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# Mental and behavioural disorders related to alcohol and their effects on EEG signals – An overview

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## Abstract

This paper reviews the clinical criteria for diagnosis of mental and behavioural disorders caused by alcohol use. We survey the literature on the effect of alcohol, mental and behavioural disorders on EEG signals. The discussion is organized on the basis of the methods used for clinical diagnosis of disorders and effect of alcohol related mental and behavioural disorders on EEG signals. We also discuss direction of future research in terms of EEG based diagnosis of mental and behavioural disorders, along with its integration with other mental and behavioural disorders.

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## 1. Introduction

The Alcohol is the most common used substance in the community. The alcoholic beverages have been a part of social life for millennia. The men are more, compared with women throughout the world, are likely to drink, consume more alcohol, and cause more problems by doing so. The 76.3 million people are diagnosed with alcohol disorders. In India, the use of alcohol among the women has been estimated less than five percent (less than 5%)

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(Mahal A., 1). But due to the popular media it is evident that the percentage of alcohol consumption among young women especially in urban setting is increasing. The health hazards due to the alcohol are clearly identified. The physical and mental problems are experienced earlier in females consuming alcohol than males (Mental Health Research in India, 2; Vivek B., et al., 3; Women's Mental Health, 4). Alcohol dependence is another major public health problem contributing to road accidents, accidents at work place and violent behavior. Early treatment is essential for better recovery. The effective treatment for associated depressive disorders are available, yet there are millions of people affected by depression, where suffering and disability is prolonged because their condition goes undetected, or is often not adequately treated leading to increased substance use such as alcohol. There is a need to strengthen mental health care and early detection of mental disorders associated with the alcohol use. The paper is organized as follows. The section 2 describes in brief diagnostic criteria given in DSM IV-TR. The analysis method including the feature extractions and classifications techniques of EEG signals from alcohol abuse patients are described in section 3. Finally, conclusion and future work are given in section 4.

## 2. Mental and Behavioural Disorders

The studies of alcoholics reported patterns of solitary drinking and a high incidence of medical and psychiatric morbidity with help seeking delayed till physical health or emotional crises made it inevitable. Disorders associated with alcoholism can be divided in three groups A) Disorders related to direct effect of alcohol on the brain includes alcohol intoxication, withdrawal, delirium, hallucinations etc. B) Disorders related to behaviour associated with alcohol like abuse and dependence and C) Disorders with persisting effects of alcohol including dementia, amnestic disorder, *Wernicke's encephalopathy* and *Korsakoff's Syndrome*. The World Health Organization (WHO) classified the mental and behavioural disorders in F00-F99 block in the edition of ICD-10. The mental and behavioural disorders due to alcohol use are mentioned in code F10. The Diagnostic and Statistical Manual of Mental Disorders IV Text Revision (DSM IV-TR) by the American Psychiatric Association clearly defines the diagnostic criteria for each psychiatric disorder. The DSM IV-TR is a categorical classification system. The brief description as per of criteria in DSM IV-TR for disorders like Alcohol intoxication, Harmful use of alcohol, Alcohol dependence syndrome, Alcohol withdrawal syndrome and Delirium tremens and Wernicke-Korsakoff Syndrome are as follows (DSM IV TR, 5).

### 2.1 Diagnostic Criteria according to DSM IV-TR:

The various alcoholic disorders are diagnosed depending upon the clinical signs and symptoms and based on the DSM IV-TR criteria, the few of these given below.

#### 1. Alcohol Dependence:

The essential feature of alcohol dependence is cluster of cognitive, behavioural and physiological symptoms. The pattern of substance use, leading to clinical significant distress, manifested as a following occurring at any time in the same 12 month period.

##### A. Tolerance :

1. A need for markedly increased amount of substance to achieve desired effect.
2. Markedly diminished effect with continued use of the same amount of the substance

##### B. The substance is taken in large amounts or over a longer period than was intended.

##### C. There is a persistent desire or unsuccessful efforts to cut down or control the substance use

#### 2. Alcohol Withdrawal :

The essential feature of alcohol withdrawal is the presence of a characteristic withdrawal syndrome that develops after cessation heavy and prolonged alcohol use.

