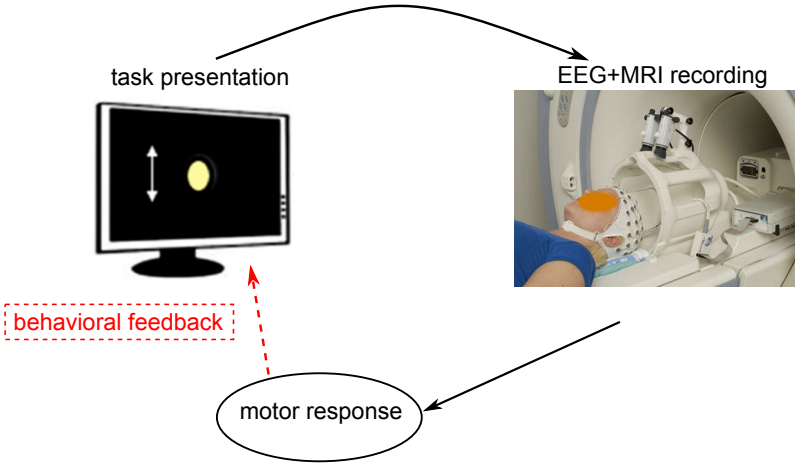
PhD Thesis Proposal

Improving visual attention by Computerized Cognitive Training

Candidate Profile: Scientist or engineer with a background in computer science and/or neuroscience. The candidate should also possess strong skills in scientific programming.

Background: Attention deficit is a typical symptom of several neuropsychiatric disorders, such as schizophrenia, Parkinson's disease and attention-deficit/hyperactivity disorder. Pharmacological medications may well improve the patients' attention. However, this medication generally causes undesirable cognitive side effects. These adversities demand alternative non-pharmacological treatments and electro-magnetic neurostimulation techniques have been shown to remedy symptoms in mental disorders. Such techniques request a high-technology environment in specialized laboratories. Moreover, such laboratories are located in larger cities only and may be difficult to reach for immobile patients and may be far from the patient's home, especially in rural areas. Consequently, it would be preferable to apply a neurostimulation technique at the patients' home by computer software and low-technology devices. A good candidate for such a low-technology stimulation is Computational Cognitive Training (CCT) [1] which involves performance feedback in real time [2]. Estimating the subject's performance allows CCT to adapt to the subject's performance, e.g., by rendering the training task more difficult in case of improved performance. The performance may represent the reaction time of the subject in CCT or the precision of the tests carried out in such a training. The performance is fed back to the subject synchronously with the experimental tasks.

To improve visual attention by CCT, it is important to understand underlying neural processes in such a feedback scheme. Since not much is known about neural processes in CCT and the impact of performance feedback, observations of neuronal activity are insightful. Previous work [3] showed that reward-based feedback enhances electroencephalographic (EEG) activity in the beta frequency range (12Hz-20Hz). Additionally, performance feedback in a reaction time task has been shown to increase the amplitude of evoked potentials [4]. To better understand visual attention, studies of sources of brain activity promise important insights, such as distinguishing different sources of different types of attention [5] or the source location of an alpha-rhythm (8Hz-12Hz) which contributes to sustained attention [6]. To our best knowledge, the impact of CCT and the performance feedback on brain sources and the brain networks of attention is poorly understood. Such a knowledge promises to improve experimental CCT parameters to achieve better visual attention impact.



Objectives. Our project will elucidate underlying functional networks during visual attention subjected to CCT and yields insights into an optimal choice of experimental adaptive training parameters. By combining behavioral and neurophysiological experiments as well as computational neural modeling, this project will work out a neural model for CCT and consequently will come up with an optimal training protocol for single subjects to improve visual attention.
In the CCT, we will aim to perform Continuous Temporal Expectancy Tasks (CTET) assessing sustained visual attention. The subject's performance will be fed back in real-time. Synchronously recording EEG and magnetic resonance imaging (MRI) activity will provide extended insights into brain dynamics. This experimental combination of high-resolution EEG with MRI allows the estimation of brain electrical sources which provides important information about CCT with attentional networks in the brain. In a final modeling step, we intend to estimate parameters [7] of a neural population brain network [8] which relates macroscopic EEG and mesoscopic estimated brain network activity.

Host laboratory: This PhD thesis will be carried out at the ICube laboratory and the INRIA-team MIMESIS on the Hôpital Civil site in Strasbourg, France. The PhD student will actively participate in all stages of the project, including data acquisition and analysis and model development.

How to apply: Email a CV, grades and rank of Master's degree, and a motivation letter to the two supervisors Dr. Paulo Loureiro de Sousa (ploureiro@unistra.fr) and Dr. Axel Hutt (axel.hutt@inria.fr). Interviews of the selected applicants will be done on an ongoing basis. Applications will be accepted until end of April 2024.

Expected starting date: October 2024.

References:

[1] Rosa et al.(2017). Trends Psychiatry Psychother. 39(2):65-76. doi: 10.1590/2237-6089-2016-0039
[2] Mensen, et al. (2022). *Psychol. Res.* 86 :1972–1979. doi: 10.1007/s00426-021-01602-6 . [3] Haji Hosseini and Holroyd (2015). *Sci Rep* 5 :13021. doi: 10.1038/srep13021.
[4] Groen et al. (2007). *Biol Psychol*. 76(3):174-87. doi : 10.1016/j.biopsycho.2007.07.006.
[5] Jonkman et al. (2004). *Clin Neurophysiol.* 115(7):1537-49. doi: 10.1016/j.clinph.2004.01.022.
[6] Dockree et al. (2007). *Europ. J. Neurosci*. 25 (3): 900-907. doi:10.1111/j.1460-9568.2007.05324.x.
[7] Hashemi et al. (2018). *Neuroinformatics* 16(2):231-251 . doi: 10.1007/s12021-018-9369-x
[8] Riedinger and Hutt (2022). *J. Clin. Medicine* 11(7):1845. doi: 10.3390/jcm11071845