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NEUROLOGICAL EFFECTS OF OVEREXPOSURE TO THE INTERNET: AN INTRODUCTION TO THE SCENARIO

EFEITOS NEUROLÓGICOS DA SUPEREXPOSIÇÃO À INTERNET: UMA INTRODUÇÃO AO CENÁRIO

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Abstract: Overexposure to the Internet has proliferated, leading to the emergence of so-called "Internet addiction". The subject of the effects caused on the brain by this overexposure is significant because it is considered of public utility. In this sense, this article proposes to present the main findings of neuroscience on Internet addiction and integrates them into a concise theoretical framework. This is a theoretical essay, with a bibliographical approach with a narrative character. Although this work is not a comprehensive literature review, it does provide important data on some of the research related to the neurological influences of excessive Internet exposure, articulated and organized into related categories. Internet addiction is a significant physical, social, emotional and psychological challenge. Most research on addiction seems to focus on personal, social, physical, emotional or mental factors, however few studies focus on cognitive development and its relationship with Internet use, opening up an extensive agenda on the horizon.

Keywords: Technology dependency. Neuropsychology. Nervous system diseases.

INTRODUCTION

Overexposure to the Internet has proliferated, leading to the emergence of the so-called "Internet addiction". This addiction is not yet included in the classifications of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a mental illness, yet it is seen as a specific additive disorder; compulsively using the Internet and wanting it intensely when it is not available to the point of having harmful personal and social consequences are characteristics of this disorder[1].

The use of the Internet is widespread throughout the world, and this has led to changes in the

way people interact with society. In addition to these transformations in social interactions, neurals also occurred. Simple interactions with the smartphone's touch screen cause cognitive changes, which are cortical and caused by sensory and motor processing of the hand and thumb [(2)].

Environmental and biological factors can also cause structural and functional changes in the human brain and, consequently, cause cognitive impairment[(3)]. For example, it is already known that the atrophy process is associated with cognitive decline in older people. The loss of cognitive function can accelerate with a quiet or less attractive lifestyle[(4,5)]. Many cognitive processes, especially superior executive functions and social cognition, do not only depend on innate biological factors, but are influenced by environmental aspects[(6)].

The theme of the effects caused on the brain by overexposure to the Internet is significant because it is considered of public utility. Therefore, this article aims to present the main discoveries of neuroscience on Internet addiction and integrates them into a concise theoretical structure, and can be an instrument to aid reflection and stimulate new research.

METHOD

This is a theoretical essay, with a bibliographic approach of a narrative nature, operationalized as in other studies [(7-8)]. The survey was carried out freely and for convenience in electronic academic search spaces and public libraries. Although this work is not a comprehensive literature review, it provides important data on some of the research related to the neurological influences of overexposure to the Internet, articulated and organized into four categories: studies of people affected by Internet Addiction Disorder (IAD); study that shows why it is difficult to control the desire for the Internet among chemical dependents; studies that point to the effects of excessive exposure to the Internet; and studies that point to a relationship between excessive exposure to the Internet and impulsivity.

RESULTS AND DISCUSSION

Studies of people affected by Internet Addiction Disorder (IAD)

People affected by Internet Addiction Disorder (IAD) already have confirmation of the disorder due to addiction, suffering from neural alteration. A study showed that there were significant disorders in the regions of the frontal, occipital and parietal lobes in patients in this group, causing a blockage in functional connectivity and behavioral impairment. The deeper the IAD, the more intense

the abnormalities [9].

Studies that show why it is difficult to control Internet cravings among drug addicts

Brain dysfunction occurs in the region responsible for controlling the automatic reflective and affective systems, so that the first is underactivated, and the second is overactivated [10]. The reflective system is responsible for the cognitive evaluation of stimuli and the control of responses to these stimuli, while the automatic affective system concerns the emotional evaluation of stimuli. When the person is overexposed to the Internet, there is an imbalance in the relationship between the systems, leading to increased excitement and automatic cravings, along with a low ability to control Internet appetite and inhibit addictive behavior. In addition, the reward system is activated in the face of stimuli related to addiction [10].

