

# EEG Research on a Budget

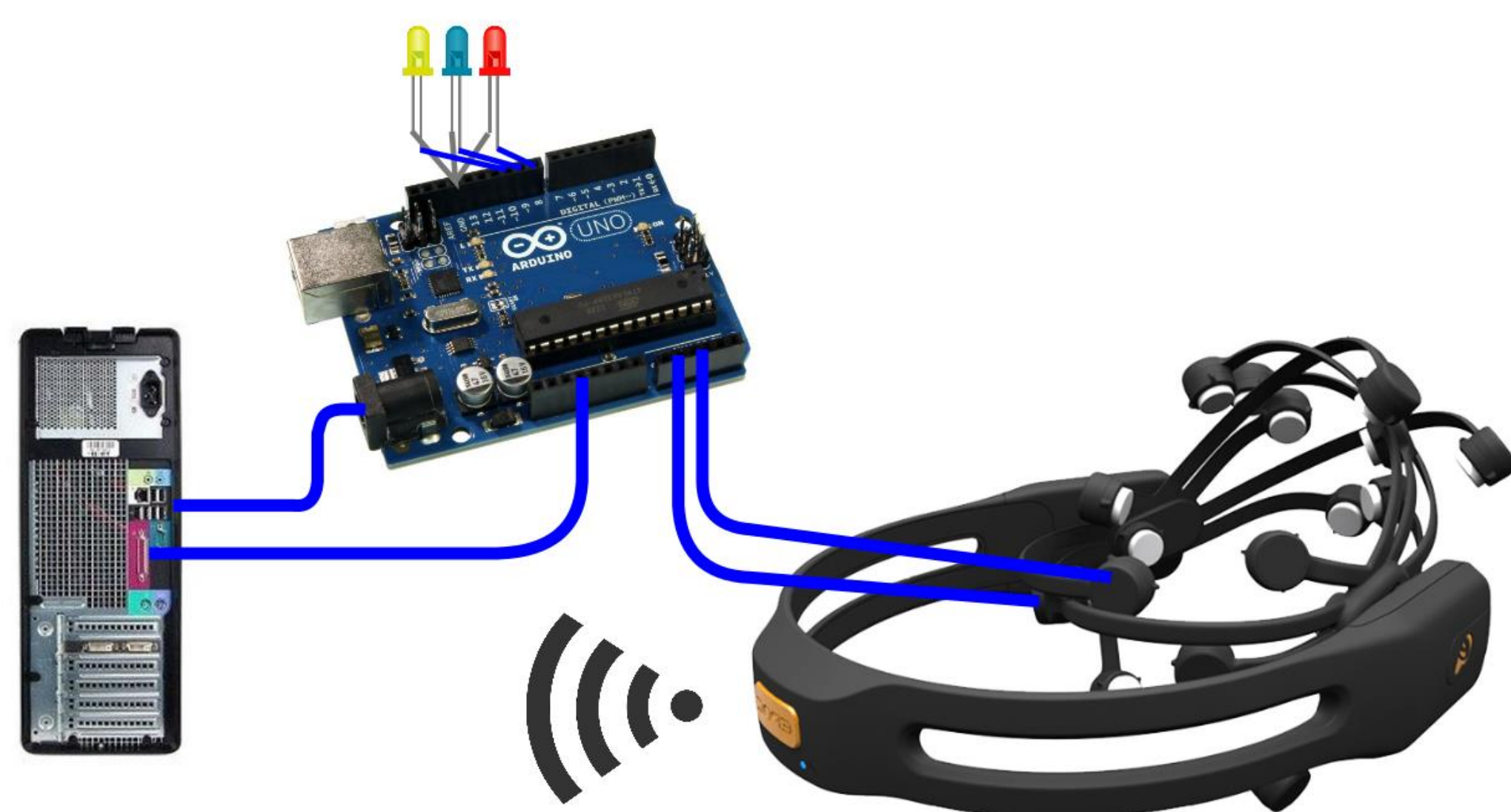
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## Introduction

Measuring electrical potential on the human scalp, called electroencephalography (EEG), is a noninvasive method for recording brain activity with high temporal resolution. EEG allows for a record of brain activity to be paired to an enormous variety of experimental paradigms from psychology. This flexibility and minimal risk to human subjects makes EEG an ideal technique for small neuroscience laboratories. The high cost of research grade equipment, however, can be prohibitive.

