Preliminary BCI Data Analysis

The provided data were collected from subjects performing two separate BCI tasks. Two sessions of data from two subjects are provided for each task. Each session contains separate files termed "runs." The details of each task and required analyses are provided below.

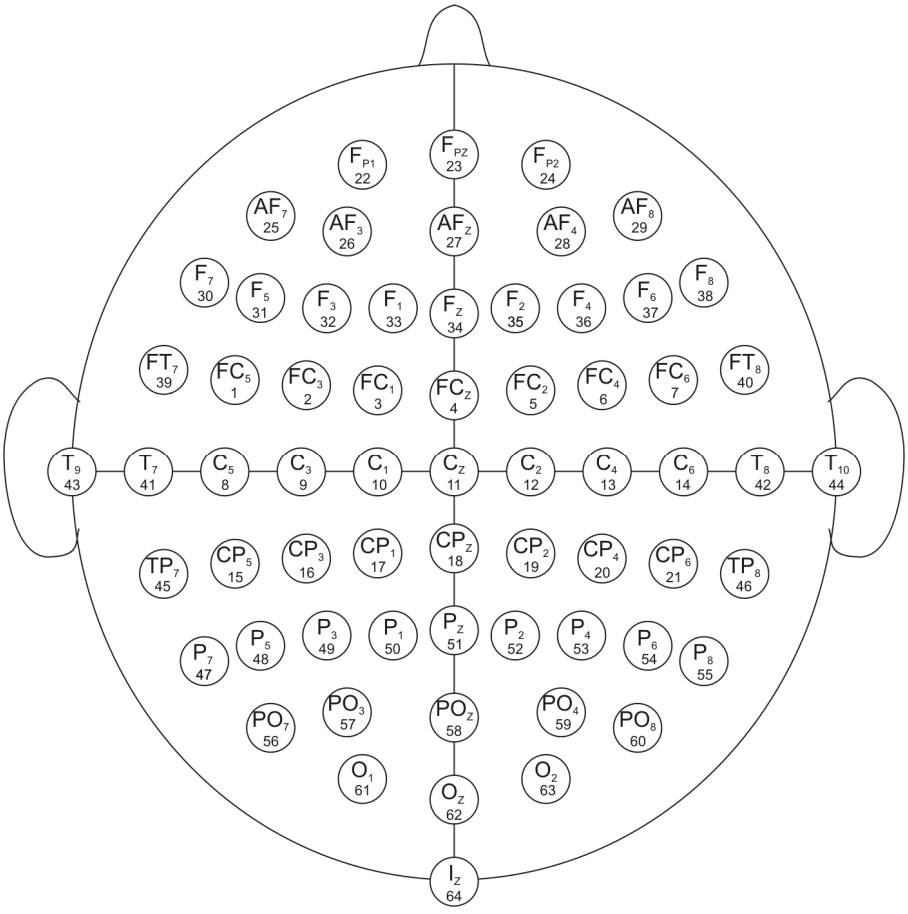


Figure 1: This diagram illustrates electrode designations and channel assignment numbers used in all data.

A. One-dimensional Sensorimotor Rhythm (SMR) Cursor Control Task

The one-dimensional sensorimotor rhythm cursor control task is shown in the figure below. For the task, the users were presented with a target randomly positioned at the top or bottom of the right edge of the monitor. The trial began with the cursor at the center of the left edge of the monitor. It moved at a constant rate toward the right, reaching the right side of the monitor after 2 s. The users' goal was to move the cursor upward or downward to the height of the target so that it hit the target when it reached the right side of the monitor. The trials continued in 3-min runs, with a 1-min break given between runs. A single 3-min run consisted of between 18 and 30 trails, and 8 runs constituted a single session.

One-dimensional task trial structure. (1) The target and cursor are present on the screen for 1 s. (2) The cursor moves steadily across the screen for 2 s with its vertical movement controlled by the user. (3) If the user hits the target, the target flashes for 1.5 s. If the cursor misses the target, the screen is blank for 1.5 s. (4) The screen goes blank for a 1-s interval. (5) The next trial begins.

