Mindscope: Bridging the gap between fNIRS and neuronal dynamics during decision making

1 Summary of the research plan

The **central question** of this proposal is to determine the neural spike activity correlates underlying the decision making process. We will use frequency domain functional near-infrared spectroscopy (FD-fNIRS), electroencephalogram (EEG), and data-driven neural modelling to answer this question.

The **problem** we aim to solve is best illustrated by the following example: A goalkeeper's defence against a penalty kick. A single player comes forward and places the ball on the penalty spot and waits for the referee's whistle to take the shot. The goalkeeper cannot move from the goal line until the ball has been kicked. The goalkeeper, with no luxury of time, is severely disadvantaged and must quickly analyse, determine or predict the ball's trajectory and compute an interception path for their outstretched hand(s), in order to stop or deflect the shot away from the goal. This is further complicated by the penalty takers' deceptive cues and approach, the motion of remaining players and the crowd, all providing numerous visual and auditory distractors that interfere with goalkeepers' decision making task.

Here, the brain needs to quickly derive an optimal or satisfactory outcome, based on explicit and tacit (implicit) information, while trying to minimize the impact of any biased influences. Understanding how this is achieved in the nervous system will have far-reaching benefits and repercussions in many disciplines including artificial intelligence (AI) and robotics. The majority of previous studies have used functional magnetic resonance imaging (fMRI) to visualize active areas of the cortex during a decision making task and EEG to ascertain the dynamic nature of such activity over time. Both fMRI and EEG lack the ability to resolve single neuron dynamics, however, recent advances in FD-fNIRS have illustrated that resolution of single neuron activity is possible.

Our projects aims are to:

1. Investigate the neural basis of a decision making task using FD-fNIRS and EEG.
2. Characterize their underlying neural activity and any associated mechanisms.
3. Use our results to develop neural mass and spiking neural network models for a decision making task in data-driven closed-loop simulations.

Our recent pilot data suggests that it is possible to achieve temporal resolutions required to image the activity of single neurons using FD-fNIRS. This makes an exciting prospect to provide a major breakthrough in understanding the fundamental basis of the decision making process and the underlying spiking activity, thus bridging the gap between population activity, fNIRS and neuronal dynamics.