1. **Proposed DSM-5 and DSM-IV Criteria** – Current proposed criteria as edited by APA staff, Dr. Michael First, and the DSM-5 Task Force

2. **1st SRC Review Summary** – Contains SRC review comments on the initial SRC proposal for Insomnia Disorder

3. **2nd SRC Review Summary** – Contains SRC scores and review comments on the 1st SRC resubmission.

4. **SRC Proposal** – Proposal submitted for SRC review

5. **Response Memo to the SRC** – The Work Group’s response to the SRC comments on the initial SRC proposal

6. **SRC Resubmission 1** – The revised SRC proposal

7. **Appendix 1**: Weinstein and Lejoyeux, 2010 – Key article

8. **Appendix 2**: Yuan et. al., 2011

9. **Appendix 3**: Ran et. al., in press
### Internet Gaming Disorder

*Substance Use and Addictive Disorders*

<table>
<thead>
<tr>
<th>Proposed Criteria for DSM-5</th>
<th>DSM-IV Criteria</th>
</tr>
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<tbody>
<tr>
<td><strong>Internet Gaming Disorder (proposed for Section III of the DSM-5)</strong></td>
<td>This disorder is not listed in DSM-IV; therefore, DSM-IV criteria for this disorder do not exist.</td>
</tr>
</tbody>
</table>

Persistent and recurrent Internet Gaming behavior leading to clinically significant impairment or distress as indicated by five (or more) of the following in a 12-month period:

1. Preoccupation with Internet gaming.
2. Withdrawal symptoms when Internet gaming is taken away (these symptoms are typically described as irritability, anxiety, sadness, but no physical signs of pharmacological withdrawal).
3. Tolerance: The need to spend increasing amounts of time engaged in Internet gaming.
4. Unsuccessful attempts to control Internet gaming.
5. Continued excessive Internet gaming despite knowledge of negative psychosocial problems.
6. Loss of interests, previous hobbies, and entertainment as a result of, and with the exception of, Internet gaming.
7. Use of Internet gaming to escape or relieve a dysphoric mood.
8. Has deceived family members, therapists, or others regarding the amount of Internet gaming.

**Note:** The criteria represent the suggestions from the SRC to set a threshold of 5 or more of the 9 criteria, and to include a distress and impairment criterion. The Work Group also notes that data do not permit any rigid age criteria. Additionally, the severity specifier was added to indicate stress.
9. Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of Internet gaming.

*Note:* For this disorder, gambling sites on the internet are excluded. Only non-gambling internet games are included. Similarly, this disorder excludes sexual internet sites.

*Specify current severity:* Internet gaming disorder can be mild, moderate or severe depending on the degree of disruption of normal activities. Individuals with less severe Internet gaming disorder may exhibit fewer symptoms and less disruption of their lives. Those with severe Internet gaming disorder will have more hours spent on the computer and more severe loss of human relationships or career or school opportunities due to Internet gaming.

*Note:* The criteria represent the suggestions from the SRC to set a threshold of 5 or more of the 9 criteria, and to include a distress and impairment criterion. The Work Group also notes that data do not permit any rigid age criteria. Additionally, the severity specifier was added to indicate stress.
SRC Memo (#28)

From: Drs. Kendler and Freedman on behalf of the DSM-5 Scientific Review Committee (SRC)

To: Dilp V. Jeste, President APA, Dr. David Kupfer (DSM-5 Task Force Chair), and Dr. Darrel Regier (DSM-5 Task Force Vice-Chair)

DATE: August 2, 2012

88=Internet Gaming Disorder: The SRC would like to send this note back to the work group:

This was a well-organized proposal that came close to meeting all the SRC criteria for inclusion of a disorder in section 3 of DSM-5. Two issues, however, arose during the review. First, we assume that for section 3 in DSM-5, proposed disorders have to have a full set of criteria. This was not provided. That is, we need a threshold for a minimum number of criteria to meet the disorder. We would urge the WG to consider being conservative here. Given the risk of pathologizing normal adolescent behavior, we suggest setting a high threshold perhaps 5 or more of the 9 criteria. Also, typically, there is some requirement for distress or impairment. Do the WG want to add anything about age?

Second, we were unable to determine the origin of the 9 proposed criteria. Could the work group clarify this for us?
2nd SRC Review Summary

From: Drs. Kendler and Freedman on behalf of the DSM-5 Scientific Review Committee (SRC)

To: Dilp V. Jeste, President APA, Dr. David Kupfer (DSM-5 Task Force Chair), and Dr. Darrel Regier (DSM-5 Task Force Vice-Chair)

DATE: September 11, 2012

88R=Internet Gaming Disorder: The SRC gave this proposal strong support and noted that this revised proposal was a pleasure to review. The work group responded well to all of the SRC's input.

The group voted on this proposal with a final score of 1 (strong support).

Scoring Summary:
1=strong support
2=moderate support (acceptable)
3=modest support (questionable)
4= limited support (probably not justified)
5= poor support (do not include)
6= insufficient data

ADDITIONAL COMMENT:

I believe the authors have addressed the concerns addressed by the SRC during the first review, at which time the SRC evaluated the proposal as a good one for Section 3. They have also provided more clearly the source of the present proposed criteria.

ADDITIONAL COMMENT:

This represents a revision of a proposal to place this disorder in section 3. We reviewed this proposal in August and felt that it well met criteria for placement in section 3 but raised 3 points of modest concern. The WG has been fully responsive to each of these concerns now providing a conservative cut-off of the needed number of criteria for diagnosis, added an impairment criterion and provided the source of the criteria. This is now a strong and well supported proposal.
INTERNET GAMING DISORDER

This putative disorder has been the topic of numerous communications to the work group from therapists in the U.S. and abroad and from public statements of the American Medical Association and the government of China. After reviewing more than 240 articles on the subject in medical journals, the workgroup concluded that the disorder did not meet the standards required for adding to the list of mental illnesses. The following proposal is for listing in Section 3 in the hope of stimulating research that might ultimately result in listing in a future version of the DSM.

GUIDELINES FROM SCIENTIFIC REVIEW COMMITTEE

Proposals for inclusion of new diagnostic categories in the appendix should be accompanied by a memo with a developed rationale for the inclusion. This rationale should address, at a minimum, the following questions:

a. Does the new diagnosis meet a clinical need not currently addressed by existing categories? If so, what is the evidence?

The evidence for need comes from the published case reports and the letters to the Workgroup and the comments on the APA website. A representative of the Workgroup visited one of the hospitals in China consisting of over 100 beds specifically devoted to treating adolescents with “Internet Addiction.” We also talked to therapists in the U.S. who spoke strongly in favor of inclusion of “Internet Addiction” in DSM-5.

b. What, if anything, is known about the prevalence of the new category in epidemiological and/or clinical samples?

The literature is lacking in scientifically designed epidemiological studies that can quantitative evidence of a need. An example is a small study (120 students) in Poland (Zborsalski et al 2009) that reported a prevalence of 25% in a school sample. A global estimate has been proposed, without hard data, to be 5-10% of all online users (Young 1998). The diagnosis appears to be much more common among adolescent males and in Asian countries especially China, South Korea and Japan. We are proposing that future studies use common diagnostic criteria.

c. What, if anything, is known about the reliability of the proposed criteria or their performance characteristics (e.g. factor or item-response theory analyses)?

Criteria have varied across studies, so the reliability of criteria is unknown at present.
d. Is there any research literature on the proposed criteria that suggest validity across any of the dimensions outlined in the Guidelines for Making Changes to DSM-V memo (i.e. antecedent, concurrent and predictive validators)?

No.

Acceptance of a disorder into the DSM-5 appendix should generally require

A. A broad consensus of expert clinical opinion supporting the proposal and

broad consensus exists both in the US and abroad based upon inclusion of a similar diagnosis in the ICD.

There is no such diagnosis yet in the ICD and there is no published report of a poll of US clinicians. Numerous clinicians working in the United States and in Asia have approached the workgroup with requests that “Internet Addiction” be included in DSM-

There have been sessions at APA meetings on the subject and over 200 published articles. The workgroup considered all of these facts and decided that further research was needed and that Section 3 would be the most appropriate place for this potential diagnosis.

B. At least one of the following two criteria:

i. The arguments for the potential clinical need that will be addressed by
the category are compelling.

This is a compelling clinical need as the diagnosis is already in use by psychiatrists specializing in behavioral addictions. Unfortunately we do not have data on the number of patients in treatment, but in China there are specialized hospitals and residential programs for this disorder and they are reportedly full of young men.

ii. Sufficient validity data exists to suggest that with additional research,
this diagnosis would likely make criteria for inclusion in the main diagnostic manual.

This is very likely given the number of clinical researchers now conducting studies. Several brain imaging papers have been published showing a similarity in brain responses to those seen in drug addictions, but more research is clearly needed.

