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Internet-video Gaming: Symptoms, Epidemiology, Neurophysiology and Interventional Aspects

Trevor Archer[1*] **and Kerstin Wentz**[1,2]

[1]*Department of Psychology, University of Gothenburg, Box 500, 405 30 Gothenburg, Sweden*

[2]*Department of Occupational and Environmental Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Box 414, 405 30, Gothenburg, Sweden*

[*]**Corresponding author:** Trevor Archer, Department of Psychology, University of Gothenburg, Box 500, 405 30 Gothenburg, Sweden, Tel: +46 738 239423; E-mail: trevor.archer@psy.gu.se

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Abstract

Excessive perseverance with video-internet game usage, or alternatively Internet Gaming Disorder, presents a condition that, despite the potential utility of the underlying technology, augurs an assemblage of poor health and well-being, psychiatric liability and psychosocial perturbation with concomitant regional brain disturbance accompanied by incremental and inexorable prerequisites for appropriate interventions and eventual prevention. The tendency within the pathological expressions of disorder is for vulnerability to reside among the young, e.g., adolescents, rather than the older adults, over gender. Symptom-profiles of the condition incorporate varied, all-consuming and protracted problems ranging from cognitive-affective dysfunctions to biopsychological abnormalities such as sleep disturbances and fatigue. Escalating prevalence and epidemiological entanglement describe a putative framework of loneliness, introversion, neuroticism and impulsivity interspersed with expressions of depression, anxiety, sensation seeking, anger, a singular lack of assertiveness and the hazardous indications of ADHD propensity. Neurophysiological, brain regional and biomarker modifications underlying disorder pathophysiology appear more-or-less attuned to the symptomatic expressions of both diagnosed patients and those found to use excessive gaming, unconstrained from age-level: child, adolescent or young adult. Interventional strategies have centred upon the distinction of individual symptom-profiles, the description of withdrawal symptoms and related tolerance and the administration of coping strategies and resourceful behaviors, as for example implied by the “Craving Behavioral intervention”.

Keywords: Internet-video gaming; Symptoms; Epidemiology; Adolescent; Neurophysiology; Brain regions; Modification; Biomarkers; Intervention; Age

Introduction

Worldwide health burdens in children, adolescents and young adults often circulate around psychological issues, propagating distress and ill-being [1-3]. This period of individuals’ lifespan is critical of the appropriate the psychological development of health and well-being, as opposed to lack of health and ill-being, may be at hazard through the advent of numerous issues, including health anxiety, low quality-of-life, long-term pathological and ill-defined physical conditions, impulsive behavior tendencies, addictive behaviors, violence and low academic performance [4,5]. The internet medium has been implicated as possible risk factor for breaching both psychological health and psychiatric preservation [6-8], despite problems with diagnostic in suitability [9]. The situation appertaining to the individual magnitude of Internet use has been found to be associated negatively with general psychological health yet more specifically with Web-based practices differing with regard to how persistently, how intensively, and the manner in which health and well-being are affected. The repercussions of Internet misuse/abuse, particularly in relation to sleep loss and withdrawal effects when Internet medium fails to be attained, have been observed to predict psychological health outcomes to a greater degree than the specific practices in themselves [10]. Alarmingly, the violence content of video games and electronic media in general available to be played has increased incrementally, rather than abating, with concurrent increments in hostile expectations regarding other individuals, a marked desensitization to the violence depicted in the games, reduced empathy, fluctuations in prosocial expression and aggressive thoughts and attitudes [11]. Thus, several health and developmental risks of excessive/unsuitable (violent, improper) exposures are readily available with distressful consequences for sleep, obesity, affective status, executive functioning, aggressiveness and other aspects of child development [12,13]. The impact of internet gaming disorder is far from negligible, in a Korean adult population it was shown to be virulently prevalent with a calamitous degree of co-morbid to other neuropsychiatric disorders and suicidal tendencies [14].

The presiding circumstance of video/internet gaming appears to be fraught with liabilities, from the viewpoint of a German study indicating that pathological internet usage (including gaming) has been confirmed be ‘on-the-rise’ among European adolescents [15], not least due to sleep disturbances and inadequacies arising in populations of younger individuals whose appropriate development relies upon the essential need for sufficient sleep patterns [16,17]. The notion of “screen time”, referring to length of time involved in video-internet gaming has been associated with impediments to normal cognitive-emotional development and risk-taking behaviors as well as being a marker for ill health [18-21]. Among secondary school pupils (N=13659, mean age=15.18 years), psychiatric problems and self-harm behavior were linked strongly to screen time exposure to video gaming

