The temporal structure of consciousness and its causal, neural underpinnings.

Consciousness and its theories

Over the past 30 years, scientists have proposed many theories to explain how consciousness arises from brain activity and how this activity shapes our experiences. Yet the mystery of the neural correlates of consciousness remains unsolved. No single theory has gained broad acceptance, largely because each one focuses on only part of the problem. The situation resembles the parable of the blind men and the elephant: each theory captures a fragment, but not the whole picture. As a result, there is still no widely accepted measure of consciousness that could be used in clinical practice. Our project seeks to change this by introducing a **new experimental approach to studying the neural correlates of consciousness** and by developing **a new version of the higher-order theory of consciousness**. We plan to do so by applying two methods not yet used in this field: **causal analysis** and **chronometry**.

Aim of the project

At the empirical level, we aim to identify the neural correlates of consciousness by determining which brain regions and networks are involved, and by selectively influencing their role in information processing using **transcranial magnetic stimulation (TMS)**. We will also record **electroencephalographic (EEG)** data, applying advanced signal analysis techniques—such as source localisation, directional connectivity, and complexity measures—to track how TMS affects brain processes related to conscious experience. At the theoretical level, the project will use these findings to develop a new version of the higher-order theory of consciousness. Causal analysis will allow us to examine how information is integrated across the brain's hierarchy. Finally, at the applied level, we will reinterpret and refine **complexity measures**, building on both our experimental and theoretical insights.

Description of research

To achieve these goals, we will conduct an interdisciplinary research program that integrates philosophy, causal analysis, behavioural studies, non-invasive brain stimulation, and electroencefalography. **Research line 1** will address philosophical and causal analysis of consciousness within the framework of the higher-order theory of consciousness. **Research line 2** will examine TMS chronometry in visual perception, building on the theoretical appraoch developed in research line 1. Analogiously, **research line 3** will focus on mental imagery, while **research line 4** will investigate self-awareness. Finally, **research line 5** will revisit the theoretical foundations of complexity measures through reanalysis of the data gathered in previous research lines. By combining precise TMS stimulation with multidimensional EEG analysis, we will be able to control both *where* and *when* brain regions contribute to consciousness across three distinct types of experience.

Expected results

We argue that human consciousness must be understood as a complex phenomenon that requires information to be integrated over time. Previous studies have been inconclusive, in part because they did not systematically control the timing of information integration. By applying causal analysis, we will be able to determine the sequence of processes that give rise to conscious experience. Our findings will also clarify why complexity measures of consciousness vary across studies, paving the way for more reliable, theoretically justified and clinically relevant tests. Ultimately, the project will result in paradigm shift in consciousness research, advancing both empirical and theoretical understanding of this construct, while laying the groundwork for clinical applications.