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Internet Addiction in Comparison to Substance Addiction

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Abstract: With 5.3 billion users, the internet has enabled the communication and sharing of information globally and has reaped numerous benefits. However, with this increase in availability, a new phenomenon known as “internet addiction” has emerged. Internet addiction (IA) is a behavioral addiction—an excessive, uncontrollable, compulsive urge regarding internet use. IA is gradually becoming a serious health issue, affecting an estimated 24 million people in China and 1.5 million in Germany. Limited research has explored the brain effects of IA, which is considered to share neural mechanisms with substance use disorders (SUD). This study compares individualized autonomous behavior (IA) to social unemployment disorder (SUD). Results show similarities in neuroimaging studies but differences in temporal regions. IA is less severe and causes dysfunction in cortical regions, while SUD affects subcortical regions. Although not recognized in Europe and America, China, and South Korea label IA as a significant health concern. More research is needed to determine the long-term neurological effects and public health policies.

Keywords: Internet addiction, substance use disorder, prefrontal cortex, Salience network, Cognitive behavioral therapy.

1.INTRODUCTION

1.1 A brief history of the internet and its advancement

Technological advancements have improved global connectivity, enabling information sharing between regions and continents. The internet, developed in 1983, is widely used, with an estimated 5.3 billion people accessing it. The Internet has enabled businesses, governments, institutions, and companies to cater to human needs in innovative ways. The COVID-19 pandemic halted education, facilitated family isolation, and provided government warnings. However, excessive internet use has led to the term "internet addiction," prompting scientists to research this phenomenon to determine its existence.

1.2 Classification of Internet Addiction

The classification of internet addiction (IA) is difficult as it intersects with many other behavioral addiction types, such as internet gaming disorders, online gambling addiction, and online pornography addiction. The scientific community is also divided on whether IA is a specific condition or not, arguing against IA as a separate entity and implicating that it is a symptom of other disorders such as anxiety and depression [1]. IA can be classified as a behavioral addiction, and it is the excessive, uncontrollable compulsive urge regarding internet use. IA can cause various symptoms, such as mood disorders such as depression and anxiety, sleeping disorders, social disconnection, obesity, and heart problems (Figure 1) [2]. IA is predominant in countries where computer access and technology are widespread. IA is gradually becoming a serious health issue with its increased access worldwide. IA prevalence varies between countries, with an estimated 24 million people in China and an estimated 1.5 million people in Germany IA Jun [3]. Survey analysis across 31 nations across all the continents has estimated the worldwide IA prevalence to be around 6% [4]. These statistics are alarming, and with internet use becoming more intertwined with our daily lives, these numbers can rise drastically in the future.

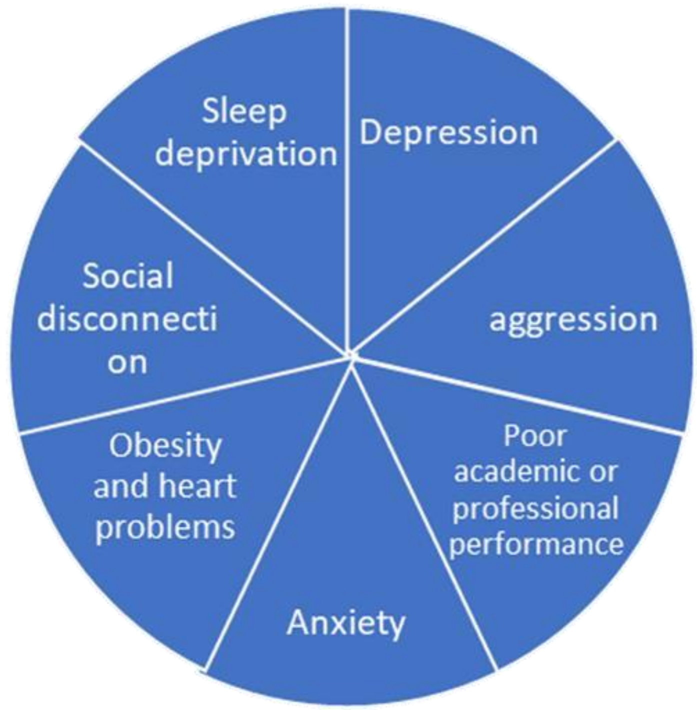

Figure 1: *Schematic of the common symptoms associated with internet addiction (Source: own)*

IA is not yet formally recognized in Europe and America, with the Diagnostic Statistical Manual of Mental Disorders (DSM) not including it as a formal condition in the fifth edition (DSM V, 2013). However, the DSM noted IA as an area of interest, requiring more research to be considered a mental disorder. In countries such as China and South Korea, IA is already recognized as a mental disorder and is classified as a behavioral addiction. IA is a prevalent and harmful issue in society, with more people online than ever before. In China and South Korea, it's considered as serious as substance abuse. Behavioral addictions, like substance addictions, develop an unhealthy dependence on a behavior or activity. Although behavioral addictions are not considered a condition by the DSM, they share symptoms like salience, euphoria, and withdrawal symptoms [5].

1.3 Neurobiology of Addiction

Behavioral addiction's neurobiology is less studied than substance addiction, which primarily affects the mesolimbic dopamine pathway. The VTA, the primary source of dopamine, contains large dopamine-producing neurons. Drug abuse increases dopamine levels in the VTA-NAc pathway, leading to overstimulation and addiction development. Addiction affects the mesocortical pathway, affecting the prefrontal cortex, ACC, and other brain regions. The PFC shrinks, affecting decision-making and impulse control [6]. The extended amygdala regulates stress and emotions, leading to negative emotions and stress. Other brain regions, like the hippocampus and insula, are involved in cravings and learning memory. [Fig2]

