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Brain Computer Interface for Modulation of Temporal Lobe Seizures

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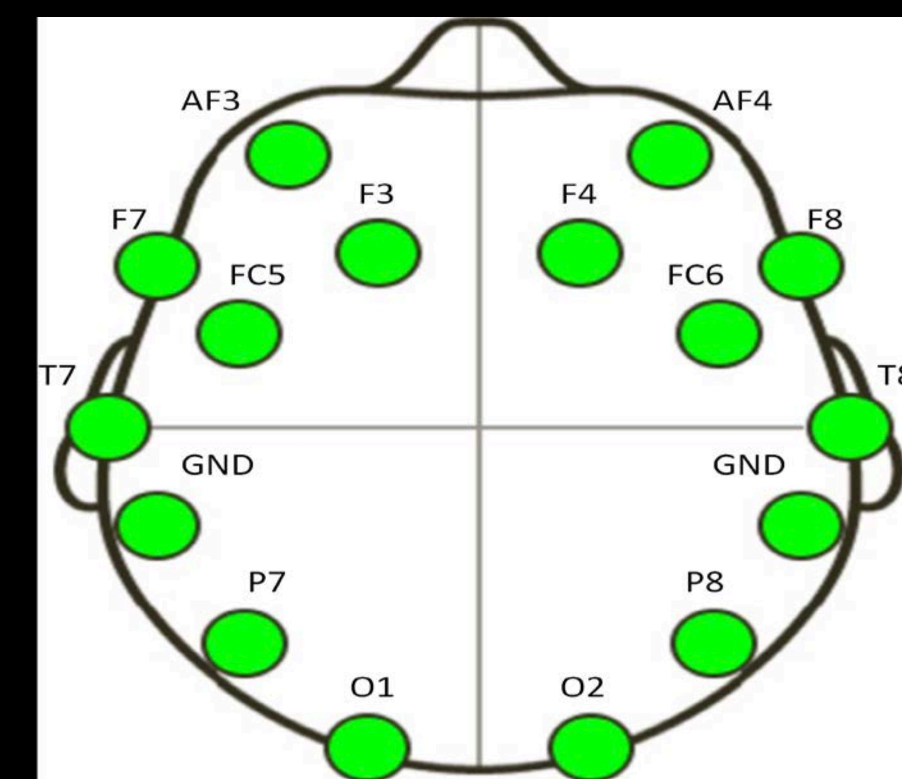
Rationale: Little research has been done on non-invasive alternatives for intractable epilepsy patients. Interruption of the seizure at the stage of aura, can be achieved by nonspecific (e.g., relaxation or concentration techniques), or by specific focus-targeted sensory or cognitive stimuli.

Brain Computer Interfaces (BCI) enable human-computer interaction using control signals generated from physiological signals. A BCI can be based on the discrimination of electroencephalography (EEG) patterns. The BCI is trained to differentiate between EEG patterns related to certain tasks or actions.

The goal for the awake and alert patient is to interfere with the progression of the seizure onset. This strategy is accomplished by the patient first recognizing that the cube is moving in the direction associated with the seizure-onset, then attempting to move the cube in a different direction, by concentrating in a manner that originally generated normal EEG signature patterns.



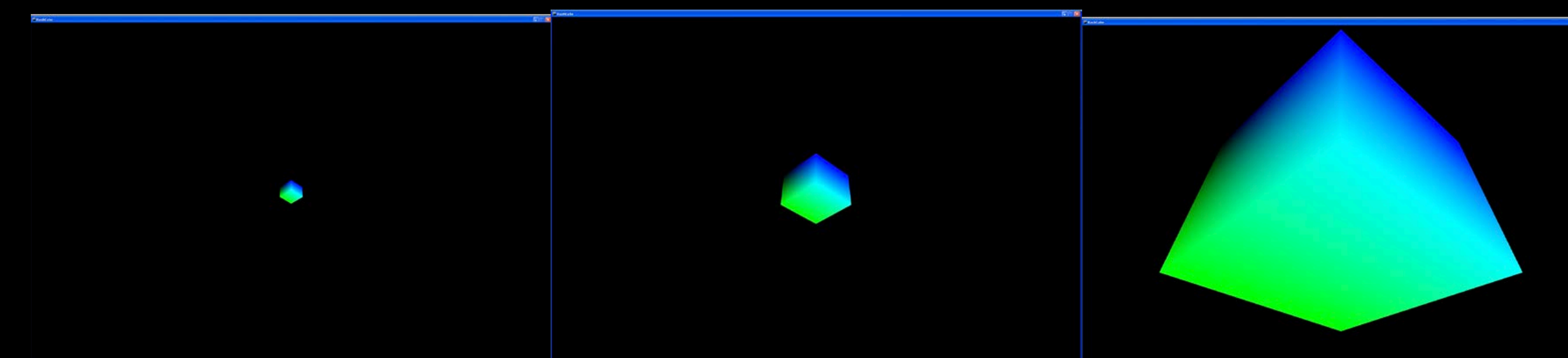
Train neutral and control action → **Patient feels aura and seizure related EEG pattern is assigned to an action** → **When patient sees the block moving in the wrong direction (seizure) tries to move it in the previously action**