and television-watching [22,23]. Furthermore, the opposing notions of prosocial and antisocial contexts in violent game frameworks may affect outcomes with regard to aggression-reducing and aggression-enhancing expressions, respectively [24]. Adolescents, an at-risk population for the onrush of internet gaming pathodevelopmental susceptibility [25], appear especially vulnerable to a distinctive set of dysfunctional convictions leading to the persistent and disproportionate adherence to the activity, that involve (i) beliefs about reward value and discernment relating to gaming, (b) maladaptive and rigid attitudes regarding gaming behavior, (c) an over-reliance upon gaming expressions to satisfy need for self-esteem, and (d) the social acceptance expedient of gaming behavior. In sample of 824 school-attending adolescents (402 male and 422 female) levels of internet-gaming symptomatology, problematic Internet gaming cognition, and psychological distress were assessed [26]. They observed that Internet gaming disorder adolescents expressed more maladaptive gaming beliefs than non-gaming adolescents, including those who play Internet games for more than 30 h per week with large effect sizes. Even after controlling for measures of gaming activity and psychological distress, the marked association between gaming cognitions and Internet gaming disorder symptoms were maintained. Finally, it has been observed that among adult users, problematic Internet usage was associated with scores for emotion and avoidance coping responses whereas, among adolescents, higher usage was associated with higher levels of rumination syndrome, the effortless regurgitation of just-ingested food into the mouth followed commonly by expulsion, and sometimes by re-chewing and re-swallowing, and lower levels of self-care [27]. Rumination is seen in children and adolescents presenting developmental disabilities.

Prevalence and properties of internet-gaming

Despite its circumstantial aspect, the link between violent-action internet-gaming and expressions of violence/aggression among children/adolescent carry an element of supportive evidence [28,29]. Prevalence, ranging from 0.7% in some cases to 27.5% in others, tends to be higher among male individual rather than female individuals in the greater majority of studies and appears to be higher among younger rather than older individuals [30]. Generally, individuals partake in internet/video games in order to obtain enjoyment, seek challenges, to relax and relive stress and escape some of the realities of life, with general happiness the major factor [31]. Taking the different aspects of evidence together, there appears to be a consensus that violent media consumption, consisting of TV news, drama and action films and violent video games, are related positively with several parameters of poor developmental outcomes. Among adults, excessive internet-gaming, which incorporates several pathological features of attention-deficit hyperactive disorder (ADHD), may lead to a deterioration of professional performance, financial adventures and familial disharmony [32]. There appears to be a huge variability in internet gaming from approximately 3.3%– 9.9% [33,34] of internet game users succumb to the addictive behavior [35] with a prevalence of 1.16% among students [36]. Nevertheless, disorder prevalence subtends an alarmingly rise, for example in East Asia countries (5.9% in South Korea) compared to Europe or North America (0.3-1.0% in United States and 1.16% in Germany). In a Chinese study, the prevalence rate of internet addiction was 6.0% among teen internet users with school, interpersonal, and anxiety problems among the factors linked with a higher risk for internet addiction [37], whereby negative coping styles mediated the effects of stressful life events to increase the risk of addiction. The spectre of co-morbidity with several psychiatric conditions seems a tragic reality covering several aspects lifestyle disruption [38,39] of video/internet gaming: It has been observed that adolescents who have developed the habit of video play that exceeds one hour of console or Internet video games are liable to present a greater number of symptoms and/or more intensive symptoms of attention-deficit hyperactivity disorder or inattentiveness than those not presenting higher levels of video game indulgence [40] as well as contributing to the notion of a "time perspective" personality aspect thereby affecting social behavior, decision-making and attitudes [41,42]. Additionally, gender analyses imply that adult male participants through a progression of 'moral-disengagements' embrace stronger tendencies to acquiesce to the "bad-guy" role [43]. The disordered behaviors linked to gaming have been associated also with anhedonia and depressive states [44] and social anxiety [45]. In an investigation of age-related and proximal context-related variations in the anxiety-internet gaming disorder association, it was observed that (i) greater levels of anxiety were linked markedly with greater internet gaming-related behaviors, (ii) the strength of this relationship did not vary over time (between the ages of 16 and 18 years), and (iii) nevertheless, the relationship diminished amongst pupils within classrooms that scored higher on the trait extraversion [46].