Studies pointing to the following effects of excessive exposure to the Internet

The third and largest category includes the decrease in the activities of the anterior and posterior cingulate cortices and the dorsal, prefrontal, posterior and anterior parts of the cerebral cortex, leading to a deficit in the ability to monitor and measure the consequences of conflicts, as well as in the ability to exercise cognitive control. Through magnetic resonance imaging, a study proved that there was more significant activity in the anterior and posterior cingulate corticals in internet users and that those addicted to it, when placed in incoherent situations, showed less medial frontal negativity (MFN) than people who were not addicted and, therefore, did not exhibit this type of compulsive behavior [11]. A separate study was done based on the potential related to events of brain activity. The MFN is associated with cognitive control processes and is used as an indicator in the detection of cognitive conflicts.

Other research revealed that people addicted to the Internet, like other addicted populations, showed reduced efficiency of pre-frontal areas when involved in cognitive tasks [12,13]. These results were confirmed by functional magnetic resonance imaging and complemented by electroencephalography [14].

A study identified that greater activity in the dorsal part of the anterior cingulate cortex and in the left caudate nucleus was found in people addicted to the Internet [15]. These regions are involved in monitoring and analyzing the consequences of conflicts. The same study pointed out that Internet addicts reduced ventrolateral prefrontal activity. These reduced regions may be related to the deficits in cognitive control that Internet addicts have [15]. Another research correlated the scores of the Internet Addiction Test and the strength of the connection between the medial prefrontal cortex and

the dorsolateral prefrontal cortex [16]. The correlation was negative, which suggested that this relationship may be associated with a decrease in self-control and cognitive control. The findings allowed us to conclude that Internet addicts have inhibition deficits.

In a similar study, using the Stroop Test, a neural neuroimaging test, it was found that the anterior and posterior areas of the cingulate cortex were active in people not exposed to Internet addiction, giving them ample control capacity [11]. However, when performing the same procedure in people addicted to the Internet, there was a reduction in the productive capacity of the same regions, reducing the capacity for control. In addition, it was evidenced that there was probably a combination between the reduced ability to detect conflicts and the need to put more cognitive effort into controlling inhibition processes. Another type of study came to the same conclusion, finding inhibitory deficits in the context of exposure to Internet-related words in dependent Internet users [17].

Before presenting the last category of neural effects, it is essential to characterize the additive behavior [18]. It is related to several neural mechanisms: (a) the control of impulses is reduced; (b) when reward signals occur, the responsiveness is increased; and (c) there is greater sensitivity to anxiety stimuli. In the learning of associations between clues and rewards, the orbital cortex, the ventral striatum and the nucleus accumbens are involved [19]. In addition, activity in these regions of the brain is associated with motivation to win prizes and learn tips and clues to earn them.

The area responsible for inhibiting the action of the ventral striated striated and amygdala is the dorsolateral prefrontal cortex. Therefore, deficits in behavioral control may be due to striated ventricular activity or excess amygdala or reduction in dorsolateral prefrontal inhibition of ventricular striatal and tonsilar activity. Such actions, responsible for deficits in behavioral control, are confirmed in people addicted to the Internet.

According to the above, it is concluded that inhibition deficits are found in people addicted to the Internet [11,20,21]; however, there are cases in which they appear when individuals are in contact with stimuli related to addiction [17].

Therefore, it is necessary to be aware that, even if there are similar symptoms, they can be derived from the action of all mechanisms at the same time, as well as two or one of them. Genetic and environmental factors can induce latent neuronal mechanisms to addiction [18]. Genetic factors are genetic polymorphisms responsible for the expression of dopaminergic receptors. Learning to identify stimuli that precede a reward is an environmental factor. Study revealed that, with regard to the specific Internet dependency model, similar mechanisms arise [14].

Studies point to a relationship between excessive exposure to the Internet and impulsivity

Possibly caused by the inhibition of the ability to control, the relationship between excessive exposure to the Internet and impulsivity can occur in extreme emotional expression and flexibility disorders. Research found that people who participated in online RPG games for six weeks had reductions in gray matter in the orbitofrontal cortex, the region of the brain responsible for impulse control and decision-making [22]. A study on the differences in beta and gamma signal strength between netizens and control group pointed to greater impulsivity associated with addiction [23].

Perhaps impulsivity is related to impaired inhibitory control and excessive emotion [24]. Other studies have also indicated that Internet addiction and other addictions are associated with impulsivity [25,26]. Likewise, studies have also pointed to a correlation between cognitive flexibility disorders and impulsivity. Cognitive flexibility disorders can also include reaction stiffness, even with a change in the context of the situation [21], and difficulty in inhibiting usual responses [11].

