ThinkFast: Brain dynamics studied by frequency domain near-infrared spectroscopy (FD-fNIRS) during decision making

The **main research issue** of this proposal is to establish precisely the correlation between the decision-making process studied at the behavioral level and patterns of brain activity studied by frequency domain functional near-infrared spectroscopy (FD-fNIRS). The **problem** we aim to solve is illustrated by the following example: You are entering a shop to buy a birthday present for one of your friends. While doing your shopping, you make up your mind on a maximum amount of money you want to spend. If your willingness-to-pay for a certain item lies above the salesperson's willingness-to-sell, then money and item are transferred, otherwise no deal is made. After having made your selection by queuing at the shop checkout, you notice another item of interest likely to fit at best your friend's taste, but it is the last one available. The price is slightly above the value you have initially set. With no luxury of time, you must quickly analyze, determine or predict the other customers' behavior and decide either to move forward to the counter or move immediately away from the queue to pick the new item. This is further complicated by other customers' movements around you and their comments on the items on display, all providing visual and auditory distractors that interfere with your decision. Based on explicit and implicit information, the brain needs to derive the best decision quickly, while trying to reduce the impact of biases and any distorted influences.

The **main working hypothesis** is that an experimental setting with simultaneous FD-fNIRS and electroencephalographic (EEG) recordings allows the separation of a signal due to neural activity from its vascular coupling. A **further hypothesis** is that a data-driven neural modeling based on these experiments will provide new insights to understand the dynamics of brain activity generated during the decision-making process. Then, our **projects goals** are the following:

1. To investigate brain dynamics of a participant performing a neuroeconomic decision-making task with simultaneous EEG and FD-fNIRS recordings.
2. To characterize the neural activity underlying the brain signals, thus separating neurogenic from vascular associated mechanisms.
3. To use our results to develop neural mass models (and potentially spiking neural network models) and corresponding simulations for a value-based decision-making task assessing risk choice.

Our pilot results suggest that our setting combining FD-fNIRS and EEG achieves the necessary accuracy in space and time to study the activity of neural ensembles. During a decision-making task, this ability was not offered by previous studies using functional magnetic resonance imaging (fMRI) to localize active areas of cerebral cortex and by EEG to determine the dynamic patterns of activity. This proposal makes an exciting prospect to provide a major interdisciplinary breakthrough in bridging the gap between neural population activity, FD-fNIRS techniques and brain dynamics, thus contributing new data in understanding the fundamental basis of the decision-making process. Understanding this process will have far-reaching benefits and repercussions in many disciplines including computational intelligence and neuroeconomics.