Whether or not the personal profile tendencies towards psychopathological vulnerability to the constitution of addictive behaviors remains under investigation since "Internet Gaming Disorder" is classified under the term, "Condition for Further Study" according to the DSM-5 [47], with particular regard to the plethora of pathological co-morbidities [48,49]. Additionally, taking into account the presiding situation that more than 90% of children/juveniles indulge in video games, some sufficiency and necessity of comprehending the psychological mechanisms through which these games may modulate children's behaviors seems important for parents, research psychologists, teachers and pediatricians as well as for the design and application of preventative and interventional efforts to enhance or mitigate these effects. Media (video, TV, radio) violence exposure exerts detrimental effects upon psychological adjustment with outcomes not uncommonly expressing aggression-related attitudes and behaviors. Nevertheless, it has been argued that the premature inclusion of "Gaming disorder" in ICD-11 implies significant stigma to the millions of children and adolescents using video games within otherwise healthy, normal lives [50]. Diagnostic criteria for Internet Gaming Disorder involve the repetitive indulgence in internet-based games, with or without other players, that culminates in serious problems with daily functioning and assignments, whereby five of the following behaviors must be fulfilled: (i) preoccupation/obsession with internet games, (ii) withdrawal symptoms when not indulging in internet games, (iii) tolerance to gaming development whereby more-and-more time spent upon internet gaming, (iv) attempts to abolish internet-gaming result in failure, (v) a pervading loss of interest in leisure and other life activities, including sports and bobbies, and (vi) persistent over-use and over-indulgence of internet-gaming despite information regarding its negative impact. The notion of "Screen-time" is defined as the amount of time spent each day on activities related to video games, computers and television. In adolescent girls, screen-time was inversely related to psychological well-being although there is evidence too that computer-gaming affected positively the stress system and the perceptual-cognitive system. "Playing-time", a mediating variable, was shown to affect the strength of habitual regulation through exerting both positive and negative influences upon excessive and problematic use [51]. Among 6287 Spanish children it was observed that "screen time" was related to

a greater frequency of consumption of energy-dense, micronutrient-poor products and a lower frequency of consumption of fruit and vegetables [52]. Even when physical activity was controlled for, leisure time gaming was shown to be a risk factor for pronounced weight gain in the females, specifically, among young gamers [53]. In a relatively large sample of adolescents (N=380) presenting high levels of exposure to video games the relationship between problem video game playing and emotional welfare was assessed [54]. The authors obtained a clear-cut relationship between high game-playing exposure and anxiety and emotional distress among the male and female participants.

Epidemiological aspects of internet gaming

There exists a paucity of epidemiological consensus pertaining to personal factors contributing to internet-gaming disorder [55,56]. Furthermore, efforts to enhance validity and reliability across interventional approaches and derivation of useful and efficient treatment approaches for afflicted individual have taken several forms generally, that include: (i) types of treatment-seeker characteristics, (ii) utility psychopharmacotherapy, (iii) applications of psychological therapy; and (iv) certain selected derivations of various combined treatments [57]. Despite the need for further epidemiological studies, using hierarchical regression, it has been shown that demographic factors had explained between 11 and 12% of the variance in internet video/gaming adherence (addictive technology) whereas psychological health variables, on the other hand, explained between 7 and 15% of the variance [58]. It was observed also that correlations between symptoms of these gaming forms use and psychological disorder symptoms presented markedly positive relationships with a somewhat weak interrelationship between social media and video/internet gaming. Age was inversely related to the phenomenon whereas male gender was linked directly to abuse of video games (see above); female gender was associated markedly with addiction to social media whereas single status was associated positively both addictions, social networking and video/internet gaming. The risk factors for the disorder have been categorized according to three main themes: (i) afflicted individual's psychopathology and personal profile, (ii) factors linked to family, parenting attributes and parental stress and parent-child, adolescent relationships, and (iii) miscellaneous factors that include Internet usage, motivation and cognition, time perspective and academic performance [59-61]. Further, internet-gaming has been associated also with loneliness and lower life satisfaction [62], introversion, neuroticism and impulsivity [63-65], trauma and alexithymia [66] and physical aggressiveness among boys [67]. Encouragingly, the ever-increasing derivation and application of psychometric instruments for assessment of internet game addiction displays high levels of internal consistency and concordance with both related instruments and those reflecting the presence of affective conditions [68].

