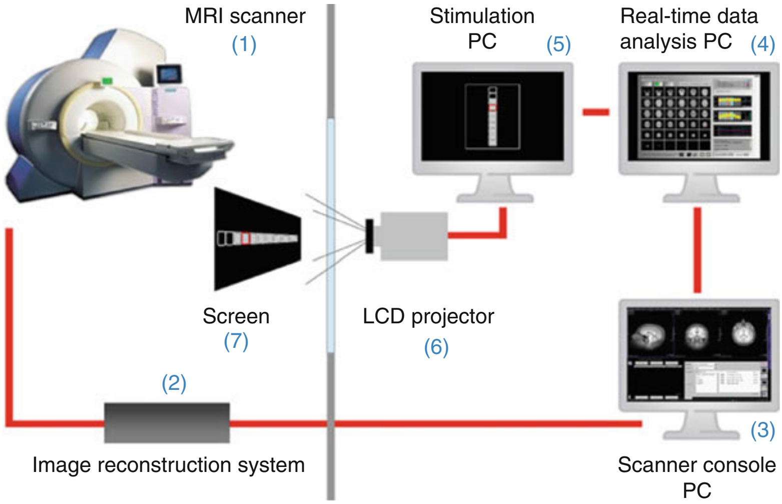

Fig. 18.1 General technical setup and information flow during real-time fMRI experiments used for neurofeedback and other brain-computer interface (BCI) applications. Following acquisition of functional data (*1*), the images are reconstructed (*2*) and sent to the scanner console's hard disk (*3*). The real-time fMRI analysis PC (*4*) accesses the reconstructed images as soon as possible. Calculated feedback signals (or visualizations) are transferred to the stimulation PC (*5*), which sends the final feedback visualization (here a simple thermometer display) via a projector (*6*) onto the screen (*7*) and is then visible to the participant (taken from Goebel and Linden 2014)

sessions of rt-fMRI NF training in over 100 patients with chronic pain did not reveal an association between rt-fMRI NF training and an increase in the number or severity of adverse event (Hawkinson et al. 2012), suggesting that rt-fMRI NF represents a treatment strategy with minimal side effects in patient populations.

With regard to addictive disorders, initial studies revealed promising results, suggesting that rt-fMRI NF might be a complementary neurophysiological-based strategy to increase treatment success in addictive disorders. A recent proof-of-concept study successfully trained heavy social drinkers to downregulate striatal activity in response to alcohol cues (Kirsch et al. 2016), suggesting that rt-fMRI NF might represent a promising supplemental therapeutic strategy to reduce cue-induced craving and, thus potentially, prevent relapse in alcohol use disorders. In line with these findings, an initial pilot study in patients with alcohol use disorder that used individualized target regions in insular and prefrontal regions provided preliminary evidence that patients with alcohol use disorders are capable of learning to reduce their exaggerated neural reactivity to alcohol cues and that this might reduce craving (Karch et al. 2015).

18.2 Potential Strategies in Internet Addiction

The number of studies employing neuroimaging and neuropsychological methods to examine alterations in Internet addiction meanwhile reached a critical number to warrant comprehensive qualitative and quantitative reviews (see, e.g., Brand et al. 2014; Meng et al. 2015; Park et al. 2016). Converging evidence from neuroimaging and neuropsychological studies indicate that Internet addiction might be associated with deficient cognitive and emotional control, both of which critically rely on the integrity of the prefrontal-limbic-striatal circuitry. Interestingly, reduced prefrontal top-down control in the context of exaggerated reactivity within the limbic-striatal reward and salience circuitry have been determined as underlying neurobiological denominator across related disorders, including substance use disorders (Koob and Volkow 2016; Goldstein and Volkow 2011), pathological gambling (Goudriaan et al. 2014; Potenza 2013), and obsessive compulsive disorder (Figee et al. 2016), indicating partly overlapping neuropathological substrates between these conditions and Internet addiction.

Initial studies using rt-neurofeedback (rt-NF) approaches targeting the core hubs within the prefrontal-limbic-striatal circuitry, including the amygdala (Li et al. 2016) prefrontal regions (Sarkheil et al. 2015), or the anterior insula (Kadosh et al. 2016) in healthy subjects revealed neurofeedback training-induced strengthened connectivity within the emotion regulation networks and some evidence of increased emotional control on the behavioral level, suggesting a potential therapeutic application of rt-NF trainings as complementary strategy to increase emotional control in Internet addiction. Given the importance of cue-induced craving for relapse across addiction disorders, including substance-related addictions (Carter and Tiffany 1999; Kühn and Gallinat 2011; Chase et al. 2011) and pathological gambling (Noori et al. 2016; Goudriaan et al. 2010), and a recent report on increased striatal reactivity to Internet-gaming cues in subjects with Internet addiction (Liu et al. 2016), reduction of striatal cue-reactivity via fMRI-based rtNF training might represent an alternative promising supplemental therapeutic strategy to facilitate abstinence and prevent relapse in patients suffering from Internet addiction.

18.3 Oxytocin—A Potential Neurohormonal Approach to Treat Internet Addicts?

Oxytocin (OT) is a hypothalamic neuropeptide that was initially known for its peripheral actions, including uterine contraction and milk ejection. Based on animal studies reporting the first central effects of OT on memory and learning in rodents, researchers started to explore the central effects of intranasal OT in preclinical studies in humans in the late 1980s. One of the first experiments that administered intranasal oxytocin to healthy individuals and aimed to study the combined effects of social support and oxytocin on psychosocial stress during a public speaking task was conducted by Heinrichs et al. (2003). Here, oxytocin decreased the physiological stress response as assessed by cortisol levels as well as subjective feelings of anxiety, providing initial evidence for anxiolytic effects of oxytocin in humans. During the following 10 years, the number of studies using intranasal oxytocin to study the involvement of the oxytocinergic system in human behavior rocketed and a growing number of studies have highlighted the potential of intranasally administered oxytocin to modulate not only basal emotional processes such as anxiety, but also to facilitate complex social cognitive processes that form the foundation of successful interaction in our daily life (Bakermans-Kranenburg and van Jzendoorn 2013; Shahrestani et al. 2013). Neuroimaging studies that combined the placebo-controlled intranasal application of oxytocin with task-based and resting state pharmacological fMRI provided supplementary evidence that even single-dose administrations of oxytocin modulate activity and functional connectivity in core hubs of the emotional and cognitive processing networks, including the amygdala, striatal regions and prefrontal regions (Gao et al. 2016; Hu et al. 2015; Striepens et al. 2012, quantitative overview in Wigton et al. 2015).

Based on the putative anxiolytic and pro-social effects on the behavioral level and the pattern of modulatory effects on the neural level observed in healthy subjects following intranasal oxytocin application, comprehensive reviews advocated the therapeutic potential of oxytocin in several psychiatric disorders (e.g., Striepens et al. 2011), including, e.g., autism (Guastella and Hickie 2016), social anxiety disorders (Neumann and Slattery 2016), and addictive disorders (Lee et al. 2016a, b; Sarnyai and Kovacs 2014; McGregor and Bowen 2012). Initial studies in patient populations indeed suggest potential beneficial effects of oxytocin treatment on symptoms of schizophrenia (Feifel et al. 2016), autism (Bakermans-Kranenburg and van Jzendoorn 2013), anxiety as well as general psychopathology (Hofmann et al. 2015). Importantly and in line with oxytocin administration studies in healthy individuals, no adverse effects were observed in the patients studies, even after daily treatment for several weeks (Lee et al. 2016a, b) or application in young children with autism during 5 weeks of intranasal oxytocin treatment (Yatawara et al. 2015).

Animal models examining the effects of oxytocin on symptoms of disorders related to addiction such as substance-dependence, indicate a potential impact of oxytocin on addiction-relevant markers, including alcohol consumption (MacFadyen et al. 2016; Peters et al. 2013). Initial pilot studies revealed preliminary evidence in human subjects with substance use disorders, suggesting that oxytocin administration might reduce withdrawal symptoms in alcohol use disorder (Pedersen et al. 2013). However, other studies found that effects of oxytocin on cue-induced craving in alcohol use disorder were modulated by attachment style (Mitchell et al. 2016) and another study found that oxytocin might increase the desire for drugs in cocaine-dependent individuals (Lee et al. 2014), suggesting complex effects of oxytocin in addictive disorders. Nevertheless, these first pioneer studies show that oxytocin might be of relevance to treat addiction—potentially also Internet addiction?

A putative link between oxytocin and Internet addiction is also supported from another empirical perspective (besides the obvious presented link as already discussed on general oxytocin-addiction research in the last section). Recently, a study by Melchers et al. (2015) demonstrated in one sample from China and one sample from Germany that lower empathy is associated with higher tendencies toward Internet addiction. This fits to some extent with a recent study providing evidence that higher scores on the autism quotient questionnaire are also associated with higher Internet addiction (Romano et al. 2014).[1] Finally, it has been demonstrated that social anxiety is of importance to understand negative outcomes due to Internet addiction via its influence on the variable preference for online social interaction (Caplan 2006). As apparent from what has been summarized above, a key player to understand the biological underpinnings of empathy (e.g., Hurlemann et al. 2010), autism (e.g., Anagnostou et al. 2012; Andari et al. 2010), and social anxiety (e.g., Guastella et al. 2009) is the neuropeptide oxytocin. This said, we formulate that oxytocin indeed might also be an interesting new neurohormonal supplemental treatment of Internet addiction (this adds to what has been proposed in Chap. 14 by Carmadese and others on the pharmacological treatment of Internet addiction). Admittedly, oxytocin will not represent the first-line treatment for all patients suffering from Internet addiction, but might rather have beneficial effects in a subgroup of patients. The previous chapters in the present book emphasized the existence of several different types of Internet addiction. For instance, a subsample of Internet addicts seem to be better characterized by the ADHD/Internet addiction type, whereas others seem to be better characterized by the depressed/Internet addiction type (e.g., see Chap. 15 by Cho). With respect to the ADHD/Internet addiction type, it clearly has been outlined that drugs such as ritalin influencing dopaminergic neurotransmission might represent a promising therapeutic strategy as adjunct pharmacological therapy in combination with cognitive behavioral therapy approaches. In contrast, and on the background of previous studies showing beneficial effects of oxytocin in patients with social anxiety and depression (e.g., Dodhia et al. 2014; Labuschagne et al. 2010; Hofmann et al. 2015) subtypes characterized by increased social anxiety and depressive symptoms might benefit from oxytocin treatments.

Finally, we would like to mention a recent published framework to study the molecular basis of Internet addiction on the background of Panksepp's Affective Neuroscience theory. Following ideas from this study, in particular facets such as preference for online instead of offline interactions might be modulated by oxytocin (Montag et al. 2016).

Summarizing, the aim of the present chapter was to hypothesize innovative and potentially promising treatment strategies for Internet addiction on the background of recent developments in basic and clinical neuroscience, going beyond what has been described in section III of the present volume. Although the proposed treatment approaches represent exciting new strategies, their application to Internet addiction need to be carefully evaluated in proof-of-concept studies and randomized

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[1]This study shows that the link between autism quotient and Internet addiction is more complicated than that, because comorbities such as psychopathological anxiety need to be taken into account.

clinical trial designs in patient populations. Moreover, it is still a long way to comprehensively characterize the neuropathological basis of Internet addiction, particular common and distinct alterations in the subtypes of Internet addiction, to warrant empirically based individualized treatments.

Acknowledgements This work was supported by the German Research Foundation (Deutsche Forschungsgemeinschaft, BE 5465/2-1).

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Chapter 19
The Korean National Policy for Internet Addiction

Young-Sam Koh

Abstract The Korean Government was the first in the world to develop a national policy to tackle the problem of Internet addiction. For this reason, it has received global attention. To combat the problem of Internet addiction, Korea has established specific laws and systems; a governance system is administrated in government offices, and a "master plan" (revised at 3 year intervals) has been developed. In addition to these measures, many practical spheres of counseling and treatment have also been established. Examples of Korea's efforts to tackle the problem of Internet addiction include the development of the evaluation scale for Internet addiction, an extensive counseling program, and treatment systems linked to hospital care. This study comprehensively outlines Korea's national policy on Internet addiction.

19.1 Overview

Having overcome the 1997 Asian financial crisis[1] through a powerful policy of informatization,[2] Korea continues to invest in the development of the Information and Communication Technology (ICT) industry even during the present age of big data and smart computers.

[1]The 1997 Asian financial crisis was a period of financial crisis that affected much of East Asia, including Korea. As a means to stabilize the currencies, the Korean government received a loan from the International Monetary Fund (IMF), under the condition that it tighten its financial and fiscal policies, implement a policy for opening to foreign investment, restructure its financial sector and companies, and improve corporate transparency. Moreover, the Korean government stimulated the information industry for an economic revival. In other words, the ICT promotion policy of Korea was used as a tool to revitalize the economy.
[2]Informatization involves establishing communication infrastructure, introducing information technology in the manufacturing sector to enhance productivity, and industrializing games and computer software as a means to become an information-based society.

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_19

The introduction of such a radical policy of informatization was particularly successful, as it facilitated Korea's joining the circle of developed countries. The dark side of the radical informatization of Korean society has been the emergence of Internet addiction as a national issue. Korea was the first country in the world to allocate a national budget to tackle the problems of Internet addiction and has established projects for prevention and resolution. Diverse types of training and counseling are offered for the prevention of Internet addiction, which enables hospitals to provide the necessary help for patients. Korea established new laws and systems to maintain these projects. Other countries have yet to set up similar projects.

As the process of informatization accelerates digital media, including online video games, is an increasingly central part of our global society. In the future, it will be impossible for anyone to live in this global society without using digital media. This means that most countries will face difficulties similar to those currently affecting Korea, particularly in terms of digital media addiction. In what follows, this chapter will introduce Korea's national policy for the prevention and resolution of Internet addiction.

19.2 Status of Internet Addiction in Korea

The Internet Addiction Prevention and Counseling Center of the National Information Society Agency conducts an annual nationwide survey on Internet addiction, which gives insight into the percentage of the population suffering from Internet addiction. Presently, the Korean government is developing an appropriate policy in response to Internet addiction based on both the results of the survey and on known characteristics and tendencies of Internet addicts.

According to the 2013 survey on Internet addiction (the Ministry of Science, ICT and Future Planning and National Information Society Agency 2013), 7% of Internet users aged 5–54 are classified as 'at risk' for developing Internet addition.[3]

[3]The various sub-categories of Internet addiction are differentially explained. For example Kimberly S. Young categorizes Internet addiction as computer game addiction, information overload, network obsessive compulsion, cyber relationship addiction, cybersex addiction, and so on (Young 1998). Davis (2001a, b) used the terminology, 'Pathological Internet Use,' instead of 'Internet addiction' and classified PIU into two types: namely, generalized PIU and specific PIU. Generalized PIU occurs due to the nature of Internet itself such as the anonymity of cyber space, convenience of use, communication speed, immediate response of the Internet, etc. Meanwhile, it is worth acknowledging the influence of gaming and content. Many individuals are severely addicted to computer games, due to game-specific features, such as high levels of stimulation, fantasy etc. Among online games, Massive Multiplayer Online Role Playing Game (MMORPGs) act like an 'emergency exit from reality' for those who cannot adapt and socialize. Recently, Montag et al. (2015) found empirically that there is distinction between specific (such as online video gaming, online shopping, online social networking, and use of online pornography) and generalized Internet addiction, as proposed by Davis (2001a). However there was a large correlation between addiction to online social networks (such as Facebook in Germany and Taiwan or QZone in China) and generalized Internet addiction. In Korea, the categories are drawn from

When we examine the recent statistics on Internet addiction in Korea, several implications emerge. For example, after the first study was conducted in 2004, the percentage of Internet addicts decreased each subsequent year, despite the increasing number of Internet users. Also the percentage of addicts shows clear differences per age group. For example, the percentage of addicts was 6.4% among children aged between 5 and 9, 11.7% among youths in their teens, 5.9% among adults aged from 20 to 25, and so on. Of the different age groups, the group of teens showed the highest percentage of addiction. Another important matter to note is that pathological Internet use is being observed at an increasing rate among the middle-aged adult group between 50 and 54, of which, 3.8% were reported to be addicted to the Internet (the Ministry of Science, ICT and Future Planning and National Information Society Agency 2013).

The fluctuations in the Internet addiction rate among youths represent the primary focus of the Internet addiction debate in Korea. This is supported by the belief that addiction during adolescence could especially harm the foundation of one's life with profound consequences for adulthood (e.g., Anderson and Bushman 2001; Griffiths and Hunt 1998).

The results of the survey by the above mentioned Ministry of Science, ICT and Future Planning and National Information Society Agency (2013) showed that the Internet addiction rate was higher for adolescent males (12.8%) than adolescent females (10.5%) and for male middle school students (15.0%) than female middle school students (9.8%). In addition, the Internet addiction rate was higher for adolescents from single-parent households (12.0%) and from double-income households (12.3%) than the average addiction rate for adolescents (11.7%). As the number of people with smartphones has increased in Korea, an annual survey has also been conducted to examine pathological use of smartphones. These results show that smartphone addiction rates have been increasing annually, with the highest percentage (11.8%) reported in 2013. Taking participants' age into account, the percentage of smartphone addicts among the youth group (10–19 years) was three times higher (25.5%) than that for adults (20–54 years, 8.9%). Another important finding was that individuals from higher income households are at a greater risk of developing smartphone addition.

19.3 Korea's Response to Internet Addiction

Korea's response to Internet addiction may appear quite remarkable to other countries. The government has been at the forefront of finding a solution to this problem. This differs from the USA and countries in Europe, where universities and

(Footnote 3 continued)

practical counseling experience and comprise online game addiction, online obscene materials addiction, online search addiction, online community addiction, online chatting addiction etc.

research institutes primarily conduct research and investigate treatment efficacy and provision. Korea also differs from Japan, where private hospitals and nongovernmental organizations are most active in this sphere. The following section provides an overview on the Korean response to Internet addiction.

