BME 120 PBL Progress Report (11/16/20)

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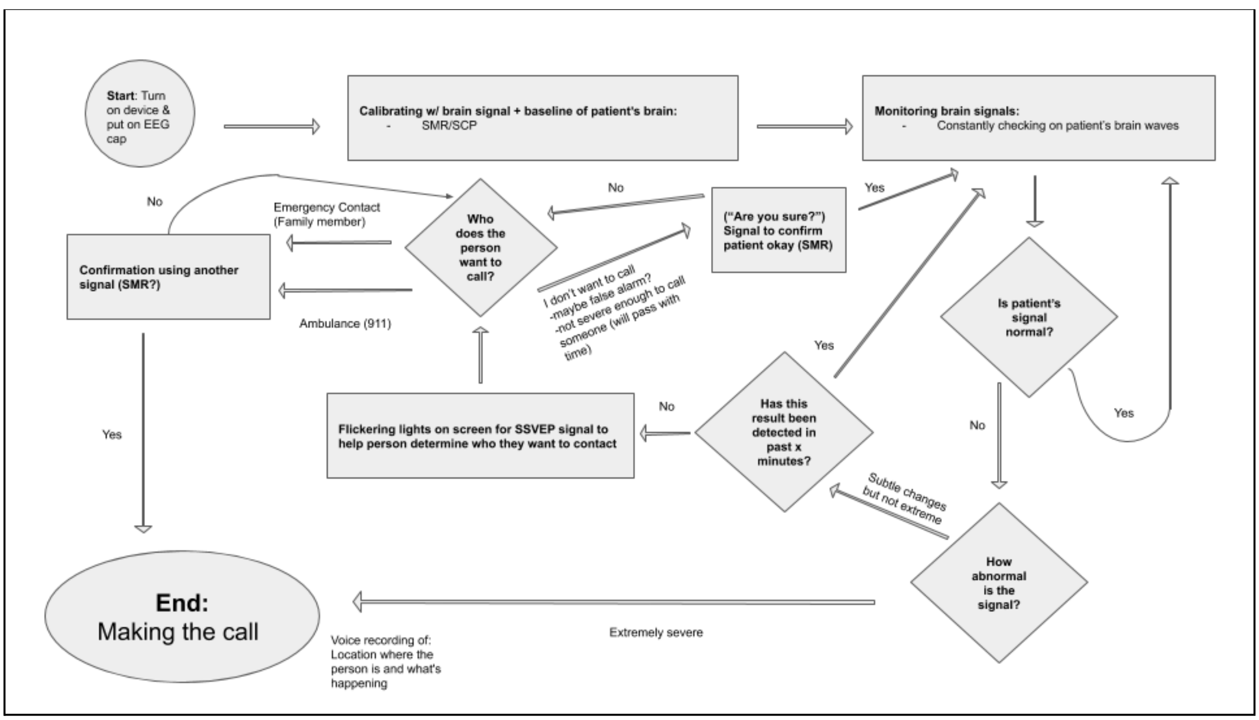
Questions/ Concerns:

1) Are the brain signals we are using efficient / effective for this kind of device?
2) Does our flowchart make sense?
3) Is the SSVEP system good enough to detect / prevent false positives

Design: “Help I’ve fallen and can’t get up” Device

Target Audience: Patients who struggle with Acute Ischemic Stroke and cannot speak or move. Meant to work with people of all ages.

Preliminary Flow Chart:



What does it do?