References


From: Substance-Related Disorders Work Group

To: The Scientific Review Committee

DATE: August 15, 2012

RE: SRC Memo (#28) Internet Gaming Disorder

We have decided to agree to all of the SRC recommendations. We were reluctant to be more specific originally because the literature is so variable. We can be conservative as the SRC suggests because future research will have to decide the correct threshold. Five is as good as any at this stage of development so we have revised the criteria as suggested. We have also added a distress criterion. Age as defined in the literature and cases that we have interviewed depends on age of access to internet. Most cases are in adolescent males within a year of discovering the internet games. Some cases have occurred in males and females in their 20’s and 30’s. Thus the data do not permit any rigid age criteria.

The source of the proposed criteria (Ran Tao et al 2010) is shown in the paragraph just before the criteria list and it has been added a second time to the list itself. A tenth criterion on stress was added to the published criteria at the suggestion of SRC.
B. Non-Substance Related Disorders

Gambling Disorder is currently the only behavioral disorder proposed for inclusion among the substance use disorders in DSM 5. There are other behavioral disorders that show some similarities to Substance Use Disorders and for which the word addiction is commonly used in non-medical settings. Disorders that have been suggested by both professional and non-professional members of the public include, but are not limited to Internet gaming, sex, work, running and food. Sex and food are addressed in other sections of the DSM. The only condition for which there was a considerable literature was the compulsive playing of Internet games. Internet use has been reportedly defined as an “addiction” by the Chinese government (http://www.wired.com/magazine/2010/01/ff_internetaddiction/all/1) and a treatment system involving hospitals and camps has been set up. Reports of treatment of this condition have appeared in medical journals, mostly describing studies from Asian countries.

The DSM5 work group reviewed over 240 articles and found some behavioral similarities to gambling disorder and to substance use disorders. The literature suffers, however, from lack of a standard definition from which to derive prevalence data and follow-up data on long-term treatment results and natural history of cases. The papers do describe many underlying similarities to substance addictions including aspects of tolerance, withdrawal, repeated unsuccessful attempts to cut back or quit, and impairment in normal functioning. A strong tendency to relapse after treatment has also been recorded. A sub-committee of the work group reviewed all potential behavioral addictions and decided that while internet use did not qualify for listing in the DSM as a disorder at this time, the rising prevalence rates, both in Asian countries and to a lesser extent in the West, justified its inclusion in Section 3 of DSM-5.

The working group believes that this condition has growing public health importance and that additional research may eventually lead to evidence that Internet Gaming Disorder (also commonly referred to as Internet Use Disorder, Internet Addiction, or Gaming Addiction) has merit as an independent disorder. As with Gambling Disorder, there should be epidemiological studies to determine prevalence, clinical course, possible genetic influence, and potential biological factors such as brain imaging data. A description of the behaviors related to this condition commonly called “Internet Addiction” taken from a study in China follows. (Ran Tao et al 2010)

Internet Gaming Disorder

Internet Gaming Disorder (proposed in place of Internet Addiction to be consistent with terminology for substance use) (after Ran Tao et al 2010) Five or more of these symptoms are suggested as the threshold, but the threshold may change depending on the results of future studies.

Proposed Diagnostic Criteria:
1) Preoccupation with the Internet gaming;
2) “Withdrawal” symptoms when Internet gaming is taken away; (these symptoms are typically described as irritability, anxiety, sadness, but no physical signs of pharmacological withdrawal)
3) Tolerance: the need to spend increasing amounts of time engaged in Internet gaming;
4) Unsuccessful attempts to control Internet gaming;
5) Continued excessive Internet gaming despite knowledge of negative psychosocial problems;
6) Loss of interests, previous hobbies, and entertainment as a result of, and with the exception of internet gaming;
7) Use of Internet gaming to escape or relieve a dysphoric mood;
8) Has deceived family members, therapists, or others regarding the amount of Internet gaming
9) Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of Internet use
10) Continued Internet gaming despite strong efforts by family to restrict time spent on the computer and significant family stress

Diagnostic Criteria

Internet Gaming Disorder is a pattern of excessive and prolonged Internet gaming that results in a cluster of cognitive and behavioral symptoms, including progressive loss of control over gaming, tolerance, and withdrawal symptoms, analogous to the symptoms of Substance Use Disorders. Similar to Substance-Related Disorders, individuals with Internet Gaming Disorder continue to sit at a computer and engage in gaming activities despite neglect of other activities and in spite of family stress caused by conflicts with parents over Internet use. Those afflicted typically devote 8-10 hours or more per day to this activity and at least 30 hours per week. If they are prevented from using a computer and returning to the game, they become agitated and angry as though they are in withdrawal from a drug. They often go for long periods without food or sleep. Normal obligations such as school or work or family obligations are neglected. This condition is separate from Gambling Disorder using the Internet because money is not at risk.

Diagnostic Features

The essential feature of Internet Gaming Disorder is the daily participation in computer gaming, often group games such as “World of Warcraft” for many hours, typically at least 8-10 hours per day. Attempts to direct the individual towards schoolwork or interpersonal activities are strongly resisted with significant familial stress. Thus personal, family or vocational pursuits are neglected. When asked, the major reasons given for using the computer are more likely to be “avoiding boredom” rather than communicating or searching for information. The literature varies on the amount of engagement in Internet social networks.

Prevalence

The published literature varies a great deal in diagnostic criteria and questionnaires used to diagnose Internet Gaming Disorder so there are no definite figures. The afflicted individuals tend to be male adolescents, 12-20 years of age and there is an abundance of reports from Asian countries, especially China and South Korea. Some authors have proposed the possibility of a genetic pre-disposition, but no actual data have been published. The medical literature from Europe and North America is relatively sparse and the prevalence estimates are quite variable. One published study on prevalence (Fu et al 2010) defined the disorder by symptom count (five or more). The point prevalence in adolescents (15-19 years) was 8.4% for males and 4.5% for
females. Age of onset typically is during adolescence, but it varies according to the age of first Internet access. The compulsive gaming behavior tends to crowd out normal social, scholastic and family activities. Those in a student status show declining grades and eventually failure in school.

**Associated Features Supporting Diagnosis**

No consistent personality types have been identified. Some authors describe associated diagnoses such as Depressive Disorders, ADHD or Obsessive-Compulsive Disorder.

**Subtypes**

There are no subtypes well researched to date. Internet Gaming Disorder most often involves specific Internet games, but it could involve non-Internet computerized games as well. It is likely that preferred games will vary over time as new games are developed and popularized, and it is unclear if behaviors and consequence associated with Internet Gaming Disorder vary by game type. Some authors separate patients according to the type of Internet activity such as sex (see hypersexual disorder), video games or gambling (which may qualify for a separate diagnosis of Gambling Disorder).

**Severity specifiers (mild, moderate, severe)**

Internet Gaming Disorder can be mild, moderate or severe depending on the degree of disruption of normal activities. Individuals with less severe Internet Gaming Disorder may exhibit fewer symptoms and less disruption of their lives. Those with severe Internet Gaming Disorder will have more hours spent on the computer and more severe loss of human relationships or career or school opportunities due to Internet gaming.

**Course specifiers (episodic vs. chronic)**

Little is known about clinical course because longitudinal studies are lacking.

**Descriptive feature specifiers**—not applicable

**Risk Factors**

Obviously, computer availability with Internet connection and without parental control are required conditions. Adolescent males seem to have greatest risk, and it has been speculated that Asian environment and/or genetic background are risk factors, but data are lacking.

**Associated Laboratory Findings**

Several groups have published brain-imaging studies of patients with compulsive Internet gaming. (Du et al 2011; Kim et al, 2011) These studies have demonstrated brain activation in specific regions triggered by exposure to the Internet game but not limited to reward system structures.

**Prevalence**

The point prevalence rate of Internet Gaming Disorder varies widely due to varying diagnostic standards. The prevalence seems highest in Asian countries.

**Course Modifiers**—not well enough established to comment upon.
Functional Consequences

Internet Gaming Disorder may lead to school failure, job loss or marriage failure. In at least one case, a couple in South Korea who were compulsive computer users allowed their baby to die of neglect while they were intensely occupied with a virtual baby in a computer game.

Differential Diagnosis

Excessive use of the Internet not involving playing online games (excessive use of Facebook, viewing pornography online, etc.) is not considered analogous to Gaming Disorder, and future research on other excessive uses of the Internet would need to follow similar guidelines as suggested herein. Excessive gambling online may qualify for a separate diagnosis of Gambling Disorder.

No differential diagnosis has been proposed because in most cases the diagnosis is very clear.

Associated Comorbidity

General Medical Conditions

Health may be neglected due to compulsive gaming.

Psychiatric Conditions

The literature contains descriptions of other diagnoses apparently associated with Internet Gaming Disorder. These include Depression, Obsessive-Compulsive disorder and ADHD.

Suggested lines of research required for inclusion with the main group of disorders

1. A consensus in the field is needed to define the characteristics of the disorder. This consensus must be international such that investigators in all countries are measuring the illness in the same manner by the same definition across countries.

