REVIEW ARTICLE

# Effect of alcohol dependence on neuropsychological functioning

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## Abstract

**Background:** Alcohol use disorders (AUD) associate with structural and functional brain differences, including impairments in neuropsychological function. Alcohol is the most widely used psychoactive substance worldwide. More than 50% of alcohol dependent subjects can have alterations in cognitive functions. Cognitive dysfunction interferes with treatment and increases the risk of relapse in alcohol dependence; hence, its identification has potential therapeutic implications. Alcohol-dependence is related to large-scale cognitive impairments, particularly for executive functions (EF). These deficits persist even after long-term abstinence and have a major impact on patients' everyday life and relapse risk.

**Aim:** This study aims to investigate the affect of alcohol dependence on neuropsychological functioning.

**Methods:** For this, literature has been looked for manually as well as through electronic resources like PubMed and Google Scholar.

**Conclusion:** There is a significantly greater cognitive impairment in those with alcohol dependence compared to those without. Evaluating alcohol dependent patients for cognitive impairment can have important therapeutic and prognostic implications.

**Keywords:** alcohol-dependence, neuropsychological , cognitive impairments

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## Introduction

Alcohol is the most widely used psychoactive substance across the world. Alcohol dependence is characterized by three or more of the following at some time during a period of one year – strong desire or compulsion to use alcohol, difficulties in controlling substance taking behavior, physiological withdrawal state as evidenced by characteristic withdrawal syndrome or taking alcohol for relieving or avoiding withdrawal symptoms, tolerance, progressive neglect of alternative pleasures or interest and continued use despite harm as per ICD-10 (1).

Alcoholism is associated with brain damage and poor cognitive functioning (2). The alcoholrelated neuropathology and cognitive impairment for different etiological factors, such as alcohol, thiamine levels, and age vulnerability show inconsistent evidence (2-4).

Around 5.8 liters of alcohol is consumed worldwide with a prevalence of 2.6% for alcohol dependence, 5.1% for alcohol use disorder (AUD). It has also been associated with 5.6% of all causes of death (5) and 5.1% of all disability-adjusted life years (DALYs) attributable to alcohol (6).

AUD is a chronic relapsing and remitting illness and affects various cognitive functions like executive functions, processing speed, memory, attention, and fluency; the impairment ranges from modest to intense (7,8).

In India, the 12-month prevalence of alcohol dependence in the year 2010 was estimated to be 2.1% (9). National Family Health Survey (NFHS-3) found that 45.2 % of males drink alcohol in Kerala (10). A more recent study by the Indian Council for Medical Research (ICMR) found that 35.9% and 23.6% of males consumed alcohol at least once during the last 12 months and one month, respectively, in our state (11). In Kerala, 8.8 % of drinking males consumed alcohol almost daily, while 26.5% drank alcohol 1-4 days/week. Moreover,

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10.5% had at least a day of binge drinking during the last seven days (12).

Significant differences in attention, spatial working memory span, and visual episodic memory were found between alcohol dependent patients and healthy controls in one cross-sectional study (13). Poor cognitive functioning increases the risk of relapse in alcohol dependent patients (14).

Alcohol dependence is a common disorder which leads to physical, psychological, and social problems. Chronic excessive alcohol consumption is associated with cognitive impairments manifesting memory impairments. Cognitive deficits hamper the initiation and sustaining of abstinence, obstruct good decision making, better social interactions, healthy interpersonal relationships, and behavioral dysfunction (15). Considerable evidence shows that excessive use of alcohol is associated with increased cognitive deficit that can persist after cessation of drinking. The executive functioning deficits among the cognitive impairment are most likely to affect rehabilitation success (16) These individuals also exhibit cognitive symptoms such as impulsivity, concentration, and memory issues, even if it is not expressly indicated in the diagnostic criteria.