- Detects life threatening conditions like seizures or acute ischemic strokes in order to call 911 and/or emergency contacts
- If the patient unsuspectedly undergoes a stroke or seizure, the device can contact the emergency services with an automated recording of what the patient is experiencing
- Consistently monitoring the patient's brain signals to determine if they are about to experience a stroke or seizure in order for the patient to get help prematurely
- Location tracking for the automated call if the patient is not at their usual home and experience a stroke or seizure
- The housing of the device is able to attach to the patients power wheelchair or alternative access control wheelchair for easy access; it will be attached using a mount

Brain Signals to use

- The use of routine EEG in acute ischemic stroke patients without seizures: generalized but not focal EEG pathology is associated with clinical deterioration
    - 10-20 system (19 scalp, 2 earlobe)
    - The EEG filter configuration was as follows: 50 Hz filter; low pass filter: 0.5 Hz; high pass filter: 70 Hz.
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6790298/
- SMR Neurofeedback Study (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4945651/) & BMI's in Neurorehabilitation of Stroke Patients using SMR signals (https://www.sciencedirect.com/science/article/pii/S0969996114003714)
- SSVEP - signal that won't create false positives (https://www.nature.com/articles/srep36267#Sec5)
    - SSVEP-BMIs provide very accurate high temporal and spectral resolution information
    - Reads neuromuscular control of eyes/ head

Research (What's next):

SSVEP : confirm what is correct/ more details (Talah)

- presented with some periodic stimuli, SSVEP is generated strongly at the occipital areas of the brain
- . SSVEP is usually acquired from various electrode sites like Oz, O1, O2, Pz, P3, P4, and some surrounding locations to the occipital region.
- In SSVEP-based experiments, the user is asked to identify the target with eye-gaze. The attention of the user is supposed to be visually fixed on the target and the target is identified by feature extraction and its analysis
- The SSVEP stimulus produces a response in the EEG signal, which is characterized by oscillations of the order of the stimulation frequency and sometimes at harmonics or sub harmonics of it

- SSVEPs were selected as compared to VEP because they are less vulnerable to artifacts produced by the eye blinks, eye movements as well as EMG noise
- Low frequency subsystem (near 10 Hz). It gives the greatest SSVEP amplitudes.
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Calibration of brain: how do we / should we calibrate the brain / EEG electrode placement (how many and where?) (Kelsey/Alyssia)

- So far found papers that discuss the EEG signals were recorded with the patient in a seated position with 5 minutes of data collected with eyes closed and 5 minutes of data collected with eyes open; we are looking at this for our calibration technique to set up the EEG cap with a specific sensitivity unique to every patient. (2 PDF Reference)
- The Geodesic Sensor Net was used within the multiple research papers; this is placed over the scalp with around 129 electrodes, one of which being the reference electrode at the vertex; 128 channels are of time series being 10s long digitized at 250 points. (2 & 3 PDF references)
- EEG examination of Acute Ischemic Stroke (AIS) patients. 21 electrodes placed according to the 10-20 system (19 scalp electrodes + w ear reference electrodes) to obtain the signal (research paper)
- EEG examination of Acute cerebral ischemia (5 with AIS). Scalp EEG was used for 3 minutes using a dense array (256-electrode). EEG recording underwent 6th order, 50 Hz low-pass filter. Bands of interest: delta (1-3 Hz) low beta (13-19 Hz), and alpha (8-12 Hz) (research paper).
- EEG usage for patients with Middle cerebral artery (MCA) ischemic strokes. EEG recorded using 19 channel EEG system with standard EEG electrode placement. Analyzed EEG from four lateral frontal (F3, F7, F4, F8) and corresponding posterior (P3, P4, T5, T6). Slower alpha frequency showed no amplitude change. EEG alpha activity in subacute stroke patients were decreased in alpha PPS over the frontal cortex. Stroke induced slower alpha. *EEG alpha generation synchronization and flow are potential biomarkers of cognitive impairment onset and/or compensatory post stroke re-organizational process.* (research paper)

Strokes: what brain signals = strokes vs. what signals = normal brain activity (Garrett/Ruhiyah)

- Article #8 listed claims that EEG across BCI interventions can give important info for prognosis and BCI cortical activity targets.
    - BCI system had an electrode cap with 11 g.LADYbird electrodes placed in the F3, F4, Fz, P3, ,P4, Pz, C3, C4, Cz, T3 and T4.
    - Frontal, temporal, and parietal regions showed significant changes across sessions in the alpha and/or beta and some in patients presented a significant association with time since stroke.