Epidemiological analyses of video/internet gaming make for rather disquieting disclosure: among male children the indulgence of playing more video games showed significantly greater odds of scoring borderline/abnormal points on conduct and emotional problems as an increment each additional hour of weekly usage [69]. There appears to be a strong relationship between symptoms of ADHD and liability for internet gaming and eventual addiction in young adults, e.g., university students, and adolescents [70-72]. Dalbudak et al. [73] categorised student participants into a high risk for Internet addiction group (11%) and a low risk for Internet addiction group (89%), noting that the mean age was lower in the former group concomitant with higher levels of depression, anxiety, sensation seeking, anger, lack of assertiveness and symptoms of ADHD scores being expressed by this group. Furthermore, hierarchical regression analysis indicated that severity of sensation-seeking and symptoms of ADHD, especially with regard to attention deficiency, predicted the internet gaming disorder and addiction. Both intuitively and observationally a case may be made for the involvement of impulsiveness and impulse control impairments in internet gaming disorder with accompanying cognitive deficits [74-76], not least in view of the impulsivity contribution to several addictive behaviors [77,78]. Severity of internet gaming disorder and addiction was shown to be related several instances of psychopathology emanating from impulse control impairments (attentional and motor), including obsessive-compulsive disorder and interpersonal sensitivity [79], as well as high levels of alexithymia, "difficulty in identifying feelings" and "difficulty in describing feelings" factors, depression and anxiety [80]. In the latter study (ibid), marked effects upon expressions of Temperament and Character responses were observed with higher levels of novelty-seeking accompanied by lower levels of self-directedness and cooperativeness associated with severity of internet gaming and addiction. Positive associations between internet gaming and addiction and trait neuroticism-anxiety and trait aggression-hostility of the Zuckerman-Kuhlman Personality Questionnaire have been established [81]. Using multiplayer Online Battle Arena internet game in a laboratory task environment, it was observed that excessive game involvement was related impaired ability to postpone rewards and self-reported traits of impulsiveness among male gamers aged between 18 and 24 years-of-age [82].

The dual notions of "cyberaddiction"/"cyberdependence", invariably occurring synonymously, refer to the problematic over-indulgence of video/internet gaming behavior, as well as other forms of 'internet-addiction', over the lifespan [83] with the consideration that not all observed problematic video or Internet game users present the above characteristics; under certain conditions, overindulgent persistence in gaming may offer one symptom among many others within the context of an adjustment/conduct disorder (i.e., presenting difficulties in the necessary adaption to a contexts/circumstances within an individual`s life situation). For present purposes, the focus of behavioral disorder revolves around the centrifugal hub of video and internet games. In general terms, two types of symptom-profiles have emerged: (i) a concatenation of irritability, acerbity, irascibility, impetuosity or nervousness or combinations thereof with concomitant behavioral (i.e. playing) termination that are reminiscent of the withdrawal symptoms observed with other addictive expressions [84], and (ii) tolerance symptoms, illustrated by the necessity for gaming behavior escalation so as to achieve previous levels of satisfaction although the definition and characterization of tolerance in internet gaming withstands all but complex formulations [85]. The presence of addictiveness is suspected when elements of compulsiveness (repetitive expression that permit avoidance/escape from negative emotions) and impulsiveness (loss of self-control in relation to gaming, lack of planning, unrestricted motor expression with negative consequences, etc.), accompanied by the emergence of withdrawal and tolerance symptoms [86]. The pre-existing co-morbidity pertaining to internet game disorder has been considered in relation to time-management, regional brain deficits and connectivity, impulse-control difficulties and/or psychosocial contingencies that in the related issues of generalized internet dependence involve lower levels of positive orientation, conscientiousness, emotional stability, and openness to experience, on the one hand, and extraversion and agreeableness on the other [87]. Co-morbidity for internet addiction is linked to high levels of psychosocial distress which bears a major relationship to symptoms of

depressiveness [88-90], as well as markedly higher frequencies of presenting personality disorders (29.6%) compared to those patients not presenting (9.3%) internet addiction [91].

Individuals presenting video/internet gaming co-morbidities develop both externalizing and internalizing pathologies whereby in a sample of 86 patients, consulted in the Addictive Behavior hospital Unit of a hospital that were assessed with diagnostic criteria for internet game disorder [92], 45,76% matched the internalizing profile, presenting co-morbidity with Mood Disorders (44,4%), with Anxiety Disorders (44,4%) and with Personality Disorders (11,1%); alternatively, externalizing profile comprised 52,54% of the sample presenting co-morbity with Disruptive Behavior Disorder (48,4%), ADHD symptoms (29%) and Disruptive Behavior Disorders that were not otherwise specified (22,6%). The former (internalizing profile) presented family histories identified of psychiatric problems (63%), persistent difficulties in social relationships (77,8%) and applied internet gaming behavior in order to escape/avoid psychological discomfort (66,7%) whereas the latter (externalizing profiles) displayed improvements as treatment interventions progressed. It has been shown also that adolescents, from the United Kingdom, playing video games with high levels of tobacco and alcohol content were more likely to have experimented with these drugs [93]. In a study of 87 young adult individuals diagnosed with Internet gaming disorder and 87 with an Internet gaming history, it was observed that the disorder was linked to ADHD symptoms accompanied by hostility and enhanced levels of impulsiveness that mediated the relationship between the two disorders [94]. Further, it was observed in a relatively large sample of 465 young adult Australian problematic internet gamers (84% men, mean age=26.2 years), whose gaming had developed over the preceding 12 months, displayed higher baseline scores on perfectionism, cognitive salience and regret with implications of maladaptive gaming-related cognitions [95]. Table 1 presents the different aspects of defective internet gaming as beacons of eventual risk behavior and ill-being.

