

Title Using EEG in the diagnosis and evaluation of the effect of medication and neurofeedback (NF) in adult AD/HD

EPI Equipe Defi, Inria-Saclay

Financement 100% demandé: CORDIS INRIA Saclay

Context

Travail de these

Expertise souhaitée

The candidate should have a Master's degree in Computer Science or Applied Mathematics and be able to program in **Matlab or Python**, have done classwork in **statistics**. Past experience in **Brain-Computer Interface** is helpful. The desire to make a contribution to mental health is necessary.

Contact

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Lieu de la these

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Ecole Doctorale

Ecole doctorale de mathématiques Hadamard

Encadrement Co-directed by Jing-Rebecca Li (INRIA-Saclay, Equipe DEFI) and Dr. Hassan Rahioui

Hassan Rahioui est psychiatre et docteur en psychologie. Chef du pôle psychiatrique du 7e arrondissement de Paris rattaché au centre hospitalier Sainte-Anne, il est également enseignant chercheur en psychopathologie à l'université Paris Diderot et président de l'Association française de thérapie interpersonnelle.

Jing-Rebecca Li est chercheuse au sein de l'équipe Defi travaillant en modélisation mathématiques et neuro-imagerie.

Thématique Mathématique et Science de la Vie

Description détaillée

Context and objectives

1. Background on AD/HD

Attention Deficit Disorder with or without Hyperactivity (AD/HD) in adults is gaining attention only recently in the scientific community because it had been considered, wrongly, that this pathology disappeared after adolescence. It is a neurobiological disorder that can be very disabling in the personal and professional life of the person who has it. Though it can be aggravated by psycho-social factors, AD/HD is essentially genetic (and therefore often hereditary). **AD/HD affects approximately 5% of the general population**, leading to attention deficit with possible hyperactivity and impulsivity problems. Hypersensitivity problems, frequent and short fluctuations in energy, emotions and mood, as well as organizational difficulties often resulting in procrastination, are also common.

Attention deficit is the main symptom of AD / HD and it is presented in 3 types that differ greatly in the behavioral aspect:

- Inattentive Type

It is more an inconsistency of attention than a deficit of attention. Those who only have this component are dreamers and move from one idea to another, often without putting them into action and thus starting few actions.

- Hyperactive type

Hyperactive adults become with age less physically agitated but relentlessly move from one action to another without finishing most, preventing them from reaching their goals (which are too many or incompatible with their disorder).

- Impulsive type

Here the patients act or speak before thinking, take risks, have an explosive temperament or give up on everything regularly.

From a therapeutic point of view, alongside medication, neurofeedback (NF), the interest in which has been constantly increasing, is a technique that allows informing in real time the subject on his or her level of concentration. When a decrease in attention occurs, the subject must then remobilize his attentional resources to find an acceptable level of concentration. It is thus a technique of reeducation, where during the sessions, the subject can reappropriate the ability to maintain his attention.

2. EEG diagnosis and treatment (neurofeedback) for AD/HD

Given that the diagnosis is not obvious and complementary evaluation tools are lacking, the practitioner is looking to investigate tools that may facilitate his or her evaluation. In particular, electroencephalography (EEG) is one of these promising lines of research. After a long period of decline, the use of EEG has become attractive for research and clinical purposes. Recent work recommends the use of EEG with high densities (256 electrodes) for more precise spatio-temporal

information on the dynamic aspects of cortical activation and intracortical communication. These new recording capacities are gradually entering the field of psychiatry.

A vertex-measured theta-to-beta power ratio under open-eyes or closed-eyes conditions was proposed to capture the relative contributions of two relevant frequency bands to diagnose and monitor ADHD; However, the true functional significance of this measure remains unknown. An increase in theta band was found throughout the life span of adolescents and adults with AD / HD compared to non-AD / HD populations [1]. This increase, however, may be a non-specific marker for cortical dysfunction common to other disorders, such as epilepsy, bipolar disorder, and polysubstance abuse [2].