        - Implication that regions not usually associated with motor tasks can become involved in stroke pateitsn during MI of their impaired upper limb.
    - BCI intervention in stroke patients more likely to elicit beta band modulation across time
    - Speculation that beta oscillations are associated with neural networks that propagate activity between the primary motor cortex and muscles, while the alpha is associated with motor information processes (like learning motor tasks).
    - Involvement of larger AH and UH areas during motor tasks can be compensatory mechanisms in patients with severe stroke motor impairment (Cassidy and Cramer)
- Article 1 (link) reports that the following attributes can help characterize a potential stroke in patients:
    - Widespread polymorphic delta activity in the involved hemisphere seen in temporal and frontotemporal regions
    - Ipsilateral attenuation or loss of alpha and beta activity as well as sleep spindles
    - Marked suppression of all EEG frequencies
    - With mass effect, contralateral frontal delta activity and intermittent projected bursts of delta activity.
- Article 1 (link): Some seizures are nonconvulsive and cannot be detected without an EEG/CEEG
- Article 2 (link): Lists increased power in delta frequencies in tandem with decreased power in alpha frequencies as a potential indicator of a stroke in the near future.
    - Used a 256 electrode cap for this study, 1000 Hz sample speed
    - Note that the patient had to be situated at a 30 degree angle. Precarious setup?

SMR: signal to use for confirmation. Is it effective/ helpful in this case (Michael)

Article 7# goes into depth on EEG monitoring and changes in frequency recordings as it relates to stroke, cerebral vascular symptoms, etc

- Series does not clearly establish the advantages of EEG monitoring, which is expensive (+375/patient) and may not detect ischemia in all areas of the brain as eeg monitoring may not detect abnormalities in all parts of the brain
- EEG readings do not change when patients who had infarcts (brain tissue damage) awoken with worsened motor ability
- EEG may not select each patient that requires shunting (false negative)
- Argues monitoring should be done in high risk patient groups since they have less morphologic damage and are more likely to survive a stroke and more efficiently from a financial and medical point of view.

References:

PDF Titles:

1) Continuous EEG Monitoring in the Neuroscience Intensive Care Unit and Emergency Department; K. Jordan
2) Stroke detection based on the scaling properties of human EEG; R. Hwa & T. Ferree
3) Localizing Acute Stroke-related EEG Changes: Assessing the Effects of Spatial Undersampling; P. Luu, D. Tucker, R. Englander, A. Lockfeld, H. Lutsep, & B. Oken
4) Omitting the Intra-session Calibration in EEG-based Brain Computer Interface Used for Stroke Rehabilitation; M. Arvaneh, C. Guan, K. Ang, & C. Quek
5) Role of Monitoring in Management of Acute Ischemic Stroke Patients; A. Cavallini, G. Micieli, S. Marcheselli, & S. Quaglini

Website URL's:
1) https://insights.ovid.com/pubmed?pmid=15592008 (Emergency EEG and continuous EEG monitoring in acute ischemic stroke)
2) https://pubmed.ncbi.nlm.nih.gov/31174955/ (Electroencephalography measures are useful for identifying large acute ischemic stroke in the Emergency Department)
3) https://www.tandfonline.com/doi/full/10.1080/00207454.2016.1189913 (for EEG filter placement in stroke patients)
4) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6790298/ (another usage of EEG relating to stroke patients)
5) https://www.intechopen.com/books/evolving-bci-therapy-engaging-brain-state-dynamics/ssvep-based-bcis (Benefits of SSVEP)
6) https://www.nature.com/articles/srep36267#Sec5 (Using SSVEP for patients to look at symbol intended for communication)
7) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1250821/(Benefits, shortcomings, and costs of EEG monitoring.
8) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6487113/ (Longitudinal Analysis of Stroke Patients' Brain Rhythms during an Intervention with a Brain-Computer Interface)
9) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5623310/ (How slower EEG alpha generation/synchronization and flow are markers of cognitive impairment)