Using Quantitative Electroencephalography to Predict, Detect and Monitor Neurobehavioral Changes

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Since its early stages of development, over 70 years ago [1], quantitative electroencephalography (qEEG) has been widely employed in research studies not only to **identify functional anomalies in the brain**, naturally occurring or drug-induced, but also to monitor the effects of a wide range of interventions, including **pharmacotherapy, psychotherapy, meditation and peak performance training.**

For example, qEEG has shown its diagnostic value in **the early diagnosis and management of severe acute cerebral infarctions**, supplementing regular EEG acquisition [2], in the early detection of acute **intracranial complications during cerebrovascular surgery**, and in situations where the cerebral blood flow is severely altered. In comatose patients, qEEG can provide otherwise unobtainable diagnostic and prognostic data [3] and may assist clinicians in evaluating the optimal time-point when a patient can be disconnected from the ventilator [4].

Studies employing qEEG have revealed decreased slow wave (delta and theta) activity in **cocaine-dependent persons** and encephalopathy-like profiles in **abstinent methamphetamine-dependent subjects** [5]. Further, research indicates that qEEG can also be employed clinically to **define rehabilitation outcomes** in persons with substance abuse history [6]. Other evidence suggests that **qEEG can play a role in the selection of the most appropriate pharmacological intervention**, and consequentially increase positive treatment outcome rates. For example, studies have shown a reversal of the disease-induced change on EEG by haloperidol and that this effect was reversed by atypical antipsychotics, which suggests not only a difference in mechanism between typical and atypical antipsychotic agents [7] but also that baseline and follow up qEEG investigations have the potential to guide mental health clinicians in their attempt to alleviate behavioral disturbances in their patients, eventually replacing the trial-and-error approach most typically adopted and reducing the risk for the adverse effects associated to unsuitable treatments.

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Importantly, evidence supports the use of qEEG in the **evaluation of non-pharmacological interventions**. For example, **meditation practice** is thought to produce serotonin inhibition in hippocampal cells, which in turn increases hippocampal/septal slow-wave EEG activity (i.e., alpha, delta, and theta) that eventually triggers slow-wave synchronization across the temporal lobes [8, 9]. Other research has explored the effects of a range of meditation styles (e.g., Buddhist monks, shamans, and with greater than 10 years' experience mindful practice) and has demonstrated distinct EEG patterns in experienced practitioners when compared with beginners [10, 11]. Importantly, there is evidence that Yoga and meditation practices alleviate anxiety and depression symptoms in patients with stress-related neuropsychiatric disorders and that the improved psychological states correlate with a wide range of frequency-specific changes in the EEG [12], suggesting that qEEG methods can be employed to measure and monitor the functional effects of **self-administered non-invasive interventions.**

Finally, more evidence on the ability of qEEG to measure distinct brain activity patterns comes from studies with athletes. When compared with non-athletes, the qEEG of athletes at rest or during motor activity exhibits stronger alpha rhythm (which generally correlates with a more relaxed state) and increased beta activity in the fronto-parietal area, suggesting improved decision making and resilience [13]. These data, in line with the findings that indicate that regular physical exercise improves wellbeing/mood [14], may offer support for the regular use of qEEG-guided interventions in **sportive peak performance training.**

Conclusions

Supported by hundreds of studies, qEEG methods offer the opportunity to non-invasively, objectively and reliably detect distinct brain activity patterns before and after interventions in both healthy persons and also in clinical populations. In particular, there is evidence that qEEG is a valuable resource that can assists clinicians in providing more targeted interventions for their patients. Moreover, qEEG investigations and evaluations can be regularly used to guide training programs aimed and optimizing cognitive and emotional performance in healthy persons under stressful conditions.

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