



COGNITIVE IMPAIRMENTS IN SUBSTANCE ADDICTION: NARRATIVE REVIEW

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ABSTRACT

Cognition is an intricate mechanism governing the executive functions in the human body and undergoes a developmental process influenced by genetic, biological, and ecological factors. The addicted substance can be denoted as a trigger of deteriorated cognition, impacting memory, decision-making, attention, and reasoning. Specific examination of alcohol, nicotine, cannabis, cocaine, opioids, and amphetamines elucidates the unique ways each substance impairs cognitive functions, ranging from memory deficits to impaired attention and psychomotor skills. Hence the relevant information was gathered by referring to Google Scholar, PubMed, and Elsevier databases. To extract the updated information selected journals were filtered up to the previous ten years. Dopaminergic dysregulation arises as a central theme, influencing reward schemes, motivational drives, and memory pathways, disseminating compulsive behaviors, and obstructing substance cessation. This inclusive exploration highlights the urgency of addressing these complications for informed prevention strategies, effective public health initiatives, and targeted interventions. By elucidating the cognitive impairment in substance addiction, this review strives to emphasize the danger of substance usage.

KEYWORDS: Substance, Cognitive impairment, memory, processing speed

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1. INTRODUCTION

Cognition is a complex set of mental processes incorporating the acquisition, storage, and retrieval of information. The developmental trajectory of cognition commences with birth associating genetic, biological, and ecological factors (Guez et al., 2021). Substances are emphasized as one of the most considerable triggering factors that can directly cause declined cognition including memory, decision-making, attention, and reasoning (Shau & Zhou, 2022). United Nations Office on Drug and Crime (UNODC) reported that 5.8% of individuals aged 15 to 64 habituated to use substances all over the world. Of them, 35 million were diagnosed with substance use disorders. Apart from the physiological damages according by the prolonged usage of substances, severe neurobiological changes can occur in the brain (Melugin et al., 2021). Due to the addictive properties of various substances including alcohol, nicotine, cannabis, cocaine, opioid, and amphetamine, cognitively compulsive behaviour will be manifest that inhibits the termination of the addictive substance. Thereby, observable changes become apparent within individuals' reward schemes, motivational drives, and related memory pathways linked to memory with the continuous craving for a particular substance (Lüscher & Janak, 2021). Consequently, performance in academics and occupations, mental health, and individual quality of life will drastically deteriorate. Hence, the main scope of this review is to elicit the harmful effects of various substances on human cognitive functions.

World Health Organization defines the substances as psychoactive drugs including alcohol and tobacco products. Previous research reveals that ages between 18 to 25 are the most vulnerable period to exposure to the substances (Nawi et al., 2021). A recent research done by using Canadian high school students to investigate the prevalence and correlates of youth poly-substance use revealed that 39% of the youth population engaged with substance use, 53% of them were poly-drug users (Zuckermann et al., 2020). Reviewing the recent literature on the Sri Lankan context, 57% of substance-related arrests were reported in 2021 and 36.5% of substance users were

reported among the emerging adult population in the Western Province (National Dangerous Drug Control Board [NDDCB], 2022). Of them, 3.8% of Advanced Level were at a high risk of engaging in tobacco products, 16.1% of them were reported at moderate risk of alcoholic beverages and 3.8% of them reported a high risk of Cannabis use in the Sri Lankan context (Charuni et al, 2023). Through exposure to media, commercial advertisements, and peer pressure, most adolescents are prone to initiate the substance with addictive properties, and they gradually become addicted to those substances. Some adolescents initiate substance by hearing myths regarding substance usage and end up with substance addiction. One of the studies revealed that openness and extravert personality traits can have a substantial correlation with the initiation of substance use among emerging adults (Thennakoon et al, 2023; Mezquita et al., 2018). Further denoted that the harmful use of substances by people mentioned above causes substance abuse after a longer period (World Health Organization [WHO], 2024). Alcohol, tobacco, cannabis, cocaine, opioids, and amphetamines are the widely used psychoactive drugs that can switch on dopamine neurotransmitters and dysregulate the functions of the brain (World Health Organization [WHO], 2024).