Issues	Expressions	Representative studies
Prevalence/ properties	High but varying/Disharmony, dysregulation, broad co-morbidity, anxiety, altered 'time perspective'	[38,42,48]
Epidemiology	Lower psychological well-being, higher impulsiveness, alexithymia, addiction, 'internalizing-profiles'	[66,82,92]
Neuropsychology	D-type personality, high reactivity, functional connectivity-reward-default-executive network deficits, multiple regional involvement	[96-99]
Intervention	Symptom-focus, "Craving behavioral intervention", symptom-amelioration and regional alterations	[100-102]
	Interventional insufficiency and drawbacks:	[103]

Table 1: Issues, behavioral and neurophysiological expressions and interventions that affect outcomes in internet-gaming disorder.

From the perspective of preventional necessity the case for morbidity and co-morbidity cannot be overstated since internet-gaming is markedly and positively associated with suicide plans, even after controlling for neuropsychiatric disorders in addition to socio-demographic factors, such as nicotine use disorder, depressive disorder, and anxiety disorder [14]. Among epidemiological issues the prevalence of anxiety, which is elevated with elevations of the disorder and is relative constant among adolescents longitudinally, needs to be targeted as a point-of convergence in matters pertaining to prevention [46].

Psychophysiological and brain regional aspects of Internet gaming

Excessive video/internet gaming may evolve problematic features with outcomes emanating negative developments for daily living and functioning, such as the loss of control over gaming behaviors, the disruption of social and individual quality-of-life and the disharmony of planning capability accompanied by concomitant neurophysiological markers. In a study of variations in autonomic expressions and personality profiles associated with distress in adolescent Korean male participant with or without Internet gaming disorder diagnosis [96], it was found that most parameters for heart rate variability differed between the two groups. The former ('gaming') group showed higher levels of type D personality, both total and subscale scores, negative affect and social inhibition, with a high percentage (68%) being classified as type D personality. In turn, type D personality total scores, and excessive internet gaming, were linked to the logarithmic value of total power and low frequency of heart rate variability parameters. Heart rate variability, physiological phenomenon of variation in the time interval between heartbeats, is linked to respiratory rates is measured by the variation in the beat-to-beat interval; reductions in heart rate variability are related generally with deteriorations in health. Type D personality individuals display the propensity to experience negative emotions (negative affect) to a greater extent across time over different situations thereby tending not to share these emotions with others, due their fear of rejection and/or disapproval [104,105]. In a similar group of Korean adolescents, high-school pupils [106], it was observed that an extortionate level of Internet gaming over extended time induced reduced levels of peripheral adrenaline and noradrenaline therewith altering presiding autonomic regulation, and elevating chronically anxiety levels in the Internet gaming disorder diagnosed participant. It should be noted that, similar to pathological gambling, excessive internet gaming is associated with a reduction of loss-sensitivity; enhanced reactivity to gaming and gambling cues, respectively; enhanced impulse-based choice behavior and aberrant reward-based learning [107].

Several risk factors for pathological video/internet gaming are provided by emotional status, stress-vulnerability, self-regulation, impulsiveness and cognition as well as presumptions regarding to 'safety-havens', such as delay discounting, risk-taking propensity and social rejection sensitivity [108-113]. Peripheral nervous system activity, particularly vagal tone measured respiratory sinus arrhythmia and galvanic skin conductance [114,115], have been applied fruitfully

to assess psychophysiological changes linked to a range of psychosocial behaviors especially under conditions of neurodevelopmental adversity. Under normal conditions, high levels of resting vagal tone are linked to positive psychological health outcomes, and vice versa; high levels of GSC reactivity are associated with high anxiety and fear. Coyne et al. [116] have shown that high levels of GSC reactivity, physiological markers of stress and/or anxiety, and low vagal tone, were likely to express greater signs of pathological video/internet gaming, especially among girls. Resting state fMRI offers a useful method for analysis of intrinsic brain regional activity for several disorder conditions including internet gaming disorder [117,118], thereby elucidating differences in functional connectivity [97,99], default mode network [119], executive control network [98] and reward network [112,120]. Finally, it has been observed that excessive online gaming may lead to increased intra-hemisphere connectivity in the fronto-temporo-parieto-occipital regions [121]. In view of the severe psychological health hazard posed by video-internet gaming, at all ages but particularly in younger age-groups, the implications of the above differences assume greater significance in the consideration of interventional endeavors (see below).

