SRTP - Project Description Form #218

PART I:

Name of Schulich faculty member who will supervise the project	Giovanni Pellegrino
Supervisor's Schulich, Western, Hospital or Lawson Email	giovanni.pellegrino@lhsc.on.ca
Schulich Department	Clinical Neurological Sciences

PART II - Project Description

Title of Project	Structure-function relationship in epilepsy: how brain MRI features influence EEG activity (MRI2EEG)

Background

This study aims to assess the relationship between brain structure and brain activity in individuals with epilepsy. Epilepsy is a neurological disorder affecting approximately 0.7% of the global population and is characterized by recurrent seizures. It is associated with various challenges, including social stigma, cognitive and psychiatric comorbidity, and significant economic burdens. Epilepsy is a network disorders characterized by changes of the brain structure and function, spanning across multiple interconnected brain regions. Understanding the relationship between brain structure and activity in individuals with epilepsy is crucial for advancing our knowledge of the condition and improving clinical management strategies. Non-invasive in vivo imaging techniques, particularly magnetic resonance imaging (MRI), are widely employed to assess brain structure in epilepsy. MRI provides a standard of care and routine clinical methodology for identifying structural changes associated with this condition. Quantitative analysis of MRI images has demonstrated progressive atrophy (thinning) in the epileptic brain, particularly in regions where seizures originate and interconnected areas. Electroencephalography (EEG) allows for direct measurements of the electrical waves generated by large populations of neurons. EEG is a standard clinical tool that can detect hypersynchronous activity specific to epilepsy, including interictal epileptiform abnormalities (pathological electric activity between seizures) and ictal epileptiform activity (electric seizures). Quantitative analysis of EEG data has revealed abnormal brain activity even in the absence of epileptiform abnormalities. Furthermore, the analysis of invasive EEG (iEEG) data obtained from clinical recordings with intracranial electrodes in patients with medically resistant epilepsy corroborates findings from scalp EEG. While the relationship between MRI anatomy and oscillatory activity is well-established in healthy subjects, further exploration is needed to understand this relationship in patients with epilepsy.

Hypothesis

1. Structural changes occur in epilepsy patients and can be detected with quantitative analysis of clinical MRI anatomical scans
2. Activity changes occur in epilepsy patients and can be detected with quantitative analysis of clinical EEG data
3. A relationship between brain MRI features and EEG activity exists

Proposed Methodology

This will be a cohort study of quantitative analysis of MRI and EEG data acquired in the context of clinical management of patients at LHSC. Study Population

Patients with epilepsy or suspected of having epilepsy evaluated as outpatients or inpatients at LHSC will be considered for this study. Standard of care includes the acquisition of clinical information, brain MRI and EEG, which we plan to quantitatively analyze for the purpose of this study.

Inclusion Criteria

- Patients with a suspected or defined epilepsy condition

- Age 18+
- Availability of clinical MRI and EEG

We will ask participants to provide consent to use already available MRI, EEG and complementary data in the medical charts to investigate the relationship between brain structure (MRI) and function (EEG/iEEG) in epilepsy.

Data Analysis

MRI images will be processed by applying available and validated tools, such as the free-surfer toolbox (https://surfer.nmr.mgh.harvard.edu), the FastSurfer toolbox (https://deep-mi.org/research/fastsurfer/), the Computational Anatomy Toolbox (https://neuro-jena.github.io/cat/) and the fMRIPrep toolbox (https://fmriprep.org/en/stable/)

EEG recordings will be processed by applying available and validated tools, such as EEGLab (https://eeglab.org), Brainstorm (https://neuroimage.usc.edu/brainstorm/Introduction) and custom-made code. Anatomical images and functional data will be combined with Brainstorm. Statistical analysis will be performed with Matlab.

Descriptive statistics (mean, median, range, standard deviation, confidence interval, interquartile range) of structural features (cortical thickness, gyrification, cortical complexity, white matter hyperintensities, myelination, etc.) as well as functional features (presence and location of epileptiform activity, power spectral density, cortical connectivity, excitability, etc.) will be estimated. We will then test potential relationship between anatomical and functional measures by applying correlation and regression analysis. We will test the potential role of clinical variables and potential confounding factors with hierarchical regression.

Expected Outcomes

By investigating the intricate connections between epilepsy and the underlying brain mechanisms, we aim to uncover valuable insights that may ultimately lead to more effective diagnostic techniques and personalized treatment strategies. While individual participants may not immediately benefit from the study, the collective knowledge gained can significantly impact the broader epilepsy research and medical communities. Through this research, we aspire to make meaningful advancements in the field of epilepsy, ultimately improving the lives of those affected by this condition in the long run.

Research Environment – Description of the number of research personnel, primary location of research, size of lab, etc

This project is supported by the Western Epilepsy Research group (5+ researchers). The primary location is the LHSC.

Names and titles of other individuals who will be involved with the research project?

Milad Khaki, PhD, Greydon Gilmore, PhD, Jonathan Lau, MD, PhD, Ana Suller-Marti, MD, PhD, Suzan Brown, MsC, Jorge Burneo, MD, David Steven, MD, Michelle Lee-Jones, MD

Can this project be done remotely?	No
Duration of Project	Two Summers

Expected Objectives/Accomplishments for Student for Year 1?

Analysis of EEG data

Expected Objectives/Accomplishments for Student for Year 2?

Analysis of MRI data and relationship with EEG data

PART III - Certifications

If the project will require any certification approvals from one or more of the following offices, please check the appropriate box below.	- Human Ethics

Human Ethics: If you have the protocol information, please enter it below (or

enter the status of the approval).	Approved (HSREB 123729)

Note: certification approval should be obtained prior to the start of the summer. Projects without this approval will not be a priority for funding.