Dopamine is a neurotransmitter that regulates the sensation of pleasure, motivation, and self-satisfaction internalizing in the brain's reward system. (Heimgärtner, 2020; Conrad, 2018). Individuals utilizing addictive substances can increase the level of dopamine which can act as a reinforcing factor for the maintenance of a particular substance (Gould, 2010). Thus, chronic usage of substances dysregulates the brain reward system. Studies reveal that heavy use of substances cause impairment in the prefrontal cortex. Thereby substance-related impulsive behavior will increase declining self-regulation (Goldstein & Volkow, 2011). For this reason, most of the executive functions like decision-making, planning, and memory will be impaired (Martini et al., 2022). Considering memory, individuals who are addicted to substances will be unable to form new memories because of the impairment of the hippocampus (Kutlu & Gould, 2016).

Alcohol-related cognitive impairments

Alcohol is a substance that is quickly absorbed into the bloodstream and affects the brain, kidneys, lungs, and liver. Alcohol is capable of dysregulating neural function that leads to symptoms of intoxication, slurred speech, and poor memory (Cox & Klinger, 2022). Teenagers and adolescents are prone to binge drinking as per the developmental storm that they are experiencing at that time. With the continuous arguments with parents and being a part of society, they might start drinking (Aleixandre et al., 2011).

Even though the dopamine neurotransmitter increases happiness and motivation, continuous alcohol usage leads to the reduction of the number of dopamine receptors causing hopelessness and depression (Lath & Meshram, 2021). Along with that, alcohol reduces the level of glutamate leading to the feelings of low energy and lethargy. Prolonged and extreme alcohol usage may cause vitamin B deficiency and diminished appetite. Consequently, malnutrition associated with alcohol intake can contribute to cognitive impairment (Butler Center for Research [BCR], 2015). Moreover, it diminishes the sizes of both gray matter and white matter in individuals who are diagnosed with alcohol dependence (Daviet et al., 2022). If these conditions were untreated, serious memory and language damage including Wernicke-Korsakoff syndrome might appear in the future.

Nicotine-related cognitive impairments

Nicotine is the psychoactive compound in tobacco products that directly interacts with the central nervous system (Valentine & Sofuoglu, 2018). Once, individuals use tobacco products acetylcholine receptors get stimulated by nicotine compounds which dysregulate the formation of novel memory and memory consolidation. Despite the fact that a slight quantity of nicotine increases alertness and cognitive performance, enduring exposure causes desensitization of the neurotransmitters which can affect cognitive decline (Hahn et al., 2019). The toxic dose of nicotine is estimated to be 40-60 mg for adults, with a dose of 0.8-1 mg/kg body weight

(Tiwari et al., 2020). A study conducted among the Pakistani young population to investigate the smokers' and nonsmokers' variance of cognitive functions evoked a lack of attention-switching tasks within smokers (Riaz et al., 2021). Another research revealed that individuals who identified as severe smokers indicate damages of selective attention, alternating attention, and working memory (Nadar et al., 2021).

Cannabis-related cognitive impairments

Cannabis compounds with tetrahydrocannabinol, which consists 64 active isomers, leads to a psychoactive effect. Thus, different mental and behavioral reactions can appear with each 64 isomers (Atakan, 2012). Despite some countries implementing harsh penalties for the use and sale of cannabis, it has become the most commonly used substance in the world (Shrivastava et al., 2011). As per the WHO statistics, 2.5 % of Substance addicts reported as cannabis users and youth have been identified as the most vulnerable population to initiate this substance (World Health Organization [WHO], 2024). As previous research findings imply, cannabis directly affects individuals' cognitive development. Thus, if an individual initiates cannabis in adolescence, over a period of time their learning, recall and psychomotor performance will be impaired (Gorey et al., 2019). Compared to late-onset initiation, early-onset initiation has caused more damage to the executive functions according to one of the research findings related to cannabis dependence.