2. The distinguishing characteristics of Internet Gaming Disorder need resolution. Research is needed to establish how it differs from other mental disorders.

3. The course of Internet Gaming Disorder needs to be better defined. Studies are required to determine what is its natural trajectory without intervention (and possibly how its course varies with some form of treatment). Evaluating the natural course of the disorder requires large-scale longitudinal study. Do the majority of adolescents or young adults outgrow it as they mature? Can it be viewed as a phase in adolescence or is it a chronic disorder?

4. After a consensus on how to measure it occurs, there needs to be careful prevalence surveys in the general population of both adolescents and adults in different countries. With the exception of convenience samples, very few studies to date have included adults. The available cross-cultural data on prevalence rates are very discrepant. For example, there are very low rates in US and many European countries when it was fairly strictly defined vs. higher rates in Asian countries, with varying definitions of the disorder.

5. Of course, biomarkers for any mental disorder would be ideal. There have been a few studies of brain imaging showing abnormalities of microstructure and activation of brain reward pathways in response to Internet game cues. These studies should be replicated.
6. A few studies of naltrexone treatment of Internet Gaming Disorder have been published, but the sample sizes are generally small, and the studies suffer from methodological concerns, including lack of adequate control conditions. This work should be repeated with properly designed trials in patients carefully assessed at baseline, during, and after treatment and throughout long-term follow-up periods.

7. A potential genetic influence should be studied by conducting family studies and twin studies.

References


Widyanto L, Griffiths MD, Brunsden V. A psychometric comparison of the Internet Addiction Test, the Internet-Related Problem Scale, and self-diagnosis. Cyberpsychol Behav Soc Netw 2011; 14(3): 141-9


Internet Addiction or Excessive Internet Use

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Background: Problematic Internet addiction or excessive Internet use is characterized by excessive or poorly controlled preoccupations, urges, or behaviors regarding computer use and Internet access that lead to impairment or distress. Currently, there is no recognition of internet addiction within the spectrum of addictive disorders and, therefore, no corresponding diagnosis. It has, however, been proposed for inclusion in the next version of the Diagnostic and Statistical Manual of Mental Disorder (DSM). Objective: To review the literature on Internet addiction over the topics of diagnosis, phenomenology, epidemiology, and treatment. Methods: Review of published literature between 2000–2009 in Medline and PubMed using the term “internet addiction.” Results: Surveys in the United States and Europe have indicated prevalence rate between 1.5% and 8.2%, although the diagnostic criteria and assessment questionnaires used for diagnosis vary between countries. Cross-sectional studies on samples of patients report high comorbidity of Internet addiction with psychiatric disorders, especially addictive disorders (including depression), anxiety disorders (generalized anxiety disorder, social anxiety disorder), and attention deficit hyperactivity disorder (ADHD). Several factors are predictive of problematic Internet use, including personality traits, parenting and familial factors, alcohol use, and social anxiety. Conclusions and Scientific Significance: Although Internet-addicted individuals have difficulty suppressing their excessive online behaviors in real life, little is known about the pathophysiological and cognitive mechanisms responsible for Internet addiction. Due to the lack of methodologically adequate research, it is currently impossible to recommend any evidence-based treatment of Internet addiction.

Keywords Behavioral addiction, excessive Internet use, Internet addiction

INTRODUCTION

Problem Definition

Problematic Internet use, or addiction, is characterized by excessive or poorly controlled preoccupations, urges or behaviors regarding Internet use that lead to impairment or distress. The condition has attracted increasing attention in the popular media and among researchers, and this attention has paralleled the growth in computer use and Internet access (1). Phenomenologically, there appear to be at least three subtypes: excessive gaming, sexual preoccupations (cybersx), and e-mail/text messaging. Addicts may use the Internet for extended periods, isolating themselves from other forms of social contact, and focus almost entirely on the Internet rather than broader life events. In a sample of Italian adolescents, 36.7% showed signs of problematic Internet use. They used the Internet for many hours per week, mostly utilized dysfunctional coping strategies and showed worse interpersonal relations than peers who do not show signs of problematic Internet use (2). Others have suggested that Internet addiction can be explained by a need to escape from oneself and that may account for the excessive playing of Internet games (3).

There is considerable controversy with respect to diagnosis of Internet addiction and whether it ought to be included as a diagnosis entity in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM V). Several impulse control disorders have been suggested to have similarities to substance addictions. These include pathological gambling and kleptomania. Computer/video game playing and Internet addiction have also been considered for inclusion in the forthcoming DSM V. This article reviews the evidence for similarities between Internet addiction and substance use disorders, their distinction from obsessive compulsive disorder, and identifies areas of uncertainty warranting future research. There are three different models proposed for Internet addiction (4). Some researchers have considered the impulse-control disorders as part of the obsessive-compulsive disorder spectrum a model. This model is supported by brain-imaging and pharmacological treatment studies with Selective Serotonin Reuptake Inhibitors (SSRIs) (although other treatments and brain-imaging studies may challenge it). Secondly, the DSM V task force has decided to create a separate category of compulsive Internet usage disorder from the nonspecified impulse-control disorder (ICD-NOS). Thirdly, some psychiatrists have argued that Internet addiction should be included in the behavioral...
addiction spectrum, since it shows the features of excessive use despite adverse consequences, withdrawal phenomena, and tolerance that characterize many substance use disorders; however, there are little data bearing on these claims. It is not clear whether Internet addiction usually represents a manifestation of an underlying disorder, or is truly a discrete disease entity. The frequent appearance of Internet addiction in the context of numerous comorbid conditions raises complex questions of causality. It has been argued (5) that, based on the limited available data regarding course, prognosis, temporal stability, and response to treatment, it appears premature to consider Internet addiction as a discrete disease entity. However, growing research suggests that some individuals with Internet addiction are at significant risk and merit professional care and treatment. Carefully controlled studies are required to settle these controversies. This review searched articles published between 2000 and 2009 in Medline and PubMed, using the key word “Internet addiction” over the topics of diagnosis, phenomenology, epidemiology, and treatment.

DIAGNOSIS AND PREVALENCE

The diagnosis of Internet addiction (dependence) remains problematic. It does not appear in any official diagnostic system, including DSM-IV, and there are no widely accepted diagnostic criteria. Four components have been suggested as essential to the diagnosis (6): 1) excessive Internet use, often associated with a loss of sense of time or a neglect of basic drives, 2) withdrawal, including feelings of anger, tension, and/or depression when the computer is inaccessible, 3) tolerance, including the need for better computer equipment, more software, or more hours of use, and 4) adverse consequences, including arguments, lying, poor school or vocational achievement, social isolation, and fatigue.

There are currently no diagnostic instruments for Internet addiction that show adequate reliability and validity across countries. A recent systematic analysis of the various diagnostic instruments found that previous studies utilized inconsistent criteria to define Internet addicts, applied recruiting methods that may cause serious sampling bias, and examined data using primarily exploratory rather than confirmatory data analysis techniques to investigate the degree of association rather than causal relationships among variables (7). Thus, prevalence data on pathological Internet use are limited by methodological difficulties concerning the diagnosis and the heterogeneity of diagnostic instruments. This makes it difficult to compare prevalence rates across countries.

The questionnaires for diagnosis of Internet addiction have used items from substance dependence questionnaires, as well as new items related to Internet addiction. The most commonly used questionnaire is Young’s Internet Addiction Scale (IAT) (cut off point score 70 and above), which has been validated in the United Kingdom (8), the United States (9), Finland (10), and Korea (11). The Chen Internet Addiction Scale (CIAS) has been widely used in Taiwan (12, 13). The Questionnaire of Experiences Related to Internet has been validated in Spain (14), the Compulsive Internet Use Scale (CIUS) in Holland (15), and the Problematic Internet Use Questionnaire (PIUQ) in Hungary (16). The assessment methods have been reviewed by Beard (17). The IAT was developed to help Internet addicts, those who are not sure if they are Internet addicted, and those who believe that they know someone who is pathologically using the Internet. The PIUS has the advantage of having 7 subscales of Internet addiction that were correlated with psychosocial health variables including: depression, loneliness, shyness, and self-esteem. These instruments are based on different theoretical underpinnings and do not agree on the underlying dimensions that make up problematic Internet use. Another criticism is that some items do not relate to addiction. There are also general concerns related to using self-reports, having dishonest answers, participants may not understand various questions or misinterpret the various test items. Additionally, there is also a problem of selection bias with the participant pool obtained from Web sites or undergraduate courses and no adequate control group. The use of a Web page may influence how people responded as well as the number of valid responses obtained. Finally, a person may show addictive behaviors toward one application, but not others.