##### A. Cessation of alcohol use that has been heavy and prolonged.

##### B. Developing within several hours to a few days after criterion

1. Autonomic hyperactivity
2. Increased hand tremor
3. Nausea or vomiting

##### C. The symptoms are not due to a general medical condition and not accounted by another mental disorder.

**3. Alcohol Abuse:**

- A. A maladaptive pattern of substance use leading to clinically significant impairment, the following occurring within a 12 month period.
  - 1. Recurrent substance use in situation in which it is physically hazardous
  - 2. Recurrent substance use resulting in a failure to fulfill major role obligation at work, school or home.
  - 3. Recurrent substance – related legal problem
- B. The symptom have never met the criteria for substance dependence for this class of substance

**4. Alcohol Intoxication:**

- A. Recent ingestion of alcohol
- B. Clinically significant maladaptive behavioral or psychological changes
- C. The signs, developing during, alcohol use
  - 1. Slurred speech
  - 2. In coordination
  - 3. Unsteady gait
  - 4. Impairment in memory
  - 5. Coma
- D. The symptoms are not due to a general medical condition and not accounted by another mental disorders

**5. Delirium Tremens :**

- A. Disturbance of consciousness with reduced ability of focus, sustains, or shift attention
- B. A change in condition
- C. The disturbance develops over a short period of time and tends to fluctuate during the course of the day
- D. There is evidence from the history, physical examination, or laboratory finding of either 1. or 2.
  - 1. The symptoms in criteria A and B developed during substance intoxication
  - 2. Medication use is etiologically related to the disturbance.

**6. Wernicke-Korsakoff Syndrome (WKS):**

WKS is disease caused due to abuse of alcohol that includes the presence of Wernicke's Encephalopathy (WE) and Korsakoff's Syndrome (KS), two memory related disorders.

- A. Classic Trio of Sign: Mental Confusion, eye movement disorders and ataxia
- B. Language disturbance (aphasia), inability to carry out motor activity (aproxia), inability to recognition objects (agnosia), or deficits in planning, initiation, organization and abstraction.

**3. Analysis and classification using Electroencephalogram**

Electroencephalogram (EEG) is a noninvasive method for cerebral investigation. It is useful for early detection of substance use disorders. Sokhadze, Cannon and Trudeau reviewed substance use disorders with respective EEG biofeedback. They discussed the quantitative electroencephalography (qEEG) in alcoholism, Marijuana Abuse, Heroin Addiction, Cocaine Addiction and Methamphetamine (Tato S., et al., 6). We reviewed the different types of mental and behavioral disorders due to the abuse of alcohol and correlation with EEG signals. In this regards, the literature exists and demonstrating that EEG is sufficiently relevant to obtain pattern in mental disorders. With this relation, the numerous research articles describe that the EEG is a widely accepted and used as an informative measure of the status of the alcoholic brain and the neurophysiologic effects of chronic alcohol abuse and withdrawal, sensitive to thoughts created in human mind (Alan G. and Michal S., 7; Arm M., et al., 8). Madhavi Rangaswami and her research groups studied the magnitude and spatial distribution of the theta power in resulting with EEG to explore the changes in the neurophysiologic status of the alcohol brain. They conducted an experiment on 307 alcohol – dependent subjects (cases) and 307 age and gender – matched unaffected control (baseline). Alcoholic dependant subjects were found increased absolute theta power at all scalp locations. The theta log power was increased in male alcoholics at the central and parental regions and in female alcoholics at the parietal region from the scalp of brain, when compared with the respective matched controls (Madhavi R., et al., 9). Similarly, classification of disorders, emotions and their effect on neurophysiological signals has been studied through various

research articles (Malar E., et al., 10; Cokyilmaz M., 11; Projez B. and Begleiter H., 12; Cindy L., et al., 13; Janvale G., et al., 14).

Alcohol has the larger effect on neurophysiologic parameters. It increases absolute power (amplitude) in the delta (0–4 Hz) and theta (4 – 8 Hz) of EEG bands during resting condition and increases the amplitude of alpha rhythm in both the frontal midline and parietal regions of the brain in both high load and low load task conditions. Similarly, the pre frontal region of brain decreases an absolute power with increase in the amount of alcohol intake and increase in central, occipital region of the brain scalp increases. Therefore, power spectrum density can be used as a parameter to differentiate EEG of alcoholic from non-alcoholic (Saletu-Zyhlarz G., 15; Winterer G., et al., 16).