19.3.1 Response to Internet Addiction

The Korean response to Internet addiction is unusual in that the government stands very much at the frontline. Even more unique, it is not just one specific bureau or office providing this response; rather, a variety of federal bureaus help to fight Internet addiction.

For example, because the proportion of young people experiencing Internet addiction is high, the Ministry of Gender Equality and Family is one of the organizations involved in developing the response. The Ministry of Culture, Sports and Tourism which oversees the video game industry, has also been involved in developing this response, because online games are a significant facet of Internet addiction. The Ministry of Education is involved in educating elementary, middle and high school students, who display relatively higher Internet addiction rates. The Ministry of Health and Welfare is also involved, as Internet addiction is associated with psychological mechanisms. Additionally, the Ministry of National Defense, the Ministry of Justice, and the Korea Communications Commission, administer policies to fight Internet addiction. The reason for the involvement of the Ministry of National Defense is reflected by the number of soldiers experiencing Internet addiction, while the involvement of the Ministry of Justice is reflected in the volume of crimes committed by Internet addicts.

Despite the large number of governmental institutions working to combat Internet addiction, it is the Ministry of Science, ICT and Future Planning, which currently plays the key role in this work. Overseeing the ICT promotion policy,[4] the Ministry of Science, ICT and Future Planning considers the Internet addiction policy a specialized field of ICT promotion policy. In accordance with the Framework Act on National Informatization, as the ministry responsible for policy regarding Internet addiction, the Ministry of Science, ICT and Future Planning consolidates the work of other associated ministries on the one hand, and also carries out its work through the National Information Society Agency (NIA).

There has been constant controversy over the efficiency of projects established by the eight ministries to tackle Internet addiction. Arguments abound over whether it

[4]The ICT promotion policy is a national policy implemented to create advanced wired and wireless communication networks for the rapid exchange of information, as well as to establish an e-government, utilize big data, stimulate the software industry, develop the digital contents industry, mitigate the digital divide, and create a sound online culture. The Internet addiction response policy tends to work against the ICT policy, and thus, the latter policy must include the necessary countermeasures.

would be more efficient for a single ministry to be responsible for the issue. In any case, it is apparent that projects for Internet addiction receive top priority from the state.

19.3.2 Laws and Systems of Response to Internet Addiction

Laws and systems must be furnished if the national policy is to remain viable. The projects tackling Internet addiction designed by the eight ministries outlined above are administered according to the laws governing each ministry. The competent law for each ministry is outlined below.

As the organization responsible for overseeing informatization and the response to Internet addiction, the Ministry of Science, ICT and Future Planning oversees the 'Framework Act on National Informatization.' As the basic law for the ICT promotion policy of the state, the Framework Act on National Informatization encompasses the vast field of national informatization, and stipulates the establishment of a master plan to mitigate Internet addiction.

The Ministry of Gender Equality and Family administers the "Juvenile Protection Act." The purpose of the Act is to protect the youth generation from harmful or inappropriate environments, and protects them from overexposure to the online gaming environment. Based on the Act, a new system entitled "The Shutdown System" was introduced to prohibit individuals under the age of 16 from playing games between 12 midnight and 6 am. Specialists presently doubt the effectiveness of the Act,[5] and it has been criticized by politicians who support the gaming industry. However, the law is still active, owing to the powerful support of many parents.

The Ministry of Culture, Sports, and Tourism administers the "Game Industry Promotion Act." This Act provides details for the prevention of excessive preoccupation with games. To expand on this, the principle of "a selective shutdown" needs to be introduced. This system does not rigorously prohibit gaming during the nighttime hours between 12 midnight to 6 the next morning. Instead, the guardian can forbid the young individuals from playing games at any time during the 24 h of a given day. Thus, compared to the Shutdown System, it enables the individuals to exercise autonomy more freely.[6]

Moreover, as Internet addiction falls within the area of mental health, the Ministry of Health and Welfare is involved in the response through the administration of the "Mental Health Act." A very delicate issue has recently emerged in the context of the prevention and resolution of Internet addiction. The Ministry of Health and Welfare seeks to enact a law that will view Internet games as an

[5]Many minors currently use the identification numbers of their parents and other adults to play games after midnight. Also, this system does not apply to game sites with overseas servers and smartphone games.

[6]Guardians of adolescents below the age of 18 can access the homepage of a game that they want to prohibit and demand from the game company technological measures that prevent access to the game from the guardian's home.

addiction factor similar to drugs, alcohol, gambling, and so on, which must be resolved. This same law identified the above-mentioned addictions as “4 major addictions” and a national system was established to deal with them in a comprehensive manner. Another law currently awaiting approval specifies that game corporations should provide a substantial monetary donation to fight against Internet addiction, which will be managed by the Ministry of Health and Welfare.

In Korea, there is currently much conflict between representatives of the game industry, the ministries targeting addiction, nongovernmental organizations, and politicians over this legislation. Those who support it view Internet gaming as very harmful, presenting an obstacle to family harmony, school achievement, and so on. In contrast, people who are against these new laws criticize the view that games are as harmful as drugs such as alcohol, due to the lack of adequate research on the subject.

19.3.3 Key Policy per Ministry

For Korea, multiple ministries are charged with responding to Internet addiction as illustrated above. Thus, the response system for Internet addiction is not simple.

As the table shows, the Ministry of Science, ICT and Future Planning is the chief overseeing body for Korea. For example, according to the Framework Act on National Informatization, the Ministry establishes a 3 year master plan, which outlines projects to be undertaken by the various ministries, and manages the implementation of the master plan (Koh 2014). The ministry has also established an Internet addiction response center (IAPC: Internet Addiction Prevention and Counseling Center) within an affiliated organization—the National Information Society Agency, which aims to train counseling professionals, develop the Internet addiction diagnostic scale (‘K-Scale’) for Internet abusers (National Information Society Agency 2013), develop counseling programs for various age groups, administer an annual survey on Internet addiction, and develop policies based on the results. A new aim seeks to combat and prevent the rising smartphone addiction. A full list of ministries dealing with Internet addiction and their agenda is presented in Table 19.1.

19.3.4 Professional Institutions for Preventing and Solving Internet Addiction

In Korea, there are national agencies which are not governmental departments but are operated with funding provided by the government. Civil servants working for government ministries are transferred to different departments or assigned different

Table 19.1 Key policies per ministry related to Internet addiction problems

Classification	Details of key projects
Ministry of Science, ICT and Future Planning	• General oversight of responses to Internet addiction according to the "Framework Act on National Informatization"
	• Establishes an Internet Addiction Prevention and Counseling Center (IAPC) in a National Information Society Agency (NIA) which plans and executes national informatization policies
	• Develops human resources for professional counseling such as fostering counseling professionals, administering staff training, etc.
	• Develops Internet addiction diagnostic scale (K-Scale) and counseling programs
	• Conducts an annual survey of Internet addiction
	• Establishes and manages a 3 year master plan
	• Sets up projects to prevent, counsel, and manage outcomes for Internet and smartphone addictions
Ministry of Culture, Sports and Tourism	• Oversees the interventions to fight side effects of Internet games according to the "Game Industry Promotion Act"
	• Plans for preventative training and campaign of excessive preoccupation with games
	• Develops diagnostic scales to screen game preoccupation users and counseling programs
	• Supports hospital care for excessive preoccupation with games
Ministry of Gender Equality and Family	• Oversees youth protection according to the "Juvenile Protection Act"
	• Sets up projects for counseling in over 180 youth counseling centers countrywide
	• Administers residential schools for limited term care
	• Provides financial support for medical treatment for those at high risk of internet addiction
Ministry of Health and Welfare	• Research medical scientific facts and develop a treatment model of internet addiction
	• Operating 200 mental health clinics countrywide
Ministry of Education	• Cooperates with various ministries' school-related projects to respond to Internet addiction
Autonomous regional organizations	• Seoul Metro City: establishes and administers "the I Will Center"
	• Other sixteen regional governments: the Ministry of Science, ICT and Future Planning and NIA establish and administer each response and counseling center local branches

jobs every couple of years, meaning that they cannot gain the extensive knowledge required to plan and execute policies for highly specialized fields. On the other hand, national agencies are staffed by people with a master's or doctoral degree, who can contribute their expertise in specific areas, and for this reason, national agencies are considered useful by the government.

Korea's policy for Internet addiction cannot be explained without mentioning the National Information Society Agency (NIA, www.nia.or.kr). While the Ministry of Science, ICT and Future Planning is the overarching government body for Internet addiction, the NIA represents a professional institution for national informatization, which plans and executes policies to support the work of the ministry. With its budgets and projects ratified by the National Assembly, the NIA opened the Internet Addiction Prevention and Counseling Center (IAPC, www.iapc.or.kr) in 2002. This is the first of its kind worldwide, in which a state institution countenances systematic activity related to Internet addiction.

The NIA is presently establishing Internet addiction response centers across regional governments. The NIA has established a response center in 13 regional governments, of a total of 17 metropolitan regional governments, and the IAPC headquarters directly allocates human resources and project budgets for administration/management. Approximately 50 Internet addiction researchers, counselors, project planners, and directors of IAPC are currently active countrywide. Also IAPC administers over 300 freelance counselors so that the people can readily receive counseling.

There is also another Internet addiction prevention and counseling institution. It is the Korea Youth Counseling and Welfare Institute, affiliated with the Ministry of Gender Equality and Family. The same organization was originally established to analyze—and provide counseling for—youth problems such as depression, anxiety, study-related stress, family relations, friendships, future plans, etc. Administering approximately 200 branch organizations countrywide, the same institute also works to prevent—and provide counseling for—Internet addiction, as this problem becomes increasingly serious in the everyday life of youths. Hospitals for counseling and care related to game preoccupation have also been established countrywide, for those suffering from serious game addiction or comorbid symptoms such as depression and requiring medication.

19.4 Internet Addiction Response Program in Korea

The Internet addiction response program in Korea is administered according to the project plans of each ministry, with 1 year as a unit. The plans are developed according to the comprehensive plan to prevent and solve Internet addiction. At the national level, the program is composed of the prevention campaign and training, counseling, treatment, posttreatment outcome management, and policy formulation. The next section examines the contents of the comprehensive plan, as well as the projects mentioned earlier.

19.4.1 The Second Master Plan to Prevent and Solve Internet Addiction

The Second Comprehensive Plan constitutes the working plan for 2013–2015 (Koh 2014). As the supervisory body for the plan, the Ministry of Science, ICT and Future Planning along with National Information Society Agency, developed this plan after analyzing and evaluating the results of previous projects for solving addiction over the past 3 years by the eight ministries. The Master Plan's policy objective is to "foster capacity to regulate Internet use and promote recovery function," through the plan's total of 52 projects.

The key characteristics of this plan are outlined below. First, the danger of addiction as a result of the proliferation of smartphone technology has been sufficiently considered. Second, in divergence with the first master plan implemented to prevent and provide counseling for Internet addiction among adolescents, we are now providing support for all age groups of Internet and smartphone users ranging from young childhood to adults. Third, the plan should extend services to encompass posttreatment outcome management, beyond the existing program of prevention, care, and so on. Fourth, the plan should be tailored to the specific needs of the client. Fifth, the plan should establish a form of governance among the federal government, regional government, and civilians from schools, corporations, NGOs, etc. Sixth, the plan should develop competent well-trained professionals.

19.4.2 Prevention

Prevention is a key aspect in tackling the problem of Internet addiction. With this in mind, special efforts are put into prevention training. For example, the law provides for mandatory training once a year, for prevention of Internet addiction in children, elementary, junior high, and high school youths, and those from public institutions. The content of the preventative training differs for each age group. For example, the prevention program for teenagers aims to promote self-control. The prevention training also supports school club activities, which help facilitate appropriate Internet use by students.

In cultivating prevention, campaigning is as important as training. A recently launched campaign bears the slogan: "Smart Off Day." This is to promote recognition of the hazards of spending a disproportionate amount of time using smartphones. The campaign is highlighted through radio, TV, newspapers, and also social media. Prevention activity also entails a story composition contest for people who have overcome Internet addiction. A collection of their stories has been distributed widely, to raise awareness of addiction and develop confidence that one can overcome it.

19.4.3 Screening and Counseling

Unique to the Korean treatment of Internet addiction, is the development and implementation of an evaluation scale.[7] The K-Scale (Korean Internet addiction screening scale) has been developed for youths, adults, soldiers, and others. The K-Scale is used both as a tool for self-screening and for assessment by a clinician. The scale measures seven auxiliary factors, including; withdrawal, tolerance, disturbance of adaptive function, disturbance of reality testing, addictive automatic thoughts of the Internet, virtual interpersonal relationships, and deviant behavior such as cyber bulling, adolescent violence, etc.[8] The K-Scale, rather than merely diagnosing the level of Internet addiction for particular individuals, is a tool that effectively conducts group screening to determine who is at risk of developing Internet addiction.

To establish the power of this measure, several international conferences have been convened, at which specialists from each of the Asian countries, including Japan, China, Thailand, etc., utilized this scale and compared their results.[9] Telephone counseling is another representative component of the counseling project for Internet addiction. The call number, 1599-0075, offers emergency counseling to addicts anywhere across the country. This type of service is particularly difficult to find in other countries.

Group counseling is also available and is provided by professional counselors on-site at schools. The counseling is put in place upon receipt of an application from each school early in the year. A variety of group counseling programs have already been developed, including art therapy. These programs are administered in accordance with approaches to other types of addictions such as gambling, explicit materials, games, etc. The programs also target specific mediums, e.g., games, general Internet, smartphones, etc. Another unique feature of counseling in Korea is

[7]The validity and reliability of K-Scale have been supported through the following psychometric measures: (1) Process of the preliminary test: developed the preliminary questions for the survey (110 questions), conducted the preliminary survey (300 subjects), analyzed the questions (test reliability: 0.97), and extracted the questions for the actual survey (64 questions); (2) Process of standardization: conducted a nationwide sampling survey (2,000 subjects), analyzed the questions (test reliability: 0.96), extracted the final questions (40 questions), computed the cutoff score (70T, 63T), and classified the resulting groups (high-risk group, potential risk group, nonrisk group); (3) Process of validation: conducted a validation study (2,781 subjects), verified the difference among the resulting groups, and verified the model fit ($x2 = 17{,}211.828$, $df = 719$, $p = 0.000$; $GFI = 0.901$, $AGFI = 0.887$; $NFI = 0.887$, $NNFI = 0.871$; $RMSEA = 0.05$). For more details, refer to the copy of the English summary available at http://www.iapc.or.kr.

[8]Meanwhile, as more people spend an increasing amount of time using their smartphones, a separate screening scale for smartphones users—the smartphone K-Scale—has been developed and is also being employed. The correlation coefficient of this scale and the K-Scale for youth is $r = 0.67$ ($p < 0.001$).

[9]For example, International Society of Internet Addiction (2012), National Hospital Organization Kurihama Medical and Addiction Center (2013), International Society of Internet Addiction and National Information Society Agency (2013) etc.

its “Home Visitation Counseling Program.” This project entails home visits to individuals who have cut themselves off from social relationships in the real world, in order to play Internet games at home. The objective of the project is to facilitate their eventual attendance at the counseling center rather than to completely treat them at home.

The development and management of professional human resources for Internet addiction counseling must also be considered when discussing this counseling policy and program. Highly specialized therapists focusing on Internet addiction are needed to turn the government’s policy into a success.

19.4.4 Treatment

Among Internet addicts, there is a high-risk group, for which counseling has limited efficacy. Typically this group includes people with comorbid difficulties such as depression, anxiety, ADHD, etc. For assessment with the K-Scale, it is important to distinguish between low and high-risk persons and those with comorbid mental health difficulties, and to provide hospital care as appropriate.

The government provides for some of the costs associated with hospital care for those requiring medication. Depending on the circumstances, the government offers support of around 400 USD for early medical examination, or provides financial aid toward the cost of 1 year hospital care. The government puts those addicts at highest risk in direct contact with local hospitals, to ensure they receive cooperative treatment.

Although the government first established a counseling center in 2002, in-depth research by psychiatrists has only begun recently. Through the development of animal models, psychiatric researchers are unveiling neurobiological indicators for addiction and are distinguishing the neurological characteristics of addicts, pursuing research to investigate their biosocial linkage.

19.5 Tasks Requiring Solution

19.5.1 Enhancement of the Diagnostic Function of K-Scale

As discussed above, Korea has developed and employed a diagnostic scale for Internet addiction known as the K-Scale. Schools and professional counseling centers utilize this scale for the diagnosis of Internet addicts. Moreover, annual surveys are conducted at a national level to assess Internet addiction rates and to accurately inform policy.

The K-Scale differs from the Young-Scale (Young 1998; Widyanto and McMurran 2004), which has been used in most earlier clinical work and research.

The Young-Scale has been widely used and to great effect, however, limitations do apply. Namely, as it is developed from the diagnostic criteria for pathological gambling, the Young-Scale is limited to describing the current state of the client and fails to consider previous difficulties in the client's life (Young 1996; Koh 2007; Davis 2001b). In consideration of these limitations, Korean researchers have developed an alternative scale, which already has been psychometrically validated (Kim 2002).

Despite this, it is necessary to enhance the K-Scale as it currently exists. Although the K-Scale proves effective in screening people with a tendency toward addiction from among the general population,[10] there is an insignificant basis for determining the cutoff score for diagnosis. It would be more useful if its scope could be broadened beyond screening to encompass assessment of the extent of addiction. Current research efforts aim to further develop the K-Scale to be used in diagnostics.[11] In the future, it would be desirable to establish a basis for the methods of screening, preventing, treating, and examining the progress of addiction among risk groups, by identifying the psychosocial factors and protective factors of Internet (game) addiction.

19.5.2 Heteronomous Regulation or Creation of Culture?

Should there be regulations for the prevention and resolution of Internet addiction in Korea? If so—to what extent? From these questions, a controversy springs up between those who agree that regulation is necessary and those who disagree with this view.