International prevalence rates for Internet addiction using questionnaires such as the IAT range from 1.5% to 8.2% (18). In the United States, an online survey of 17,251 responders to a joint project with ABC-NEWS.com found that 6% of those surveyed met the criteria for Internet addiction (19). A recent random telephone survey of the general U.S. population reported an estimate of .3–.7% (1). A study of Southern U.S. university students found that about a quarter met criteria for Internet dependence (20).

In Germany, an estimated 1.5 million people, i.e., 3% of the German population is believed to be at risk of Internet addiction (21). The rate of problematic Internet use in Italian adolescents was 5.4% (22). The prevalence of borderline Internet use in Greek adolescents was 12.8%, while 10.4% of male excessive Internet users reported addictive Internet use (23). Using the Pathological Internet Use (PIU) scale in British students, 18.3% were considered to be pathological Internet users (24).

Internet addiction has been most studied in the Far East. A Chinese study using the IAT scale found that, among respondents aged 13 to 18 years, 10.2% used the Internet moderately and .6% was severely addicted (25). Prevalence rates of Internet addiction range from 6.44% in Shaanxi Province in China (26) to between 2.4% and 5.52% in Hunan province in China (27, 28). Among Taiwanese university freshmen, 17.9% were addicted to the Internet (29). Among Korean middle school students, 16% were potential at-risk users and 3.1% were high-risk users (30). Other studies in Korea have found 4.3% (31), 10.7% (32), 20.3% (33), 1.6% (34), and 3.5% (35) of adolescents diagnosed with Internet addiction. The main difficulty with these studies is that they use vague terms to describe levels of Internet use, such as “borderline,” “excessive,” “at risk,” and “addictive,” which are not operationally defined or clinically validated. The prevalence
rates of Internet addiction have been examined elsewhere (12, 36).

COMORBIDITY

Cross-sectional studies on samples of patients report high comorbidity of Internet addiction with psychiatric disorders, such as affective disorders, anxiety disorders (including generalized anxiety disorder, social anxiety disorder), and attention deficit hyperactivity disorder (ADHD). It has been suggested (37) that the relationship between loneliness and preference for online social interaction is spurious and that social anxiety is the confounding variable.

German Internet-dependent students had a 78% rate of comorbid depressive mood disorder and higher rates of impulsivity and depression (38). A higher percentage of anxiety disorder was found in a group of problematic Internet users compared with nonproblematic users of the Internet (39). Comorbidity with hypomania, dysthymia, obsessive compulsive personality disorder, borderline personality disorder, and avoidant personality disorder was found in U.S. adolescents (9). A combination of alexithymia, dissociative experiences, low self-esteem, and impulse dysregulation were suggested as risk factors for Internet addiction in a sample of Italian adolescents (40). Male students in Finland had higher mean score on the IAT than women and subjects with cannabis use had higher mean score on the IAT compared to non-users (10). There was a significant association between Internet addiction and depressive symptoms in South Korean adolescents (33), along with high levels of depression and suicidal ideation (34).

Adolescents with Internet addiction had higher ADHD symptoms, depression, social phobia, and hostility in Taiwan (41). Higher ADHD symptoms, depression, and hostility are associated with Internet addiction in male adolescents, and only higher ADHD symptoms and depression are associated with Internet addiction in female students. Internet addiction and impulsivity were associated with adult ADHD, and the association between attention deficit and Internet addiction was more significant among female Taiwanese college students (42). Finally, an association was found between Internet addiction and harmful use of alcohol among Taiwanese students (43, 44). It is unknown whether Internet addiction and these comorbid disorders could be explained by shared risk factors or are best considered as secondary disorders.

NEUROBIOLOGY AND BRAIN IMAGING

Currently, there have been very few studies on the neurobiology of Internet addiction. There were reported studies on computer and videogame addiction (see Weinstein, elsewhere in this issue). Among the first brain imaging studies (13) has reported 10 participants with online gaming addiction who were presented with gaming pictures and the paired mosaic pictures while undergoing functional magnetic resonance imaging (fMRI) scanning. In the addicted group, right orbito-frontal cortex, right nucleus accumbens, bilateral anterior cingulate and medial frontal cortex, right dorsolateral prefrontal cortex, and right caudate nucleus were activated in contrast to the control group. The activation of the regions-of-interest (ROI) was positively correlated with self-reported gaming urge and recalling of gaming experience provoked by the pictures. The results demonstrated that the neural substrates of cue-induced gaming urge/craving in online gaming addiction was similar to that of the cue-induced craving in substance dependence. Thus, the results suggested that the gaming urge/craving in online gaming addiction and craving in substance dependence might share the same neurobiological mechanism.

GENETIC FACTORS

There is some evidence for genetic factors influencing Internet addiction. A Korean study (45) compared adolescents diagnosed with excessive Internet use with healthy control subjects on genetic polymorphisms of the serotonin transporter gene and with respect to novelty seeking and harm avoidance on Cloninger’s Tridimensional Personality Questionnaire (TPQ). They found that the excessive Internet users had higher frequencies of the long-arm allele (SS-5HTTLPR), greater harm avoidance, and higher Beck Depression Inventory scores. SS-5HTTLPR frequency was closely related to harm avoidance in excessive Internet users. This study suggested that subjects with excessive Internet use may have genetic and personality traits similar to depressed patients.

WHY DO PEOPLE BECOME ADDICTED TO THE INTERNET?

For addicted Internet users, their excessive behavior may serve as an (inadequate) stress coping strategy. A study of Internet-dependent children in Germany revealed patterns of watching television, communication, ability to concentrate in school lectures, and preferred strategies for coping with negative emotions that differed from other children (46).

The Internet may also be used as a forum for expanding social networks and, consequently, enhancing the chance of meaningful relationships, self-confidence, social abilities, and social support. Although those who primarily used the Internet for online chat believed that the Internet is psychologically beneficial to them, they also believed that frequent Internet users are lonely and that the Internet can be addictive. It is, therefore, argued that “chat” users who are socially fearful may be using the Internet as a form of low-risk social approach and an opportunity to rehearse social behavior and communication skills, which may help them improve interactions in face-to-face social environments (47).

Others have suggested that people with Internet dependence use the Internet as a coping mechanism against underlying psychological developmental issues; the fifth and sixth Eriksonian crises (identity, intimacy) were related to Internet dependence among Taiwanese college students (48). Students who were
Internet-dependent scored significantly lower on most measures that reflected successful resolution of these crises, and scored higher on the measures that reflected unsuccessful resolution of these crises (48).

Compulsive cybersex has become a significant component of Internet addiction for many men and women who have fallen prey to the accessibility, affordability, and anonymity of online sexual behaviors (49). Some patients develop problems with compulsive cybersex due to predisposition or accidental conditioning experiences, while other compulsive users have underlying trauma, depression, or addiction. Both men and women with cybersex problems exhibit maladaptive coping, conditioned behavior, dissociative reenactment of life trauma, courtship disorder, intimacy dysfunction, and addictive behavior (49). The problematic Internet use group showed higher scores in the Self-Directedness and Cooperativeness profiles and lower scores in the Novelty Seeking and Self-Transcendence profiles of the JTCI, compared with the nonproblematic Internet use group, after controlling for the ADHD symptoms.

These maladaptive coping mechanisms seem overlap with sexual addiction (see Thibaut elsewhere in this issue), but they are using the specific media of the Internet.

In the case of compulsive cybersex, the content of display, more specifically pornography, is a specific form of sexual computer-assisted behavioral addiction. Therapists report a growing number of patients addicted to this activity, a form of both Internet addiction and sexual addiction, with the standard problems associated with addictive behavior.

FACTORS PREDICTIVE OF PROBLEMATIC INTERNET USE

Several studies have examined the role of personality factors in excessive Internet use. Higher frequency of Internet use, lack of perseverance (an aspect of impulsivity), and online group membership significantly predicted problematic Internet use in Australian students (50). The personality dimension of psychoticism correlated positively with the constructs of harmonious and obsessive passion, and this was mediated by the tendency to express one’s true self on the Internet in Turkish adolescents (51). South Korean Internet-addicted adolescents had more interpersonal problems than healthy users (30). Personality factors such as high harm-avoidance (HA), novelty seeking (NS), reward dependence (RD), low self-directedness, and low cooperativeness were positively correlated with Internet addiction in two South Korean studies (33, 52). However, there was contradictory evidence of high Self-Directedness and Cooperativeness profiles together with low scores on the Novelty Seeking and Self-Transcendence scales in another South Korean study (53). Internet addiction was positively associated with social anxiety and discontent with peer interactions (54), and with parenting attitudes, family communication, family cohesion, and family violence exposure (32).

In mainland China, potential risk factors for Internet addiction in adolescents were identified as being male, drinking behavior, family dissatisfaction, and experience of recent stressful events (25). Similar associations with adolescent Internet addiction were found in Taiwan, e.g., greater substance use experience, including friends or siblings with habitual alcohol drinking, low connectedness to school, high family conflict, low family function, perceived positive parental attitude towards adolescent substance use, and living in rural areas (12, 41). High NS, high HA, and low RD predicted a higher proportion of adolescents with Internet addiction, whereas high NS, low HA, and low RD predicted a higher proportion of adolescents with substance use (48).

