Short review of EEG Anomalies in Addiction Disorders

Dr. Steven Rondeau BCN-BCIA(EEG) | March 2021

From a scientific perspective, addiction is an example of motivation taking a maladaptive direction, in many cases leading to altered functional connectivity in the brain [1]. In this context, electroencephalography (EEG) has been widely used to non-invasively investigate the neural correlates of addictive behaviors, and recent research has provided a number of biomarkers of altered brain activity, which hold promise in both the diagnosis and treatment of addiction disorders.

For example, EEG-based methods have been proposed in the investigation of the disruptive effects of **alcohol abuse** such as neurochemical imbalances [2], deficiency in attention [3], new information processing deficits [4]), and impaired information retrieval from memory and attention [3]. Other research suggests that EEG can provide objective **measures of medication effects** on structural and functional recovery [5] or even identify individuals with the highest **risk for relapse** [6, 7].

Evidence for altered EEG has also been widely reported in drug users. For example, in **crack cocaine-dependent subjects** examined during the withdrawal state, quantitative EEG (QEEG) revealed widespread delta activity deficits [8] and increased alpha activity in the anterior region of the scalp, which have been proposed to be linked to altered dopaminergic transmission in the brain [9]. Altered interhemispheric hypercoherence in fast activity, between occipital regions and between frontopolar regions were also found. Moreover, activity asymmetries in all frequency bands, were found in this population, with left greater than right magnitude at posterior regions and right greater than left magnitude at frontal regions [9].

In terms of behavioral addictions, there is EEG evidence for abnormal connectivity in the brain of individuals with **compulsive buying behavior** [10] or **internet addiction** [11]. Studies investigating **frequency changes** (typically decreased beta and increased gamma) in behavioural addiction suggest a link between **increased impulsivity** and imbalances of dopaminergic transmission, GABAergic disinhibition, excitatory activation, and cravings [12]. These EEG frequency changes have also been proposed to underpin a link between learning processes and impulsivity [13]. More specifically, it has been proposed that inhibition and punishment-related learning in individuals with greater impulsivity may be associated with increased **risk-taking behavior** [14].

Hypercoherence (increased synchronicity) in the fast-frequency EEG bands have been found in subjects with **internet gaming disorder (IGD)** and it has been suggested that hypercoherence in this population may reflect a state of **hyperarousal within the visual system** [15]. Individuals with IGD spend significant amounts of time playing videogames, which has been proposed to induce a restless state, even after playing sessions, during a resting state with the eyes closed.

Interestingly several studies have demonstrated that the **Brain-derived neurotrophic factor (BDNF)** is elevated in patients with pathological gambling [16-18]. More specifically, it has been suggested that the increased BDNF in pathological gamblers is related to changes in dopaminergic transmission in the ventral tegmental area and nucleus accumbens, two key components of the reward system [19, 20].

Positive correlations between serum BDNF level, the severity of **pathological gambling** and beta band activity in the frontal and central regions have also been observed. Interestingly, the positive correlation between beta band activity and the severity of the disorder may be associated with hyperexcitability and increased cravings [15].

These findings suggest a link between **objectively measured markers** of a specific neurophysiological state and behavioural manifestations in gambling disorder, and may be key in establishing **evidence-based clinical assessments/interventions.**

Conclusions

In individuals with addiction, EEG anomalies have been widely demonstrated suggesting that EEG methods can be highly valuable for the screening of altered brain activity and related neurochemical imbalances in this population.

This suggests that EEG mapping should be routinely used to selectively detect non-normative brain activity, devise ad hoc interventions, and regularly monitor treatment response.

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