Korean parents today encounter repeated family conflicts over children's usage of Internet and smartphones. Within this context, many parents believe that the government should take effective measures against the problem of Internet addiction, rather than leaving it to the family. As a result, the Ministry of Gender Equality and Family introduced the so-called "shutdown system," which has been supplemented by the Ministry of Culture, Sports, and Tourism introduction of "the selective shutdown system." However, many people also draw attention to the inherent difficulties with the present system. There are Assemblymen who wish to abolish the system. The Assembly audit posed many critical questions about the

[10]On the K-Scale, individuals at a risk of developing Internet addiction are classified into either a high-risk group or a potential risk group. Individuals in the high-risk group exhibit problems associated with mental health resulting from excessive gaming such as anxiety and hostility, and require professional treatment, as they cannot exert self-control. On the other hand, individuals in the potential risk group exhibit similar problems albeit to a lesser extent, but still require professional counseling.

[11]A study under the title, "A Validation Study of K-Scale as a Diagnostic Tool," has already been conducted. There are plans to publish this study in an international academic journal.

efficacy of the system. These criticisms were supported by the findings of Uk-jun Seong (2013), which also suggested that the system is ineffective.

The key problems are the lack of convincing alternatives for parents of affected children, and how parents are to combat addiction should the current system be abolished. Those who oppose it argue that the cause of Internet addiction is not just any individual game, but comprises a variety of factors including socioeconomic factors, family/environmental factors, individual psychological factors, etc. They believe it is overly simplistic to think that addiction can be prevented solely by the prohibition of games in isolation of these other factors. This logic is correct. Yet Korean parents' general stance is unreservedly in favor of state regulation. With this in mind, it is time for the present government to develop more viable policies.

19.5.3 Federal Government or Regional Government Guided Governance?

Who should be responsible for dealing with the problem of Internet addiction is a matter of significant controversy. The federal government is currently the primary provider of solutions to the problem of Internet addiction in Korea. Yet controversy exists over how long this role can be fulfilled by the federal government. This is due to the fact that Internet addiction is an issue that is related to the private lives of people living in local communities. In other words, the characteristics and causes of Internet addiction differ for each community. For this reason, solutions must also be different for each community. With that in mind, it is insufficient to suggest that the federal government establish and carry out one uniform plan to solve the problem of Internet addiction. Outside of the Seoul region, there are currently 16 metropolitan and regional governments directly operating apart from the federal government. Henceforth, regional governments should play the central role in carrying out measures to deal with Internet addiction and operate with consideration for the social welfare delivery systems presently existing in relevant communities.

At the same time, there is also the question of how long the government alone should be considered responsible for acting to prevent and solve the problem of Internet addiction. Currently, ICT companies, private psychological counseling centers, religious organizations, and other private bodies have taken interest in this issue and are working to provide solutions. In this context, it will be more effective for a greater number of private organizations including businesses and religious groups, and also the press and NGOs, among others, to work together to solve this issue. Moving forward, regional governments must play a central role in determining the actual conditions of addiction in their region, and those in each region are working to provide solutions.

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Part IV
Smartphone Addiction as a Distinct New Emerging Disorder?

Chapter 20
Psychopathology of Everyday Life in the 21st Century: Smartphone Addiction

Yu-Hsuan Lin, Sheng-Hsuan Lin, Cheryl C.H. Yang and Terry B.J. Kuo

Abstract In recent years as the prevalence of smartphones has increased, so too has excessive smartphone use become a prominent social issue. "Smartphone addiction" is one form of a more general technological addiction. In this chapter, we review the evolution of substance and behavioural addiction through an examination of the process for the diagnosis of mental illness. We introduce four common factors between smartphone addiction, and other forms of addiction, diagnostic criteria, and a mobile application (App) to identify smartphone addiction.

20.1 Introduction

As their presence becomes increasingly ubiquitous, smartphone overuse has emerged as a form of technological addiction, which is rapidly becoming an important social issue worldwide. According to Griffiths (1996), technological addiction is a type of behavioural addiction that involves human–machine interaction and is non-chemical in nature. Gambling disorder, the most well-known behavioural addiction, has been categorized in the "substance related and addictive

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_20

disorders" section of the current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association; APA 2013), owing to similarities in symptomatology, biological dysfunction (Potenza et al. 2003), genetic liability (Slutske et al. 2000), and treatment approach (Hodgins et al. 2001; Petry et al. 2006; 2008). Another similar behavioural addiction, Internet gaming disorder, has been listed in the research criteria of DSM-5 (APA 2013), indicating that this potential disorder requires further research. In a similar manner, smartphone addiction also requires further research. The ready availability of smartphones has led to overwhelming smartphone penetration and this has attracted increasing attention on the investigation of smartphone addiction.

The variety of novel electronic devices is constantly increasing. With the introduction of niche terms such as "Internet addiction" and "Smartphone addiction", it is possible that pathology will generalize to other mediums, e.g. "Apple watch addiction" and "Google Glass addiction". In fact, a debate already rages as to whether it is appropriate to categorise "television addiction" (Sussman and Moran 2013) and "cellphone addiction" (Yen et al. 2009) as discrete behavioural addictions. However, only Internet gaming disorder (i.e. addiction to online games) has yet obtained experts' consensus in the DSM-5 research criteria. Behavioural addiction refers to a compulsive engagement in natural reward seeking, despite incurring adverse consequence (Olsen 2011). The natural reward refers to a behaviour that is inherently rewarding, such as gambling or online gaming. Unlike substance rewards, these behaviours do not rapidly activate the brain's reward system, but gradually activate similar mechanisms over time. We hypothesize that in online games, especially Massively Multiplayer Online Role-Playing Game (MMORPG), players could satisfy the high level of the Maslow's (1943) hierarchy of needs, i.e. love/belonging, esteem and self-actualization (see Fig. 20.1) through interacting with other players in online games. Similarly, smartphone users can also satisfy their needs through interacting with their smartphone. However, users of video games, TV and cellphones (i.e. mobile phones that do not enable Internet access and are thus distinct from smartphones) cannot satisfy higher level needs, such as esteem and self-actualization, exclusively through use of their preferred technology. In this way, Maslow's model may be able to explain why Internet gaming and Smartphone overuse enable addictive rewards despite adverse consequences in a similar manner to other addictive disorders.

Smartphones are not without their advantages, however. Over and above their everyday uses, the advent of smartphone addiction has provided researchers with a

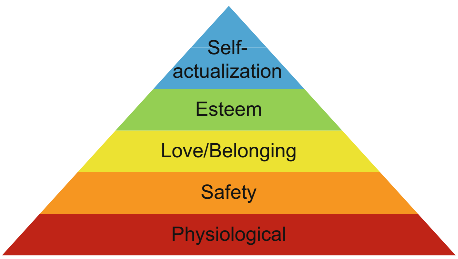


Fig. 20.1 Maslow's hierarchy of needs. Maslow's hierarchy of needs represented as a pyramid with the more basic needs at the bottom

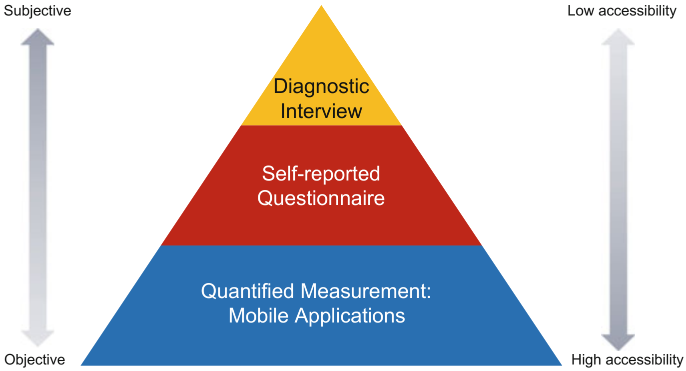


Fig. 20.2 The hierarchy of psychiatric diagnosis. The gold standard to assess mental status is diagnostic interview, despite the more objective and accessible approach enabled by self-report questionnaire and quantified measurements

new method of assessing mental health issues (Markowetz et al. 2014; Miller 2012; Yarkoni 2012). The traditionally accepted method of defining mental illnesses relies on symptomatology, which is almost exclusively obtained via diagnostic interview or, in the case of preclinical screening and large-scale studies, self-report questionnaires. Since the essence of scientific research is the pursuit of objectivity and replicability, recent decades have sought to incorporate increasingly objective measurements, such as brain imaging, electrophysiological investigation, and neuropsychological tests, which have been developed to decipher human mental status in complement to traditional subjective psychometry (i.e. interview or questionnaire). However, it is paradoxical that most of these studies still used the traditional psychometrics as the gold standard, which is the most subjective among all assessments (Fig. 20.2).

While psychiatric disorders are traditionally diagnosed via psychiatric interview, the introduction of smartphone addiction represents a turning point for the traditional paradigm of diagnosis (Fig. 20.2). The smartphone addiction assessments, either diagnostic interview or self-report questionnaire, consist of the patterns of smartphone use. However, Lin et al. (2015) and Montag et al. (2015a) have demonstrated that smartphone users are unable to accurately estimate their smartphone use. In order to increase the reliability of these measures, it is thus reasonable to quantify the addictive behaviour or to diagnose smartphone addiction by recording actual smartphone use, rather than relying on subjective report. Mobile applications (Apps) have been developed to record smartphone use data, which has been incorporated into psychiatric diagnostic processes and been used as screening tool for large-scale surveys (e.g. to investigate personality; see Chittaranjan et al. 2013; Montag et al. 2014; Montag et al. 2015b).

In this chapter, we will first introduce the four main components of smartphone addiction: compulsive behaviours, functional impairment, withdrawal, and tolerance. We will also describe the diagnostic criteria based on traditional psychiatric interview and App-incorporated assessment for smartphone addiction.

20.2 Self-Report Questionnaires and the Four Main Components of Smartphone Addiction

Self-report questionnaires have been most commonly used to assess the characteristics of smartphone addiction. Identical to the components of all variants of Internet addiction (Block 2008) (Fig. 20.3a), the results of factor analysis showed that smartphone addiction consists of four main components: compulsive behaviours, tolerance, withdrawal, and functional impairment (Lin et al. 2014), which are outlined in more detail below.

20.2.1 Compulsive Behaviour

Compulsive behaviour, a symptom of impaired control, is regarded as the core symptom of addiction, and has been widely assessed in individuals with alcohol dependence (Gau et al. 2005) and Internet addiction (Lin and Gau 2013). The most

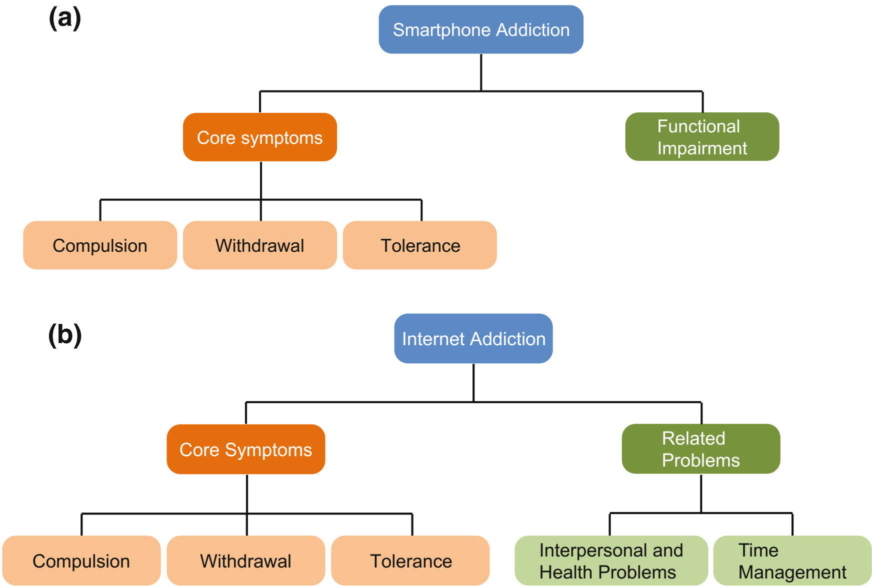


Fig. 20.3 **a** Factor structure of Smartphone Addiction Inventory. The three core symptoms of Internet addiction are present in smartphone addiction. The "Time Management Problems" and "Interpersonal and Health Problems" in Internet addiction merge into "Functional impairment" in smartphone addiction. **b** Factor structure of Chen's Internet Addiction Scale. There are two main factors, "Core Symptoms" and "Internet Addition Related Problems". Three classical core symptoms are "Compulsion", "Withdrawal" and "Tolerance". The "Internet Addition Related Problems" include "Time Management Problems" and "Interpersonal and Health Problems"

representative item, "*although using my smartphone has brought negative effects on my interpersonal relationships, the amount of time spent on my smartphone remains unreduced*", is present in almost all versions of self-reported questionnaires (Kim et al. 2014; Kwon et al. 2013a, b; Lin et al. 2014). It encompasses two symptoms most associated with decision-making problems in a previous study of problematic mobile phone use (Yen et al. 2009), and demonstrates that compulsive smartphone use cannot be stopped, even when the addicted individuals are aware of the negative consequence. The accessibility to the Internet via smartphone enhances the "online disinhibition effect" (Suler 2004). "In this way, the "*recurrent failure to resist the impulse to use*" and "*smartphone use for a period longer than intended*" results in excessive smartphone use. This excessive, frequent and prolonged smartphone use would, in turn, bring negative consequences, e.g. a loss of productivity or impaired social relationships.

20.2.2 Functional Impairment

Similar to obsessive-compulsive disorder and substance related and addictive disorders, the functional impairment of smartphone addiction includes marked distress, time consumption/waste, and significant interference with a person's normal routine, occupational or academic functioning or usual social activities or relationships. Compared with computer-based Internet addiction, the portability of the smartphone has dampened the severity of the functional impairment in smartphone addiction, but influences many domains of a person's life. The factor analysis of the Smartphone Addiction Inventory, derived from the Chen's Internet Addiction Scale, merged two factors—time management problems and interpersonal and health problems—in Internet addiction (Chen et al. 2003) into one factor "functional impairment" in smartphone addiction (Lin et al. 2014) (see Fig. 20.3).[1] Functional impairment is characterized by distraction through frequent, short-period smartphone use. For example, texting, using the Internet and reaching for the phone increases the risk of a motor vehicle crash or near crash (Klauer et al. 2014). The portable nature and multiple Internet-based Apps inherent to the smartphone have led to this unique addictive behaviour. However, the causal inference between health problems and smartphone use has not been well studied. A small body of evidence suggests sleep disturbances related to smartphone use. Epidemiological surveys have demonstrated how not only Internet use itself, but also "screen time" can affect sleep (Vollmer et al. 2012), and physiological studies specify that blue light emitting diodes, such as those found in smartphone screens, influence the circadian system (Cajochen et al. 2011). Smartphone use at bedtime has been a

[1]Of note, studies such as by Kwon et al. (2013a, b) demonstrate that Internet and smartphone addiction are not exactly the same, but overlap only about 25% (i.e. have a correlation of 0.50); see also next chapter for more information.

source of increasing interest, not just to mental health professionals, but also paediatricians, ophthalmologists, and multidisciplinary professionals.

20.2.3 Withdrawal

Although all questionnaires include a measure of withdrawal symptoms and demonstrate the presence of this factor in smartphone addiction, the ease with which people access their smartphones results in a difficulty in precisely evaluating withdrawal symptoms. Furthermore, despite the manifestation of withdrawal symptoms in individuals with gambling and Internet gaming disorders (APA 2013), withdrawal symptoms remain controversial in behavioural addictions (Petry et al. 2014; Ko and Yen 2014). Withdrawal occurs when blood or tissue concentrations of a substance decline in an individual with prolonged heavy use of a substance, but behavioural addictions do not involve this mechanism. Smartphone withdrawal symptoms include negative mood states (e.g. dysphoric, anxious) and active symptoms (e.g. irritability), and these are consistent with symptoms of withdrawal in Internet gaming disorders (Petry et al. 2014). Nevertheless, the emotional response after a period without smartphone use may also be viewed as a craving response, rather than evidence of withdrawal symptoms (Ko and Yen 2014).

A prominent withdrawal symptom in smartphone addiction is known as the "eye opener". This is analogous to early-morning withdrawal in patients with alcohol dependence, who require a drink first thing upon waking as an "eye opener" (Ewing 1984). However, for individuals with smartphone addiction, the portability of the smartphone means that they are rarely without their device. Thus, the period while they are asleep may be the longest time of nonuse and withdrawal may be most strong when the individual awakens (literally, opening their eyes). Moreover, the frequent, short duration use and high accessibility of smartphones make this addictive behaviour most similar to nicotine dependence, which also emphasizes the need for nicotine as an "eye opener" (Lin et al. 2014). Half of the six items in Fagerstrom Tolerance Questionnaire, the most well-known questionnaire for assessing nicotine dependence, pertain to the eye opener's smoking patterns (Fagerstrom and Schneider 1989).

20.2.4 Tolerance

Tolerance is defined as spending more and more time engaged in smartphone use. However, there are several arguments against the value of tolerance in the assessment of smartphone addiction. The tolerance factor demonstrates the most unstable structure, with the lowest eigenvalue and fewest items in both Smartphone

Addiction Inventory (Lin et al. 2014) and Smartphone Addiction Scale (Kwon et al. 2013a). The clinical interview reveals that tolerance has the lowest inter-rater reliability among all twelve of the candidate criteria (Lin et al. 2015). The evidence suggests that tolerance does not contribute to the diagnosis, indeed that there may be no tolerance in smartphone addiction. Smartphone users exchange increasing amounts of information since the beginning of ownership of smartphone. It is conceivable to be natural that they have to increase the frequency and duration of smartphone use to achieve satisfaction. Furthermore, unlike substance addictions, in which the substance itself is not a necessity for the general population, smartphones are rapidly becoming ubiquitous in everyday life. Thus, increasing use of smartphones, which could be viewed as the manifestation of tolerance, is not necessary pathological nor fundamental to this form of addiction, but may rather reflect a more general societal change. Furthermore, the nature of the frequent and short-duration use of smartphones can make tolerance difficult to assess.