COGNITIVE FACTORS ASSOCIATED WITH PROBLEMATIC INTERNET USE

Internet-addicted individuals may have difficulty suppressing their excessive online behaviors in real life. A study using the Iowa Gambling Task found that Internet-addicted individuals have deficits in decision-making function, chiefly a strategy learning lag rather than an inability to learn from task contingencies. They showed better performance on a Go/no-go task, suggesting some dissociation between mechanisms of decision-making and those of prepotent response inhibition (55).

A recent study has investigated the neurocognitive correlates of Internet addiction describing the characteristics of decision making (Iowa Gambling Task), potential to take risks (BART), and personality of college students with Internet addiction (56). The study has shown that the addicted students on the gambling task indicated better decision making, and performance on the BART indicated that they were not more likely to engage in risk-taking behaviors; and (d) TPQ scores showed lower reward dependence (RD) and higher novelty seeking (NS) for the addicts. Their higher performance on the Iowa gambling test differentiates the Internet addiction group from the substance use and pathologic gambling groups that have been shown to be deficient in decision making on the Iowa test.

PROSPECTIVE STUDIES ON OUTCOME OF INTERNET ADDICTION

Very little is known about factors associated with the outcome of Internet addiction. A prospective, population-based study evaluating the incidence and remission rates for Internet addiction and the associated predictive factors in Taiwanese adolescents found that the 1-year remission rate for Internet addiction was 49.5% (57). High exploratory excitability, low reward dependence, low self-esteem, low family function, and online game playing were associated with greater severity of the Internet addiction, while low hostility and low interpersonal sensitivity were associated with remission. A further two-year prospective study examined the predictive values of psychopathology for the occurrence of Internet addiction (58). Depression, ADHD, social phobia, and hostility were found to predict the occurrence of Internet addiction in the 2-year follow-up, and hostility and ADHD were the most significant predictors of Internet addiction in male and female adolescents.
respectively. Finally, a study examined the associations between aggressive behaviors and Internet addiction and online activities in adolescents (59). The results demonstrated that after controlling for the effects of shared associated factors and watching violent TV programs, adolescents with Internet addiction were more likely to have aggressive behaviors during the previous year. The association was more significant among adolescents in junior high schools than in senior high/vocational schools. Online chatting, adult sex Web viewing, online gaming, online gambling, and Bulletin Board System were all associated with aggressive behaviors.

HEALTH HAZARDS

The known health hazards associated with Internet addiction appear related to sleep deprivation or disturbance. A South Korean study of high school students with Internet addiction found a 37.7% prevalence of excessive day time sleepiness, whereas the prevalence in possible Internet addicts and non-addicts was 13.9% and 7.4%, respectively. The prevalence of insomnia, witnessed snoring, apnea, teeth grinding, and nightmares was also higher in Internet addicts compared with possible addicts and non-addicts (60).

INTERNET ADDICTION SUBJECTIVE EXPERIENCES AND DISABILITY

Prior research explores the addictive qualities sustaining drug and alcohol abuse, pathological gambling, and even video game addiction; however, given the relative newness of Internet addiction, little is understood about the habit-forming nature of the Internet and its potential for abuse. As the Internet permeates our lives at home, school, and work, the Internet can create marital-, academic-, and job-related problems (61–63). A study of a small sample of adult Italian Internet addicts showed that the disease was felt to be strongly disabling, especially for family life (9).

A close look to the subjective experience during the Internet use would be helpful for distinguishing between pathological cases from just problematic. The Italian study has shown that dissociative symptoms were prominent and strongly related with measures of IAD severity, subjective disability, and OCD symptoms.

TREATMENT

Treatment for Internet addiction is based on interventions and strategies used in the treatment of substance use disorders. Psychosocial approaches are the mainstay of treatment, with very little study of pharmacological treatment. Due to the lack of methodologically adequate research, it is currently impossible to recommend any evidence-based treatment of Internet addiction (18).

There is preliminary evidence for success of an “initiated abstinence” program in 12–15 year old pupils in Austria, Germany, and Italy (64), and for a counseling program in Hong Kong (65). Preliminary results from a study of 114 patients receiving cognitive behavior therapy indicated that most clients were able to manage their presenting complaints by the eighth session, and symptom management was sustained at 6-month follow-up (66). There are no evidence-based treatments for Internet addiction. Cognitive behavioral approaches and psychosocial support may be helpful. Marital and family therapy may help in selected cases, and online self-help books and tapes are available. Lastly, a self-imposed ban on computer use and Internet access may be necessary in some cases (67).

There are media reports that unlicensed training camps in China are used to “wean” children, often in their teens, from overuse of the Internet, which has resulted in the death of at least one youth (68). In November 2009, the Chinese government banned physical punishment to “wean” teens from the Internet (69). A residential treatment center for pathological Internet use (ReSTART) has recently been established in Seattle, WA, but no outcome results are yet available.

Given that there is comorbidity between Internet addiction and other psychiatric disorders such as OCD and ADHD, several studies have used pharmacological agents that are designed to address the common mechanism. Others have identified the comorbidity with ADHD as the rationale for using methylphenidate in children with Internet video game addiction together with ADHD (11). A pharmacological open-label treatment study using extended release methylphenidate (mean dose 30.5 ± 13.3 mg/d, range 18–54 mg/d), in 62 Korean children with Internet video game addiction and comorbid ADHD found that, after 8 weeks of treatment, measures of Internet use and Internet use duration were significantly reduced, and this improvement was positively correlated with improvement in measures of attention. These findings led the investigators to suggest that Internet video game playing might be a form of self-medication for children with ADHD.

Another study has identified the comorbidity of impulsive-compulsive Internet use with OCD to examine whether SSRIs such as Escitalopram can be useful for treatment of Internet addiction (71). A pharmacological open-label treatment study using Escitalopram (dose 10 mg/day) with impulsive-compulsive Internet users showed significant decrease in the number of hours spent on the Internet during the first phase of treatment (week 1–10) but not later. Further placebo-controlled double-blind studies are required.

DISCUSSION

Internet addiction, i.e., excessive use of the Internet with resulting adverse consequences, does not appear in any official diagnostic system, including DSM-IV. Block has argued that Internet addiction is a common disorder that merits inclusion in DSM-V (5). Conceptually, the diagnosis is a compulsive-impulsive spectrum disorder that involves online and/or offline computer usage. At least three subtypes have been identified: excessive gaming, sexual preoccupations, and
e-mail/text messaging. All of the variants share the following four components: 1) excessive use, often associated with a loss of sense of time or a neglect of basic drives, 2) withdrawal, including feelings of anger, tension, and/or depression when the computer is inaccessible, 3) tolerance, including the need for better computer equipment, more software, or more hours of use, and 4) adverse consequences, including arguments, lying, poor achievement, social isolation, and fatigue. Others have argued that Internet addiction is not a true addiction and may be no more than a symptom of other, existing disorders such as anxiety, depression, ADHD or impulse control disorders (70). Little data are available to resolve this question, and the pathophysiological mechanisms underlying Internet addiction remain unknown. This relative ignorance also extends to treatment. The few published treatment studies for Internet addiction are based on interventions and strategies used in the treatment of substance use disorders. Thus, it is impossible to recommend any evidence-based treatment of Internet addiction.

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Internet addiction
Neuroimaging findings

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The Internet has so radically changed the way we conduct our lives for a long time. However, maladaptive use of the internet has resulted in impairment of the individual’s psychological well-being and reduced work performance. While not yet officially codified within a psychopathological framework, Internet addiction disorder (IAD) is growing both in prevalence and within the public consciousness as a potentially problematic condition with many parallels to existing recognized disorders. Neuroimaging is a noninvasive way to reveal altered regional cerebral activity and structural changes. As there has been a recent rise in IAD, here, we review some of the neuroimaging IAD studies and discuss these findings.