Although the pathogenesis of internet gaming (with/without accompanying addiction) remains unclear, several studies, utilizing fMRI, have demonstrated that a number of brain regions are involved functionally, including right hemisphere orbitofrontal cortex and nucleus accumbens, bilateral anterior cingulate cortex, medial frontal cortex, and right hemisphere dorsolateral frontal cortex and caudate nucleus [122-125]. Using the Color-word Stroop test together with MR-imaging results it was observed that there was an increased cortical thickness in the left precentral cortex, the precuneus, middle frontal cortex, inferior temporal and middle temporal cortices during late adolescence with online gaming addiction, accompanied by decreased cortical thicknesses of the left lateral orbitofrontal cortex (OFC), insula, lingual gyrus, the right postcentral gyrus, entorhinal cortex and inferior parietal cortex [126,127]; these changes were concomitant with marked reductions in the functional connectivity interconnecting certain essential subcortical regions, including the dorsal striatum, pallidum, and thalamus, with several of these alterations being associated with the severity of the online gaming [128]. Furthermore, in comparison with healthy controls, also university students, matched for age and gender, in a task-state fMRI study, it was found that the internet gaming group displayed increased activation in the right superior parietal lobe, right insular lobe, right precuneus, right cingulate gyrus, right superior temporal gyrus and left brainstem [129]. These latter indications imply that the internet gaming diagnosis may have altered or be associated with several functional expressions that include: self-awareness, selective attentional processes pertaining to emotions, conscious information processing, sleep and the default-mode network and subjective happiness [130]. In a study comparing severity of internet gaming addiction disorder with plasma metabolites, a very strong and unique relationship between a co-linearly regressed set of plasma metabolites, including arabitol, myo-inositol, methionine, pyrrole-2-carboxylic acid, and aspartic acid, with the internet gaming addiction severity scale was obtained [131].

There appears to be a strong consensus that the experience of excessive internet gaming alters brain reactivity whereby gaming signals induce increases in the reactivity of selective brain regions: for example, in healthy individuals, 'gaming group', without gaming history an elevated reactivity was obtained, after several exposures, in the right ventrolateral prefrontal cortex that was correlated positively to the self-reported "desire-for-gaming" whereas conversely a linked drama group showed increased reactivity in the caudate, posterior cingulate and precuneus (see below) on presentation of drama cues [132]. Internet gaming disorder diagnosed individuals were compared with healthy controls, using fMRI, during the performance of an addiction Stroop task. The former group displayed showed greater activation, reactivity, during confrontation with Internet gaming-related stimuli in brain regions such as the inferior parietal lobule, the middle occipital gyrus and the dorsolateral prefrontal cortex that are implicated in selective attentional processes, visual processing, working memory and cognitive control [133]. In a systematic functional review comparing excessive internet gaming users (N=666) as opposed to healthy controls, it was found that the gamers were preponderantly male and young, even remarkably young displaying regional brain abnormalities that were selectively linked to the superior temporal gyrus, limbic, medial frontal and parietal regions with regard to resting state analyses; fMRI task-related analyses displayed a lower frequency of behavioral differences that were reported between excessive users and healthy controls; nevertheless, all these described marked differences in the cortical and subcortical brain regions that were involved in cognitive control and reward processing, as well as in the orbitofrontal cortex, insula, anterior and posterior cingulate cortex, temporal and parietal regions, brain stem and caudate nucleus [134]. The associations between cue-reactivity and cue-induced craving with regard to severity and duration in excessive internet gaming have been studied in the context of cue-induced neural activations in the ventral and dorsal striatum [135]. It was observed that greater cue-induced activations of both the ventral and dorsal striatum were obtained by the gamers in comparison with healthy controls. Among the former, left ventral striatum neural activity was correlated negatively with cue-induced craving whereas positive correlations were obtained among those activations arising from the dorsal striatum, including the right putamen, pallidum and left caudate, and duration of the internet gaming disorder. Concurrently, cue-induced activity within the left putamen was associated negatively with the volume of the right ventral striatum among gaming addicts [136,137] for related and co-morbid aspects of cue-signaling reactivity and markers for internet gaming disorder.

Extended periods of exposure to internet gaming implies that these individuals are exposed to a continuous myriad of visual, auditory and tactile stimuli/situations that may be associated fatigue or deficient selectivity linked to psychiatric conditions such as depressiveness and anxiety, loss of proactive interference and behavioral inhibition, decision-making impairments and choice behavior, motivation, craving behavior, hostility, etc., with deficits in related brain regions [138-147]. Park et al. [148] compared 26 internet gaming diagnosed individuals with 23 age-, gender-, education- and intelligence-matched healthy control on an auditory Oddball task with concurrent measurement of the auditory P300 component of event-related potentials. They observed that the former group displayed marked response reductions to deviant tones in the P300 amplitudes at the midline centro-parietal electrode regions concomitant with a negative correlation between disorder severity and P300 amplitudes implying dysfunctional auditory information processing and cognitive adequacy. Similar to other addictive behaviors, problems involving decision-making are associated with internet gaming disorder [149-152]. internet gaming diagnosed individuals in, comparison with healthy controls, chose a greater number of 'risk-disadvantageous' endeavors that was linked to lower activation in the anterior and posterior cingulate gyri and medial temporal gyrus, as well as shorter