There are also inherent problems assessing tolerance based on history alone, e.g. in the case of substance use, one addictive substance may be used in addition to others (APA 2013). Similarly, with smartphone addiction, individuals may access the Internet via a computer in addition to their smartphone; for example, they can log onto their social network using either device. Thus, to evaluate tolerance, additional information is required, such as reports from significant others, App-recorded data and questions such as "I have been told more than once that I spent too much time on my smartphone". In sum, this supplementary information is necessary to evaluate the tolerance of smartphone addiction. These items that investigate increasing smartphone use are still of value, especially with respect to the time course of smartphone addiction and the relapse prevention beyond the tolerance.

20.3 The Diagnostic Criteria for Smartphone Addiction and Its Clinical Implications

Diagnostic interview is the gold standard for diagnosing smartphone addiction, but only one pilot study has so far explored the diagnostic criteria used in the clinical interview (Lin et al. 2016a). This study recruited 281 college students as participants to examine 12 candidate symptom criteria and four functional impairment criteria. The 12 candidate symptom criteria originated from (1) the Diagnostic Criteria of Internet Addiction for College Students, a version for generalized Internet addiction (Ko et al. 2005) and (2) the research diagnostic criteria of Internet gaming disorder in DSM-5 (American Psychiatric Association; APA 2013), which are described in Table 20.1.

Table 20.1 The comparison of symptom criteria in smartphone addiction and its spectral/analogical disorders

Criteria	Candidate diagnostic criteria of smartphone addiction	Smartphone addiction	Generalized Internet addiction	Internet gaming disorder	Gambling disorder	Substance-related disorders
Preoccupation	Preoccupation with smartphone use, and hence keeping smartphone device available all day		✓	✓	✓	
Impulsivity	Recurrent failure to resist the impulse to use the smartphone	✓	✓			
Tolerance	Tolerance: a marked increase in the duration of smartphone use is needed to achieve satisfaction		✓	✓	✓	✓
Withdrawal	Withdrawal: manifested as a dysphoric mood, anxiety and irritability after a period without smartphone use	✓	✓	✓	✓	✓
Loss of control	Smartphone use for a period longer than intended	✓	✓			✓
Reduce/stop	Persistent desire and/or unsuccessful attempts to cut down or reduce smartphone use	✓	✓	✓	✓	✓
Excessive use	Excessive smartphone use and/or time spent on quitting the smartphone use	✓	✓			✓
Effort to access	Excessive effort spent on smartphone use as much as possible, even when it is inappropriate to use it		✓			
Continue despite problems	Continued excessive smartphone use despite knowledge of having a persistent or recurrent physical or psychological problem resulting from smartphone overuse	✓	✓	✓		✓
Escape	Use of the smartphone to escape or relieve dysphoric mood (e.g. helpless, guilt, anxiety)			✓	✓	
Give up other activities	Loss of previous interests, hobbies and entertainment as a result of—and with the exception of—smartphone use			✓		✓
Deception	Deception of family members, therapists, or others regarding the amount of time spent on smartphone use			✓	✓	

We proposed 12 candidate symptom criteria originating from (1) the Diagnostic Criteria of Internet Addiction for College Students, a version for generalized Internet addiction, and (2) the research diagnostic criteria of Internet gaming disorder in DSM-5. The preliminary diagnostic criteria for smartphone addiction demonstrated that eight of the symptom criteria in smartphone addiction are similar to generalized Internet addiction, rather than the more specific Internet gaming disorder. The smartphone addiction also shares several symptoms with gambling disorder, a typical behavioural addiction, and substance-related disorders in DSM-5

20.3.1 Symptom Criteria for Smartphone Addiction

The smartphone addiction shares similar features with substance related and addictive disorders, but the high accessibility and multiple Internet-based Apps of the smartphone can result in a unique, but prevalent addictive behaviour. The preliminary diagnostic criteria for smartphone addiction demonstrates that smartphone addiction is similar to generalized Internet addiction, rather than to the more niche Internet gaming disorder. This is likely because smartphone use is characterized by the use of multiple Apps (Lin et al. 2015) (Table 20.1).

Of the twelve criteria, compulsive behaviours, which are the manifestation of impaired control, are the core symptoms for both smartphone addiction and substance related and addictive disorders. These compulsive behaviours are described by the following three criteria: "smartphone use for a period longer than intended", "recurrent failure to resist the impulse to use", and "continued use despite knowledge of having a persistent or recurrent physical or psychological problem" (Lin et al. 2016a). The criterion "recurrent failure to resist the impulse to use the smartphone" is a central factor involved in the etiology of behavioural addiction (Metcalf and Pammer 2014). The ready availability of the smartphone highlights this impulse, while the comparatively restrictive nature of illegal substances results in "craving" the substance, rather than a "recurrent failure to resist the impulse to use".

It is noteworthy that this preliminary study was restricted by a sample of 281 college students. A much larger sample is necessary to validate the diagnostic accuracy of these candidate criteria. Furthermore, the sample contained a majority of male college students, which limits the generalizibility of the findings. Smartphone use, unlike substance use, is not a problematic behaviour in and of itself. More detailed information, such as the quantity and nature of the Apps used by participants should be identified in future studies.

20.3.2 Functional Impairment Criteria for Smartphone Addiction

To evaluate the functional impairment, we will summarize the description of functional impairment from the previous study (Lin et al. 2014) into three criteria. Because smartphone addictive behaviours are similar to compulsive behaviours (Fig. 20.4), we also add "subjective distress or is time-consuming" as the fourth functional impairment criterion, which originates from the criteria for obsessive-compulsive disorder. It is noteworthy that when assessing the criterion "continues excessive smartphone use despite problems", the problems do not have to meet the extent of functional impairment criteria, e.g. distraction from the class but not jeopardized the school performance (Table 20.2).

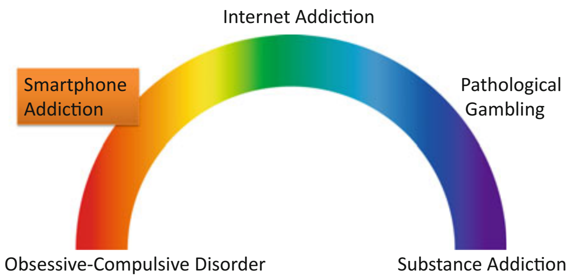


Fig. 20.4 Smartphone addiction with its spectral/analogical disorders. The core symptoms of smartphone addiction overlap with those for substance related and addictive disorders. The compulsive behaviours and functional impairment evident in smartphone addiction are similar to the compulsive behaviours in obsessive-compulsive disorders (based on clinical observation). However, the core symptoms of smartphone addiction are markedly different from obsessive-compulsive disorders

Table 20.2 Functional impairment criteria of smartphone addiction

1. Excessive smartphone use resulting in persistent or recurrent physical or psychological problems
2. Smartphone use in situations in which it is physically hazardous (e.g. smartphone use while driving, or crossing the street) or significant negative impact on daily life
3. Smartphone use resulting in impairment of social relationships, schoolwork, or job performance
4. Excessive smartphone use causes significant subjective distress, or is time-consuming

Compared to computer-based Internet addiction, the portability of smartphones dampens the severity of functional impairment associated with smartphone addiction, but instead influences multiple domains of an individual's daily life. In addition, as a newly identified addictive behaviour, we suggest two strict approaches to the assessment of functional impairment in order to minimize over-diagnosis: (1) to determine the functional impairment by two (or more) of the four functional impairment criteria (Table 20.2), which is different from DSM-5, and (2) to confirm the functional impairment in at least two settings, e.g. both school and home. The researchers should be careful to interpret the causal inference between functional impairment and smartphone addiction symptoms.

20.3.3 Smartphone Gaming and Smartphone Addiction

Smartphone gaming has risen dramatically in recent years. Revenue estimates from 2015, indicate that the personal computer/web was the leading platform for video gaming, closely followed by the smartphone (Wolf 2015). The top ten games earned 25% of the total $23 Billion in global revenue from the App Store and Google Play (Wolf 2015). To our knowledge, only one case report of tendon rupture has been associated with excessive smartphone gaming (Gilman et al. 2015), but no literature exists on smartphone gaming addiction. Non-pharmacological effects, such as pleasure and excitement, caused by smartphone games or online computer games, suppress pain perception in paediatric patients (Das et al. 2005) and during burn treatment (Haik et al. 2006). These non-pharmacologic effects can, however, lead to compulsive addictive behaviours and even functional impairment.

An official survey by the Institute for Information Industry in Taiwan showed 58.7% (12.25 million people) own a smartphone and 25.4% (5.3 million) own a tablet (Market Intelligence and Consulting Institute 2015) among the Taiwanese population over 12 years of age in 2015. The top five types of Apps were games (53.7%), social network (27.8%), tools (27.7%), music (27.4%), and video (24.4%). This report suggested that smartphone gaming might indeed be a crucial factor in the excessive use of—or addiction to—the smartphone.

It is interesting to note that males are observed to be more addicted to Internet use than females, while the pattern is reversed for smartphone use, possibly because females are more inclined towards the social interaction facilitated by smartphones (Billieux et al. 2007). In recent years, however, the numbers of female and male smartphone game players have been close, which is quite different from the male-dominated online gaming (Market Intelligence and Consulting Institute 2015). The combination of gaming and social networking available on the smartphone may play an important role in its addictive nature. For example, the smartphone game players easily show their scores on Facebook and timely get the feedback. They are also more easily able to invite their friends to join the smartphone game via Facebook than MMORPG on PCs. It is conceivable that marketing strategies have exploited the potential female game player, e.g. through use of cute avatars in advertising (see Fig. 20.5).

Although the smartphone addiction criteria were more similar to those associated with generalized Internet addiction rather than Internet gaming disorder as outlined in the DSM-5 (Table 20.1), smartphone gaming, regardless of multiple-App use, can increase the risk of smartphone addiction as assessed in a recent survey conducted among students in a senior high school (Liu et al. 2016). Smartphone gaming allows players to connect with other players through the Internet via social networking Apps. These Apps promote the game and enhance addictive gaming behaviours. This evidence suggests that smartphone addiction is a multiple-App addiction, which meets the high level needs in Maslow's hierarchy model, i.e. esteem and self-actualization (Fig. 20.1), which is similar to the case of MMORPG. In sum, smartphone gaming plays an essential role in maintaining addictive smartphone behaviour, but the nature of multiple-App use makes the symptoms of smartphone gaming addiction different from the symptoms of Internet gaming disorder.

Fig. 20.5 **a** The bus wrap advertising for smartphone game. The cute style is attractive to both female and male adolescents from a marketing perspective. The instruction "download on App store/Google play" is essential. The label shows that the game is suitable for people aged six and above, in-line with the game rating regulations in Taiwan. **b** and **c** The advertisement of the globally popular smartphone game "Clash of Clans" in the Taipei Mass Rapid Transportation in Taiwan, both outside (**b**) and inside (**c**) the train

20.4 Identifying Smartphone Addiction via a Mobile Application (App)

Two fundamental indicators of smartphone addiction, excessive use and increasing use, are defined based on user estimates of usage duration. However, estimating frequent and short-duration smartphone use is very difficult when relying on self-report questionnaires or supplementary information from family members. Therefore, mobile applications (Apps) to automatically detect the time of smartphone use, such as those developed by Lin et al. (2015) and Montag et al. (2015a), are necessary to improve the accuracy of the assessment of smartphone addiction. In this section, we first define the App-recorded parameters and compare the time spent on smartphones recorded by the App with self-reported assessment. Then, we consider how to delineate the trend of smartphone use for weeks to months via empirical mode decomposition. Finally, we outline the smartphone addiction and the relevant App-generated parameters.

20.4.1 App-Recorded Parameters and the Inconsistency of Time Estimation Between Self-report and App-Record

Lin et al. (2015) and Montag et al. (2015a) both examined the association between self-reported assessment and App-recorded data for smartphone use. Lin et al. (2015) defined an epoch as a use that starts from screen-on and ends at screen-off. The daily epoch count (frequency) and the total daily epoch time (duration) are obtained from the data. The median duration per epoch per day, rather than the mean, is used as a representative for the average epoch within a day, because the duration of the epochs are not normally distributed (see Fig. 20.6).

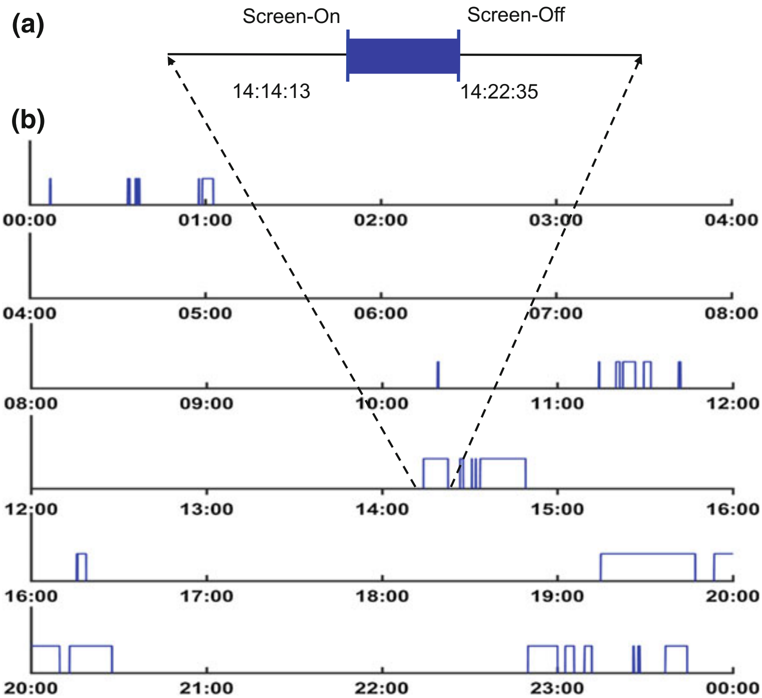
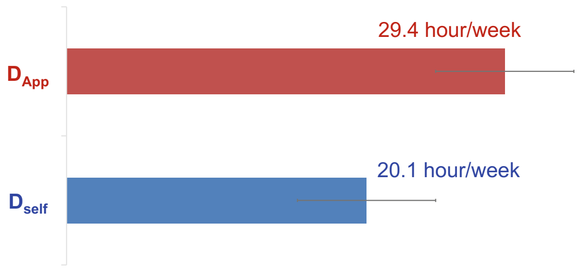


Fig. 20.6 The App-recorded smartphone use for one day. **a** An epoch, defined as one use which starts when the screen is turned on (from 14:14:13) and ends with the screen-off (14:22:35). The duration of this epoch is 502 s. **b** There are 29 epochs in this day (frequency = 29) and the total duration of the 29 epochs is 7841 s. Among the 29 epochs, the epoch with the median duration is magnified in (**a**), that is, the median duration is 502 s

Fig. 20.7 Smartphone users' underestimation of usage time compared with App-recorded usage time



Lin et al. (2015) investigated the association between total smartphone use time as measured by self-report with the assistance of a psychiatrist (D_{self}) and App-recorded total smartphone use time (D_{App}) for 66 young adults. The D_{self} (20.11 ± 12.40 h/week) was significantly lower than D_{App} (29.39 ± 14.45 h/week) ($p < 0.001$) (Fig. 20.7). The differences (ΔD) between self-reported and App-recorded total smartphone use duration was defined as $\Delta D = (D_{App} - D_{self})/D_{App}$. ΔD is positively correlated to D_{App} ($r = 0.352$, $p = 0.004$), that is, the participants with more actual smartphone use underestimated their use to a greater extent (Fig. 20.8) due to time distortion.

This "time distortion" effect has been explored previously among online game players (Rau et al. 2006). The underestimation of smartphone use time can explain the low reliability and validity of tolerance as a symptom of smartphone use assessed by diagnostic interview (Lin et al. 2015). Traditionally, tolerance is defined so that "*a marked increase in the duration of smartphone use is needed to achieve satisfaction*". Since the element "duration of use" is underestimated by users, it is conceivable that any "increase in the duration" is also likely to be unreliable in the absence of supplementary information.

Montag et al. (2015a) focused on typical mobile phone use, i.e. calls and Short Message Service (SMS) behaviours, and found that weekly phone use in hours

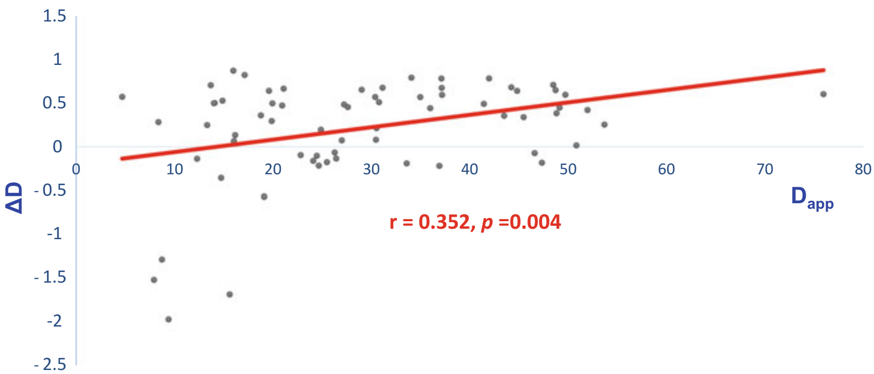


Fig. 20.8 The time distortion effects. Participants with more actual smartphone use (D_{App}) were found to underestimate their use to a greater extent (ΔD)

(duration) was overestimated, whereas the numbers of call and text message (frequency) related variables were underestimated among 58 participants. The inconsistency between these two studies might be explained by the following reasons (Montag et al. 2015a; Lin et al. 2015). First, the weekly phone use time in the survey of Montag et al. (2015a) was markedly shorter than that of Lin et al. (2015) (10.16 ± 6.06 vs. 29.39 ± 14.45 h/week). In addition, in the survey by Montag et al. (2015a), the participants' scores on the Mobile Phone Problem Use Scale (MPPUS) were within normal range, while a large number of the participants in the study by Lin et al. (2015) were characterized as being smartphone addicted (31 out of 79 participants) based on clinical interview. The difference in the average smartphone use time and level of addiction between two populations implies that the extent of the time estimation inaccuracy is associated not only with the actual smartphone use, but also with the participants' addiction psychopathology.

