Chapter 9
Molecular Genetics, Personality, and Internet Addiction Revisited

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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

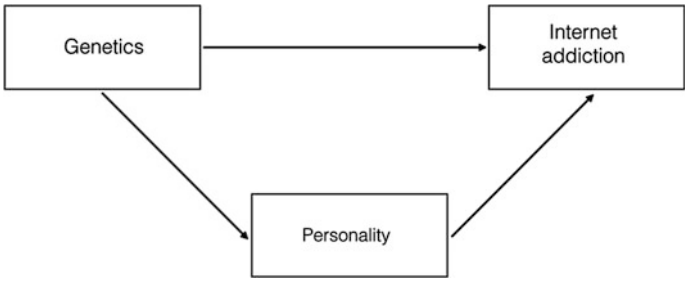

Fig. 9.1 Genetics could influence Internet addiction either directly or mediated via personality traits or other variables

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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