Title: Bedside assessment of residual brain function in patients with disorders of consciousness

Trainee Name: Androu Abdalmalak

Supervisor(s): Dr. Keith St. Lawrence and Dr. Adrian Owen

Structured Abstract:

Consciousness can be defined as the state of being awake and aware of oneself and one’s surroundings. Even though determining if someone is awake is a relatively simple task, assessing awareness is not trivial. In clinical scenarios, patients are usually assessed against a neurological scale and the presence of awareness is measured by the ability to follow commands, either behaviourally or verbally. Because of this reliance on observable responses, a subset of patients who retain some cognitive function but are unable to follow commands are frequently misdiagnosed as suffering from impaired consciousness or what is clinically referred to as a disorder of consciousness (DOC). Previous work by Owen and colleagues showed using functional magnetic resonance imaging (fMRI) that some DOC patients are in fact aware and are able to regulate their brain activity in response to commands (Owen et al., Science, 2006).

Although promising, the cost and accessibility of fMRI hinders its use at the bedside. An alternative approach is to use functional near infrared spectroscopy (fNIRS), an optical technique that is portable and inexpensive. Furthermore, brain regions associated with motor imagery can be interrogated by NIRS making it an ideal modality for bedside measurements. Our group has developed an fNIRS system dedicated to measuring motor imagery activity and we were able to achieve a sensitivity of 93% in comparison to fMRI in healthy controls (Abdalmalak et al., BOE, 2017).

Given these promising results, the next critical milestone was to use our system as a brain-computer interface to establish rudimentary mental communication. One approach for mental communication is to use motor imagery as affirmation for questions. In 2017, our team tested this approach on a patient under intensive care at University Hospital (Abdalmalak et al., Neurophotonics, 2017). The patient was functionally locked-in with very limited eye movements. The patient was asked a series of clinically relevant questions and the presence of eye movements provided a unique opportunity to validate our responses. Interestingly, the fNIRS responses were in full agreement with the eye responses.

Our ongoing work is to assess the feasibility of fNIRS to detect residual brain function in DOC patients. To date, we have visited 7 patients in their home/long-term care facilities across London and Toronto, and have identified 2 patients with residual awareness. Our goal is to provide longitudinal assessment of these patients and potentially develop an objective assessment of awareness. In conclusion, our work highlights the potential of fNIRS as a portable tool to assess consciousness at the bedside.