The neuropsychological profile associated with alcohol use disorders encompasses deficitsin executive functions (17), working memory (18), episodic memory (17), visuospatial abilities (19,20) and motor functions including ataxia (19) Although these impairments are reported to concern a large proportion of alcoholic patients (AL) (17), the effects of chronic alcoholism on cognitive and motor functioning are heterogeneous (21). According to the continuum hypothesis(22) alcohol-related neuropsychological impairments range from mild-to-moderate (19) to severe deficits(21) comparable to those observed in patients with Korsakoff's syndrome (23), and the main contributing factor is the total amount of alcohol consumed over the drinking lifetime (22). However, some studies have indicated that recent alcohol consumption may be a better predictor of neuropsychological performances (24,25) Although other alcohol variables have been regarded as potential explanations for patients' neuropsychological profiles, such as the duration of alcohol dependence (19,24), length of sobriety (25), and number of withdrawals (26), there is still no consensus as to the sources of the cognitive heterogeneity observed in AL. Other potential factors indirectly related to the pattern of chronic alcohol consumption, such as malnutrition, thiamine deficiency and liver complications, therefore need to be considered as well.

Evidence suggests that numerous determinants such as environmental, individual, and genetic factors could favor evolution toward alcohol-dependence. These factors may also interact with each other. Among environmental factors, quality of the neighborhood (27) or socio-economic factors (e.g., lower educational level, employment status) (28, 29) for example may increase risks of alcohol abuse. Individual and psychological characteristics including comorbid psychiatric disorders (30, 31), early life stress exposure (32), or impulsivity (33) are also risk-factors associated with chronic alcohol consumption. In addition, family, twin, and adoption studies have highlighted that genetic factors play an important role in the pathogenesis of alcohol-dependence (34-36). Heritability of alcohol-dependence is estimated between 50 and 80% (37) and is considered as a complex polygenic phenotype. In the same way, recent studies have examined cognitive endopheno type in alcoholism. They have shown that non-alcoholic relatives of alcohol-dependent individuals performed worse on cognitive tasks (specifically executive functions) and presented greater impulsiveness compared to control (38). Cognitive impairments observed in alcohol-dependent patients not presenting any other neurological complications are increasingly becoming the focus of attention of addiction medicine professionals due to their impact on management, as, according to various studies, between 50 and 80% of these patients present impaired cognitive function (39, 40). These impairments are moderate to severe but usually remain undiagnosed when they are not specifically investigated. However, detailed neuropsychological assessment or screening of these cognitive impairments appears to be fundamental to optimally adapt patient management strategies.

The characteristic profile of alteration of episodic memory in alcohol-dependent patients comprises limited learning capacities, impairments of encoding, and recollection processes, difficulties recalling the temporospatial context and deficits of autonoetic consciousness, while information storage is preserved (41, 42). Alteration of executive functions, particularly disorders of inhibition, flexibility, or dual-task coordination also constitute predictive factors of memory impairment (41, 42). In contrast, apart from obvious deficits (i.e., related to dysexecutive syndrome), there is also probably a genuine impairment of episodic memory likely due to the hippocampal atrophy observed in these patients (41).

Finally, visuospatial functions are also predominantly affected, as several studies have demonstrated impaired performances on visuospatial processing, memory and visual learning, visuospatial organization, and visuoconstruction tasks (43,44).

Psychosocial management of alcohol patients- The presence of cognitive impairments therefore requires adaptation of the management of alcohol-dependent patients. CBT has been demonstrated to be effective in the management of alcohol-