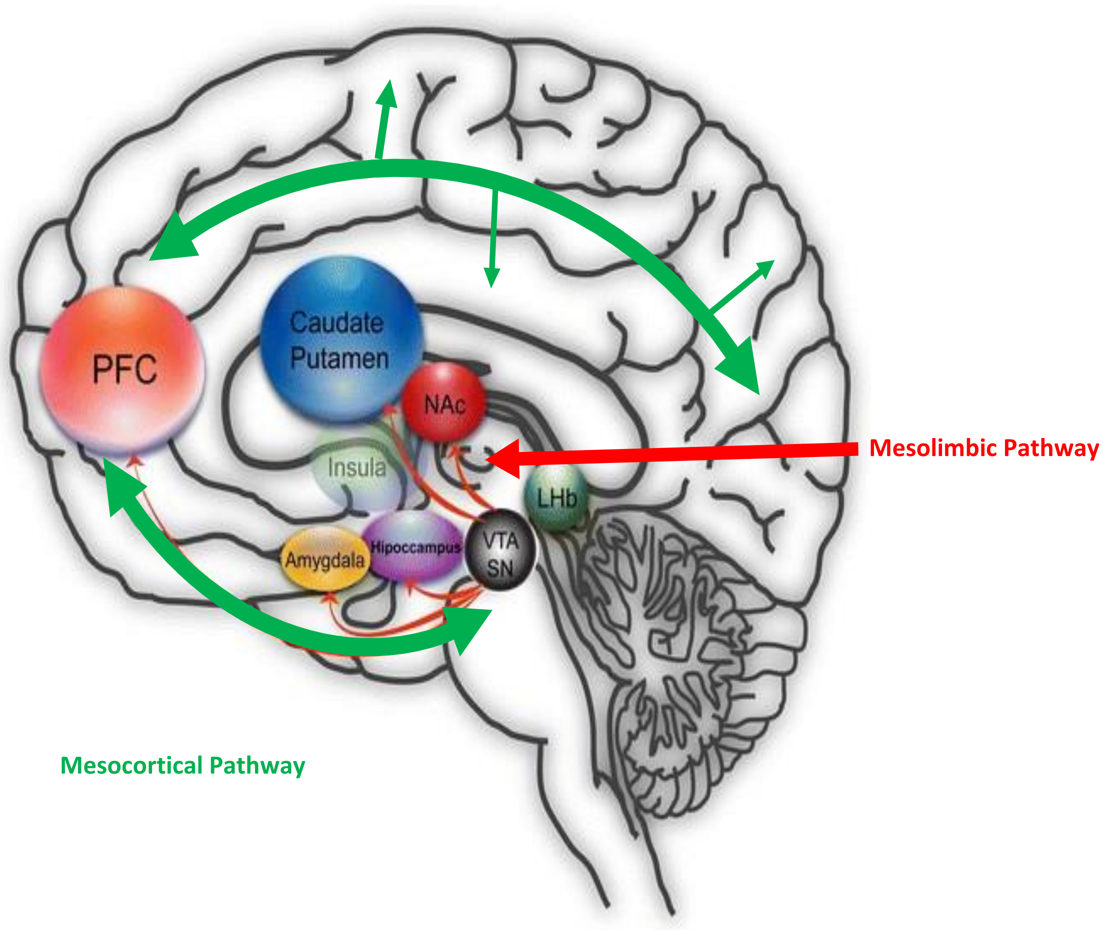

***Figure 2:** Brain regions involved in addiction: prefrontal cortex (PFC), caudate putamen, insula, Nucleus accumbens (NAc), amygdala, hippocampus, Ventral tegmental area (VTA) and lateral habenula (LHB), Green arrow- mesocortical pathway and Red Arrow Mesolimbic pathway (Amended from Vanegas and Zaghloul, 2015).*

1.4 Socioeconomic burden of addiction

Addiction is a growing concern affecting society and the economy, affecting individuals of all ages, socioeconomic classes, genders, and ethnicities. It can lead to increased crime, homelessness, social isolation, reduced workforce, family breakdowns, and financial issues. The UK economy spent £10.7 billion on healthcare, policing, and crime in 2017. Long-term use and neurological effects of Internet addiction are yet to be determined.

1.5 Diagnoses of Internet Addiction and comparison to substance use disorder.

Internet addiction (IA) is a prevalent condition, often misdiagnosed due to self-perception and others' concerns. The Youngs Internet Addiction Test (IAT), developed in 1998, is a reliable diagnostic tool for IA. The test measures IA levels using a 6-point scoring scale, with scores ranging from 0-39 to 70-100. This tool allows researchers to compare the brains of IA and healthy participants, reducing the prevalence of the condition. [Table 1]. IA shares symptoms with substance use disorder (SUD), including excessive use, withdrawal symptoms, neglect, and relationship issues. Understanding IA's neurophysiology helps categorize severity and determine concern.

	Questions	Scale					
1	How often do you find that you stay on -line longer than you intended?	1	2	3	4	5	0
2	How often do you neglect house hold chores to spend more time on-line?	1	2	3	4	5	0
3	How often do you prefer the excitement of the internet to intimacy with your partner?	1	2	3	4	5	0
4	How often do you form new relationships with fellow on-line users?	1	2	3	4	5	0
5	How often do others in your life complain to you about the amount time you spend on-line?	1	2	3	4	5	0
6	How often do your grades or school work suffers because of the amount of time you spend on-line?	1	2	3	4	5	0
7	How often do you check your email before something else that you need to do?	1	2	3	4	5	0
8	How often does your job performance or productivity suffer because of the internet?	1	2	3	4	5	0

Table 1*: A sample of questions from the Young Internet Addiction Test (IAT). IAT consists of a set of 20 questions responding with a 6-point scoring scale: (1- rarely, 2- occasionally, 3- frequently, 4- often, 5- always, 0- does not apply). Scores are calculated out of 100 and scores from 0-39 indicate average usage addiction, scores from 40- 69 indicate problematic usage, and scores from 70 and higher indicate severe problematic usage (Young, 1998).*

1.6 Aim of the Study

This review compares internet addiction (IA) to substance use disorders (SUD) using neuroimaging and behavioral studies. IA is a behavioral addiction, with differences in cortical regions and trait impulsivity. Impaired visual and auditory symptoms are distinct from IA.

2.METHODOLOGY

For this systemic literature review, IA was considered any form of addiction that used the internet, such as online gaming and social media. Furthermore, in most papers, the SUD was either alcohol or nicotine addiction. Since nicotine and alcohol are substances that are widely consumed and used in certain demographics and societies, finding participants addicted to these substances is easy, and since they are legal drugs, the participants of the study would have felt little to no shame admitting their dependency on such substances compared to illegal ones such as heroin and cocaine. A search strategy was completed to answer the research question: Is internet addiction like substance use disorder in the context of neuroimaging and behavioral studies? A database search was done using PubMed using key search terms to identify relevant literature available on this topic. The key search terms identified were "internet," “drug addiction," and "brain," with a result of 161 studies available for analysis. The remaining papers were scrutinized in three stages for containing irrelevant titles, abstracts, or final full texts, and a PRISMA flow diagram was produced (Figure 4), and all were measured against the inclusion and exclusion criteria. [Table 2]