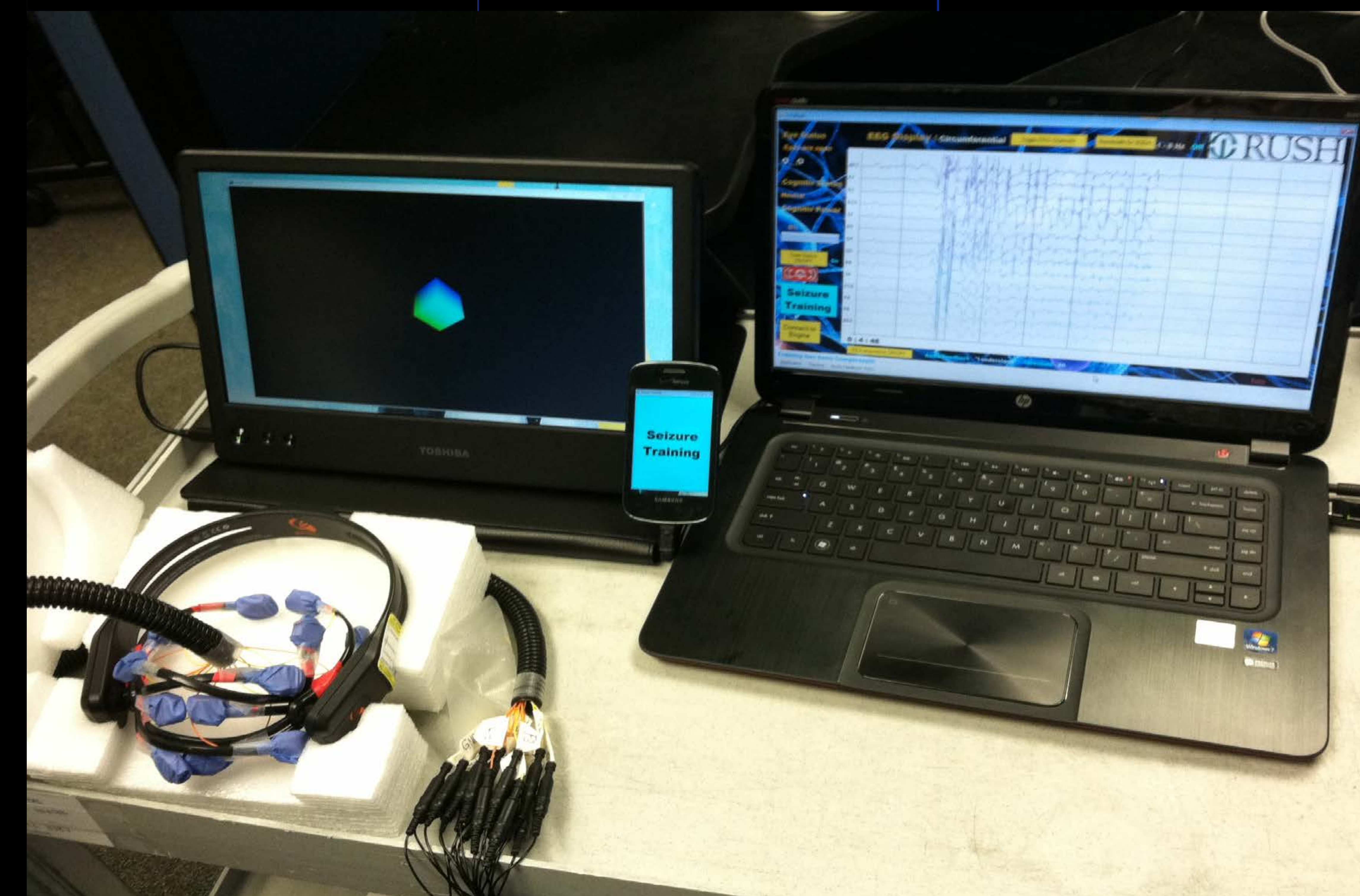
Methods: A BCI was custom-programmed in our lab to provide temporal lobe epilepsy patients with a visual feedback of the seizure. Seizure-related and normal EEG patterns are used to move a 3D-cube displayed on a computer monitor. This strategy potentially enables the patient to modulate the seizure progression by measuring the extent to which the displayed cube is moved by concentrating on it.

The BCI uses the Emotiv® Neuro-headset, EEG signals are taken from the electrode input of the EEG amplifier. Fourteen input channels are used. Signals are acquired at a sampling rate of 128 Hz, and wirelessly sent to a computer.

First, the software is trained to recognize normal EEG signature patterns. Specifically, the subject is asked to gaze at the monitor and conduct an imagery movement of the cube. The Neuro-headset extracts features every 250 ms, recording the mental state through EEG mapping. Whenever the subject feels an aura he or she will click on a button, this starts the training for a "spinning" action of the cube. This will record and assign to that action the EEG patterns related to the seizure-onset.

The electroclinical duration of the seizure and scalp field power during the seizure are correlated with an index calculated by the software that on a 0-100 scale provides the similarity of the current EEG patterns to the ones that were trained for that specific action. The index is a direct measurement of the patient's ability to concentrate on moving the cube by recreating the previously trained mental state.





Results: The BCI is fully functional and being used at Rush University Medical Center in a IRB-approved trial. Patients between ages of 15-70 years with temporal lobe seizures voluntarily enroll when admitted to the Rush video-EEG monitoring unit for diagnostic seizures evaluation. Seven patients have successfully used the BCI to cognitively move the cube on the computer display; however none of them have experienced a seizure while using the interface.

Conclusions: This BCI is a unique non-invasive tool for patients with temporal lobe epilepsy utilized for potentially modulating the progression of their seizures.

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