response times and lower activation of the inferior frontal and superior temporal gyri [153]. This pattern of behavior combined with regional fMRI activations reinforces the notion of deficits in executive control of 'risk-disadvantageous' selection with 'hasty decisions' devoid of appropriate impulse control. In this context, it appears noteworthy that individuals presenting the disorder exhibit altered modulation, i.e. higher task-related activity, in the default mode network in contrast to the observed deficits in executive control functioning, i.e. a lower level of engagement [151,154]. Thus, it appears self-evident that the increasing preponderance of video-internet gaming by children and adolescents is inciting adverse physical, cognitive-emotional and social outcomes; it comes therefore as no surprise that children presenting ADHD scored higher on the Internet Addiction Test, used the internet over longer periods and remained awake much later than children without ADHD [113,155,156]. In this respect, with the emergence of Internet gaming disorder among ADHD patients, several previously-inappreciable conditions now materialize to advance the list of ADHD co-morbidities [157]. It is important to note that diagnosed internet gamers [92] matched an internalizing profile (45.76%), with co-morbidities encompassing mood disorders (44.4%), anxiety disorders (44.4%), and personality disorders (11.1%) whereas those matching externalizing disorders (52.54%) presented disruptive behavioral disorder (48.4%), ADHD (29%) and unspecified disruptive disorders (22.6%); these patients presented also a family history of psychiatric problems (63%), social relations problems (77.8%) and video-usage to escape discomfort (66.7%). Certainly, the notion of cerebral deficits among internet-gaming disorder individuals is reinforced by the observation that recreational-gaming users demonstrated higher levels of executive control and more profound activations of those brain regions implicated in motivational processes during reward processing and more intense cortical activations during loss processing [158].

Interventional aspects of internet gaming

Studies involving the dangers and seeking the neural basis of disorder with eventual interventional recommendations revolve around the development and maintenance of problematic, excessive Internet use on several different aspects of the behavioral destructivity [159], these pertain to: (i) eventual identification of vulnerability among brain regions and biomarkers, (ii) persistent analysis of putative lower-level neurocognitive impairments, (iii) comprehensive exploration of the prevailing core, and peripheral, reflective and automatic/affective symptom profiles, (iv) systematic evaluation of observed Internet use heterogeneity and related co-morbidities, such as gambling addiction (v) associated development of novel neuroscience strategies, and (vi) extrapolation and analyses of behavioral and cognitive interventions. In the context of the 'approach bias' to internet/video gaming (see above), Rabinovitz and Nagar [160] have shown that interventions with single session training decreased automatic markedly the 'approach bias towards gaming cues' action tendencies without incurring each participant's awareness. This retraining of the 'approach bias' decreased not only participants' subjective cravings and intentions to indulge in gaming, but also reduced their game-seeking behavior: retraining individuals' automatic processes appears to promote the alteration of addictive internet/video gaming impulses. Certainly, the liability aspect of internet gaming excesses seem to open an avenue for aggressiveness, violence, desensitization, pseudo-criminality and loss of impulse control that appear to be disassociated from those brain regions that bestow planning, behavioral control, empathy and decency [161]. Interventional approaches have focused upon the technique employing different aspects of symptom recognition, withdrawal symptom identification and coping strategies. Typically, the "Craving Behavioral Intervention" involves presentation once weekly administration over six weeks as carried out by four professional therapists of whom one pair of therapists is randomly assigned to a Craving Behavioral Intervention+ group. Within each session 5 partitions of duration 2.5 to 3 hours are included, consisting of: warming-up exercise, discussions regarding homework from the last session, main structured activity, a brief summary, and the homework assignment itself. The six sessions are each focused upon a topic: (i) recognition of craving and its relationship to internet gambling disorder, (ii) reduction of craving through alleviation of the salience of cues and irrational beliefs, (iii) identification of withdrawal symptoms and other negative affectivity, (iv) enhancement of self-monitoring and craving-control through time management training, (v) relieving the fulfilment of psychological needs through Internet use and attenuation of the relationship between craving and gaming behaviors through coping skill education and training [100].