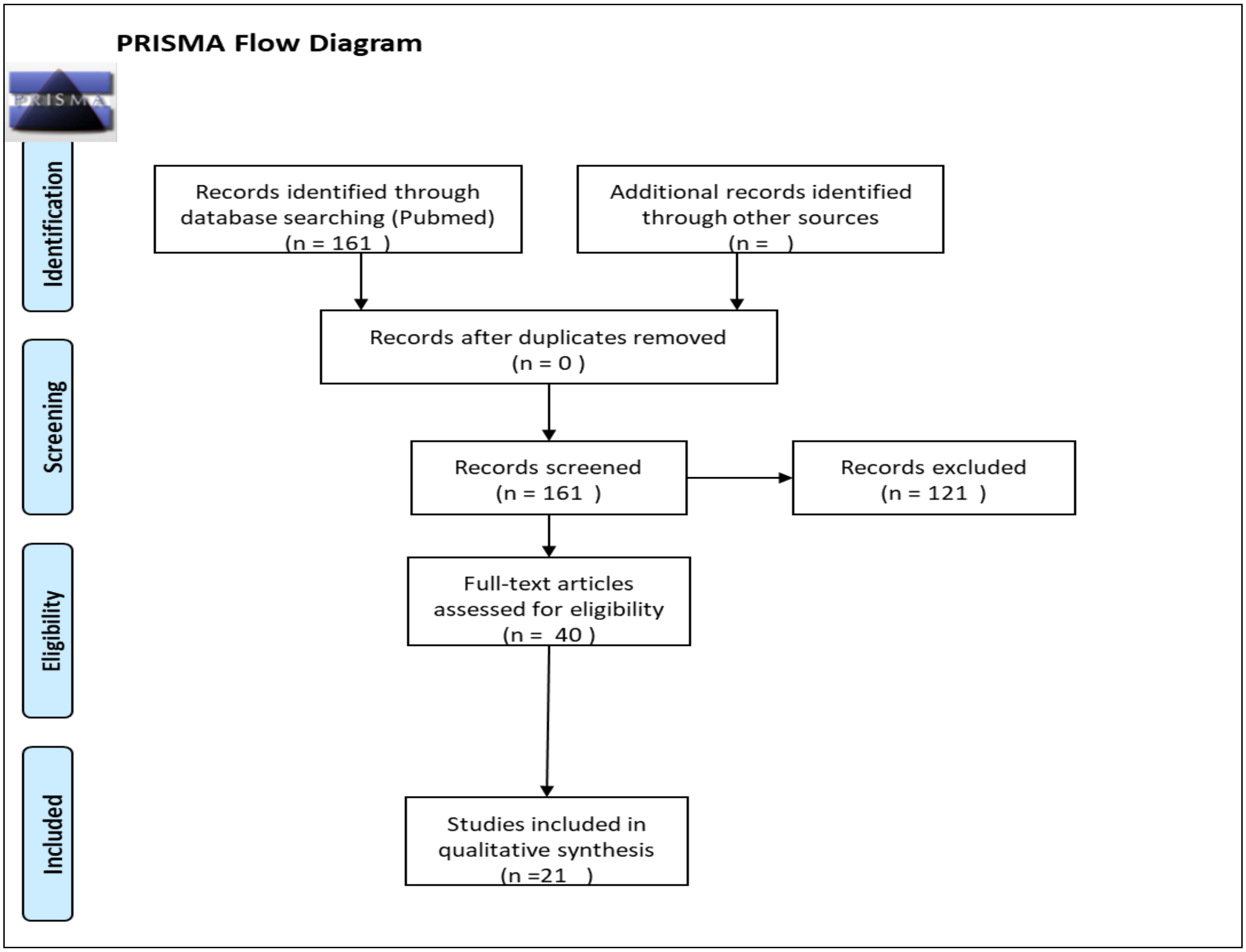

Figure 4: *PRISMA flow diagram representing the scrutinization process of the PubMed search results.*

Table 2: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria-
brain imaging (fMRI, MRI, DTI, and EEG)	No control group
behavioral studies	studies before 2005
	literature reviews
	systemic reviews

The inclusion and exclusion criteria were necessary to eliminate papers that did not help tackle the research question. Studies that included neuroimaging techniques such as fMRI, MRI, DTI, or EEG were included in this project. Non-invasive electrophysiological studies using EEG and MEG were searched for but only EEG studies came out in the results. The neuroimaging techniques were crucial to visually see the difference in neural connectivity, brain oscillations, and neural activity. According to the literature, it is understood that addiction causes an increase and decrease in neural connectivity in the brain regions involved with addiction. Comparing and contrasting these fluctuations in brain connectivity between internet addiction and substance use disorder will be helpful in assessment. EEG studies are also crucial to this project as they will allow us to assess the difference in neural oscillation in addiction [7].

Resting-state oscillations is a commonly used technique in psychiatric research, and it allows the measurement of spontaneous neural activity when the brain is at rest [8]. Previous research has shown that addiction causes neural oscillation dysfunction in patients with addiction, causing changes in absolute and relative power in EEG frequency bands. Thus, comparing the EEG studies between IA and SUD will help answer the research question. Behavioral tests were also added to the inclusion criteria and used for this project. IA contributes to a lack of control of inhibition leading to impulsivity and the lack of attention affects the short-term working memory [9] Functions such as decision-making, attention, working memory, impulsivity, and compulsivity can be assessed to determine addiction's effects on the brain. The current literature shows that addiction affects the functions mentioned above, like decision-making and impulsivity. Individuals with IA are more prone to make inappropriate decisions due to dysfunctional brain activations in regions associated with reward, control/ regulation, and conflict monitoring. This could be because of altered activation in the dorsal anterior cingulate cortex, which is involved in conflict monitoring during decision-making [10], and in the caudate nucleus, which is associated with reward prediction and anticipation [11]. Twenty-two papers were left after the thorough scrutinization. Most of the studies were conducted in China and Korea since IA is considered a health condition in those regions and as such, the subject of numerous investigations.

3.RESULTS

The core papers were summarized, and a table was produced to illustrate the addiction type of the participants and the results (Table A1, A2, A3). Figures were produced to demonstrate the different brain regions affected by IA and SUD to make it simpler to comprehend. From the 21 core papers used in this project, it was appropriate to divide the results into three main categories; fMRI, MRI, and DTI; behavioural studies; EEG studies.