20.4.2 Delineation of the Trend of Smartphone Use for Weeks to Months

Fluctuations in smartphone use usually consist of multiple periodic components, and may increase in a nonstationary and/or nonlinear manner. Empirical mode decomposition (EMD) analysis uses the Hilbert Huang Transformation to provide an adaptive algorithm that is able to decompose a complex time series of smartphone use into a set of intrinsic oscillations, which are called intrinsic mode functions (IMFs); these oscillate at different time scales and are orthogonal to each other (Huang et al. 1998; Wu et al. 2007).

The intrinsic trends of three basic App-generated parameters (see Fig. 20.6) were calculated via EMD. These comprised trend of daily epoch frequency (F-trend), trend of total daily epoch duration (D-trend), and trend of daily median duration (M-trend). Figure 20.9 shows the decomposition of smartphone use by the EMD method, using daily frequency as an example. The decomposition of the raw data yielded three IMFs and a residual (overall trend).

We also used linear regression models to calculate these trends and compared three trends via linear regression and via EMD. F-trend via EMD was significantly associated with smartphone addiction, but the F-trend via linear regression was not. The association between smartphone addiction and the other two trends, M-trend and D-trend via linear regression were also smaller than those via EMD. Therefore, it is evident that EMD serves as a better tool to delineate the trend of smartphone use compared to traditional linear regression.

The F-trend parameter, representing the extent of increasing use, significantly predicted smartphone addiction diagnosis (Lin et al. 2015). Increasing use could be regarded as a form of tolerance or as another core symptom—"recurrent failure to resist the impulse to use the smartphone". Even though the symptoms relevant to the F-trend need to be explored, the parameters automatically derived by the EMD

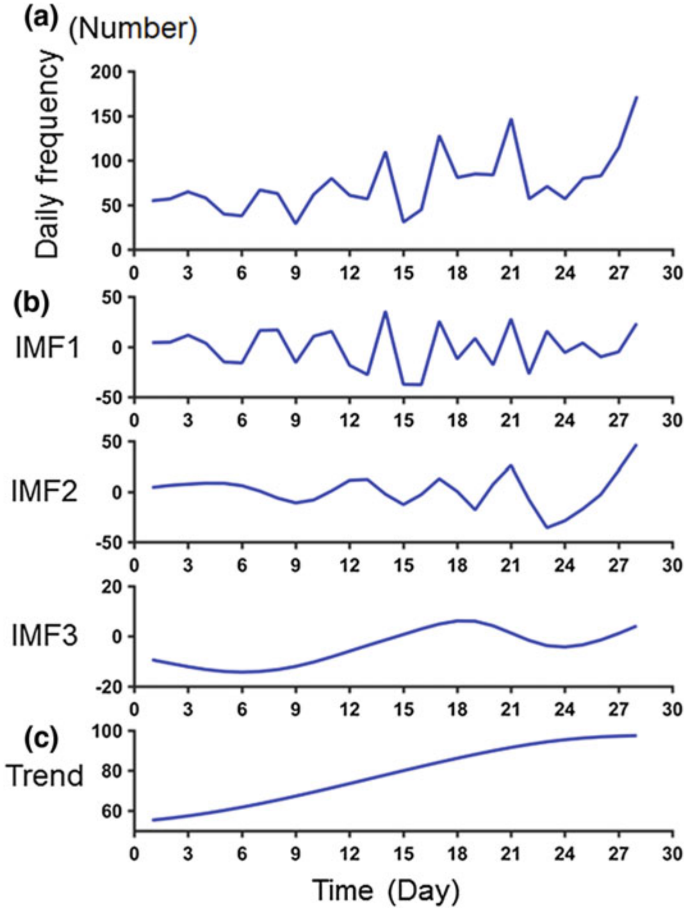


Fig. 20.9 One example of decomposition using the empirical mode decomposition method. **a** Time series of daily epoch frequency of smartphone use over 28 days. **b** The input is raw data and it the output is intrinsic mode functions (IMF1-3). **c** Residual component (overall trend)

analysis sophisticatedly delineate the trend of smartphone use in a nonstationary and nonlinear manner within a given period. On the basis of the robust association between daily use frequency and the presence of smartphone addiction, the F-trend can delineate the time course and serve as a useful tool to assess risk of relapse among smartphone addicts, which is difficult to assess via clinical interview. Relapse is an important characteristic of substance and Internet addiction and relapse prevention is a knotty problem in clinical practice (Block 2008). Thus, F-trend monitoring can be implemented as a risk index of smartphone addiction relapse and can facilitate appropriate prevention and treatment.

The M-trend parameter showed greater significance in terms of identifying tolerance, which is defined as spending more and more time engaged in smartphone use. Smartphone users found it easier to perceive the change in duration of a single epoch (M-trend) than total duration (D-trend) under the current gold standard of self-reported tolerance in the interviews. Moreover, the cut-off point for the M-trend at highest sum of sensitivity and specificity is around zero. This means that the participants were still able to sense the increase in duration of an epoch (median duration) over the past month (Lin et al. 2015).

20.4.3 Smartphone Addiction and the Relevant App-Generated Parameters

Only two studies have investigated App-generated parameters for smartphone addiction as defined by the psychiatric interview (Lin et al. 2015, 2016b). Other studies have defined smartphone addiction using self-report questionnaire measures (Lee et al. 2014; Montag et al. 2015a).

The frequency parameter robustly predicted both standard (diagnostic interview only) and App-incorporated diagnosis of the smartphone addiction (Lin et al. 2016a). A pilot study also demonstrated that the scores of Korean Smartphone Addiction Scale were correlated with daily use frequency but not duration, as recorded by the App (Lee et al. 2014). Among all substance and behaviour addictions, it is unique that the frequent and short-period smartphone use, rather than long-term use, interferes with daily routine and thus results in everyday functional impairment.

The "excessively frequent smartphone use", defined by the App-recorded frequency parameter, was the only one of the twelve candidate symptom criteria (Table 20.1) with higher sensitivity than specificity to assess smartphone addiction in the study with 79 college students (Lin et al. 2015). This high sensitivity makes "excessively frequent smartphone use" a potentially efficient screening tool for smartphone addiction. Moreover, the frequency parameter is generated automatically by the App, which will substantially decrease the cost of large-scale screening.

The duration parameter showed significant predictive ability for the App-incorporated diagnosis rather than standard diagnosis (Lin et al. 2016b). Montag et al. (2015a) also showed the correlation between the duration of weekly phone use and the scores of MPPUS. It is still noteworthy that smartphone use is specified in the phone call, and the study population spent relatively less time on the smartphone (Montag et al. 2015a). These findings suggested that the underestimation dampened the predictive ability of duration (Lin et al. 2015), demonstrating the importance of App-incorporated diagnosis for diagnostic accuracy.

20.5 Conclusion

Traditionally, difficulties in measuring human behaviour for a long term have led researchers to extrapolate from animal studies rather than attempt to measure human behaviour directly. With the close relationship between most individuals and their smartphones, however, we can now seek to direct study daily human behaviour using Apps such as those developed by Lin et al. (2015) and Montag et al. (2015a). Previous studies support the ability of such Apps to quantify the mental states involved in smartphone addiction. We also predict that the future will see the development of Apps to quantify behaviours relevant to all kinds of mental states and to facilitate cross-cultural studies on the reliability and validity of such measures. Such work will form the basis for an innovative field of "cyber-behaviourism". Other scientists have coined the term "Psychoinformatics" or "digital-phenotyping" (Montag et al. 2016; Onella and Rauch 2016).

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Chapter 21
Smartphone Addiction and Beyond: Initial Insights on an Emerging Research Topic and Its Relationship to Internet Addiction

Éilish Duke and Christian Montag

Abstract The present chapter considers early insights on some pressing issues in the investigation of smartphone (over)use. More specifically, we consider whether tendencies toward overuse of the smartphone and Internet are related. And, if so, whether the same personality structure represents a vulnerability factor for both kinds of digital addiction. This chapter also identifies some similarities and differences between Internet and smartphone overuse, beyond the findings from personality psychology. Finally, the chapter provides a short overview of the important relationship between smartphone use, flow experience at work, and productivity issues. This section is followed by a simple behaviorist model, which aims to explain the aetiogenesis of problematic smartphone use. The chapter closes with some easy to implement therapeutic interventions designed to reduce smartphone use in order to live more meaningful lives in the here and now.

21.1 Background

Since the introduction of the iPhone by Steve Jobs in the year 2007, smartphones have become a runaway success story. This is reflected in the large number of smartphone users around the globe. Recent statistics suggest about two billion people worldwide use a smartphone to communicate, surf the web, navigate unknown territory, or simply play video games (cited in Miller 2012). Clearly smartphones are very practical and—when used in a *smart* way—they are helpful in

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_21

numerous everyday situations. While these short examples clearly highlight the positive aspects of owning a smartphone, there is also a darker side to smartphone use, which we wish to discuss in this chapter. A brief note of caution must first be observed, however; as with Internet use, researchers of smartphone use must take care not to pathologize everyday life (Billieux et al. 2015; Kardefeld-Winther 2014). There have been many attempts over the past years to investigate phenomena like book/reading addiction, TV addiction, overuse of computer games and, most recently, Internet gaming disorder and its related umbrella term, Internet addiction. Yet not all of these perceived threats have proven (that) problematic. With this in mind, we present a short review of some early evidence on the topic of *smartphone addiction* to lay the foundation for the subsequent scientific debate on the relevance of this new research area.

Compared to the main topic of this book—Internet addiction—the literature on smartphone overuse is relatively scarce. This is particularly true when searching for neuroscientific studies investigating smartphone (over)use. Chapter 22 presents some initial evidence on smartphone use and neural plasticity. Arko Ghosh highlights how smartphone use can leave a lasting imprint on our brain by shaping neural motor areas (Gindrat et al. 2015). In anticipation of this chapter, we will not discuss the neuroscience of smartphone use further here, but will consider some alternative issues in this chapter.[1]

21.2 Are Smartphone Addiction and Internet Addiction Related?

One of the first questions that arise regarding smartphone addiction is whether we really need another category of a discrete digital addiction. As discussed elsewhere in this book (e.g., see Chap. 2), we already have to deal with terms for (generalized) Internet addiction, Internet Gaming Disorder (as a specific form of Internet addiction) and now arguably also with smartphone addiction?[2] First of all, and as is the case with

[1]To our knowledge only one recent paper had used neuroscience methods to investigate "smartphone addiction" at time of print. This study used electroencephalography to demonstrate that excessive smartphone users were characterized by a more negative N2 amplitude when confronted with NoGo trials on a Go/NoGo task. This may be interpreted as indicative of difficulties with early stage inhibitory processing among smartphone addicts (Chen et al. 2016), however, more work is needed to draw any strong conclusions in this respect. Finally, we would like to point to a recent published molecular framework to study smartphone addiction, which might guide researchers to disentangle the molecular underpinnings of smartphone overuse in the future (Montag et al. 2016c).

[2]In Internet addiction research it has been demonstrated that generalized and specific forms of Internet addiction such as overuse of online video games or online pornography only overlap in small proportions (Montag et al. 2015d). Moreover, we would like to mention that in the following text we use the terms "smartphone addiction", "problematic smartphone use", etc. somewhat exchangeably, because until now this new phenomenon has been not properly defined.

Internet addiction, it is not yet clear if we are facing "real" addictive behavior in the context of problematic smartphone use. Given some initial evidence—and as outlined in the Chap. 20 by Lin et al.—several observable symptoms such as withdrawal when the smartphone is not to hand, loss of control when using the phone, and preoccupation with the smartphone in everyday life, suggest that smartphone overuse could indeed be characterized as an addiction. Recent studies suggest that smartphone addiction may also be associated with shyness and loneliness (Bian and Leung 2015), as well as lower academic performance (Samaha and Hawi 2016). In line with this, Lee et al. (2015) reported that higher smartphone addiction is associated with lower self-regulated learning and less flow experience when trying to learn (see more on flow experience and smartphone addiction below). Some further evidence also supports this notion: Insights from the Menthal project (see also Chap. 13) demonstrate that smartphone users check their phones on average every 18 min (Markowetz 2015; S. 12). This frequent checking suggests that people are constantly either on their smartphone or are planning (albeit unconsciously) the next session. Moreover, personal observations from everyday life show that many people become anxious upon leaving home and discovering they have left their phone behind (hence we observe (mild) bodily withdrawal symptoms). Negative emotions arising from this experience may even lead people to return home to get their smartphone, as being away from it for too long seems unbearable.

Returning to our main question on the relationship between smartphone and Internet overuse, some initial studies have sought to investigate whether smartphone addiction and Internet addiction overlap. Kwon et al. (2013) observed an overlap between their newly developed smartphone addiction scale and the Korean self-report Internet addiction scale of $r = 0.61$ in males and $r = 0.38$ in females. Taking the groups together, a correlation of $r = 0.42$ could be observed, suggesting an overlap of approximately 18% of the variance in both constructs (i.e. 0.42^2). More recent data from our work group suggest a similar degree of overlap. In this case, a correlation of 0.49 could be observed between Kwon's version of the smartphone addiction scale and the Generalized Problematic Internet Use Scale-2 (GPIUS-2; Caplan 2006), both of which were administered to a sample of over 600 participants (Montag et al. 2016c). In other words, the overlap between both constructs was 24%. Taken together, these data suggest that while smartphone and Internet addiction are related, there remains enough room for differences between both constructs.

21.3 Similarities and Differences Between Smartphone and Internet Addiction

In the absence of any studies that simultaneously compare both types of problematic digital use, we want to hypothesize some common features, which may contribute to explaining the overlap between these constructs, while also identifying reasons for differences. Before starting to speculate, we can provide the reader with some initial empirical evidence from personality psychology showing that the same vulnerable personality structure can be observed when dealing with smartphone addiction on the one hand and Internet addiction on the other. In unpublished data, we observe that the personality trait of (low) self-directedness (see Chap. 9) is linked both to higher Internet and also higher smartphone addiction tendencies. Moreover, individuals with higher tendencies towards Internet or smartphone overuse are characterized by higher neuroticism, lower agreeableness and lower conscientiousness. All these associations are highly significant for our sample. Interestingly, the associations between personality and digital overusage tendencies are slightly stronger with respect to Internet addiction compared to smartphone addiction, which warrants further investigation. For more information on these personality traits please see Chap. 9 in the present book where a detailed overview of personality and Internet addiction is given. Thus, initial evidence from personality psychology suggests that the same personality traits may represent vulnerability factors for both forms of digital addictive tendencies. Beyond our data, studies from other work groups suggest that both high narcissism (Pearson and Hussein 2015) and traits such as locus of control, social anxiety, need for physical contact, and materialism (Lee et al. 2014) might also play an important role in understanding smartphone overuse. Finally it is of importance to understand the motivation behind the usage; Zhang et al. (2014) suggest several possible motives, including social, coping, conformity and enhancement (searching for information) reasons.

A key reason for the observed overlap between Internet and smartphone addiction may be attributed to the simple fact that a smartphone without access to the Internet is more or less worthless. Most functions of the smartphone, such as the use of applications like WhatsApp, or browsing the web rely on a connection to the Internet. Thus, an integral part of smartphone usage represents nothing more than Internet use. In contrast, when asking participants about their general Internet use (or addictive tendencies towards the Internet), a much broader area is considered compared to the smartphone alone. In the latter case, participants responding to a questionnaire on general Internet usage are unlikely to only consider their smartphone use (if this feature at all), but also their Internet activity on desktop computers or digital tablets. Nevertheless, smartphones are now ubiquitous and many people carry these devices with them on a 24/7 basis. Therefore, access to this little device with connection to the Internet is possible everywhere in modern industrialized societies. Complicating things—and further explaining why Internet and smartphone addictive tendencies only partially overlap—many prominent communication channels are exclusive to smartphones and cannot be accessed via desktop computers. The messenger service WhatsApp is a good example of a successful application dominating smartphone usage in everyday life (Montag et al. 2015a). This application has only recently become available on desktop computers. In sum, the Internet (World Wide Web) is accessible via many devices, whereas the smartphone represents just one (albeit very powerful) device to access and connect with the online world. The latter technology possesses unique messenger/communication services, which may also explain why these digital activities are highly pursued by females (more so than by males; see Montag et al. 2015a), which is rather untypical for other areas of online activities such as online video gaming, online pornography use or online pathological gambling.

21.4 Smartphone Use, Flow Experience at Work, and Self-Reported Productivity

Addictions typically lead to negative consequences, be it at work, home or both. For this reason, we wish to discuss an interesting side-effect of smartphone (over)use. As previously acknowledged, when used in a *smart* way, smartphones are helpful and can enhance our productivity. These devices help us schedule our day, plan our routes and help and support our work endeavors in many situations, as long as a signal is available. Moreover, information on almost every subject imaginable is available everywhere thanks to constant access to the Internet.

Beyond these very positive aspects, however, many smartphone functions can interrupt and fragment our lives on a constant basis. This is particularly problematic for our work lives. To illustrate this, we refer to a central concept in work psychology. Csikszentmihalyi's *flow* concept is arguably not only one of the most important psychological concepts in work psychology (Csikszentmihalyi and LeFevre 1989), but also more generally when we want to understand how humans achieve happiness and wellbeing (Csikszentmihalyi and Csikszentmihalyi 1991). Flow describes a positive state of full concentration where one's own cognitive abilities are matched by the difficulty of the given task (for more details see Landhäußer and Keller 2012).