The details of the data collection and analysis are as follows: Using BCI2000 software, the EEG activity was collected from 64 channels at standard locations provided in Figure 1. All 64 channels were referenced to the right ear, bandpass filtered (0.1–60 Hz) and digitized at 160 Hz.

Analysis Instructions:

1. Read all of the BCI2000 run files from the session into Matlab using **getSMRInfo.m**. Note that the function returns three separate variables:

   Signal: The recorded EEG data in a Channels X Samples matrix.
   States: Various vectors that correspond with the Samples dimension of the signal matrix. The states indicate when specific events related to the task feedback occurred.
   Parameters: These include the hardware and software configuration parameters that determine how the data was collected.

2. Separate the individual trials by the target position (**state.Targetcode**). For all trials, while a target is present on the screen (**state.Feeback=1**), compute the 80-point FFT spectra for each channel using the past 400ms of data and updating every 50ms (overlapping windows).

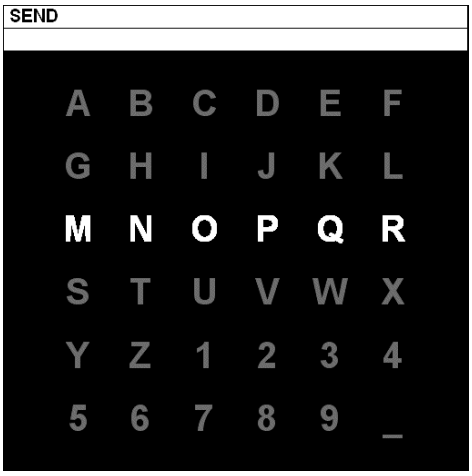
3. Average the FFT magnitude response within each trial.

4. Compute the correlation between the target position and the FFT bin for each frequency and channel.

5. Plot the correlation spectrogram for all frequencies/channels, and the individual topographies (using topoplotEEG.m) for the 0 - 24Hz bins. Be sure to provide colorbars for all plots, each scaled to the same range.

B. P300 Speller Matrix Task

The user was presented with a 6 by 6 matrix of characters as shown in the figure below. The user's task was to focus attention on characters in a word that was prescribed by the investigator (i.e., one character at a time). All rows and columns of this matrix were successively and randomly intensified at a rate of 5.7Hz. Two out of 12 intensifications of rows or columns contained the desired character (i.e., one particular row and one particular column). The responses evoked by these infrequent stimuli (i.e., the 2 out of 12 stimuli that did contain the desired character) are different from those evoked by the stimuli that did not contain the desired character.



This figure illustrates the user display for this paradigm. In this example, the user's task is to spell the word "SEND" (one character at a time). For each character, all rows and columns in the matrix were intensified a number of times (e.g., the third row in this example) as described in the text.

The details of the data collection and analysis are as follows: Using BCI2000 software, the EEG activity was collected from 64 channels at standard locations provided in Figure 1. All 64 channels were referenced to the right ear, bandpass filtered (0.1–60 Hz) and digitized at 240 Hz.

In each run, the subject focused attention on a series of characters. For each character epoch in the run, user display was as follows: the matrix was displayed for a 2.5 s period, and during this time each character had the same intensity (i.e., the matrix was blank). Subsequently, each row and column in the matrix was randomly intensified for 100ms (i.e., resulting in 12 different stimuli – 6 rows and 6 columns). After intensification of a row/column, the matrix was blank for 75ms. Row/column intensifications were block randomized in blocks of 12. The sets of 12 intensifications were repeated 15 times for each character epoch (i.e., any specific row/column was intensified 15 times and thus there were 180 total intensifications for each character epoch). Each character epoch was followed by a 2.5 s period, and during this time the matrix was blank. This period informed the user that this character was completed and to focus on the next character in the word that was displayed on the top of the screen (the current character was shown in parentheses).

For each sample in the *signal* matrix, associated events are coded using the following variables:

Flashing: 1 when row/column was intensified, 0 otherwise

StimulusCode: 0 when no row/column is being intensified (i.e., matrix is blank)
1…6 for intensified columns (1 … left-most column)
7…12 for intensified rows (7 … upper-most row)
See Figure 4 for details.