However, the relationship between impulsivity and addition to the Internet is not seen unanimously. A study indicated that it was not possible to control the variation of impulsivity and its relationship with the scores of the Internet Addiction Test [27], while in another respondents who presented impulsive responses in experimental procedures and subsequent analyses were excluded [17].

Although studies indicate that there are no criteria for defining the use of the Internet [12,13], a survey presented steps in a circular process of dependency [28]. The first step refers to the fact that there is a prerequisite for the use of the Internet, that is, people use it impulsively to seek pleasure and avoid pain. In the second stage, the stimulation of the central nervous system, which causes euphoria in the person when accessing the Internet, contributes to the continuity of focused behavior. In the third stage, there is tolerance or increase in the pleasure threshold, and thus the subject needs to spend more time connected to obtain the same effect. The fourth stage is an abstinence response to the Internet when there is interruption or reduction of use. Such abstinence is manifested in symptoms of mood, insomnia, emotional fluctuations, irritability and others. The fifth stage is the manifestation of ineffective and passive behavior, based on defense and escape mechanisms when challenges and adversities arise. The sixth and last stage produces the avalanche effect, that is, there is a repetition of the use of the Internet as pathological behavior to satisfy the need for pleasure and avoid the reactions that are caused by retraction. In addition, excessive time on the Internet is an escape strategy to avoid dealing with stressful situations.

Another critical point related to overexposure to the Internet is that different forms of content cause dependence. Internet Game Disorder (IGD) is an addiction and, at the same time, a form of content. There is a parallel between the neurobiological correlates of IGD and behavioral addiction, recognized in the DSM-5, which still needs to be more deeply considered in the review articles[29].

According to this thought, people who suffer from IGD have altered cognitive behavior and changes in brain function, manifested through impulsivity, compulsiveness and sensitivity to rewards and punishments. Regarding impulsivity, they are impulsive in the choices they make in everyday life, not considering the negative consequences in the long term, focusing more on their immediate needs and concerns. Neuroimaging-based studies show that prefrontal cortex dysfunction can influence response inhibition in people with IGD.

Another form of content associated with Internet addiction is smartphones. Studies show that their use can perpetuate compulsive behaviors. These devices, so accessible even to children, are used for verification, consultation, quick and frequent inspections and to receive information from news, social media or personal contacts, provoking typical and habitual behaviors [30]. In this sense, information rewards that are received immediately after verification of the device constitute a behavioral reinforcement [31], which involves the corticoestriatal dopaminergic system due to its immediate nature [32].

It should be noted, however, that there is no unanimity among scholars on the brain damage caused by Internet addiction. A large group points to the inhibition of activity in the cerebral cortex due to excessive exposure, while there are those who explain the change in brain physiognomy by the concept of neuroplasticity. Neuroplasticity is the ability of neurons to create new connections or strengthen existing ones in response to everyday experiences [33]. Some scientists with this view deny that irreversible changes occur in the human brain due to such overexposure.

A study compared the behavior of three people not used to using the Internet with that of three others who grew up among computers (digital natives) [34]. The two groups were asked to do a Google search and browse the results while their brain activities were monitored. The results showed that the digital natives completed the task more quickly, and it was also clear that an area of the brain related to the planning of conscious activities was activated with greater intensity in the digital natives. After five days, the brains of people who were not used to using the Internet began to behave in a similar way to that of digital natives. In this case, neuroplasticity occurred. It was evidenced that the brain creates "new" connections between neurons and changes according to learning. The brain is not modified by technology, but changes all the time in response to changes that occur in the environment.

FINAL CONSIDERATIONS

The use of the Internet affects the brain and cognitive processes, although some deny an irreversible change in the brain. Internet addiction is a significant physical, social, emotional and

psychological challenge. Most research on addictions focuses on personal, social, physical, emotional or mental factors related to the topic, however few studies are focused on cognitive development and its relationship with the use of this technological tool. This research focus is essential for a complete understanding of the psychopathology of this addiction.

Through this work, it is concluded that the cognitive deficits found in people addicted to the Internet affect self-control, the ability to detect conflicts, the execution of cognitive tasks and the balance between the systems of reflection and affection. This finding implies that special attention should be paid to children and adolescents, whose brains are developing and, therefore, more susceptible to these changes.

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