Software for Closed-Loop Neurofeedback

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Previous studies have shown that slow wave sleep (SWS) provides many cognitive benefits, including improved memory and sleep quality, as well as a positive impact on many biological processes such as glucose metabolism, hormone release, and immunity. Furthermore, prior research suggests that introducing auditory stimulation in phase with these slow waves effectively increases their magnitude, amplifying their beneficial effects. We aimed to develop a MATLAB algorithm that built upon this research by using appropriately timed sound stimulation to enhance users' quality of sleep when paired with a commercially available electroencephalography (EEG) headset. While similar research-grade software exists, this algorithm is intended for use in a home environment. We connected a MuseS EEG headband to our MATLAB computer application via a Bluetooth connection with a sampling rate of 256 Hz. We then collected preliminary EEG data to train a Recurrent Neural Network (RNN) to predict the phase angle of slow wave oscillations in real-time. After conducting a literature review, we theorized that the RNN architecture was most conducive to this goal due to its ability to process sequential data in a feedback loop, thus allowing us to identify slow waves and examine phase changes in acquired EEG data. After training and optimization are complete, we will use our RNN model to predict and deliver an auditory stimulus in phase with identified slow waves so as to enhance their magnitude. We will analyze our results by calculating the amplitude of error for our predicted phase angles via a polar histogram method.