3.1 fMRI, MRI, and DTI

The results from the fMRI, MRI, and DTI studies indicate several similarities and differences between IA and SUD. A study by N.sido et al. found IA patients had an increase in thickness in the left superior temporal cortex (STC) compared to the healthy control and SUD[12]. The left STC is responsible for language processing, and it is responsible for auditory and short-term memory. There was a significant relationship between cortical thickness in the left rostral aCC and IAT scores in IA patients in the study (p value= 0.03). The study assessed the relationship between impulsivity and cortical thickness in IA and SUD groups. Impulsivity was assessed by the Barrat Impulsiveness Scale (BIS-11), which consists of 30 items answered on a 4-point scale with a higher total score indicating higher impulsivity. There was a negative correlation between cortical thickness and impulsivity in the left pars orbitalis (POrb) in IA patients. However, in contrast, there was a positive correlation between impulsivity and thickness in the bilateral insula. The insula is involved in cravings and urges, and the study suggests that the activation can signal an urge and that this urge might facilitate the immediate seeking of rewards. The left POrb, also involved in language processing, showed an increase in cortical thickness, suggesting that a distinctive feature of IA is the dysfunction in the temporal regions. IA patients tend to play video games with headsets, and gaming is an activity that requires complete focus depending on the type of game and level of difficulty. IA patients can spend hours playing online games, which could explain the changes found in the temporal regions compared to healthy controls and SUD. A study by Kim et al [13].

Further emphasizes the relationship between the temporal regions and IA. The study assessed the regional homogeneity (ReHo) between the IA, SUD, and control groups. ReHo is a voxel-based measure and is the time consistency of blood oxygenation level in the brain. Abnormal ReHo signals can be associated with changes in neuronal activity, with an increase in ReHo reflecting the excessive activity of the neurons.

Compared to the healthy controls, the study found a significant increase in ReHo in both IA and SUD participants in the posterior cingulate cortex (PCC). There was also a positive correlation between the ReHo changes in the precuneus/PCC with the IAT score in IA patients. The PCC is important in attention and self-monitoring and is part of the default-mode network (DMN). It can disengage from the DMN and exercise executive control. The alteration of the PCC in the resting state suggests an imbalance in the synchronization of the DMN in the addict groups. The PCC may be associated with the evaluation of gaming-related cues, and over-stimulation may be associated with increased spontaneous activity and risk-taking [14] Increased PCC in IA and SUD patients may be a common neurobiological feature. The study also found a positive relationship between anterior cingulate cortex (ACC) and IAT scores. The ACC, which is involved in cravings and blood flow, can be altered in the resting state of IA patients. Excessive gaming can alter the brain's metabolism and influence the brain's motivation system. Similarly, to other studies, the superior temporal gyrus (STG) showed a decrease in ReHo in the IA groups compared to the healthy control and SUD also found a reduced rSFC between the dorsolateral prefrontal cortex DLPFC, temporal lobe, and striatal areas compared to SUD due to the visual and auditory stimulation caused by IA. The results from these studies further emphasize changes in the Temporal regions as a distinct neurobiological marker of IA [15].

4.1.2 Reduced executive control and increased craving.

The DLPFC is associated with working memory, inhibitory control, and goal-directed action. Reduced functional connectivity (rsFC) has been found in IA and SUD patients in the DLPFC. The study by Ge et al [16] found that both IA and SUD patients showed decreased rsFC in the right insula and left inferior frontal gyrus. The difference between IA and SUD was found with an increase in rsFC in the left inferior temporal gyrus and right inferior orbital frontal gyrus (Figure 5) and a decrease in rsFC in the right middle occipital gyrus, cuneus and supramarginal gyrus (Figure 6). A decrease in rsFC with DLPFC may be associated with higher impulsivity, and reduced rsFC with the temporal and orbital regions may be associated with impaired hearing and vision. Most fMRI studies obtained for this project comparing IA to SUD or Healthy control are cross-sectional [17]. Wang et al. examined the longitudinal data of IA and healthy control groups at baseline and then again six months later. The study examined the connectivity between the subregions within the striatum. IA group showed a decrease in rsFC between the putamen and the left insula. However, the study found the connectivity between the nAC and the left insula stable over time. However, the nAC and insula connectivity were positively associated with IAT scores suggesting that IA has a similar neuro mechanism as SUD.