Imagine yourself opening up a word document to write a scientific article. If you have forgotten to close your mail program in the background and your smartphone social media channels are open, it will be very hard to reach the state of flow, in which you become absorbed by the work activity and forget about time and space. Hence, it will be difficult to "get in the zone" and become really productive. Each incoming E-Mail will be visually announced in the corner of your computer's operating system. Similarly, WhatsApp and SMS alerts will send visual signals announcing the arrival of new messages. These mediums may also be accompanied by acoustic signals, further distracting you from your work.

Recent research (Montag 2015; Montag and Walla 2016) has postulated that the associations between smartphone usage and productivity might resemble an inverted U-function (see Fig. 21.1). Using the smartphone in a *smart* way will make us more productive, overusing it and becoming distracted on a constant basis, will, however, reduce productivity. The point where *smart* usage becomes *non-smart* usage likely depends on the degree to which it fragments everyday life, as constant interruptions will hinder flow experience and reduce opportunities for productive work and states of happiness.

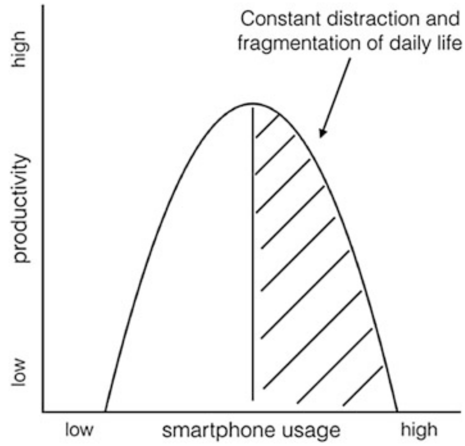

Fig. 21.1 The association between smartphone usage and productivity might resemble an inverted U-function

21.5 The Role of Conditioning in Smartphone Overuse or a Simple Framework to Describe How Overuse Develops

As with many other forms of addictive behaviors, learning mechanisms play a central role in the development of problematic smartphone use. Although this idea will need to be backed up by distinct empirical evidence, we want to briefly outline potential conditioning principles that likely contribute to problematic smartphone use.

Public transport is often a key location for people to spend time on their smartphones or other digital devices. Regarded by many as "dead time", people often do not see a problem in spending their commuting time playing online video games or fiddling with the smartphone. We wish to argue that this time may be better spent occasionally gazing out the window rather than trying fiercely to break the next high score on the latest computer game. Let's start by taking the bus stop/bus station as an example of how principles of conditioning could indeed shape our digital behaviors. Imagine a time before 2007—the pre-smartphone world. After leaving work, you arrive early at the bus station. Prior to the advent of the smartphone you would have spent this time looking at your fellow commuters (perhaps you spot a colleague and have a chat), you might read the newspaper or simply do nothing at all. Before looking around, you would have anticipated a state of boredom and asked yourself what to do in the next few minutes (see also Fig. 21.2, upper line). With the introduction of smartphones, you became aware that you could bridge the waiting time fiddling on your smartphone. It is possible to get so absorbed in this activity that you even miss your bus (yes, people can also have flow experiences on digital devices!). But honestly, besides missing the bus, one could ask what is the harm in using the smartphone on the way home. The problem is that many users cannot control their usage anymore, because mighty

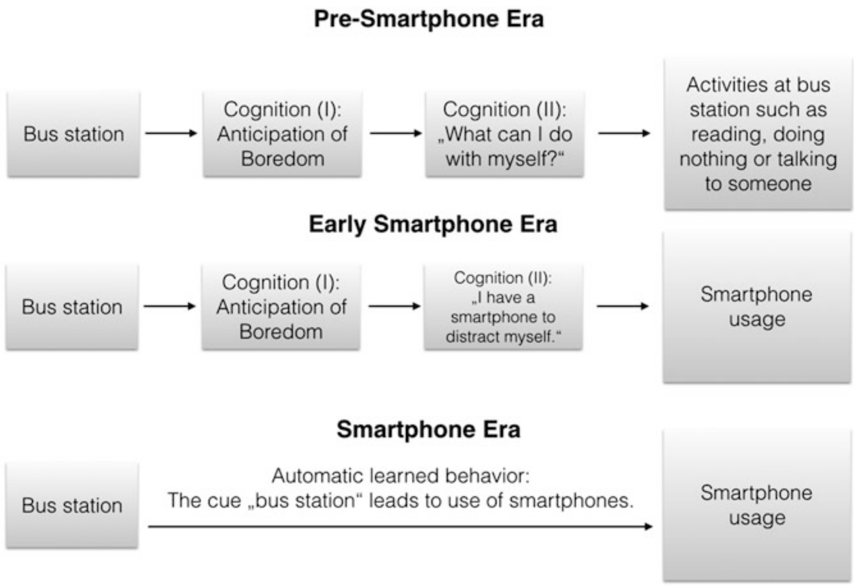

Fig. 21.2 (Potential) Conditioning principles at work in the era of smartphones—nowadays one cue such as the bus station can be enough to trigger automatic smartphone behavior

conditioning principles have shaped many of us into so-called "Smombies" (combination of smartphone and zombie). This word was chosen as the top-rated slang word of the year, 2015 to describe people unintentionally absorbed by their phone to the extent that they fail to notice traffic lights (and subsequently got run down by a car or train).[3] Figure 21.3 illustrates how city planners have met this challenge by anchoring traffic lights in the street so that people become aware of the changing lights while staring down at their phones. In New Jersey pedestrians are now fined for texting on the streets, because they are arguably endangering traffic zones. So even law-makers are spotting problems with smartphone overuse.[4]

Coming back to our example in Fig. 21.2 (middle line), the introduction of the smartphone also solved our cognitive need to distract ourselves and prevent boredom through using the new little device. We argue that this learning mechanism is so strong, that in our smartphone era (lower line in Fig. 21.2), the sight of the cue "bus station" is enough to elicit automatic behavior. Namely, grabbing the smartphone without even thinking about it anymore. In conditioning terms the neutral stimulus "bus station" has become the conditioned stimulus, eliciting a conditioned response—namely smartphone use. As the processes depicted in the

[3]Information taken from the website http://www.spiegel.de/schulspiegel/smombie-ist-jugendwort-des-jahres-a-1062671.html (website accessed in 21th July 2016).

[4]Information taken from the website http://abcnews.go.com/blogs/headlines/2012/05/texting-while-walking-banned-in-new-jersey-town/ (website accessed in 21th July 2016).

Fig. 21.3 New traffic lights anchored in the ground are tested in Cologne, Germany to prevent traffic accidents due to smartphone use (pictures by Christian Montag)

last line of Fig. 21.2 are automatic and largely unconscious they are hard to break. You have to trick yourself by putting the smartphone in a place that is not easy to reach when leaving the office, so that your automatic response (i.e., grabbing the smartphone) is not rewarded and after a while extinction processes will set in.

Some final points of note: these behaviorist processes are clearly an oversimplification, because conditioning principles such as that described will work better with some people than with others (see also classic works such as Franks 1956). We already noted that the personality trait (low) self-directedness is associated with smartphone overuse. Individuals low in self-directedness are typically characterized by rather low self-esteem, they are not satisfied with their own personalities and have problems achieving their goals (partially explained by low will power; see also the seminal work on will power in children by Mischel et al. 1972; in a way we deal nowadays not with the Marshmellow test, but the Smartphone test). It is no surprise that low self-directed individuals are also less conscientious than others and tend to procrastinate more. As individual differences in this trait are influenced by both genetics and the environment, and given that personality shapes our thinking style in the context of media use, one might suggest a more complex model, such as that depicted in Fig. 21.4.

Genes and the environment shape our personalities (for example, towards high or low self-directedness, Hahn et al. 2016), which in turn shape dysfunctional cognitions and attitudes (e.g. Kimbrel et al. 2012) probably also toward smartphone use. Such dysfunctional cognitions could include "I have to show off on WhatsApp or Facebook, so that others do not see my poor life (or so that others will envy me)." These dysfunctional thoughts enhance the conditioning principles described above, leading to increased smartphone use. Finally, an important driver in smartphone use is the smartphone usage of our peers. In particular, when everyone in a school class

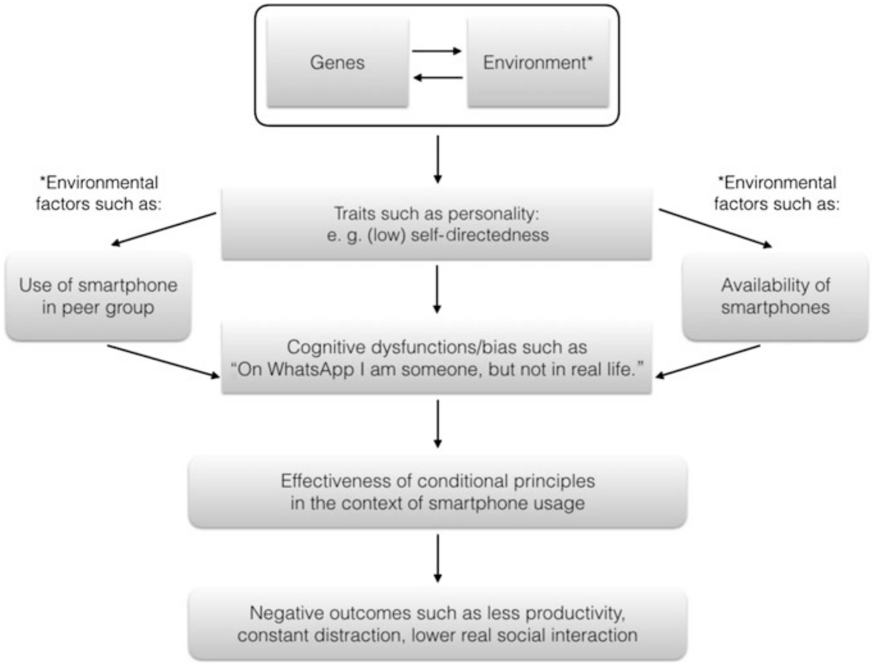

Fig. 21.4 A model of smartphone addiction including variables such as personality and cognitive dysfunction, as well as environmental variables such as peer-group and availability of technology

owns such a device, it is very hard for young children to resist usage.[5] Moreover, the peer-group could exert stress on the individual child by excluding it, so that this young person develops even stronger urges to present itself in a desirable way via the smartphone to secure attention from their peers.

A final consideration here is our pronounced vulnerability to intermittent reinforcement principles. In this context, the smartphone can be compared with a slot machine. The slot machine does not reward a person every time he/she pushes a button; instead, the individual is rewarded from to time, without any discernible pattern. This kind of reinforcement principle elicits a robust action association, i.e., a constant level of button-pushing (and money insertion) on the slot machine. The same process can be observed with the smartphone. Smartphones reward us on an intermittent, but not predictable level with funny messages via WhatsApp or E-Mails, leading to a robust smartphone usage pattern. A last note: upon looking

[5]One idea would be to restrict usage to a certain time window—such as between 17.00 and 18.00 h. The children know that everyone will be online in this time window but not around this time frame. This of course can only be achieved by a concerted action by parents. The attraction of the smartphone for most young people lies only in the access it permits to friends, e.g. online chatting. In contrast, if everyone is out playing soccer, the smartphone will be much less attractive.

through the proofs of the present chapter, we became aware of Billieux's model to explain mobile phone addiction (a broader term than smartphone addiction). We hint to this more elaborate model for interested readers (Billieux 2012).

21.6 Some First Thoughts on Possible Therapeutic Interventions

In our opinion an official diagnosis of "smartphone addiction" is not necessary to reach the conclusion that a bit less smartphone in everyday life is desirable (although we may yet require this diagnosis to properly treat severe cases of smartphone addiction). Again we wish to highlight this point with an example: Imagine yourself buying a concert ticket for a lot of money. The evening of the concert has finally arrived; the hall is getting dark and the crowd cheers in anticipation. Instead of dancing and singing along, many concert attendees will demonstrate the "smartphone reflex". The complete concert will be filmed, photographed and immediately posted on WhatsApp or Facebook. Fully focusing on not shaking the smartphone while producing bad videos or photos in the dark will emotionally distance you from the experience. Although physically present in the concert hall, focusing on the phone will prevent your brain from forming a lasting impression of the concert. This same process occurs when we meet friends in bars or cafes. Instead of fully engaging in conversations face-to-face with real people, we prefer to behave impolitely and text with people who are absent. This also signals that the phone is more important to me than the person sitting at the table. Situations as these serve to demonstrate that society needs some form of behavior modification to reduce smartphone use to better enjoy everyday life. New research also suggests that overuse of the Internet is associated with lower empathy (Melchers et al. 2015). Although no causal mechanisms can be derived from this study, we might ask in the future if abundant texting and sending photos in lieu of training ourselves and practising to read emotions from faces or voices might alter our brain toward less social capabilities (for a discussion see Montag and Walla 2016). This is, of course, speculative, but our brain is highly plastic and digital technologies will shape our brains in ways we cannot yet imagine.

In the following we would like to provide the reader with some (mostly empirical tested) suggestions for how to successfully cut down smartphone use (as presented also in Montag and Waller 2016).

- In a recent study we observed that many people no longer wear wristwatches. Instead they rely on smartphones as "zeitgebers" (literally—time givers; Montag et al. 2015c). As a consequence they commonly check the time on their smartphone. However, when doing so, they maintain their smartphone use by checking other features, such as E-Mail and thus prolong the online session. This distraction often leads to individuals still not knowing the time as they replace their phone in their pocket! We suggest that use of analogue zeitgebers, e.g., wristwatches, may help to reduce smartphone use.

- In-keeping with this argument, we also observed that people rely on their smartphones in lieu of classic alarm clocks to wake up in the morning. With the smartphone in the bedroom, many users also prolong their smartphone sessions in this private room, where we should find some rest. This is also reflected in the numbers from our study: about 36–40% of participants claimed to check/use their smartphone in the last 5 min before going to bed and in the first 5 min after waking up (Montag et al. 2015c). Checking E-Mail in this manner potentially leads to a situation where work stress is the first and last thing we think about every day. Therefore, a ban on smartphones from the bedroom could lead to better sleep (see also Christensen et al. 2016 showing a negative association between screen time and sleep quality) and better performance at work the next morning (Lanaj et al. 2014; but see also the importance of motivation behind usage as discussed by Ohly and Latour 2014).
- Checking E-Mails on smartphones or desktop computers also needs to be regulated. A new study by Kushlev and Dunn (2015) observed that constant checking of E-Mails results in high stress and negative emotionality. In contrast, checking E-Mails at planned and regular time points (e.g., 10 am and 16 pm) results in less stress.
- When meeting friends or having a good time at concert or other cultural events, try not to use the phone. Carpe diem and enjoy this quality time (Montag and Walla 2016).
- Commuting on trains and buses is a typical activity, during which people turn to digital use. Research on creativity indicates that situations in which we "do nothing" provide important momentum for our creativity and problem-solving (Baird et al. 2012). Therefore, a bit of mind-wandering while staring out of the window may be more useful than stressing ourselves out chasing the next high score on a smartphone game.

21.7 Conclusion

Much less is known about smartphone addiction compared to its sibling Internet addiction. Smartphone addiction clearly represents a catchy work-term and we will hopefully see in the near future how best to characterize this new phenomenon. Besides the possible psychopathology resulting from more extreme forms of use, we hope that some of our examples serve to convince our readers that, above and beyond debate over its addictive nature, many of us suffer—to a greater or lesser degree—from our high daily dose of smartphone.

Of note, some other important areas dealing with smartphone usage have not been tackled in this present chapter. Data derived from smartphone usage (human-machine-interaction) can be used for scientific purposes to study behavioral addictions (Andrews et al. 2015; Lin et al. 2015; Montag et al. 2015a, b), but also to predict many other psychological states (Gao et al. 2016; Saeb et al. 2015). Moreover, cross-cultural issues need to be addressed and explained to account for variance in the prevalence of smartphone use/addiction (e.g., Koo and Kwon 2014; Mak et al. 2014 and see work on power distance and Internet addiction by Montag et al. 2016b). This provides great opportunities but also challenges for our society as individuals become more transparent in their actions than ever before. We reviewed this new area of Psychoinformatics in a recent article (Montag et al. 2016a) and we illustrate its potential in the treatment of Internet addiction in Chap. 13 of this book.

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Chapter 22
Linking Elementary Properties of the Human Brain to the Behaviour Captured on Touchscreen Smartphones

Arko Ghosh

Abstract Explaining how the human brain operates in the real world remains far from the reach of modern systems and cognitive neuroscience. The brain is measured in highly controlled laboratory settings and most neuroscientific research is laser focused on explaining highly simplistic behaviours designed in the laboratory. The ubiquitous use of smartphones provides a fresh opportunity to radically reverse this trend by providing a quantitative insight into human actions in the real world. Addressing how this digital behaviour maps onto elementary neuronal measures is a powerful starting point towards appreciating the complexity of human actions.

22.1 Introduction

The height individuals grow to is a simple measure, and according to a news feed on my smartphone the citizens of the Netherlands are the tallest (NRFC 2016). Explaining the processes underlying this apparently simple measure or why the citizens of the Netherlands are the tallest is profoundly complicated—and linked to geography, development, nutrition and genes. The news illustrates just one of the many instances in biology where a simple measure can have a bewilderingly complex explanation (Karmon and Pilpel 2016). Modern neuroscience offers an array of simplistic measures of the brain but little do we know of the genetic and environmental factors that influence these measures. How can smartphones help link the simple neuronal measures to the rest of biology and environment? Why should neuroscientists study touchscreen smartphone use? We shall address these questions in this chapter.