Characteristically, in a study of 36 young adults presenting internet gaming disorder and 19 matched healthy controls, the former displayed decreased amplitude of low fluctuation in the orbito-frontal cortex and posterior cingulate cortex combined with elevated resting-state functional connectivity between the latter and the dorsolateral prefrontal cortex in comparison controls [162]. "Craving Behavioral intervention" was provided for 20 of the 36 internet gaming addicts; compared with those non-receptive of the intervention, those treated showed markedly decreased resting-state functional connectivity between: (i) the orbito-frontal cortex and the hippocampus-parahippocampal gyrus, and (ii) the posterior cingulate cortex and the supplementary motor area, precentral gyrus and postcentral gyrus, implying an abnormal neural activity in the executive control, default mode and reward networks (see above also). In related study, internet gamers (N=40) were compared with healthy controls (N=19) on assessments of neural activation during the course of an internet-gaming cue-reactivity task that induced activations over several brain regions including the dorsal striatum, brainstem, substantia nigra and anterior cingulate cortex but decreased activation in the posterior insula region [102]. Twenty-three of the internet gaming addicts who received the Craving Behavioral intervention therapy, who expressed a decrease in gaming severity, displayed enhanced activation in the anterior insula region concurrent with reduced insular connectivity in the lingual gyrus and precuneus. Additionally, Craving Behavioral intervention therapy induced a marked reduced cortical-ventral striatum-left inferior parietal lobule connectivity that was aligned with an alleviation of the addictive gaming severity [100]. Despite this evidence of interventional progress, substantial criticism has been levelled at clinical trials, including (i) inherent inconsistencies in the definition, diagnosis, and measurement of disordered internet use, (ii) the recurring lack of randomization and 'blinding', (iii) a paucity of control conditions, and (iv) the insufficient information regarding recruitment dates, sample characteristics, and effect sizes [103].

The basis of internet health care for psychiatric disorders is relatively well-established for affective disorders such as depression and anxiety [163,164]. In view of the susceptibility of video-internet addicts and gamers for these disorders [165,166], the notion of internet health care offers a tempting modality both for treatment intervention and for the reduction of an intrinsic risk for development of further co-morbidity and systematic and structured approaches to counteract the disorder progression [167,168]. Psychological interventions, including cognitive behavior therapy and motivational interviewing,

have tended to incorporate harm minimization approaches and attempts to deal with underlying issues and associated problems [169] by mobilizing the deviant computer-users' sense of autonomy, competence, and relatedness [170]. In this context, smartphone applications have been developed, among Koreans users, to provide immersive virtual reality – cognitive behavior therapy in order to provide interventions that are seemingly more relevant to the target group of gamers [101]. Unsurprisingly, it appears that the utility of psychopharmacological intervention ought not to be neglected: in a sample of 84 young adult male participants (19–21 years) of whom 44 were diagnosed with internet gaming disorder and 40 were healthy controls [171], pharmacotherapy using selective serotonin reuptake inhibitors induced significant amelioration of poor quality-of-life, affective symptoms, improved response inhibition and impulse control [172,173], and executive and working memory functioning. One major aspect for eventual interventional progress involves that nature of psychiatric health misadventure: in a sample of male and female online gamers (N=3186, mean age=21,1 years), Brief Symptom Inventory, Problematic Online Gaming Questionnaire and Motives for Online Gaming Questionnaire were administered [174]. A Global Severity Index of the Brief Symptom Inventory indicated that psychiatric distress was related directly to Problematic Online Gaming through the mediation of two gaming motives: (i) Escape and (ii) Competition. Furthermore, it was observed that the female participants expressed higher escape scores that male participants and evidenced a stronger association between the escape motive and Problematic Online Gaming [175-179]. Finally, Deng et al. [180] have obtained encouraging improvements in the expressions of internet disorder through applications of the 'craving-behavior' intervention program.

Conclusions

Video-internet gaming, whether as diagnosed disorder condition or harbinger for the forewarning of ill-being, when abused excessively has been associated with a concatenation of negative health profiles that covered a wide range of attributes and behaviors, enveloping negative affect states, addictive behavior, impulsiveness, poor executive control and high reward control, negative escapism, psychological distress, poor quality-of-life, craving and withdrawal, obsessive-compulsive tendencies, alexithymia, stress, sensation seeking, anger, a preponderance of disrupted sleep-related problems, lack of assertiveness and symptoms of ADHD with an enormous, relatively masked, real and apparent basis of co-morbidity; all of these expressions for poor health and adverse prognosis are associated with more-or-less damaging, certainly dysfunctional, alternations in brain regional networks and neurophysiological integrity. The symptomatic, epidemiologic and prevalence, neurophysiologic and biomarker aspects of an increasingly severe condition underline requirements for wide spectrum, multi-faceted interventional strategies, particularly those incorporating interventions linked to novel, relevant-to-user technologies. From a perspective of prevention, the role of parental attitudes and lifestyles in combination with family functioning must be awarded much greater focus.

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