Additionally, it is indicated that the early onset of cannabis use could be a factor in the initiation of other narcotics during later times (Hawke et al., 2020).

Cocaine-related cognitive impairments

Cocaine is also a plant-based addictive stimulant drug (National Institute on Drug Abuse [NIDA], 2022) that can also have a significant impact on cognitive functions (Chao et al., 2019). Researchers found that once an individual uses cocaine, it stimulates the brain pleasure center releasing dopamine neurotransmitters. Along with that chronic usage might increase the tolerance and eventually end up with substance use

disorder with severe cognitive impairments (memory, attention, learning, motor skills, psychomotor speed, and emotions) and withdrawal symptoms (Vonmoos & Quednow, 2017; Moeller et al., 2014). Chao et al. (2019) conducted an experimental study that revealed there is a significant impairment that can appear in attention, processing speed, visual memory, and working memory among young adults who smoke cocaine.

Opioid-related cognitive impairments

Opioids can be considered highly addictive narcotic that is used as a pain medication. As per the strong interaction between brain receptors and opioid-active compounds, tolerance will be rapidly generated within the human body. Hence, within a short period of time they might encounter physical and psychological withdrawal symptoms (Koob, 2020). Apart from that opioids combined with the brain reward system and secrete dopamine neurotransmitter continuously reinforcing behaviours associated with pleasure. A cross-sectional study conducted by Moghaddam et al. (2021) indicated that among the individuals diagnosed with opium use disorder, the majority of them present impairments in working memory and speed of information processing. Additionally, individuals can develop psychological dependence involving strong emotional or mental reliance on this drug (Moghaddam et al., 2021).

Amphetamine-related cognitive impairments

Amphetamine is a synthetic stimulant drug that has been made to increase the message traveling speed between the brain and body. Earlier, this drug was designed to treat attention-deficit hyperactivity disorder (Boos et al., 2021). However, drug addicts are habituated to misuse this drug without a prescription due to their addictive properties. Chronic use of amphetamine can lead to memory deficits, including both short-term and long-term memory impairments (Nyberg, 2012). Nevertheless, using a high dose of Amphetamine can impair certain cognitive processes including impulse control, decision-making, and problem-solving (Yechiam & Zeif, 2021). Amphetamines are known for their stimulant effects,

but ironically, chronic use may lead to a reduction in processing speed that delays cognitive tasks to complete (He et al., 2022). Chronic usage of amphetamine may cause psychiatric symptoms including anxiety, hallucination, and paranoia (McKetin et al., 2017).

2. CONCLUSION

This exploration highlights the complex relationship between substance use and cognitive function, emphasizing the profound implications for individual well-being and societal health. Cognition, a pivotal mechanism governing executive functions, is intricately shaped by genetic, biological, and environmental factors from birth. The compelling evidence presented in this review reveals substances as an alarming factor, directly compromising cognitive domains such as memory, decision-making, attention, and reasoning. The comprehensive literature review underscores the vulnerability of emerging adults, with a spotlight on the Sri Lankan context revealing alarming rates of substance-related arrests and use among these demographic areas. The influence of personality traits, media exposure, and peer pressure on substance initiation further complicates this multifaceted issue. The dopaminergic dysregulation induced by substances such as alcohol, nicotine, cannabis, cocaine, opioids, and amphetamines emphasize the neurochemical underpinnings of addictive behaviors, impacting executive functions and cognitive decline. The specific examination of alcohol, nicotine, cannabis, cocaine, opioids, and amphetamines reveals the intricate ways in which each substance uniquely impairs cognitive functions, ranging from memory deficits to impaired attention and psychomotor skills. Understanding these cognitive consequences is imperative for informing preventative strategies, public health initiatives, and targeted interventions aimed at mitigating the profound impact on academic performance, occupational functioning, mental health, and overall quality of life. As we conclude this review, it is evident that a holistic approach is necessary to address the complex interchange between substance use and cognitive function, ultimately adopting healthier outcomes for individuals and society at large.

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