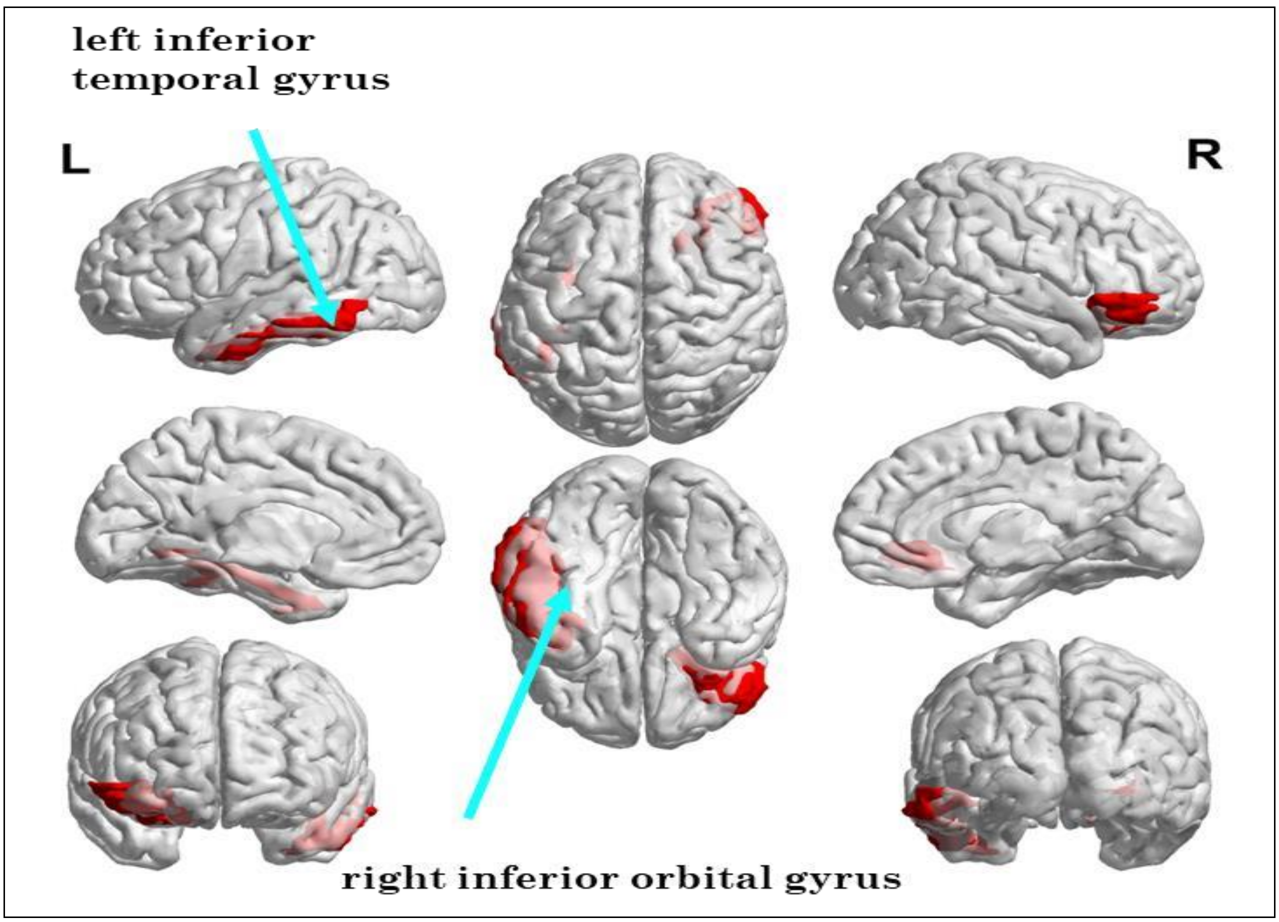

***Figure 5**: Increase in functional connectivity in Internet addicts vs smokers with nicotine dependence. Red Regions: left inferior temporal gyrus, right inferior orbital gyrus (Source: internal documentation).*

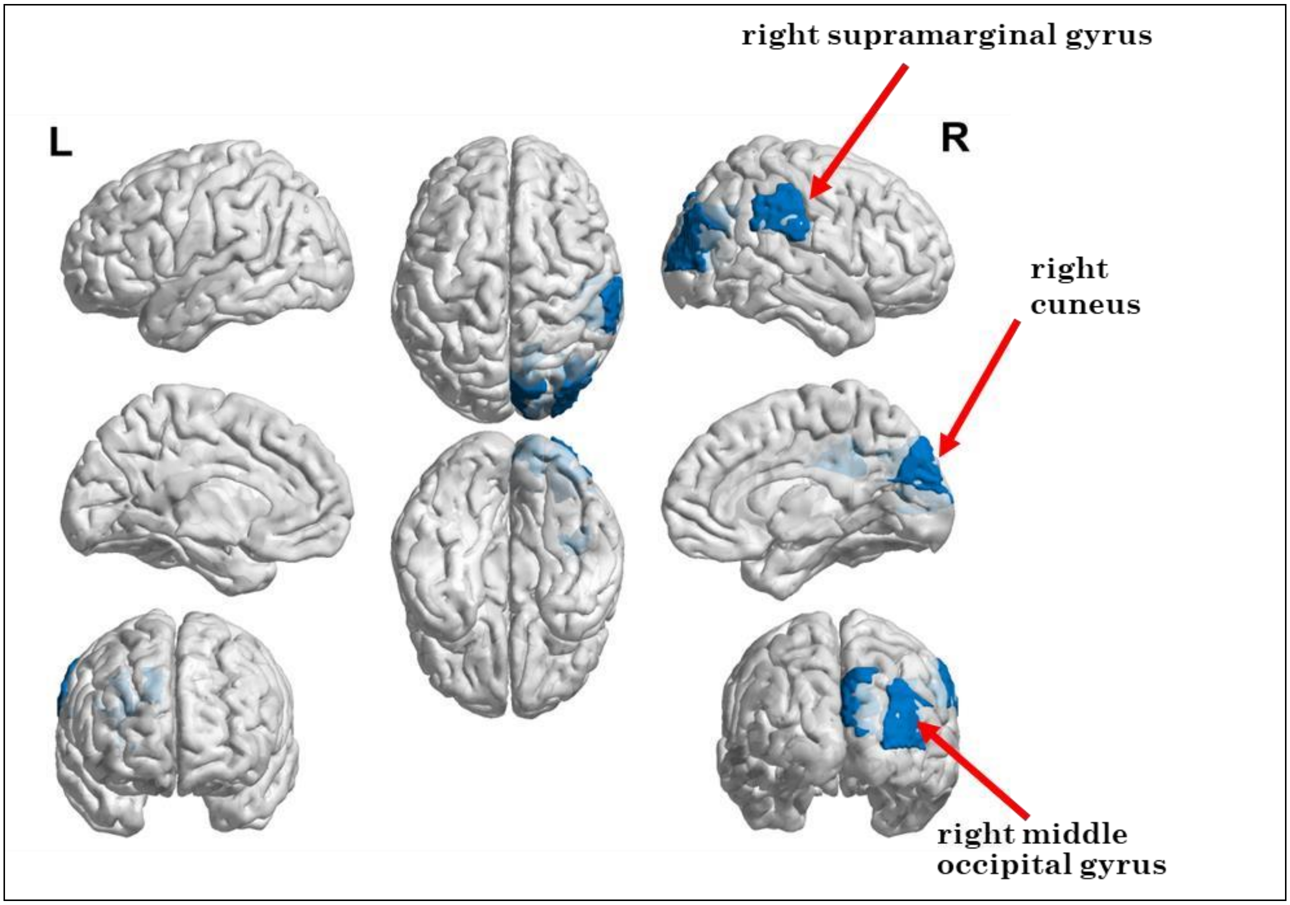

Figure 6: Decrease in functional connectivity in Internet addicts vs smokers with nicotine dependence. Blue Regions: right supramarginal gyrus, right cuneus, right middle occipital gyrus (Source: own).

From the studies' results, the critical role that the insula plays in the manifestation of the core symptoms of IA is highlighted. Furthermore, studies specifically focused on the insula have found agreeable results. The study of J. Zhang et al. examined the rSFC of the insula in association with IA and found there to be an increase in rsFC between the anterior insula and a network of regions including the ACC, putamen, angular gyrus and precuneus, which are all critical regions associated with addiction involved in craving, salience, self-monitoring, and attention [18]. Again, the regions involved in visual-auditory have demonstrated a significant increase in rsFC in the supplemental motor area and STG. The increase in rsFC between the anterior insula and angular gyrus, precuneus and inferior parietal lobule is also found in SUD, according to previous studies [19]. These regions are components of the DMN, and the dysfunction between the insula and DMN has been suggested as a significant neural marker for the development and maintenance of addiction [20]. A study by Y Zhang et al. that looked at the functional connectivity of the insula in IA found decreased rSFC in the left posterior insula, bilateral supplementary motor area, and middle cingulated cortex. The study also found a decrease in rSFC in the right posterior insula and right superior frontal gyrus. Reduced functional connectivity in these brain regions involved in motor and executive control and interception can explain the over-craving and reduced executive control symptoms found in IA patients [21].