Recently, Internet addiction disorder (IAD) or Problematic Internet use1 7 has attracted research interests across the whole world. IAD appears to be a common disorder that merits inclusion in DSM-V8 and is usually defined as the inability of an individual to control his/her use of the Internet, eventually causing psychological, social, and/or work difficulties.5 It is commonly associated with depression, anger problems and anxiety disorders.2,8 While not yet officially codified within a psychopathological framework,9 IAD is growing both in prevalence and within the public consciousness as a potentially problematic condition with many parallels to existing recognized disorders. Understanding the biological effects of IAD on the human brain may provide insight into the pathogenesis of IAD and treatment. Although there is much debate on the diagnostic definition of IAD, emerging neuroimaging studies had been performed around the world, especially in eastern Asian nations. Numerous neuroimaging studies had highlighted structural and functional abnormalities in individuals with IAD similar to other type of addictive disorders, such as substance addiction and behavioral addiction.8 10 19

PET Findings

Park et al. investigated the differences of regional cerebral glucose metabolism during resting state between young individuals with IAD and normal controls using 18F-fluorodeoxyglucose positron emission tomography (PET) study.14 The imaging results showed that the IAD group had increased glucose metabolism in the right OFC, the left caudate nucleus, and the right insula and decreased metabolism in the bilateral postcentral gyrus, the left precentral gyrus, and the bilateral occipital regions compared with normal users. Subsequently, the same group had also examined the neurobiological alterations in individuals with IAD of the dopaminergic neural system by assessing dopamine D2 receptor binding potential in men with and without IAD.20 Individuals with IAD showed reduced levels of dopamine D2 receptor availability in subdivisions of the striatum including the bilateral dorsal caudate and the right putamen. Furthermore, the significant inverse correlations between the severity of IAD and the dopamine D2 receptor availability in the left dorsal caudate, the bilateral dorsal putamen were observed. These regions implicated in impulse control, reward processing are frequently mentioned in behavioral addiction and drug addiction.21 24 Therefore, the authors suggested that IAD shares psychological and neural mechanisms with drug addiction.

EEG Findings

Dong et al.13 investigated response inhibition in people with IAD by recording event-related brain potentials during a Go/NoGo task and showed that the IAD group exhibited a lower NoGo-N2 amplitude, higher NoGo-P3 amplitude and longer NoGo task and showed that the IAD group exhibited a lower NoGo-N2 amplitude, higher NoGo-P3 amplitude and longer NoGo-P3 peak latency than the normal group. They suggested that the IAD subjects had lower activation in the conflict detection stage than the normal group; thus, they had to engage in more cognitive endeavors to complete the inhibition task in the late stage. In addition, the IAD subjects showed less efficiency in information processing and lower cognitive control.13 The same group also assessed the executive control ability by recording event-related potentials (ERP) during a color-word Stroop task.25 Behavior results showed that IAD students were associated with longer reaction time and more response errors in incongruent conditions than the control group. ERP result revealed that participants with IAD showed reduced medial frontal negativity (MFN) deflection in incongruent conditions than the control group. Both of the behavioral performance and ERP results indicated that people with IAD showed impaired executive control ability than the normal group.
MRI Findings

Functional. Craving had been defined as the accompanied emotional state or a strong desire that is produced by conditioned stimuli that are associated with the reward effects of substance or behavior.26 Craving has been regarded as the central phenomenon of substance use disorder and the underlying neural mechanism of the craving is critical to the treatment. The cue-reactivity has been employed to evaluate craving for IAD. Ko et al.19 identified the neural substrates of online gaming addiction via evaluation of the brain areas associated with the cue-induced gaming urge, which consisted of the right OFC, the right nucleus accumbens (NAc), the bilateral anterior cingulated cortex (ACC), the medial frontal cortex, the right dorsolateral prefrontal cortex (DLPFC), and the right caudate nucleus. Due to the similarity of the cue-induced craving in substance dependence, they suggested that the gaming urge/craving in online gaming addiction and craving in substance dependence might share the same neurobiological mechanisms.

The reward system is thought to play a crucial role in the development and maintenance of drug addiction and drug addicts often showed a deficient reward system.22,27 To investigate the reward and punishment processing in IAD, Dong et al. scanning the brain of the individuals with IAD and controls when they received a guessing task.28 The results showed that Internet addicts associated with increased activation in orbitofrontal cortex in gain trials and decreased anterior cingulate activation in loss trials than normal controls. The results suggested that Internet addicts have enhanced reward sensitivity and decreased loss sensitivity than normal comparisons.

Some researchers also detected resting-state abnormalities10 in IAD subjects and detected the increased regional homogeneity (ReHo) in the right cingulate gyrus, the bilateral parahippocampus and some other brain regions.

Structural. Voxel-based morphometry (VBM)29 is an automated method that allows the structural comparison of white and gray matter between patients and controls. Zhou et al.29 employed the VBM method and revealed the lower gray matter density in the left ACC, the left posterior cingulate cortex, the left insula and left lingual gyrus.23 This is the first study showing the brain structural changes in IAD adolescents and provides a new insight into the pathogenesis of IAD. However, they failed to detect the relationship between these structural changes and the duration of IAD. Therefore, more subjects and reliable controls were enrolled in our study,30 the results indicated atrophy within several clusters for the entire group of internet addicts, which were the bilateral DLPFC, the supplementary motor area (SMA), the cerebellum, OFC and the left rACC. Moreover, the atrophy of the right DLPFC, the left rACC and the right SMA was negatively correlated with the duration of IAD. These brain structural abnormalities of the individuals with IAD may be, at least in part, associated with cognitive control and goal-directed behavior dysfunctions in internet, which may explain fundamental symptoms of internet addiction.

Diffusion tensor imaging (DTI)31 is an MRI technique that allows visualization of the orientation and anisotropy of white matter. Because DTI can detect microstructural changes, it is thought to be more sensitive than conventional MRI techniques in identification of brain structural damage. Our results revealed enhanced fractional anisotropy (FA) values of the left posterior limb of the internal capsule (PLIC) in IAD subjects compared with healthy controls and reduced FA value in the white matter within the right parahippocampal gyrus (PHG). The abnormal FA value of the left PLIC may influence the sensory information transfer and processing, and finally lead to impairments in cognitive control. The lower FA value of the PHG in IAD subjects demonstrated that abnormal white matter properties maybe the structural basis of functional deficits of working memory in IAD subjects.

Conclusions

Neuroimaging studies have contributed significantly to our understanding of the effect of IAD on the brain and illustrate the broad range of brain regions involved. As outlined in this paper, the neuroimaging findings suggested that the IAD shared the similar neurobiological mechanisms of substance addiction and behavioral addiction. These noninvasive methods will play important roles in the investigation of neurobiological mechanism and adequate treatments of IAD and drug abuse. Longitudinal design and multiple imaging techniques with behavioral measurements should be necessary to improve our understanding of IAD.

References


Reduced Metabolism in Brain “Visual-Spatial Networks” following Game-Cues Exposure in Internet Gaming Addicts

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AUTHOR CONTRIBUTIONS:
T.R. and H.X. designed this study. L.C., F.H., Z.H and J.X. conducted this study;
S.Y. interpreted the data and wrote the manuscript, and L.H., S.Y. and Y.E. performed the data analysis;
The first two authors T.R. and S.Y. contributed equally to this paper.
Abstract

Objective: PET imaging has been employed to study cue-reactivity-induced neural correlates in the Internet gaming addiction (IGA) subjects.

Methods: Ten right-handed IGA subjects and 10 age-matched normal subjects participated in this study. Cue-reactivity paradigms were employed, while changes in $^{18}$F-FDG signals were acquired by PET scan for 2 times (Within 7 day's interval). The visual stimuli are “world of warcraft” (WOW) and scene movies, respectively. The PET datasets were analyzed with SPM8 software and repeated two-way ANOVA was employed for factorial analyses.

Results: Neural correlates of factorial interactions between cue-factor and subject-factor were identified in regions of left and right occipital cortex, left parietal cortex, temporal lobe, left precuneus, anterior cingulate cortex, prefrontal cortex and left and right cerebellum. The cue-reactivity paradigms significantly increased the activation of the reward system include amagdala, caudate in limbic lobe, anterior cingulate cortex, inferior prefrontal cortex, middle prefrontal cortex, and deactivated the neural activations in the visual-spatial networks (occipital cortex, parietal cortex) in IGA group. For the cue-factor comparing, the IGA group shows increased metabolism in occipital cortex, precuneus, and supramarginal gyrus and decreased responses in parietal cortex to game-cues.

Conclusion: It is suggested that the reduced metabolism in brain “visual-spatial networks” may standing for the impaired visual-spatial processes function in IGA subjects. The combine of enhanced brain activities
in the reward system and reduced metabolism of visual-spatial networks may characterize the IGA subjects addicted to the endless game playing.

**Keywords:** Internet gaming addiction; PET; Visual-spatial networks; Impulse
Introduction

Internet gaming addiction (IGA) is a newly identified condition associated with loss of control over endless online game playing, leading to negative psychosocial results (1,2). IGA is the main type of Internet addiction (IA) and accounting for 47.9% of the total number of the latter in China (3). IGA subjects are reported mainly in adolescent, and the prevalence is about 2.4~17.9% in East Asia (4, 5). In the virtual gaming world the IGA subjects could not hold them from game playing, result in not only great damage to the physical health, but also cause cognitive, emotional and social development problems(6). Increase in internet use and video-gaming contributes to public concern on pathological or obsessive play of video games among children and adolescents worldwide. Unfortunately, the neurobiological mechanism for IGA is still unclear.