The absence of quantitative behavioural insights from the real world places a major obstacle in bridging the divide between what is studied in the laboratory and the real world. This absence should not be mistaken for low interest of the neu-

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C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9_22

roscientific community in the real world. Virtually every neuroscientific exploration builds a qualitative profile of the human participants by using questionnaires. Questionnaires can assess features such as handedness, occupation and level of education (Oldfield 1971; Tourangeau et al. 2015). These qualitative assessments are driven by the notion that the inter-individual differences in the neuronal measures are linked to the behavioural profile. Apart from this qualitative approach, some studies have engaged in video recordings to survey human actions, but this approach requires computations over large data volumes, demands extensive manual supervision and can be highly obstructive to natural behaviour (Bullock et al. 2015). A lighter approach (in terms of data volume and supervision) relies on wearable sensors or accelerometers to measure gross motor activity (Case et al. 2015). The continuous monitoring of awake and rest periods using 'actigraphy' has extensively informed the neuroscience of circadian rhythms (Martin and Hakim 2011). However, this approach is opaque to the fine—cognitively engaging movements—performed by the hand. Smartphones are typically equipped with built-in accelerometers, camera(s), microphone and touchscreen sensors. With billions of smartphones in use, there is a new opportunity for quantifying human actions in the real world (without obstructing the behaviour itself).

Is data science in general and neuroscience in particular prepared for acquiring and analysing smartphone data? Simultaneous and continuous acquisition of data from all of smartphone sensors will tax the limited battery life—and obstruct the behaviour. Not just that but using all of the data simultaneously would need radically new forms of analysis. Such analysis may be detrimentally untethered from the current theoretical and empirical approaches that are typically used to understand neuro-behavioural links. To rapidly deliver new neuronal and behavioural insights, a step-wise approach where each sensor is separately studied prior to synthesising all of the data into one framework may be more successful. There are two distinct ways of collecting data from the individual sensors—(i) monitor the sensor activity continuously or (ii) collect data only when the sensor is activated by an 'event' of interest. The second—leaner—approach is not only more tangible for acquiring and processing data, and the power of such acquisition has been demonstrated in understanding website visits, library loans, phone calls and in sending/receiving mails (Barabasi 2010). For instance, the precise time-stamp of phone calls may inform us on the hidden factors that drive human actions (Jiang et al. 2013). A different class of experiments have used movement-triggered snapshots from the phone in combination with neuroimaging in the laboratory to study memory formation in the real world (Nielson et al. 2015).

The research on adult brain plasticity and skill acquisition provides a receptive platform to bridge the devide between the real world and artificial laboratory measurements. For instance, to study how the neuronal control of the hand is shaped by prior sensorimotor experiences investigators have used invasive electrophysiology in trained laboratory monkeys and non-invasive brain imaging in concert string instrument players (Jenkins et al. 1990; Elbert et al. 1995). These lines of experimentation converge towards the idea that elevated levels of sensorimotor activity lead to neuronal alterations in the brain areas directly associated

Table 22.1 A sample of real world behaviours used to understand sensorimotor plasticity

Behaviour	Direct measures in the real world	Neuronal correlate
Smartphone users (Ghosh and Balerna 2016; Gindrat 2015)	Battery use, number of touchscreen events, tapping speed, apps used.	Sensorimotor activity (EEG)
Capstan lathe operators (Seymour 1959)	Number of operations and operating speed	Not available
Typists (Cannonieri et al. 2007)	Not available	Brain structure (MRI)
Cigar machine operators (Crossman 1959)	Number of operations and operating speed	Not available
Jugglers, Golfers, and Basketball players (Scholz et al. 2009; Park et al. 2009; Bezzola et al. 2011)	Not available	Brain structure (MRI) Brain connectivity (MRI)
String instrument players (Elbert et al. 1995; Münte et al. 2002)	Not available	Sensorimotor activity (MEG) Brain structure (MRI) Brain connectivity (MRI)
Chopstick users (Ishii et al. 2002)	Not available	Sensorimotor activity (MEG) Brain connectivity (MRI)

with the corresponding body parts. However, in the real world and in the laboratory the elevated levels of activity are assessed qualitatively and how the behavioural statistics are linked to the neuronal alterations is not clear (Table 22.1).

22.2 Smartphone Behaviour in Comparison to What Has Been Studied Before in Sensorimotor Learning

Traditionally, neuroscientific and psychological studies on sensorimotor learning have largely focused on behaviours that require a lot of deliberate practice or training. Well scheduled training is common in elite athletes and musicians, imposed by fixed timetables to share a practice room and as a part of rigid discipline. Such scheduling is also imposed in the training of laboratory animals—driven by the timetables used to share laboratory resources and the fixed schedules of the experimenter. The patterns of events generated by such scheduled activities is distinct from the pattern generated by unconstrained or spontaneous activities. This contrast is well illustrated by the quantitative study of activities that do not follow a strict schedule—such as a writing mails, emails, library loans, website clicks and telephone calls (Barabasi 2010). These activities occur in bursts and the corresponding inter-event times show a power-law distribution. Essentially, subsequent events are largely separated by short gaps but longer gaps do occur more frequently than expected (Fig. 22.1). The theoretical interpretation of the power-law distribution is not clear but such a distribution is highly unlikely in the case of scheduled or rigidly planned activities. In that case, the events are separated by short gaps—as in during the practice session itself—and long gaps occur around a largely fixed value (Fig. 22.1). The implications of scheduled use versus unconstrained use in sensorimotor plasticity is not clear. There is a large body of work that suggests that the exact distribution of use influences the outcome of practice—as in the impact of 'massed' or 'distributed' practice (Lee and Genovese 1989). Moreover, in fundamental neuroscience the pattern of activity is a critical factor in determining the exact nature of plasticity—as in the induction of long-term depression or potentiation (Cooke and Bear 2014). In sum, as smartphone use is rather unconstrained, the rules of use-dependent plasticity derived from the study of elite athletes and musicians may not simply translate to smartphone users.

In stark contrast to activities such as piano playing or juggling, the basic sensorimotor skills required to operate the touchscreen are rather simplistic. The smartphone skills can be acquired quickly. According to some reports even toddlers can successfully operate the touchscreen (Hourcade et al. 2015; Bedford et al. 2016). How experienced touchscreen users differ from the less experienced users is not known and must be investigated in the near future. However, our preliminary findings suggest that neither the age of smartphone inception nor the number of years of smartphone use translates to increased speed on the touchscreen (Fig. 22.2). Nevertheless, it is plausible that individuals who engage in extensive gaming or texting on the smartphone develop motor strategies and skills that set them apart from the less experienced users. These issues must be carefully examined in the near future. In spite of the apparent ease with which individuals engage

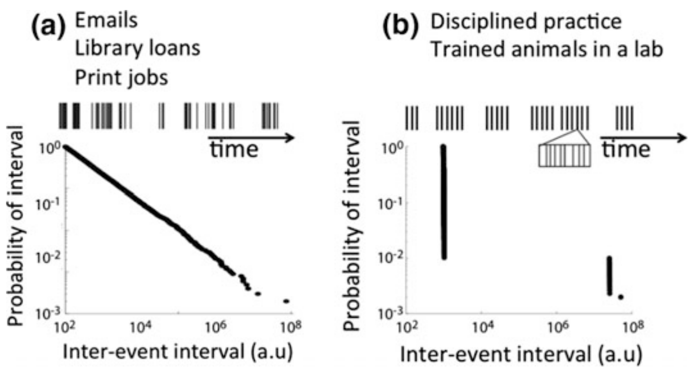

Fig. 22.1 Spontaneous behaviours such as emailing or printing follow a power-law distribution but the behaviours imposed in the laboratory or by deliberate practice cannot show the same behavioural statistics. Spontaneous behaviours occur in bursts whereas disciplined behaviour do not

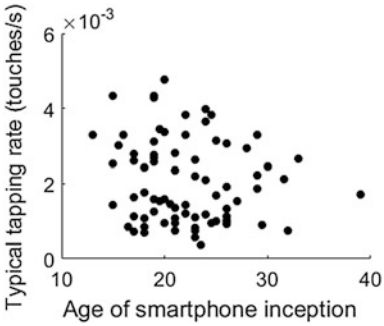

Fig. 22.2 Our current observations do not show a relationship between the skills expressed on the smartphone and the age at which smartphone use began. Each data point represents an individual and the tapping rate was derived from the touchscreen sensors in the real world

on the touchscreen, a broad range of activities—from shopping to social networking—can be accomplished by simply touching the screen. This combination of apparently simplistic sensorimotor control and broad range of activities also sets the touchscreen behaviour apart from the skilled activities that are typically studied in the area of sensorimotor learning.

22.3 Lessons Learnt from Touchscreen Smartphones

Two separate studies conducted by the author and his collaborators have linked touchscreen smartphone use to sensorimotor processing and the data supports the view the brain is continuously shaped by touchscreen use (Ghosh and Balerna 2016; Gindrat et al. 2015).

The somatosensory evoked potentials of individuals who do not use touchscreen smartphones are smaller in amplitude than the individuals who do use it (Gindrat et al. 2015). The same study also unravelled the correlations between the amount of touchscreen use—as estimated by using battery logs—and cortical somatosensory evoked potentials. These findings are in line with previous observations that increased use of a body part enhances the corresponding somatosensory representation, but there are some key differences in the details of the touchscreen–neuronal relationships than what has been studied before. The age of inception (or the age at which the task was introduced) is strongly correlated to the cortical activity in concert musicians but not in touchscreen users (also see Fig. 22.2). This suggests that developmental influences may play a smaller role in sensorimotor control on the touchscreen than in elite musicians—perhaps due to the simplicity of the movements required to operate the touchscreen. However, this initial impression needs to be seriously investigated to unravel the sensorimotor consequences of using the touchscreen through the developmental years, if any.

In a separate series of experiments, we employed a detailed form of touchscreen tracking to find sophisticated links between touchscreen behaviour and sensorimotor processing (Ghosh and Balerna 2016). The number of touches generated on social Apps such as Facebook or Twitter distinctly reflected on sensorimotor processing. To elaborate, the higher the number of social touches generated in the

Table 22.2 A summary of the behavioural parameters that can be presently extracted from the touchscreen (Ghosh and Balerna 2016; Gindrat et al. 2015)

Behavioural parameter	Sensor (resolution)	Elementary neuronal correlate
Smartphone usage	Battery logs (s)	Sensorimotor activity (EEG)
Number of touches	Touchscreen sensor (ms)	Movement time variability Sensorimotor activity (EEG)
Rate of touches	Not available (ms)	Movement time variability Sensorimotor activity (EEG)
Type of activity	App logger (ms)	Movement time variability
Contact force	Touchscreen force sensor (n.a)	Not available
Contact position	Touchscreen sensor (mm)	Not available
Estimated sleep duration	Touchscreen sensor (ms)	Not available

previous weeks the more variable is the performance on a simple motor task in the laboratory. The relationship also extended to the early stages of cortical sensory processing such that the higher the number of social touches the more variable is the neuronal processing. These social correlates were rather counter-intuitive given that increased use is typically associated with reduced sensorimotor variability (Krakauer and Mazzoni 2011; Krampe 2002). The links to other parameters derived from the touchscreen were more intuitive. For instance, users who were faster on the touchscreen also showed lower sensorimotor variability. Other parameters such as the number of Apps used and the number of non-social touches are also related to sensorimotor variability underscoring the complex interplay of various factors to shape the neuronal control of finger movements. Unravelling the mechanistic explanations for these relationships will require years of dedicated research, but they already demonstrate the power of the detailed behavioural quantification to embed elementary neuronal processing in the complexities of the real world (Table 22.2).

22.4 Opportunities

The ability to remotely monitor the fine-grained details of human behaviour will enable a new ecology of experimental neuroscience. First, this form of behavioural data is new to neuroscience so fresh analytical and modelling approaches will have to be developed to better describe and theoretically grasp the patterns of human actions (Fig. 22.3). For instance, the data collected from the phone must be understood in terms of circadian patterns, transfer from one task to another, fatigue and sensorimotor limitations. With sufficient modelling and descriptions of smartphone behaviour and more discoveries on the neuronal correlates of this behaviour, the field will be ready for perturbation-based experiments. For instance, our initial observations show that people who generate fast touches on the smartphone have a more stable sensorimotor system (Ghosh and Balerna 2016). A perturbation to slow the screen will help establish the implied causality between the touchscreen experiences and the configuration of the sensorimotor system.

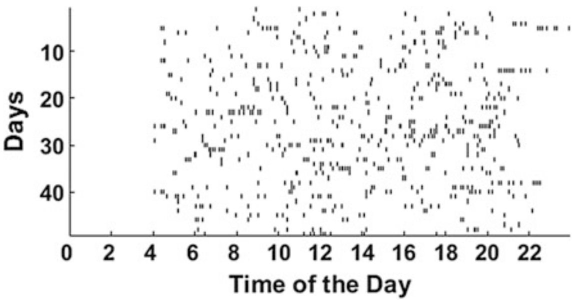

Fig. 22.3 Overview of all the touchscreen touches generated by single user over a 50—day recording period

The methodological and analytical developments to dissect through the touchscreen behavioural data will allow us to address some key questions of sensorimotor learning. The question of how the behavioural context influences sensorimotor reconfiguration can be addressed aided by the knowledge of the consequences of every touchscreen event. The questions related to the speed of brain plasticity can be addressed by using long-term behavioural monitoring and by using behavioural perturbations that may remain unnoticed by the volunteer. In sum, the introduction of touchscreen behavioural logs into the analysis of basic laboratory measurements will help fundamental neuroscience embrace the complexity of human behaviour in the real world.

22.5 Consequences in Health and Disease

Understanding touchscreen behaviour and its neuronal correlates may fundamentally shape future life-style and clinical practices. The increased use of smartphones has set-off a range of speculations on how it may adversely impact the brain—but this research path will either confirm or deny some of these speculations (Greenfield 2014). Moreover, it may raise entirely new scientific perspectives on how touchscreens influence neuronal functions—for better or for worse. However, it is rather likely that the complexity of touchscreen behaviour will prevent scientists from confidently and wisely recommending good or bad practices in the near future. Take for instance our most recent findings on sensorimotor variability and touchscreen use. This data suggests that while a subset of parameters describing touchscreen usage is detrimental to sensorimotor function by increasing variability but a different set of parameters is beneficial (Ghosh and Balerna 2016). In the clinics, the neuronal correlates of the touchscreen behaviour generated in the real world will provide new regressors to minimise the impact of inter-individual variability in neuronal measures. This in turn will make the measurements more effective in detecting and reflecting neurological dysfunctions. Not just that, but the neuro-touchscreen correlative mapping may provide entirely new ways to navigate complex outcomes of neurological dysfunctions. For instance, the slow pace at which touchscreen-neuronal links are formed may reflect the progression of certain neurological disorders. The detailed behavioural logs may directly aid in the development of new disease markers. For instance, the tapping rate on the touch-screen is expected to alter in neurological disorders such as multiple sclerosis or stroke. In conclusion, touchscreen smartphones offer an unprecedented opportunity to appreciate the complexity of brain functions in the laboratory and in the clinics, and will help bridge the large divide between the real world and the inherently artificial laboratory measurements.

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Appendix
Neuroanatomy

See Figs. A.1, A.2, A.3, A.4, A.5, A.6, A.7, A.8 and A.9.

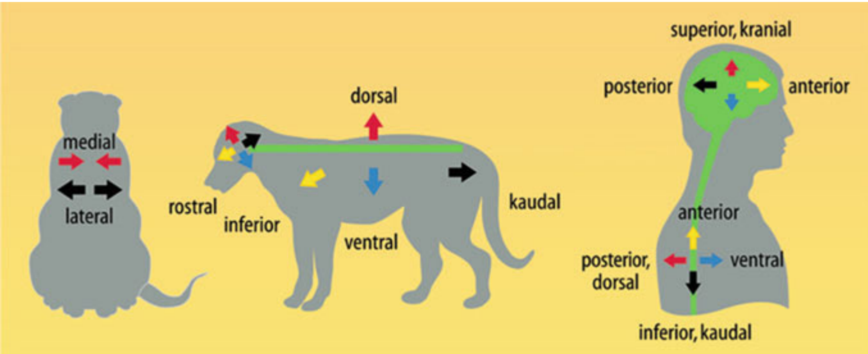

Fig. A.1 Explanation of the orientation in the human brain

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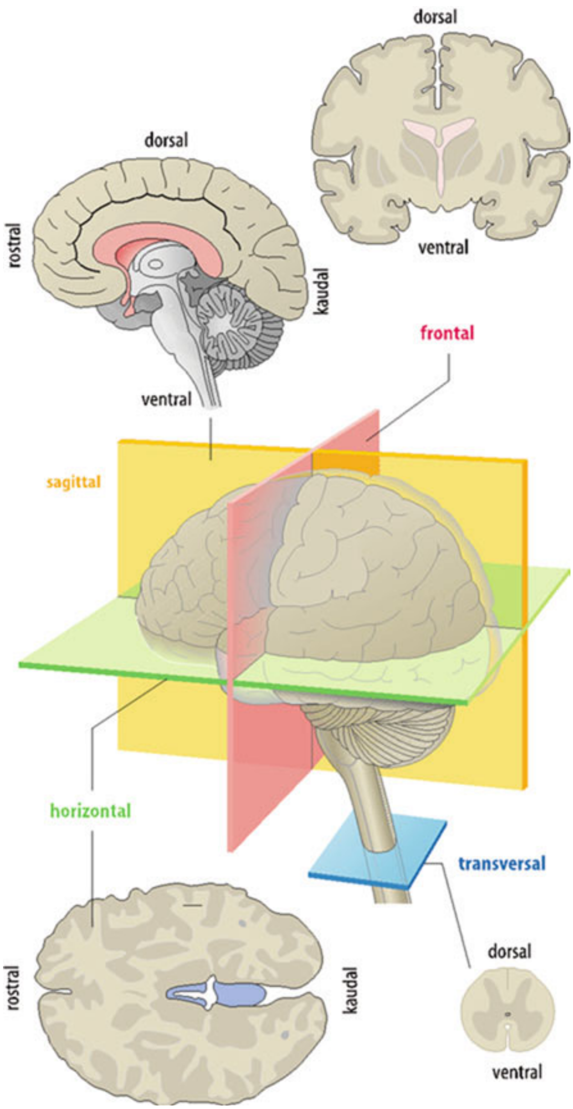
Fig. A.2 Different perspectives on the human brain