3.2 Impulsive behaviour is a common symptom.

The fMRI results show that brain regions involved with impulsivity, such as the insula and DLPFC, are impaired in both IA and SUD patients. Neuropsychological tests such as the SST and IED were done in a study by Kim et al. which found that IA patients had impaired response inhibition and cognitive inflexibility. The study compared the impulsivity and compulsivity of IA, SUD, and obsessive-compulsive disorder (OCD). The study found that both IA and OCD had the lowest performance in the SST with motor and cognitive inhibition compared to the control. The study suggests that behavioural impulsivity is a common characteristic of IA. The impairment might explain why it is difficult for individuals with IA to suppress their craving for gaming due to the presentation of cues and repetitive self-defeating behaviour. The IA group also showed the worst performance in the IED total trials, which measures attentional set-shifting. The finding suggests that IA patients lack cognitive flexibility and find learning new strategies and patterns in the IED test challenging. The study also suggests that SUD patients tend to be more goal-directed. In contrast, IA patients tend to form compulsive habits in the initial stages, giving us further context on the differences and similarities between IA and SUD. The cognitive inflexibility of IA was further examined using the Stroop test, and the IA group needed more time and effort to switch attention in the incongruent color-word condition. This does not only imply cognitive inflexibility in IA but also impaired inhibition of interfering stimuli. The evidence provided from the results in this project suggests that the impulsive and inhibitory brain systems are dysfunctional in both IA and SUD [22]. To determine which of these two brain systems is more predominant, a study by Turel et al. examined IA addiction using the GNGT in which participants were shown a Facebook stimulus and a less potent traffic sign. The level of addiction was assessed using a questionnaire, and participants were given an addiction score. Participants had to respond by pressing a button when they saw a Facebook-related cue in the Facebook Go task (FGO), and the same rule applied when they saw a traffic-related cue in the Sign go task (SGO), for the no-go task Participants were not required to respond to a cue in the no-go task for the Facebook Sign task [23]. The results found that participants took longer to respond in the SGo task and responded much faster in the FGo task. Also, participants had more false alarms in the SGo task (Facebook inhibition task) (Table 8). Impairment was found in the impulsive brain system involving the bilateral ventral striatum which was hyperactive. The fMRI analyses found that the bilateral ventral striatum in the FGo trials, positively correlated with addiction score (Figure 7). However, the prefrontal cortex's inhibitory system was not affected since there was no significant difference between the sign no-go trials and Facebook no-go trials in the prefrontal cortex activation. The findings in this study contradict the study By Zheng et al. (2021) that stated IA addiction is caused by dysfunction in the cortical regions. This could be because, in the study of Turel et al. participants had a low-medium level of IA. At those levels, prefrontal cortex impairment might not yet emerge, with the participants not having trouble with the inhibitory system.

Table 3: Result measures of the Go/No-go task Facebook addicted group (Turel et al. 2014).

Variable	SGo Task	FGo Task	P value
Hits rate	0.90 (0.11)	0.90 (0.12)	0.98
False alarm rate	0.13 (0.13)	0.03 (0.05)	0.03*
Go trial response time (sec)	552.3 (86.7)	487.3 (78.2)	0.002*
No- go trial response time (sec)	433.2 (50.7)	389.0 (44.2)	0.03*

Note: *Mean values are represented in this table, (SD), * indicates p-value <0.05.*

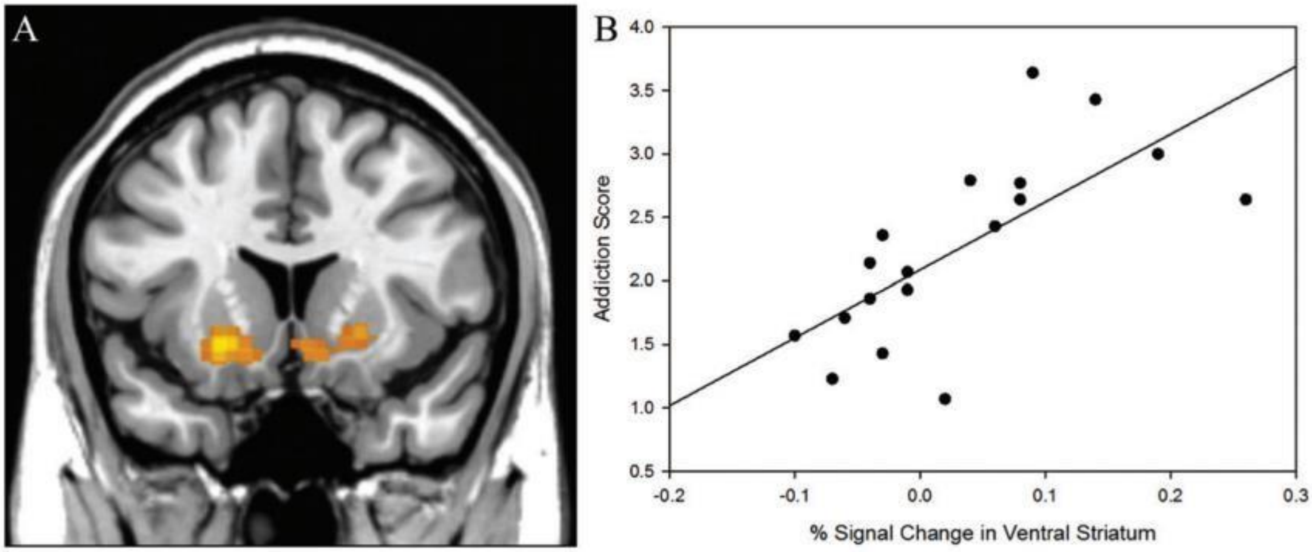

Figure 7: *Positive correlations between signals in the ventral striatum and addiction scores. (A) Coronal image of ventral striatum signal. (B) Scatterplot of the positive correlations (Turel et al., 2014).*