| *S. No* | *Authors* | *Year* | *Finding* |
|---|---|---|---|
| 1 | Sudevan SS et al (45) | 2024 | Children of parents with alcohol use disorder had significantly higher behavioral problems, more stressors, difficult temperamental traits, low intellectual functioning, deficits in attention, information processing speed, and working memory. |
| 2 | Ghai P et al (46) | 2023 | The cognitive sub-domains including orientation, execution, calculation, visuoconstructional skills, and recall functions were also significantly ($P < 0.05$) affected for the alcohol-dependent patients when compared to non-alcohol-dependent men. |
| 3 | Rajula KP, Narayan D.(47) | 2023 | The prevalence of cognitive impairment was higher in the study group. |
| 4 | Boleková V, Foriš F. (48) | 2023 | Lower level of cognitive ability in people with alcohol dependence. |
| 5 | Powell A et al (49) | 2024 | Most functions demonstrated recovery within 6–12 months, including sub-domains within attention, executive function, perception, and memory, though basic processing speed and working memory updating/tracking recovered earlier. |
| 7 | Dayal P et al (51) | 2023 | Abstinence from alcohol for approximately three weeks resulted in significant improvements in various cognitive domains including mental speed, verbal learning & memory, visual memory, verbal fluency, and response inhibition. |
| 9 | Das A et al (53) | 2021 | Comparison between early-onset and late-onset alcohol dependence revealed that the score of individual externalizing psychopathologies and the total externalizing psychopathology score on SSAGA intravenous in the early-onset group are significantly higher than late-onset alcohol dependence. |
| 10 | Caneva S et al (54) | 2020 | 31.7% of AUD patients showed cognitive impairments according to the global score scale. |
| 11 | Kaur P et al (55) | 2020 | All neurocognitive functions showed significant improvement at three-time intervals ($p < 0.05$) except for visuomotor function, for which improvement was statistically insignificant ($p > 0.05$) at one month. |
| 12 | Infante MA et al (56) | 2020 | Neither alcohol and/nor cannabis use over time was associated with performance in the verbal memory and processing speed domains. |
| 13 | Sullivan EV, Pfefferbaum A. (57) | 2019 | Functional imaging suggests the possibility that some alcoholics in recovery can compensate for impairment by invoking brain systems typically not used for a target task but that can enable normal-level performance. |
| 14 | Courtney KE et al (58) | 2019 | Longitudinal studies have identified neural abnormalities that predate drinking within most domains of cognitive functioning. |
| 15 | Ioime L et al (59) | 2018 | A year of abstinence resulted in a significant improvement in all cognitive domains assessed after detoxification from alcohol. |
| 16 | Nguyen-Louie TT et al (60) | 2017 | An earlier age of first drinking onset (AFDO) predicted poorer performance in the domains of psychomotor speed and visual attention ($ps<0.05$, $N = 215$) and an earlier age of weekly drinking onset (AWDO) predicted poorer performances on tests of cognitive inhibition and working memory, controlling for baseline neuropsychological performance, drinking duration, and past-year marijuana use ($ps<0.05$, $N = 127$). |
| 17 | Stephan RA et al (61) | 2017 | Results also varied for the individual subcategories of Inhibition, including a large effect size for decisional impulsivity ($g = 0.817$) and cognitive impulsivity (0.860), and a moderate effect size for motor impulsivity ($g = 0.529$). |
| 18 | Ritz L et al (62) | 2016 | Liver fibrosis was found to be a risk factor for executive impairments and also for ataxia, when it was associated with long-term alcohol misuse and symptoms of withdrawal. |
| 19 | Brion M et al (63) | 2017 | Executive deficits observed were centrally related to alcohol-dependence, while comorbid depressive symptoms appeared to intensify the deficits observed. |
| 20 | Lechner WV et al (64) | 2016 | Poorer working memory after alcohol administration (controlling for baseline working memory) was significantly associated with a greater number of drinks consumed per drinking day. |
| 21 | Nguyen-Louie TT et al (65) | 2015 | More post-drinking effects and greater drug use predicted worse psychomotor speed. Processing speed was not predicted by substance involvement. Unexpectedly, more alcohol use predicted better working memory performance. |

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| 22 | Lee RS et al (66) | 2015 | Psychiatric comorbidity and current depressive symptoms were predictive of poorer functional disability. Furthermore, learning and memory, and response inhibition, contributed significantly and independently to predicting functional disability over and above clinical and demographic factors. |
| 23 | Alarcon R et al (67) | 2015 | Age was negatively and education was positively associated with the Montreal Cognitive Assessment (MoCA) score. Significant cognitive deficits concerned visuospatial capacity, attention, fluency, abstraction, and delayed recall. Neither age nor sex was significantly related to the Montreal Cognitive Assessment (MoCA) score, while having a high education level (>12 years) significantly increased the likelihood of having a high Montreal Cognitive Assessment (MoCA) score. |

dependence (68), but it is somewhat paradoxical to propose management that directly involves cerebral structures and cognitive functions altered by chronic alcohol consumption. This management approach may therefore be inappropriate or at least insufficient for a certain number of patients.