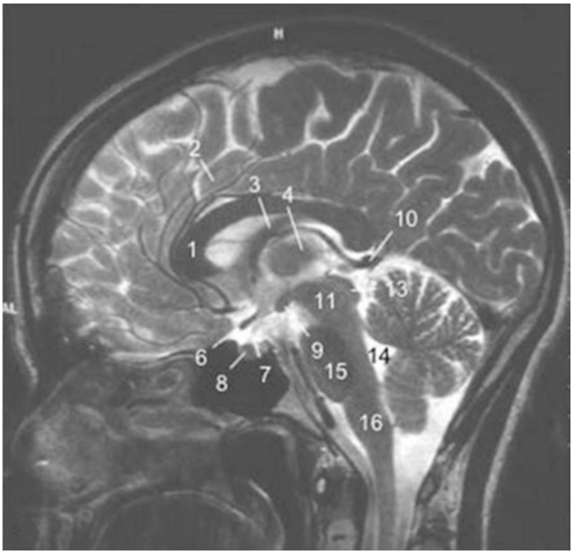
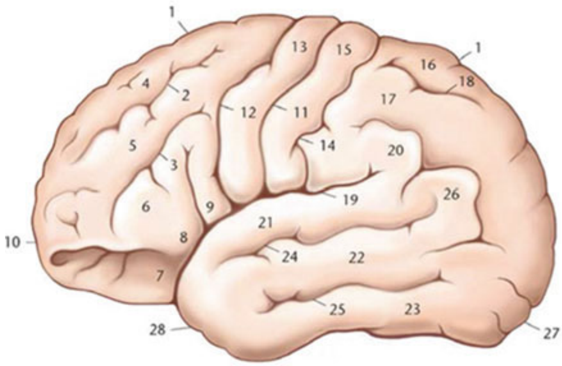


Fig. A.3 Medial sagittal section through the brain (MRI image). *1* Corpus callosum, *2* gyrus cinguli, *3* fornix, *4* thalamus, *5* chiasma opticum, *6* infundibulum hypophysis, *7* hypophysis, *8* corpus mamillare, *9* epiphysis, *10* mesencephalon (midbrain), *11* aqueductus mesencephali, *12* lamina tecti, *13* ventriculus quartus, *14* pons, *15* medulla oblongata, *16* velum medullare superius (MRI image from the University clinic in Freiburg, by Dr. J. Klisch, Department of Neuroradiology)



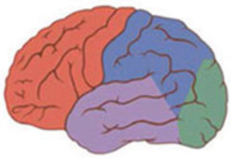


Fig. A.4 Lateral view of the cerebrum. Frontal lobe in *red*, parietal lobe in *blue*, occipital lobe in *green*, temporal lobe in *purple*. *1* Parasagittal cortical zone, *2* sulcus frontalis superior, *3* sulcus frontalis inferior, *4* gyrus frontalis superior, *5* gyrus frontalis medius, *6* gyrus frontalis inferior, *7* pars orbitalis, *8* pars triangularis, *9* pars opercularis, *10*. Frontal pole, *11* sulcus centralis, *12* sulcus precentralis, *13* gyrus precentralis, *14* sulcus postcentralis, *15* gyrus postcentralis, *16* sulcus lateralis, *17* gyrus supramarginalis, *18* gyrus temporalis superior, *19* gyrus temporalis medius, *20* gyrus temporalis inferior, *21* sulcus temporalis superior, *22* sulcus temporalis inferior, *23* gyrus angularis, *24* lobulus parietalis superior, *25* lobulus parietalis inferior, *26* occipital pole, *27* temporal pole. Modified according to Spitzer, in Duus: Neurologisch-topische Diagnostik, Thieme 1990

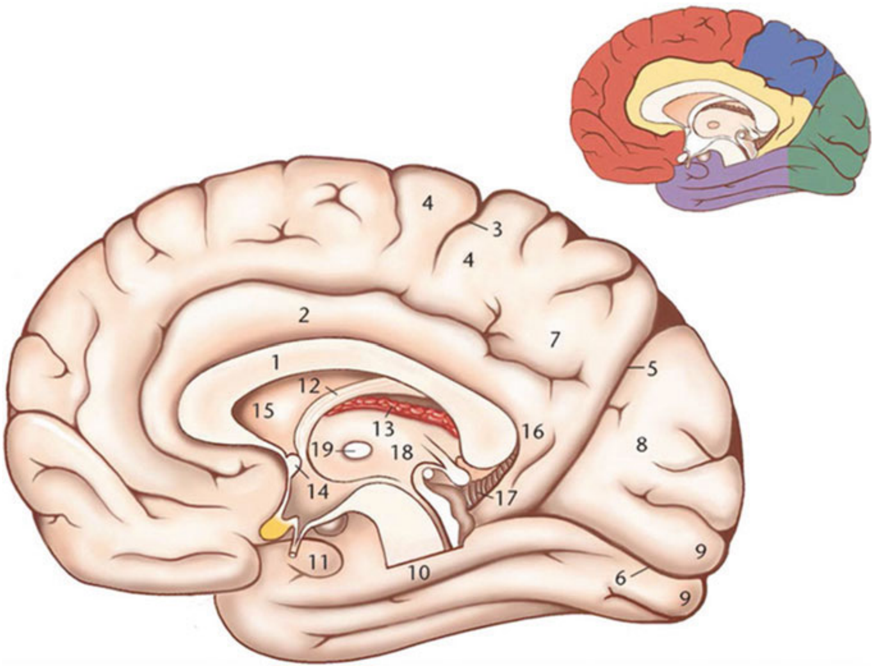


Fig. A.5 Medial view of the cerebrum. Frontal lobe in *red*, parietal lobe in *blue*, occipital lobe in *green*, temporal lobe in *purple*, cyrus cinguli in *yellow*. *1* Corpus callosum, *2* gyrus cinguli, *3* sulcus centralis, *4* lobulus paracentralis, *5* sulcus parietooccipital, *6* sulcus calcarinus, *7* precuneus, *8* cuneus, *9* visual cortex, *10* gyrus parahippocampalis, *11* uncus, *12* fornix, *13* tela choroidea, *14* commissura anterior, *15* septum pellucidum, *16* isthmus gyri cinguli, *17* gyrus dentatus, *18* thalamus, *19* adhesio interthalamica. Modified according to Spitzer, in Duus: Neurologisch-topische Diagnostik, Thieme 1990

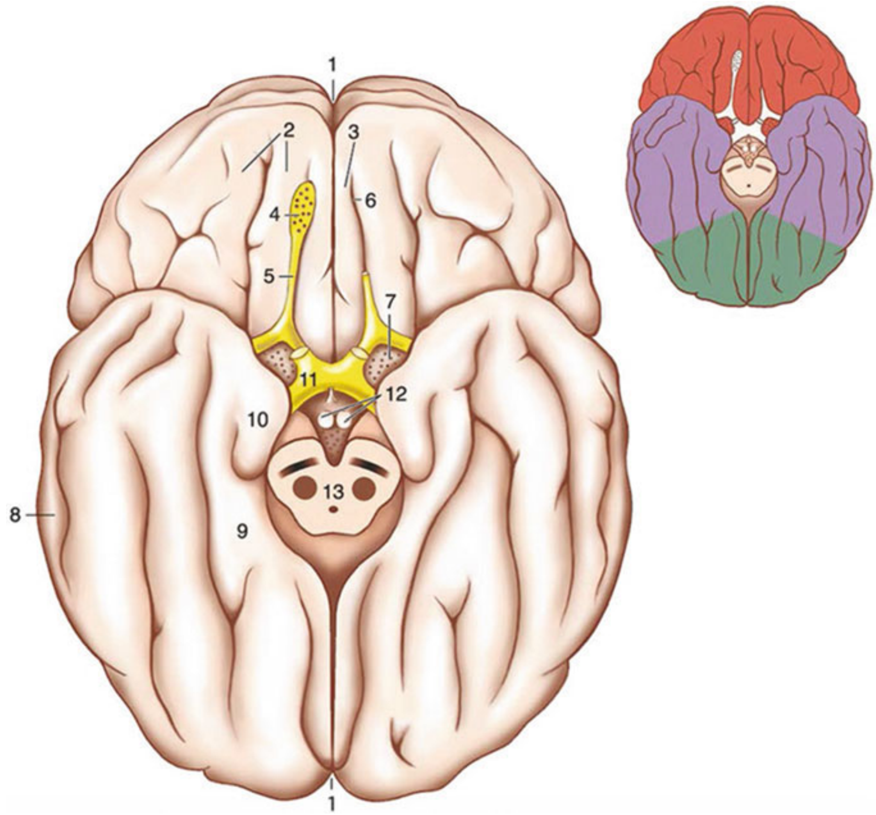


Fig. A.6 Basal view of the cerebrum. Frontal lobe in *red*, occipital lobe in *green*, temporal lobe in *purple*. *1* Fissura longitudinalis cerebri, *2* gyri orbitales, *3* gyrus rectus, *4* bulbus olfactorius, *5* tractus olfactorius, *6* sulcus olfactorius, *7* substantia perforata anterior, *8* gyrus temporalis inferior, *9* gyrus parahippocampalis, *10* uncus, *11* chiasma opticum, *12* corpora mamillaria, *13* midbrain. Modified according to Spitzer, in Duus: Neurologisch-topische Diagnostik, Thieme 1990

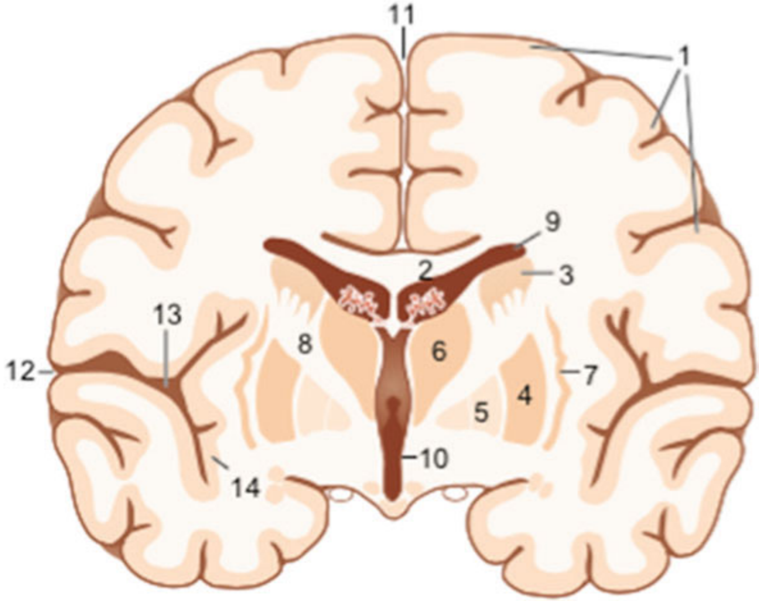


Fig. A.7 The most important inner structures of the cerebrum (frontal section). *1* Cerebral cortex, *2* corpus callosum, *3* Ncl. caudatus, *4* putamen, *5* globus pallidus, *6* thalamus, *7* claustrum, *8* capsula interna, *9* lateral ventricles, *10* third ventricle, *11* fissura longitudinalis cerebri, *12* sulcus lateralis, *13* fossa lateralis, *14* insular cortex

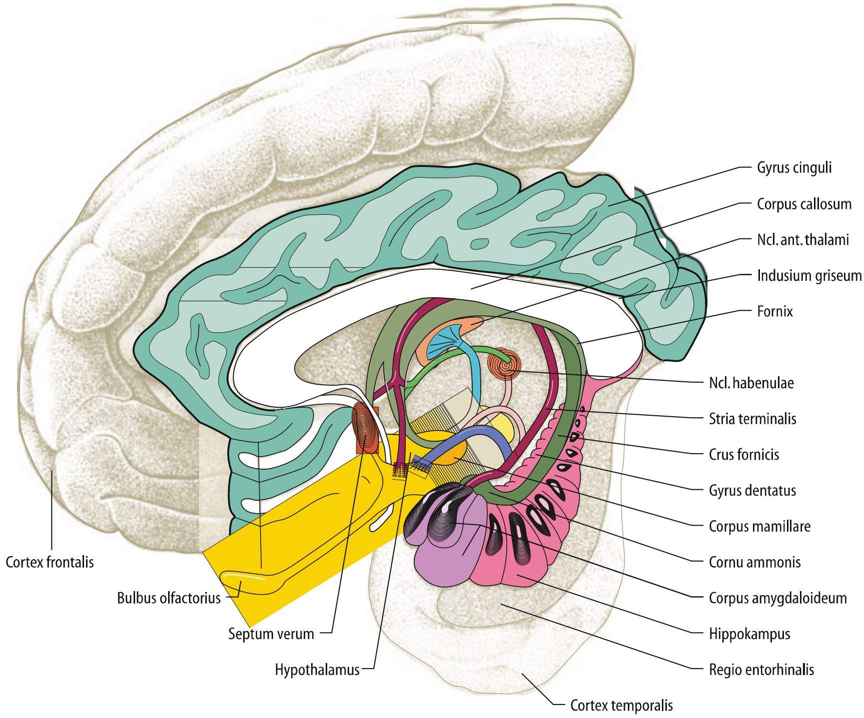


Fig. A.8 View on the limbic system

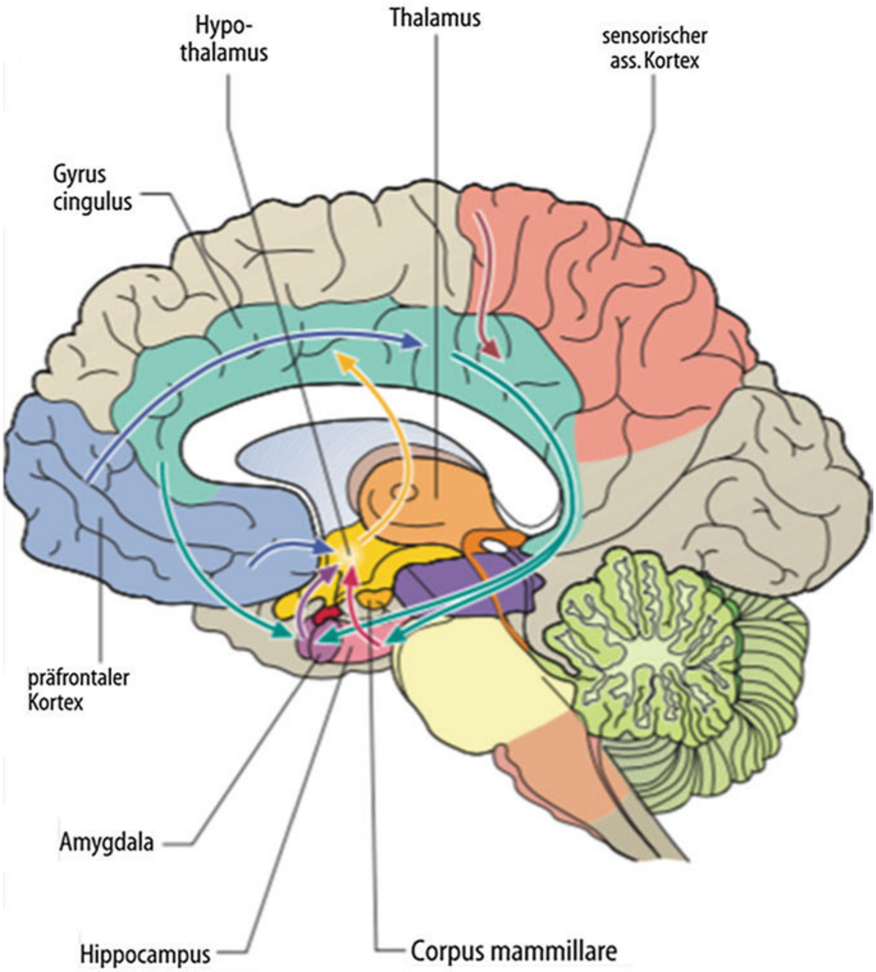


Fig. A.9 Projections of the limbic system

Glossary

DTI Diffusion tensor imaging: By applying this technique it is possible to gain insight into the integrity of white matter tracts by measuring the diffusion of water molecules in the brain. This technique is superior to VBM in investigating white matter.

EEG Electroencephalography: This technique is able to record brain activity from the skull (hence from underlying cortical areas) with a high temporal solution. Of note, compared to fMRI the spatial resolution in subcortical areas is poor.

fMRI Functional magnetic resonance imaging: this technique gives insights into brain activity both in cortical and subcortical areas while doing a specific task. Compared to EEG the temporal solution is much worse. A special version of fMRI is called resting state fMRI, where the activity of the human brain is recorded, while the participant of the study is not engaged in a specific task. This technique gives insights into the default networks of the human brain.

Gene A gene contains the information on how to build a bodily product such as a receptor structure at a neuron in the human brain.

PET Positron emission tomography: while fMRI only gives insights into brain activity, the administration of PET also allows insights into the underlying biochemistry of the human brain.

sMRI Structural magnetic resonance imaging: Through structural brain imaging, researchers gain insights into the structural neuroanatomy of the human brain. Here information on the volume or density of certain brain areas can be provided through VBM. In addition, the investigation of white matter tracts through DTI belongs to the field of sMRI.

SNP Single nucleotide polymorphism: A SNP represents a single exchange of a base at a certain locus of the desoxyribonucleic acid (DNA). SNPs represent a major source for individual differences in the genetic makeup of humans.

C. Montag and M. Reuter (eds.), *Internet Addiction*, Studies in Neuroscience, Psychology and Behavioral Economics, DOI 10.1007/978-3-319-46276-9

VBM Voxel-based morphometry: this is a statistical approach often used to obtain information on differences in gray matter volume/density in certain brain areas. Cleary, this technique also provides information on white matter. Nevertheless, the VBM approach is not optimal in investigating white matter tracts.