At present, there is no single diagnostic test for AD / HD. An appropriate diagnostic assessment for AD / HD (and all other childhood psychiatric disorders) generally involves a process of collecting data on the history, course and duration of symptoms, both at home, school, and at work using clinical interviews and behavioral scales. Because inattention is pathognomonic to almost all childhood psychiatric disorders, and it is often difficult to make differential diagnoses between AD / HD and other disorders that may have a similar presentation, including Autism spectrum disorders, mood and anxiety disorders, and learning disabilities. Thus, a biological diagnostic test or a biological marker that is sensitive and specific to AD / HD would be of great help. Based on the previously reviewed results, EEG measurements were considered a promising biomarker for AD / HD.

There is a long history of EEG research documenting EEG abnormalities in AD / HD, especially the increase in fronto-central thetatic power, decreased beta activity and increased theta / beta. Attempts to correct these EEG abnormalities, coupled with a lower positive response to stimulant drugs, are the reason for neurofeedback (NF).

The first case studies using NF in AD / HD were conducted by Shouse and Lubar [4] and Lubar and Shouse [5], and these studies demonstrated positive effects on behavioral and cognitive functioning. The treatment used was a combination of strengthening to decrease theta band activity and increase beta band activity in the 12 to 20 Hz range. In 2005, Loo and Barkley [3] examined the NF literature and concluded that methodological problems (eg, lack of randomized, placebo, blind, small sample size and inappropriate statistics) of the published studies have considerably limited the strength of positive conclusions regarding the efficacy of this NF mode for AD / HD.

The objectives of this PhD thesis are the following:

- 1) Helping with the diagnostic of AD/HD
- 2) Identify subgroups that can benefit from medication
- 3) Identify subgroups that may benefit from neurofeedback

Methodology

This PhD project concerns the analysis of EEG signals measured by commercially available wearable EEG headsets during the evaluation and treatment of AD/HD patients, recruited by Dr. Hassan Rahioui (psychiatre et docteur en psychologie, Chef du pôle psychiatrique du 7e arrondissement de Paris rattaché au centre hospitalier Sainte-Anne). A group of patients will be recruited as well as a similar group of controls. EEG measurements of controls will be taken at the beginning of the PhD

thesis. EEG measurements (14 EEG channels plus 2 reference channels, EMOTIV Epoc+ system) in the patients will be taken during evaluation and neurofeedback treatment sessions, and saved for later analysis. Concurrent to the EEG measurements, physiological measures (pulse, muscle tension, respiration) will be taken using commercial available wearable devices.

We propose to perform the following work: 1) analyze the power spectral density and coherence of the 14 EEG time series thus obtained (similar to [6]); 2) use standard classification algorithms [7] to distinguish between patients and controls; 3) follow the patient response during the course of therapy using a) self-reported outcome by the patient; b) evaluation by the therapist; c) physiological measurements taken during the sessions; d) EEG features taken during the sessions. We expect these four ways of evaluating the patient response to be correlated.

In this way, we expect to make progress in linking EEG features to quantitative measurement of attention/focus in the context of AD/HD at the individual patient level.

In addition to the above described clinical objectives, we also plan to make contribution to the validation [9] of the use of the wearable EEG headsets in clinical settings by performing the following tasks

Technology Validation

1. Comparison EEG signal reliability by comparing **two Emotiv EEG systems** (EPOC+ and Insight) and research EEG system (Biopac B-Alert)
2. **Filter and treatment** of raw EEG signal using several models
3. Comparison of signal processing/analysis/interpretation **software** included in the above EEG systems.

Expected outcome

This will be the start of a collaborative effort between the Defi team at Inria-Saclay and the mental health professionals at the centre hospitalier Sainte-Anne and l'université Paris Diderot to use EEG to aid in therapy (guidance of therapy, evaluation of therapy outcome) in clinical settings and start of software development for psychotherapy in the Defi team.

Bibliography

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