The efficacy of CBT would therefore depend on the integrity of certain brain regions of interest. For example, it has been shown in schizophrenic patients that the volume of gray matter in the frontal, temporal (including hippocampus), parietal, and cerebellar regions, brain regions that are also damaged in alcoholdependent patients, is predictive of the efficacy of management (69). Similarly, the integrity of the frontocerebellar network, a site of predilection for brain damage in alcohol-dependent patients, would play an essential role in the efficacy of CBT due to its role in executive functioning (70).

Cognitive behavioral therapy in addiction medicine also requires elaborate cognitive capacities such as episodic, semantic and procedural memories, and executive functions (71-76). Various studies have shown that alcohol-dependent patients with the most severe cognitive impairment also have the least favorable prognosis (77-79).

Cognitive impairment can also influence the expression of individual and environmental factors involved in management, such as self-efficacy, readiness to change, active participation in group therapy, or treatment compliance, as the initial cognitive impairment is predictive of poorer treatment compliance and a decreased self-efficacy. Patients with severe cognitive impairments are also less able to use their own resources during management, in which case the prognosis depends more on the role of external factors such as group therapy or the family support network (80).

Finally, Le Berre et al.(77) demonstrated the role of cognitive functions in the motivation process of patients to change their addictive behavior. In their study, the authors used the motivational model described by Prochaska and DiClemente (81), which defines three stages of change as the key to the patient's commitment to the management process: the precontemplation stage (the subject has no intention to change his/her behavior), the contemplation stage (the subject considers changing his/her behavior but remains ambivalent), and the action stage (cessation of consumption and setting-up of strategies to change behavior). Based on this model, the authors showed that episodic memory plays a role in the subject's awareness of the addictive behavior and the need for follow-up. The integrity of this function actually determines the subject's passage from the precontemplation stage to the contemplation stage. Similarly, the integrity of executive functions enables patients to weigh up their decisions to reach the action stage, which can only be implemented when decision-making capacities are preserved. Cognitive impairment therefore influences the degree of motivation of alcohol-dependent patients, an essential prerequisite to the success of management.

In the light of these findings, it appears essential to propose management based on programs ranging from cognitive remediation to optimal use of the remaining capacities. However, very few addiction medicine units propose cognitive remediation therapy and very few studies have investigated this problem in alcohol-dependent patients. The majority of studies in the field are now relatively old (76, 82) and no longer correspond to current methodological requirements. However, the results of studies conducted in this field are encouraging. A recent study demonstrated that a cognitive remediation program was able to improve divided attention, alert capacities, working memory, and episodic memory. In addition to cognitive improvement, cognitive remediation therapy also improves other non-cognitive domains, especially psychological aspects (well-being, self-esteem) and craving (83).

## Conclusion

Long-term alcohol consumption affects executive functions considerably. The review study showed significant cognitive deficits in individuals with alcohol dependence mainly in executive functions, working memory, and high impulsiveness. Patients with early-onset alcohol dependence have higher externalizing psychopathology and more cognitive deficits in comparison to those with late-onset alcohol dependence.

published in the literature suggest that it is essential to take into account the cognitive dimension of alcohol-dependent patients in order to adapt their treatment and to palliate their difficulties in activities of daily living. The brain changes and the profile of cognitive impairments presented by patients with chronic excessive alcohol consumption have now been very extensively documented in the literature. The role of these changes on drinking behavior, especially via the cognitive processes involved in the mechanisms of addiction, also constitutes a rapidly growing new field of research. Finally, the impact of these impairments on the modalities and efficacy of the proposed management is a clinical problem systematically raised in research. The last domain to be developed in the field of management of alcohol-dependent patients is therefore that of cognitive remediation, which can establish the link between the various problems related to cognitive deficits in the clinical management of these patients in order to propose specific targeted follow-up in a remediation therapy program devoted to these impairments.

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