StimulusType: 0 when no row/column is being intensified or intensified row/column does not contain desired character; 1 when intensified row/character does contain the desired character. This variable provides an easy access to the labels in the training sets in that it can be used to separate the responses that did contain the desired character from the ones that did not. (This could also be done using the variable *StimulusCode* in conjunction with the *TargetChar* that the user focused on.)

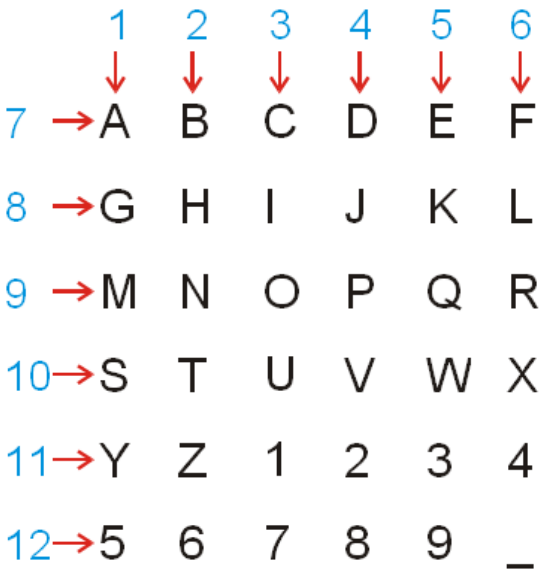
Analysis Instructions:

1. Read all of the BCI2000 run files from the session into Matlab using **getInfo.m**. Note that the function returns the same variables the previous task; however the states and parameters may differ.

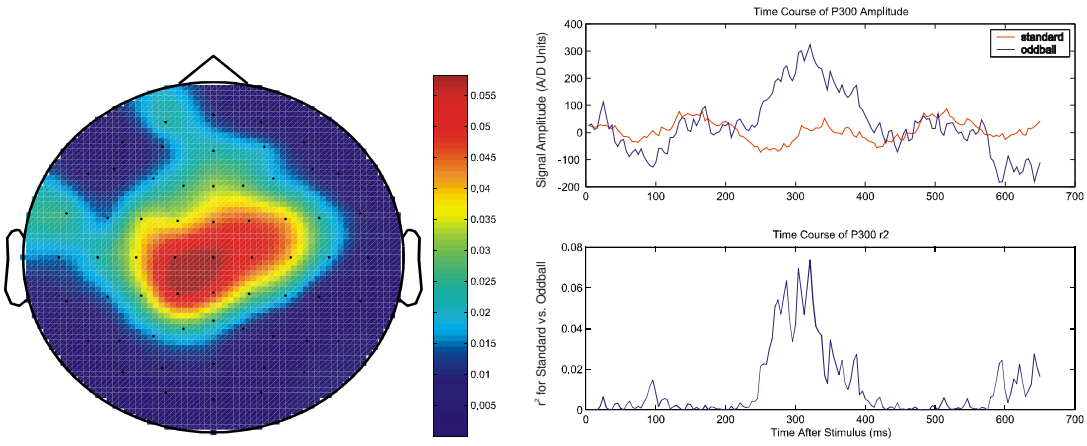
2. For all channels, collect a 800ms of signal samples after the start of each intensification, i.e., whenever *state.Flashing* changes from 0 to 1 (note: each character epoch of the data set starts at the first flash, i.e. *state.Flashing=1* for the first data sample in each epoch).

3. Compute the correlation between the *state.StimulusType* and the response amplitude for each time sample and channel.

4. Plot the correlation spectrogram for all time samples/channels and the individual correlation topographies (using topoplotEEG.m) for the time points: 100:100:500 ms. Also, plot the average temporal response waveforms (target & nontarget) at channels 11, 51, 56, & 60 and the corresponding temporal correlations for the channels. Be sure to provide colorbars for all plots, each scaled to the same range.



StimulusCode Assignments



StimulusCode

Example topography and temporal plots