Closed-loop Coupling of EEG and TMS as tool to investigate and perturb bistable visual stimuli perception.

Perception as a Decision loop

Perceiving is essentially an active decision process, making sense of uncertain sensory signals. Indeed, the information about our environment is often noisy or ambiguous at the sensory level, and it must be processed and disambiguated to yield a coherent perception of the world in which we evolve. Human perception relies on Expectation, Exploration and Exploitation (see Figure 1). **Expectation** about the physical world through our internal beliefs (*priors*), **Exploration** of the sensory evidence (the latter being *filtered* according to the context and goals), and **Exploitation** (*monitoring*) of the combined information resulting from expectation and exploration. We will make use of bistable visual stimuli to access the temporal dynamics of ongoing perceptual decision processes and dissociate exogenous form endogenous perceptual state change.
One "work packages" of the project aims at finding markers of perceptual change and decision process within EEG and then perturb either the visual stimulation or the brain activity in order to alter the perception loop.

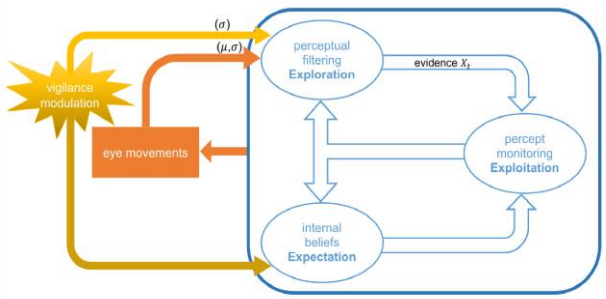

Figure 2: Vision 3E, Expectation, Exploration and Exploitation framework.

The aim of the internship is to develop a closed-loop method for transcranial magnetic stimulation (TMS – which is a non-invasive cortical stimulation tool) and electrophysiology (EEG) coupling with the ultimate goal of applying an online perturbation during the perception of ambiguous stimuli. Closed-loop methods are based on the real-time detection of EEG signatures correlated with a specific brain state (or other physiological or behavioral measurements), the fast computation of a reliable indicator of the signature and the triggering of an external event (which could be a TMS pulse or a modified visual stimulation), that in the end modulates the actual brain state.

The supervisors of the internship have now a 2- years expertise on integrating EEG markers in closed-loop protocols. and will extend these methods to the framework of ambiguous perception in two successive steps of increasing complexity and risk. Indeed, we developed and proposed a regression quality Score (RQS) that allows to evaluate the cortical excitability (Raffin et al., 2020). The RQS can be computed efficiently and will be a good candidate as a reliable indicator of the signature of perceptual or decisional brain events. The detection of one such indicator would be the triggering event for either a specific pattern of neurostimulation (Lakatos, Gross, & Thut, 2019; Thut et al., 2011), or a specific perturbation of the visual stimulus display. Each step will be validated offline on an existing database at first, and then each indicator will be estimated and computed online.

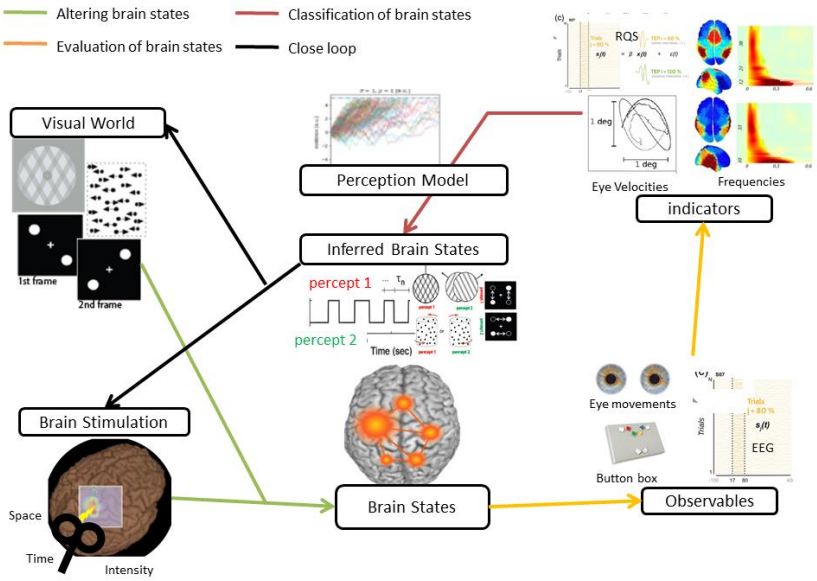

Figure 2: Project graphic description, ideas and methods. Human participants will observe ambiguous visual stimuli that lead to bistable perception and report the alternation of their percept in time. Vision-3E aims at investigating the dynamic functional processes underlying this alternation and ultimately inferring the hidden brain states across time. The research plan is articulated on different, highly interconnected experimental approaches, both analytical (yellow arrows, psychophysics, eye movement analysis and electrophysiology) and interventional (green arrow, neurostimulation). Modelling work (red arrow) will help to infer the hidden brain states state on the ground of the selected motor and EEG indicators. Finally, we will implement close-loop design experiments (black arrows) in which depending on the inferred brain state, we will apply online either a visual perturbation or localised TMS to interfere the ongoing active vision loop.

The candidate will be in charge of

- Testing EEG signature extraction on simulated and offline TMS-EEG database obtained within the team, and including them in the existing closed-loop framework
- Developing and testing real-time TMS-EEG pipeline analysis
- Conduct pilot experiment of the developed TMS-EEG close-loop protocol on real subjects.

The candidate must have strong coding (Matlab or Python are preferable) and signal processing skills, experimental or physiological experience will appreciated. It is mandatory to have a strong interest in research and a will to pursuie in a PhD.

The internship will be directed by Alan Chauvin (LPNC, UGA) and remotely by Sylvain Harquel (Hummel Lab, EPFL, Geneva), and in close collaboration with Ronal Phlypo (Gispa-Lab, UGA) and Juliette Lenouvel (LPNC and Gipsa-Lab, UGA)

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