3.2 The difference in event-related potentials (ERPs).

From this project's core papers, only one paper by M. Park et al. assessed the ERPs in IA and SUD. ERPs are useful because they assess the sensory and motor response to cognitive events in a time-locked manner involving a specific cognitive task [24]. The P300 is an ERP component that assesses cognitive functions such as concentration, attention, and working memory [25]. The P300 is mostly elicited using the oddball paradigm, an experimental design that uses sequences of repetitive stimuli interrupted by deviant stimuli. The P300 only occurs 300 m/s after the presentation of the deviant stimuli when the participants are actively engaged in detecting the stimuli. The P300 component waveform varies depending on its amplitude and latency. The N100 event related potential is an earlier negative wave response. It occurs 100 m/s after the presentation of the deviant stimuli, and it involves components generated by the primary auditory cortex in the oddball auditory task [26]. The IA and SUD group had decreased P330 amplitudes than the healthy control and the N100 amplitudes were also lower in the IA and SUD group compared to the control. The study found no difference of significance between the IA and SUD groups in both the P300 (Figure 9). Interestingly the IA group exhibited reduced N100 amplitudes at the midline frontal regions compared to the SUD and healthy control. The findings suggest that IA shares abnormal P300 wave components with SUD but has a distinct N100 which could be a potential neurophysiological trait marker of IA. The reduction of the N100 wave component in IA could indicate dysfunction in auditory information's sensory and perceptual processing. The lower P300 amplitudes in both IA and SUD could be associated with impaired cognitive capacity.

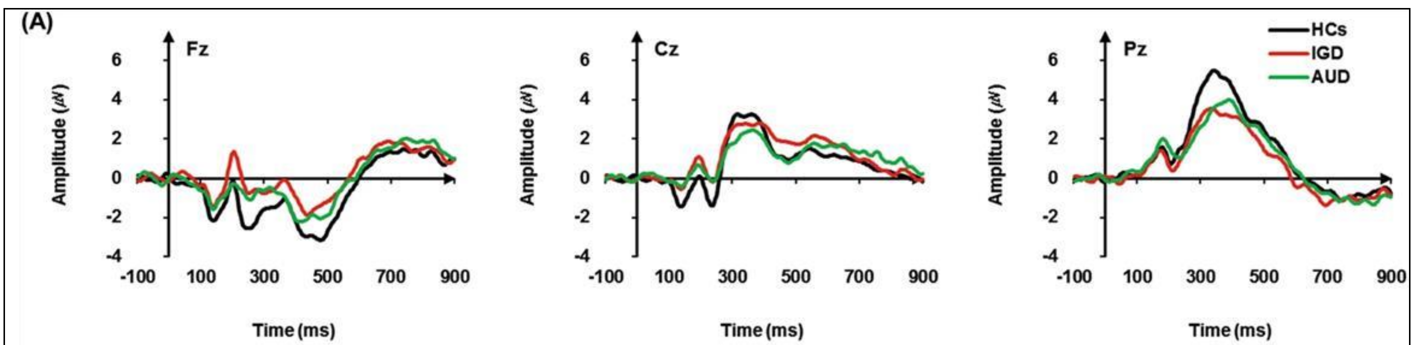

Figure 9: *Average ERP waveforms over three electrode regions (Fz, midline frontal; Cz, midline central; Pz, midline parietal) (M. Park et al., 2017).*

