

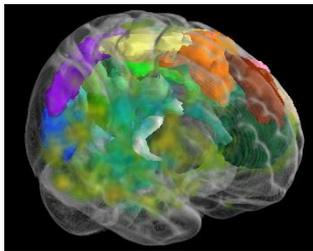
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A robust EEG tool for *classification of states of consciousness*



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Diagnosing Disorders of Consciousness (DoC) is difficult and requires robust and reliable tools. A study conducted by Denis Engemann (Inria, French national research institute for the digital sciences – CEA NeuroSpin) and Federico Raimondo (University of Buenos Aires/Sorbonne Université), directed by Jacobo Sitt, Inserm researcher at the Brain and Spine Institute (ICM), at Pitié-Salpêtrière AP-HP hospital in Paris, (CNRS/Inserm/Sorbonne Université) proposed a novel

EEG tool called “DoC-Forest” for classification of states of consciousness. DoC-Forest is now accessible to all centers in the world. The results are published in Brain.

A major challenge for medical care

Disorders of Consciousness (DoC) are a severe challenge in clinical neuroscience.

Two major conditions are described: the “vegetative” state, with no awareness from the patient and the “minimally conscious” state, with a certain degree of awareness. DoC are notoriously difficult to diagnose, increasing the need for reliable and accessible diagnostic tools in practice.

EEG can meet those demands and provide economic screening in many situations. Furthermore, compiling large data sets obtained from EEG across medical centers may enable powerful machine learning approaches.

A study conducted by Denis Engemann (Inria Saclay – Île-de-France / CEA NeuroSpin), Federico Raimondo and Jacobo Sitt, members of the PICNIC team at ICM, proposed and validated an EEG diagnostic tool based on clinical data from Pitié-Salpêtrière AP-HP hospital, Paris. They computed EEG-biomarkers of consciousness with different sets of sensors and portions of the EEG recording and combined them using machine-learning to develop a prediction tool.

Once developed, **it had to be tested with regard to several critical parameters:** can this tool be used on data from other centers around the world? What amount of data does it need to provide with a reliable diagnostic? (i.e. is this tool generally accessible, not just to the better equipped centers)? Is it robust, meaning can it provide the right diagnostic even with noise on the data?

The researchers tested their models on two new data sets from Paris and the Coma Science Group at the University of Liège (Belgium). They generalized well, also when training on the task-EEG data from Paris and testing on the resting-state-EEG Liège, suggesting the presence of common EEG-signatures of DoC.

They assessed the performance of their EEG tool “DoC-Forest” on more than a hundred EEG features either combined or individually. They found that reasonable prediction performance can already be obtained from small portions of EEG, for example, 16 sensors and from a few tens of seconds of clean EEG. They also observed that the multivariate model was more robust than the univariate ones when changing the number of sensors or EEG-trials.



A reliable, simple and accessible method

“With computational stress tests, we found that the multivariate model is particularly robust when different EEG-configurations are used for training and testing and either the diagnostic information or the data is corrupted with noise.” adds Denis Engemann.

Overall, this study validates the robustness and reliability of this EEG tool for the diagnostic of disorders of consciousness. EEG is a simple and accessible method in practice and using this tool, **detection of disorders of consciousness can be obtained collecting small amounts of data from each patient**. Further studies will aim at extending these results to prognosis of DoC as well as other states of consciousness and improve the machine-learning results by using even larger data sets.

> The article is published in Brain: <https://academic.oup.com/brain/article-lookup/doi/10.1093/brain/awy251>

> The related software can be found here: <https://github.com/nice-tools/nice>

About Inria: Inria, the French national research institute for the digital sciences, promotes scientific excellence and technology transfer to maximise its impact. It employs 2,400 people. Its 200 agile project teams, generally with academic partners, involve more than 3,000 scientists in meeting the challenges of computer science and mathematics, often at the interface of other disciplines. Inria works with many companies and has assisted in the creation of over 160 startups. It strives to meet the challenges of the digital transformation of science, society and the economy.

About the Inria Saclay – Île-de-France research centre: Since its creation in 2008, the Inria Saclay – Île-de-France research centre has developed a policy of extremely close collaboration with the major institutions in the region in which it is based, by setting up joint laboratories and teams. The 450 scientists of the centre are organized into 29 research teams, 23 of which are shared with partners from the Saclay area such as CEA, CNRS and Ecole polytechnique.

About ICM: The Institut du Cerveau et de la Moelle épinière – ICM (Brain & Spine Institute) – is an international brain and spinal cord research center whose innovative concept and structure make it the only institute of its kind in the world. The ICM brings patients, doctors and researchers together with the aim of rapidly develop treatments for disorders of the nervous system and enable patients to benefit from them as quickly as possible. The best scientists from all backgrounds and countries come together at the Institute to perform leading-edge research in this area. To help researchers advance in their work and give patients tangible reasons for hope, we must all play a role: government agencies, corporate actors and individuals. No one can afford to idly stand by, because this fight is vital to every one of us.

About the AP-HP:

AP-HP is a teaching hospital, a major clinical research in France and internationally recognized Europe. Its 39 hospitals attended each year 8 million sick people: consultation in emergency hospitalizations during scheduled or home hospitalization. It provides a public health service for all, 24/24, and that is it both a duty and pride. The AP-HP is the largest employer of Île-de-France: 100 000 people - doctors, researchers, paramedical, administrative staff and workers - work there. www.aphp.fr

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