**PhD offer: modelling perceptual decision making in multistable vision**

**Context**

In the context of the recently accepted research proposal Vision-3E: Exploration, exploitation, and expectation in visual perception (ANR funded) as a collaborative project between Institut de Neurosciences de la Timone (INT) - Marseille, le laboratoire de neurosciences cognitives (LNC) - Marseille, Sciences Cognitives et Sciences Affectives (SCALAB) - Lille, le Laboratoire de Psychologie et de neurocognition (LPNC) - Grenoble et Grenoble Images Parole Signaux et Automatique (GIPSA-lab) – Grenoble four PhD scholarships are available.

With the Vision-3E project, we aim at gathering behavioural and physiological evidence about the three key functions in the closed-loop processing of human visual perception—expectation, exploration, and exploitation,—in order to better understand and model their interaction. We will make use of multistable visual stimuli to access the temporal dynamics of ongoing perceptual decision processes and we address the causes of perceptual reversals in the broader context of perceptual decision making. Within this framework, we assume that eye movements play an important role in visual perceptual decision-making and aim at deeply investigating this role in the framework of perceptual rivalry. In addition, we will study the functional brain network involved in perceptual rivalry and aim at providing a comprehensive predictive model of percept reversals in time; both of these objectives will take eye movements into account as an active component of the perceptual decision loop.

Vision-3E proposes an original approach to this broad question, involving both correlational and interventional experiments. A series of behavioural experiments are planned to test the effect of ad-hoc selective manipulations of the oculomotor behaviour on the perceptual reversals. Our aim is to propose a novel and more comprehensive model of visual perceptual decision in the perceptual decision-making framework by combining behavioral experiments, advanced recording and stimulation techniques, data-analysis methods, and modelling.

**PhD project:** Dynamic Bayesian sampling and evidence accumulation : role of eye movements and EEG frequency-band modulations in a comprehensive computational model of perceptual decision making

**Keywords:** drift-diffusion process, perceptual decision making, Bayesian sampling, multistable visual perception.

Whereas current models of multistable perception mainly use descriptive statistics (for instance, mean relative time spent in a perceptual state or estimated transition probabilities between different perceptual states; often combined into a semi-Markov chain), our aim is to move toward a predictive model, integrating eye movements and characteristic electroencephalography (EEG) frequencies within the model as to predict the upcoming perceptual transition time. The underlying perceptual process is assumed to be composed of (i) a non-stationary noise process superimposed to (ii) an integration of constructive (in favour of a particular perceptual state) and destructive (opposed to a particular perceptual state) evidence. As such, the Bayesian sampling hypothesis is extended to an active vision framework, i.e., a drift-diffusion process with a time-varying diffusion rate, corresponding to a modulation of vigilance. This modulation is supposed to manifest itself as a modulation of the EEG amplitudes in the alpha and/or gamma band or higher variability in the viewing positions reported on the screen. A time-varying drift component will be inferred from both gaze positions and EEG markers that will be used for the integrated evidence over time.

**Team expertise**

The team has a vast experience with the moving plaid stimulus\(^1\) that is used in multistable visual perception paradigms with implementation both in psychopy (python) and psychtoolbox (matlab)
as well as with multivariate and multimodal data processing, specifically with EEG and Gaze. A semi-Markov model\(^2\) has been implemented and used for hypothesis testing of a visual motion after effect. The team has a solid background in human visual perception\(^3\), mastering the entire pipeline from experiment design to data analysis.

GIPSA-lab and LPNC offer an international and intercultural working environment. Both GIPSA-lab and LPNC possess their dedicated experimental platforms for running experiments on visual perception, with GIPSA-lab also offering the possibility of joint electro-encephalography and gaze recordings.

**Skills and abilities:** mathematical modelling, machine learning, experiment design (prior experience with psychopy highly appreciated), electrophysiological (EEG) and behavioural (Gaze, response time) data processing and analysis, scientific programming, scientific communication (oral and written). Good coding practice will be particularly appreciated.

**Prerequisites:** a master degree in computer science, signal and image processing, cognitive sciences, computational neuroscience, or a related field. English language proficiency, both oral and written communication, is obligatory.

**How to apply?** Contact the team members by email with your inquiries, an academic CV and a cover letter before August 31, 2022.

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**References**

2. Juliette Lenouvel, Ronald Phlypo, Kevin Parisot, Emeline Lalisse, Alan Chauvin. Motion after effect is perception-based, not only signal-based. ECVP 2021 - European Conference on Visual Perception, Aug 2021, Online, France. (hal-03506152)
Figure 5 The DDM model for perceptual multistability

A: Top: Simulation of the “first” perceptual choice: different families of evidence accumulation paths are generated for different sets of parameters \((\mu, \sigma)\). Bottom: model-estimated probability density of the time occurrence of the first percept (arbitrarily referred to as “primary” when it corresponds to the upper barrier crossing and as “alternative percept” otherwise). Note that when \(\mu\) is strictly 0 the probability of temporal occurrence is identical for both percepts (the two density curves are superimposed) and it only depends on \(\sigma\).

B: Top: Example of a DDM path with time-varying \(\mu\) and \(\sigma\) (see middle and bottom row) leading to several percept reversals (transitions between the blue and orange regions). Note that a positive increase in \(\mu\) leads to a (delayed) increase of noisy evidence (and likewise for a decrease), whereas an increase of \(\sigma\) leads to a random-sign rapid modulation of the evidence path.