DISCUSSION

IA and SUD share similar neural mechanisms in regions involved with craving and rewards, such as the Insula and VTA-NAc pathways. The two addiction types also share similarities in reduced DLPFC and precuneus. However, abnormal functional connectivity in IA patients was found in the superior and inferior temporal gyrus, middle occipital gyrus, and inferior parietal lobule. These regions are involved in the visual-auditory function and are distinct from IA. To these findings, reduced N100 wave component further suggests dysfunctionality of the auditory cortex in IA patients. Furthermore, atypical gamma coherence in IA patients also hints at the hyperarousal of the visual system, disturbances in the dopaminergic system and impulsive behaviours. These neuro-cognitive deficiencies were also found in the behavioural studies that found IA patients responded faster in the go-no-go trials and stop-signal tasks when internet-related cues were presented. Indicating that trait impulsivity in IA is a shared symptom with SUD. Differences between IA and SUD were found in the Stroop colored word test and IED, which found that IA patients had increased interference and cognitive inflexibility. Although IA and SUD share similar neuro mechanisms in activating the brain reward system, reduced inhibition, and increased impulsivity. A distinct difference was found in visual-audio brain regions, and differences in neural oscillations with increased gamma and reduction in beta waves in IA. This could be due to the large sum of hours spent gaming online, which requires the excessive use of the visual-audio brain regions when the brain is active. This, in turn, could cause dysfunctionality in the resting state with atypical neural oscillations and abnormal functional connectivity. These findings suggest that IA disrupts the DMN network and that brain alterations are reversible. The regions of the brain, such as the PCC, mPFC, precuneus, and inferior parietal cortices, are considered part of the DMN. In IA, these regions were affected by abnormal functional connectivity. Previous studies have shown the involvement of DMN in craving and withdrawal [26]. The DMN is active when the brain is at rest or during a passive task, and it is involved in memory, self-referential activities, and thinking about the future [27]. Dysfunction in the DMN leads to impaired choice justification, risky decision-making, loss of sociability, and dysregulation of emotion and motivation [28]. However, the dysfunctionality of DMN can be associated with other neurological disorders. The mPFC plays an important role in emotional regulation and cognitive processes, and the disruption of this region is not only associated with IA but also SUD, depression, anxiety, schizophrenia, and Alzheimer's disease. A study found that changes in the mPFC neuron morphology of the basilar and apical dendritic branches have been associated with patients with depression. The alteration of the neuron activity, synaptic plasticity, and connectivity in the mPFC have been associated with anxiety. Depression and anxiety are common symptoms associated with IA, and it could be possible that these conditions are a cause of IA. Individuals who suffer from depression and anxiety disorders tend to isolate themselves and have disrupted sleeping and eating habits. These individuals might turn to the internet use to escape reality as a coping strategy. Escapism is a common factor for addiction since IA is a behavioural addiction, not a chemical addiction. It is plausible to suggest that mental health disorders such as depression and anxiety are a cause of IA. The disruption of the DMN found in IA patients could be caused by mood disorders such as depression and anxiety. This could explain why some scientists argue against the existence of IA by stating that it is rather a symptom of mood disorders. Further studies would be necessary to determine the relationship between mood disorders and IA and to determine the link between them. The salience network (SN) is a large brain network composed of the anterior insula, anterior cingulate cortex, and ventral striatum. The SN is responsible for moderating between the two main control networks, the DMN and the central executive network (CEN). It also involves emotional processing, identification, and detecting and filtering salient stimuli [29]. Individuals with IA have reduced rFC in the insula which is positively correlated with the IAT score and symptom severity. The dysfunctionality of the SN could cause poor suppression of the DMN network, which can lead to urgers and cravings for internet use [30]. Interestingly, alterations between the SN and DMN are also found in SUD. A study found that cocaine addiction disrupts the interactions between SN and DMN. The correlation between negative emotions and emotional arousal to substance use was associated with abnormal functional connectivity of the ACC and insula, which are key brain regions in the SN [31]. The study also found an association between alexithymia and emotional processing in the insula and ACC. Alexithymia is a condition that causes difficulty in identifying emotions and describing feelings [32]. The study found that IA patients tend to exhibit greater trait alexithymia. These findings were by the study by Luo et al. which found that alexithymia can predict IA directly and indirectly. In simple terms, dysfunction in the DMN and SN is associated with IA and SUD, and it is evident that both conditions share similar neuro mechanisms [33]. However, since the complexity of the systems involving the brain networks is not yet fully understood, it is difficult to understand how these addiction types differ. Also, the neural changes of behavioural addictions in the brain are not understood. The use of animal models has allowed researchers to pinpoint the dysfunction in neurotransmission and brain deficits caused by SUD. From previous literature, it is understood that SUD, such as alcohol addiction, increases the activity of the GABA pathway and that one dose of ethanol exposure in rodents can induce these changes [34]. Due to behavioural addiction, such as IA being distinct to humans, it is difficult to understand the role it plays at a molecular level in the brain. Nevertheless, in terms of SN and DMN dysfunction, IA and SUD share similarities even though they differ in symptom severity. For example, a person with heroin addiction will suffer far worse withdrawal symptoms than an individual with IA. Also, the social ramifications of SUD are much worse. An individual with an SUD could be willing to break the law to incite their cravings, while individuals with IA might only skip class or work. The time it takes to establish addictions also varies drastically. Drug substances can take minutes to a few days to establish an addiction, while behavioural addictions tend to take longer and involve other conditions, such as OCD and mood disorders, for them to manifest as addiction [35]. Unlike SUD, which provides some medication to alleviate the symptoms, there is no medication for IA. Opioid addiction commonly uses treatments such as methadone and LAAM that alleviate craving and compulsive drug use. Methadone reduces relapses, and when used in conjunction with behavioral therapy, it enables the patients to return to everyday life and helps them maintain their social life and work commitments [36]. On the other hand, since IA has no treatment, it requires psychotherapy, such as cognitive behavioural therapy (CBT). CBT enables IA patients to understand their addictive feelings and actions and develop new strategies and coping skills to prevent relapse. IA patients can develop negative thinking habits such as "I do not like going out to the real world since nobody sees me but online, I am accepted." These thoughts can induce a negative cycle and rumination, which could develop into symptoms of depression and anxiety. By remaining in this negative loop of thinking, IA severity can worsen, developing worse withdrawal symptoms if a person decides to quit. CBT helps break this cognitive pattern and allows the patients to assess the root cause of the problem by helping them understand the reason for excessive internet use is to certainly avoid situations and feelings. The effectiveness of CBT is highly moderate, with a study of 128 IA patients finding that over 70% of the patients made a full recovery and managed symptoms [37]. Since CBT is the most effective treatment for depression and anxiety, these mood disorders are common symptoms of IA. It is plausible to suggest that CBT is the best therapeutic strategy to treat IA [38]. There were several limitations of the studies in this project. Firstly, the studies mostly used young male participants, which does not represent the total demographic. This makes it difficult to generalize the findings and understand the relationship between IA and SUD. Also, because the participants were young further longitudinal studies over a long period are required to assess the brain alterations caused by long-term IA. Secondly, most of the studies were primarily based in China or South Korea, where IA is seen as a mental disorder. Cross-cultural studies are necessary to determine and define the shared characteristics and symptoms of IA across different backgrounds. It could be possible that the high rate of IA in China and South Korea is due to the societal pressures/expectations young males face to perform highly academically and at work. In South Korea recently law was passed to reduce the maximum working hours from 68 to 52 weekly (Labor Standards Act; Chapter 1, 2018). Moreover, China also passed laws ruling the 9-9-6 working culture, which is from 9 am to 9 pm for six days a week, illegal (Supreme People's Court, 2021). It could be reasonable to suggest that young males in these countries use the internet to escape the mundane realities of daily life, hence the high prevalence rate in these countries. Those respective governments funding IA boot camps to help addicts overcome their addiction by prohibiting internet use for a period between 1- 4 weeks. To further combat the high rate of prevalence, the Chinese government has set up a law prohibiting under-18 users from playing video games during the week (BBC, 2021). Demonstrating the seriousness and the worrying concern those governments have on the rise of IA.

CONCLUSION

IA and SUD share similar neuro mechanisms but are distinct from each other in neural oscillations and temporal alterations. They were considering IA as harmful as SUD is far fetch, however, since IA tends to be easily reversible with psychotherapy sessions while some SUD requires medication. This should not take away the seriousness of IA since it can be a cause or symptom of other neurological conditions such as depression, anxiety, and ADHD. IA could also become a gateway to SUD and is highly morbid with other neurological conditions. The findings of this project consider IA to be a mental disorder and that government, and policymakers should implement laws and regulations on internet use, especially among children and adolescents. Awareness of IA should be increased, and IA should be considered as detrimental to society and the economy as a gambling addiction. The more people know about IA and its consequences physically and socially, the more it can reduce the prevalence in the future.

ABBREVIATIONS

- IA → Internet Addiction
- SUD → Substance use Disorder.
- VTA → Ventral tegmental area
- NAC → Nucleus accumbens
- PFC → Prefrontal Cortex
- ACC → Anterior cingulate cortex
- IAT → Internet addiction test
- IED → Intra-extra dimensional set shift test
- GNGT → Go/No-Go task.
- SST → Stop signal test.
- SCWT → Stroop colour word test
- Left STC → Left superior temporal cortex.
- MPFC → Medial prefrontal cortex
- POrb → Pars orbitalis
- ReHo → Regional homogeneity
- PCC → Posterior cingulate cortex
- DMN → Default mode network
- RSFC → Resting-state functional connectivity.
- DLPFC → Dorsolateral prefrontal cortex
- STG → Superior Temporal Gyrus
- DAT → Dopamine Transporter
- ERPs → Event-related potentials
- SN →Salience Network
- CEN → Central executive network
- CBT → Cognitive Behavioural therapy
- TMS → Transcranial Magnetic Stimulation

Authors Contributions

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