EEG biofeedback also has been employed in alcohol use disorders (James M., et al., 17; Scott T. and Leston B., 18). The Global field synchronization (GFS) measurements of Event Related Potential (ERP) of EEG signal in Delta (0–4 Hz), Theta (4–8 Hz), Alpha (8–13 Hz), Beta (13–30 Hz) and Gama (30–100 Hz) frequency bands are used as discriminating feature vectors in the classification of alcoholic and non-alcoholic control subjects. GFS measurements show the functional connectivity of neurocognitive networks in the patient's brain as a response to a given stimuli type. A channel optimization algorithm improves the recognition accuracy by selecting channels with the most significant attributes. This algorithm was applied during GFS prior to classification stage and probabilistic neural network was used as a classifier. This system successfully classifies alcoholic and non-alcoholic subjects with accuracy over 80 %. Event Related Oscillators measures brain activity in response to a specific stimulus, has shown in brain activity of alcoholics and non – alcoholic differs in P3 components at low amplitude in alcoholics. This difference is consistent in the brain of alcoholics and it can be used for diagnosis purpose (Kotchoubey B., et al., 19; Brig SR Mehta, et al., 20; Mckeon A. and Norman D., 21; Cheng – Jian Lin, 22; Cindy L. and Hua Hsieh, 23). The Multivariate Discriminant Analysis and Artificial Neural Network (ANN) technology was applied on quantitative EEG signals for classification of two diagnostic subgroups. The correct classification of patient's EEGs was achieved 83-85%. An ANN also improved classification result when compared with discriminant analysis. It was found that in comparison to abstainers, relapsers that were more desynchronized over frontal area of brain, was interpreted as a functional disturbance of the prefrontal cortex (Julien K., et al., 24). The Demet Kinay and group found early and late state EEG in Wernicke-Korsakoff Syndrome (WKS). The performed an experiment on 18 patients. In the early stage abnormal EEG were recorded in 5 patients. The abnormality was found in theta activity in frontal and front temporal regions of brain. They have also found the position correlation between the EEG and acute stage MRI. (Dement K., et al., 26). Therefore, the above literature discusses the significant change in an EEG signals in alcoholism and recommends that there is need of further research in this direction.

#### 4. Directions for Further Research

Even though, the systematic studies of mental disorders due to use of alcohol and access the correlation in pattern of electroencephalograph (EEG) signals between alcohol dependence and withdrawal syndrome individuals and healthy participants were reported. But, the mental and behavioral disorders due to use of alcohols are not classified and diagnosed using EEG. The aim of the new system is to classify and diagnose disorders using EEG. The EEG based Mental Disorder Recognition System (MDRS Tool) will be developed. The important steps of MDRS tool are listed below.

**Step 1:** As per DSM-IV-TR Version, the cases will be sub categorized in to following types: alcohol intoxication, harmful use of alcohol, alcohol dependence syndrome, alcohol withdrawal syndrome and delirium tremens and Wernicke-Korsakoff Syndrome.

**Step 2:** EEG signals will be recorded from these subjects categorized as above. Similarly, without any alcohol induced for control group will be taken for EEG study as base line purpose. The recording will be done under the both conditions i.e. subject's alcoholic and controlled situation (non – alcoholic). The features related to different mental and behavioral disorders will be extracted from recorded EEGs. At the same time behavioral pattern, signs and symptoms will be observed and studied using DSM-IV-TR Version.

**Step 3:** The analysis and classification will be done about these extracted features using digital signal processing (DSP) and different statistical techniques. The different recognition system will be evaluated.

**Step 4:** Mental and Behavioral disorders will be correlated with clinical, psychological and neurophysiological Information (Obtained from above methods) to measure the changes that happen to the functioning of the brain.

## 5. Conclusion

There are two types of diagnostic methods of mental disorders i.e. diagnosis through manual and system. Based on literatures, there is a clear diagnosis criterion given in ICD 10 and DSM IV-TR version. The neuro-images and other neurophysiological measurements are also used for diagnosis purpose. But, these methods do not distinguish features from Alcohol Dependence, Alcohol Withdrawal, Alcohol Abuse, Alcohol Intoxication, and Delirium Tremens or Wernicke-Korsakoff Syndrome. So, the aim of the proposed system is to analyze and classifies EEG signals of individual who are suffering mental and behavioral disorders due to use of alcohol. The MDRS Tool will be applicable to diagnosis epilepsy and Alzheimer's diseases in early stage. The proposed system will be applied in human resource department for employees' routing mental health checkup of an organization. So that, there is need to do a lot of research in this direction in Indian condition.

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