IGA is similar to other addictive behaviors and it is not only solely a symptom of comorbid disorders. The research results showed that there are obvious abnormal structure and function of brain areas related to impulse control in IA addicts (7-11). The gray matter density of IA addicts was significantly lower in the prefrontal-parietal occipital areas related to impulse control, especially in the prefrontal cortex (7). Study of Diffusion Tensor Image (DTI) further confirmed the integration ability of white matter reduced in the areas of prefrontal-parietal and others brain areas (8, 11). In functional study, by using neuroimaging techniques, a set of neural correlates of cue-induced game urge in IGA have been identified (10, 12). From the fMRI studies, IGA
group shows increased activities in the right prefrontal cortex, right nucleus accumben, bi-anterior cingulated cortex, and medial prefrontal cortex, right dorsolateral prefrontal and right caudate nuclei (1, 12). The executive control and the information processing efficiency were significantly decreased in IA addicts, while the Regional Homogeneity (ReHo) was significantly increased in the frontal lobe (13, 14). The adolescents with IGA showed strong brain activation to the stimuli of Internet game materials. Among these brain areas the occipital lobe and the temporal lobe were associated with graphics exciting of Internet game (12). The parietal lobe (temporal-parietal-occipital association cortex) was associated with information processing and integration (12). The frontal cortex is the key brain area of impulse control, and plays an important role in attention, working memory, plan, decision and supervision (15). The cingulate gyrus, nucleus accumbens, prefrontal lobe, hippocampus and caudate nucleus may all make up the “reward system” of IGA involved in the IGA formation (12). These brain areas can be included in reward, memory, and executive control brain networks, and positive correlated with the game experience and memory, is considered to be the neurological basis for IGA. These studies prove that the substance and non-substance addiction may share the same neurobiology mechanism.

Although the previous neuroimaging studies have greatly increased our understanding of IGA brain functions as well as neuropsychiatric disorders such as addiction, there are also many questions remained to be resolved. Due to the difficult of pure IGA cases collection, scares of adequate controls
or other comparison groups (16, 17), and the majority of the previous studies on game cue only analyzed the main effects of cues (12, 16), it is difficult to tell the neurobiological differences of IGA from substance addition.

Current studies in Internet addiction imaging mainly focused on fMRI research, and there were only two research articles with PET study. From PET study Koo found IGA subjects showed visual-spatial adaptation in resting state and suggest IGA may have the abnormal visual information processing (18). Jeong and his colleagues investigated the difference of quantitative metabolism between IA and health control group using $^{18}$F-FDG PET imaging, and the results showed that after Internet gaming, both groups displayed increased metabolism in occipital lobe, while IA group showed higher metabolism than control groups in resting state, indicating that IA might lead to functional change in the developing brain of adolescent (19). Both PET studies indicated that the IGA may have visual-spatial abnormalities. Until now there is no PET study that focuses on those neural responses to factorial interactions between game cues and IGA subjects. In order to better understand the neural biological mechanism of IGA, and combined with the preliminary result of Koo YJ research (18), we put forward such assumption: there exists abnormal visual-spatial processing circuit in online game addicts.

One popular facet of Internet gaming is the “world of warcraft” (WOW). Some individuals spend so much time playing these games that it creates problems in their lives. In the present study, we use the $^{18}$F-FDG PET technology to analyze brain metabolism in the pure “WOW” game addicts.
only addicted to WOW game playing) with cue-induced paradigm. We will identify neural substrates in which the cue-induced neural activations are subject-dependent. Also, we will characterize the patterns of the neural responses in these brain regions.
Materials and Methods

Participating subjects

10 right-handed IGA subjects, all males, ages from 14 to 25 years (mean age of 19.5±3.2 years with 9±2 years education), who were inpatients at General Hospital of Beijing Military Region, including 6 cases of high school students and 4 cases of junior high school. And 10 age-matched generally healthy right-handed non-gaming playing male subjects ages from 16 to 26 (22.3±3.0 years with 9±2 years education) participated in this study including 7 cases of high school students and 3 cases of junior high school students. All subjects are non-smokers. The exclusion criteria for the IGA group were as follows: current or psychiatric diseases other than IGA; past or present history of neurological, cardiovascular, or endocrinological disease; history of head trauma leading to loss of consciousness >30 min; and current medical illness and dependence or abuse on any substance. In the IGA group, each subject met the Internet addiction diagnostic criteria of Tao Ran and diagnosed by two senior psychiatrists and all were addicted to the same online game (WOW) (20). The 10 normal control subjects did not have family history of IA also diagnosed by two senior psychiatrists. The experimental protocol was approved by the Beijing Institute of Basic Medical Science and the Beijing Military General Hospital. Individual written informed consent was obtained after the procedures had been fully explained.
Experiment design

The experiment employed $2 \times 2$ repeated measure ANOVA design. The game video used was specific to the WOW context and paraphernalia for 75 minutes. These films have been reviewed by several former and current WOW players to ensure authenticity. Based on feedback and repeated modification, these films were edited to have a consistent distribution of gaming-urge for more IGA addicts. A visual fixation point was present throughout the film. A neutral-cue video consisted of people performing physical exercise, sightseeing, touring scenic gardens and parks, and fishing. The order of the videos was randomized such that on the first scan, half of the subjects were shown the game-video whereas the other half were shown the neutral video.

PET Scans

All PET experiments were performed using a GE Discovery ST16 PET/CT scanner located at the Beijing Military General Hospital in Beijing. PET scans were conducted with a whole-body, high-resolution positron emission tomography using 18F-FDG, with purity above 95%. The changes in 18F-FDG signals were acquired by PET scan for 2 times (within 7 day's interval). On the day of scanning, the subject was asked to be empty stomach.

Videos were started 15 minutes prior to injection of 18F-FDG and continued for 30 minutes after 18F-FDG injection for a total video exposure of 20 minutes. A 20 minutes emission scan was started 35 minutes after
injection of 8-10 mCi of 18F-FDG.

The subjects were asked to lie on the PET/CT scanner. To minimize movement during scanning, the subject’s head was stabilized in a rigid, foam-lined head holder. The PET scan was collected after CT scan. First, the lowest inspection was performed to get CT imaging to minimize the radiation of the subjects. Then the PET image were collected with plane spacing, 3.27 mm; and interval 0 mm. Reconstruction was performed using filtered back projection with an automatically computed attenuation correction.

Data Analysis

The image processing and statistical analysis were conducted with SPM8 software package (http://www.fil.ion.ucl.ac.uk/spm/software/spm8). Two neutral scans were excluded from the analysis because of the technical problems in the data acquisition. The PET images for each subject were co-registered. The images were then spatially normalized using the PET template provided in SPM and subsequently smoothed with a 7 mm isotropic Gaussian kernel.

After the PET datasets were preprocessed, the metabolism values of individual subjects were laid out on a voxel-by-voxel basis. Based on the two-by-two factorial design, the analysis of the main effect and interaction were performed with two factors: A (cue type) and B (subject type). The factor A has two levels of neutral (A₁) and game-cues (A₂) and the factor B has two levels comprised of non-game player (B₁) and internet game addicts (B₂). The four factorial levels of A₁B₁, A₂B₁, A₁B₂, and A₂B₂ are the four
experimental conditions (two-by-two design).

We consider a repeated measures model, with mean observation vector

$$\mu^T = [\mu_{11}, \mu_{12}, \mu_{21}, \mu_{22}]^T,$$

Where $\mu_{11}$, $\mu_{12}$, $\mu_{21}$, and $\mu_{22}$ are the mean responses for the combinations of factor levels of $A_1B_1$, $A_2B_1$, $A_1B_2$, and $A_2B_2$. We are interested in determining whether there is an interaction between factors $A$ and $B$, which is tested by:

$$H_0: \mu_{21} - \mu_{11} = \mu_{22} - \mu_{12} \text{ vs. } Ha: \mu_{21} - \mu_{11} \neq \mu_{22} - \mu_{12}.$$

Or, equivalently:

$$H_0: \mu_{12} - \mu_{11} = \mu_{22} - \mu_{21} \text{ vs. } Ha: \mu_{12} - \mu_{11} \neq \mu_{22} - \mu_{21}.$$

To implement the factorial interactions test, a 2 by 2 factorial repeated analysis were performed to estimate for each contrast to find the difference between the cue-factor and the subject-factor. The test results were then threshold at $P < 0.005$ for activated regions, corrected for multiple comparisons (individual voxel threshold at $P < 0.03$, cluster size $> 10$ voxels).
Results

The results from the $2 \times 2$ factorial analysis showed that there was a significant factorial interaction effect between the cue-type factor and the subject-type factor in the regions of the left and right occipital cortex, the left parietal cortex, the precuneus cortex, the left and right temporal lobe, the left anterior cingulate cortex, the right inferior frontal gyrus, the middle frontal gyrus and the left and right cerebellum. The detailed activated position ($x$, $y$, $z$) in the Talairach space and activated brain volumes are listed in Table 1. These interactive regions are further presented in Figure 1.

Figures 2 and Figures 3 show the individual regions of the factorial interactions along with the regional neural activations at the four factorial levels of $A_1B_1$, $A_2B_1$, $A_1B_2$, and $A_2B_2$. The cue-reactivity paradigms significantly increased the activation of the reward system include amagdala, caudate in limbic lobe, anterior cingulate cortex, inferior prefrontal cortex, middle prefrontal cortex, and deactivated the neural activations in the visual-spatial networks (occipital cortex, parietal cortex) in IGA group (figure 2a, figure 2b). For the cue-factor comparing, the IGA group shows increased metabolism in occipital cortex, precuneus, and supramarginal gyrus and decreased responses in parietal cortex to game-cues (figure 3a). No significant brain activities were observed between cue-factor comparing in control groups (figure 3b).
Discussion

Excessive or addictive Internet use can be linked to different online activities, such as watching online pornography, online gambling and online gaming (21, 22). With the growing number of gamers worldwide, adverse effects (isolation, hospitalizations, excessive use, etc) are observed in a minority of gamers, which is a concern for society and for the scientific community (23). In the previous studies, although non-game players were recruited for study, no factorial interactions were reported (8, 19). One of the major findings in this study is the identification of the regions representing factorial interactions that indicate regional neural activations induced by game-cues linked with the IGA subjects. The cue-reactivity paradigms significantly increased the activation of the reward system include amagdala, caudate in limbic lobe, anterior cingulate cortex, inferior prefrontal cortex, middle prefrontal cortex, and deactivated the neural activations in the visual-spatial networks (occipital cortex, parietal cortex) in IGA group. For the cue-factor comparing, the IGA group shows increased metabolism in occipital cortex, preceneus, and supramarginal gyrus and decreased responses in parietal cortex to game-cues. The results indicated that there are abnormal of brain functional activities in IGA addicts, and suggested that the impulsive behaviors were involved with the abnormality.

Compared with the substance addiction research, one of the most striking findings of this study was the change of addict’s visual-spatial attention circuit. IA, especially IGA, is a kind of special non-substance
addiction, and its cue-induced crave was quite different from that of substance addiction. (1) For substance-addiction, addicts don’t need too much visual attention processing because the activated scene provided by cue is the related feeling of medicine administration. (2) For IGA, it needs more involvement of visual processing throughout the game, while the processing itself can be called visual experience and induces reward directly. In this study, for the IGA group compared with control group, the activity of parietal and occipital lobe decreased when watching game cues while that of occipital lobe decreased when watching scene cues. This declining metabolism in visual-spatial networks suggested that IGA addicts might have visual-spatial attention processing disorder.

For the IGA group, the main effect analysis found decreased parietal lobe activity as well as increased occipital lobe activity when watching game cues compared with scene cues. The parietal lobe’s activity and function are very complex. It is not only closely related to episodic memory processing but also working memory and visual-spatial attention processing (24, 25). In this study, IGA group showed decreased parietal lobe metabolism, whether for group or cue effect. Long-term visual fatigue and visual-spatial game operation both had seriously damaged the subject’s visual-spatial attention processing function. Koo once found this in his PET study on the rest state of IGA (18). But because there were very limited subjects, its result failed to get further attention. This study revealed decreased parietal lobe metabolism function of IGA using cue-induced paradigm, especially on the left side of the brain.
Besides, for the decreased parietal lobe activity, another possible explanation was that the subjects were not allowed to operate during the experiment process of cue-induced paradigm. This might cause inhibition of prefrontal cortex to motor cortex. When the cue was game scene, the addicts were used to operating, while the subjects were asked to keep still in the experiment task. Thus appeared decreased parietal lobe activity.

Although IGA group showed decreased parietal lobe activity when watching game comparing to scene, the activity of occipital lobe increased. Because the occipital lobe is the brain area in charge of visual attention, it indicated attention bias to game cues. Therefore, compared with natural cues, game cues can much more attract the IGA addict's attention. In sum, for different cues, IGA group still showed attention bias to games cues, but compared with normal group, the visual-spatial processing ability declined.

In natural and substance rewards, the relationships between crave of substance cue, relapse behavior and the activation of reward circuit have been proved by a large number of studies. Whether in drug taking or in drug craving, the reward circuit activation was found, representing that the functions change of reward circuit was an important reason of substance addiction. Through main effect analysis, the IGA group showed reward circuit activation comparing with control group, whether for game cues or scene cues. The activated brain areas of IGA group included bilateral caudate nucleus, anterior cingulate cortex and medial prefrontal cortex comparing with control group, but there were no such difference between game and scene
cue in control group. The main functions of the reward system are to evaluate information of cues and reward expectation value (26). According to Volkow’s theory, the addicts will compare the value of the stimulus with related cues in memory circuit, to create impulses to play game or not. When IGA received the video clues stimulation, a reward value will produced by comparing and evaluating the clues with the value in the memory system (27). The addicts will stimulate the value in the memory circuit. If the stimulus is stronger than the memory value, the brain reward system will amplified it and passed it to the execution system, result in the urge to decision whether to gaming. This result is similar to that of Koo study (18). The IGA subjects will activate the reward circuit for the processing of visual cues, always stimulate the pleasure response of the individuals.

In this study, cue-induced paradigm also found decreased activity of posterior cingulate cortex. The role of cingulate cortex may be associated with impulse control. Plenty of studies have demonstrated IGA addicts have impulse control disorder (1, 2, 4). The increased impulse induced by reward circuit can’t be successfully inhibited. It was found that cingulate cortex, prefrontal cortex and some were both activated when watching either cue in IGA group, through interaction analysis between cue and group factor. Moreover, there were differences in degree between game and scene cues, and the activation of game cue was stronger than scene cue. Previous studies also found the activation of cingulate cortex and prefrontal cortex through research paradigms such as Go/Nogo and cue-induced. This study
was in line with these above results. It suggested that there were changes of executive function in IGA addicts and the change of cingulated metabolism was related to impulse control disorder of IGA.

Some limitations of the present research should be noted. First, the sample size was small. It was difficult to collect IGA samples without comorbidity, especially addicted to only one certain kind of game. Although the sample was screened from 1,200 inpatients of Chinese Young Mental Growth Base, the sample size was relatively small as a research, therefore undermine the result generalization. Second, there might exist different kinds of neural mechanism corresponding to different kinds of game, but this study is only focused on subjects addicted to WOW. Finally, PET image represented the brain metabolism after watching game not real time state, due to drug injection. Despite the shortcomings mentioned this study has the advantage of good subject homogeneity, more real brain activation using video cues than picture cue, reflecting single factor influence and effectively remove other factor influence by using interaction analysis. This study observed brain metabolism of IGA addicts through the interaction analysis of PET image. The research suggested that the decreased metabolism of visual-spatial attention processing circuit of IAD addict might reflect visual-spatial attention processing disorder of the subject, and this kind of decreased metabolism combined with excessive activation of reward circuit might reflect the addiction feature of IGA addict’s endless gaming.
Reference


Figure 1. The brain regions activated from the factorial interactions on the "normalized metabolic images". Comparison correspond to IGA (Game-View)>Control (Game-View) for corrected threshold $p<0.03$ cluster> 10 voxels.
Figure 2. A. SPM results for the metabolic images for IGA vs control group to Game-cues. Comparison correspond to IGA group > Control group to Game-cues for uncorrected threshold $p<0.005$ cluster>10 voxels. The IGA group shows increased metabolism in caudate, amagdala, anterior cingulate cortex, prefrontal cortex, preceunus, temporal lobe and supramarginal gyrus and decreased responses in occipital cortex, parietal cortex, cingulate cortex to game-cues. B. SPM results for the metabolic images for IGA group vs Control group to Scene-cues. Comparison correspond to IGA group > Control group to Scene-cues for uncorrected threshold $p<0.001$ cluster>10 voxels. The IGA group shows increased metabolism in caudate, anterior cingulate cortex, prefrontal cortex, temporal lobe and supramarginal gyrus and decreased responses in occipital cortex, cingulate cortex to Scene-cues.
Figure 3. A. SPM results for the metabolic images for Game vs Scene-cues video conditions in the IGA group. Comparison correspond to Game > Scene-cues for corrected threshold $p<0.01$ cluster $>10$ voxels. The IGA group shows increased metabolism in occipital cortex, precuneus, and supramarginal gyrus and decreased responses in parietal cortex to game-cues. B. SPM results for the metabolic images for Game vs Scene-cues video conditions in the Control group. Comparison correspond to Game > Scene-cues for corrected threshold $p<0.01$ cluster $>10$ voxels. There were no regions where metabolism was higher during the game-cues than the Scene conditions.
Table 1  the brain areas activated by the factorial interaction between cue-factor and subject-factor, \( p = 0.03 \)

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Table 2  the metabolism differences to game-cues between IGA group and control group,  $p = 0.005$

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Table 3 the metabolism differences to game-cues between IGA group and control group, $p = 0.001$

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