## Materials



- Windows PC
  - Eprime software
  - Emotiv software
- Arduino UNO microcontroller
- Emotiv EPOC headset
- Wiring and LEDs

## Methods

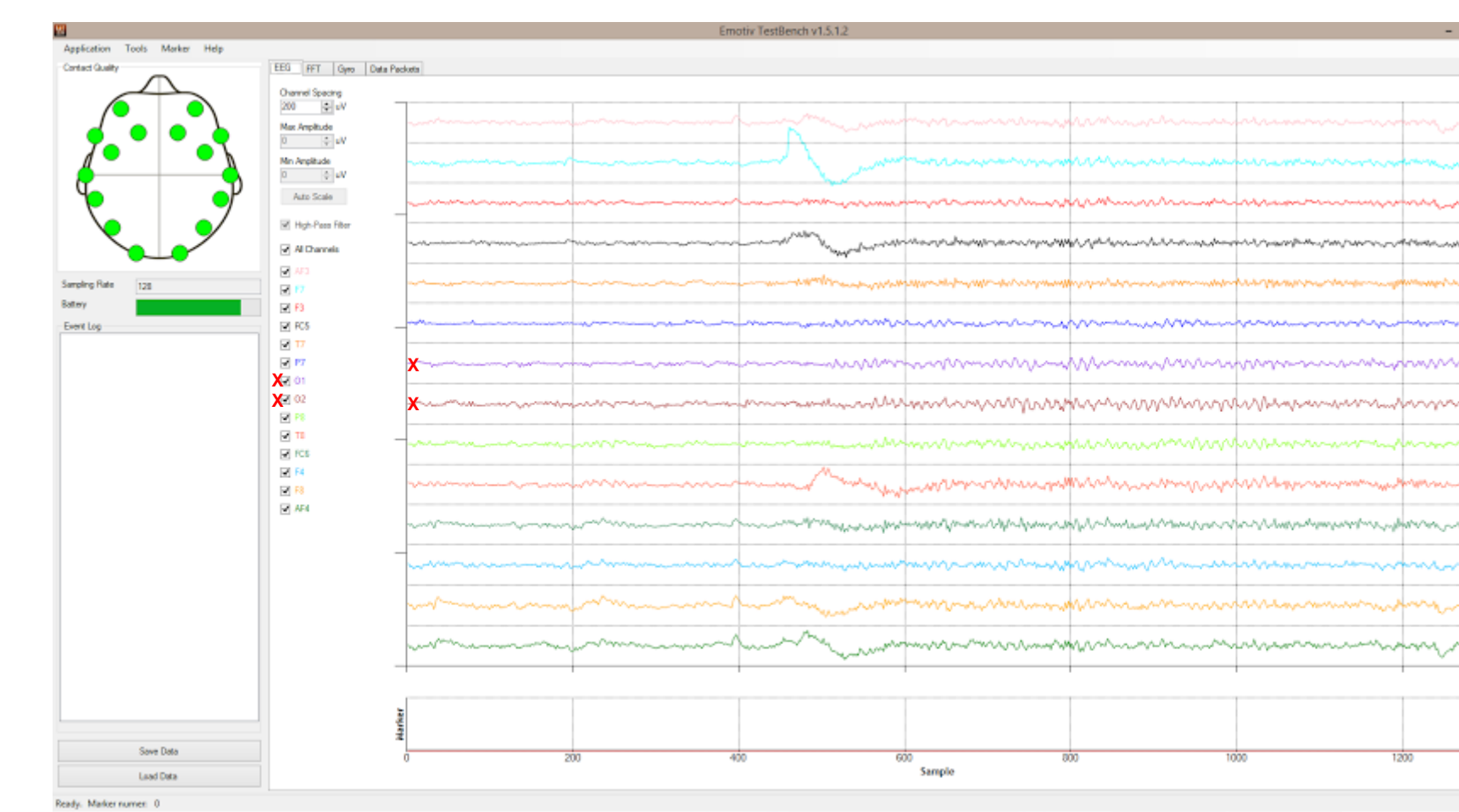
To facilitate EEG research at a bearable cost, we modified a consumer grade Emotiv EPOC gaming EEG system to synchronize its signal with E-Prime software. This equipment allows us to record scalp potential from 12 channels, while sacrificing 2 channels for timing signals (Fig 1). Potentials are oversampled at up to 2048Hz and reported at 128Hz resolution, synchronized temporally with our experiments, running on E-Prime software. We are currently using E-Prime to assess aspects of working memory with the following two tasks.

**The Libet task** is used to investigate the relationship between brain activity and volition. It requires participants to press a button “at will” then report which letter was shown on the screen at the time (W) they decided to act. This task can be repeated many times, then the EEG signals are synchronized to W and averaged. Activity in primary motor cortex, contralateral to the finger pressing the button, can be detected from EEG around W. Premotor activity begins ramping up prior to reported W.

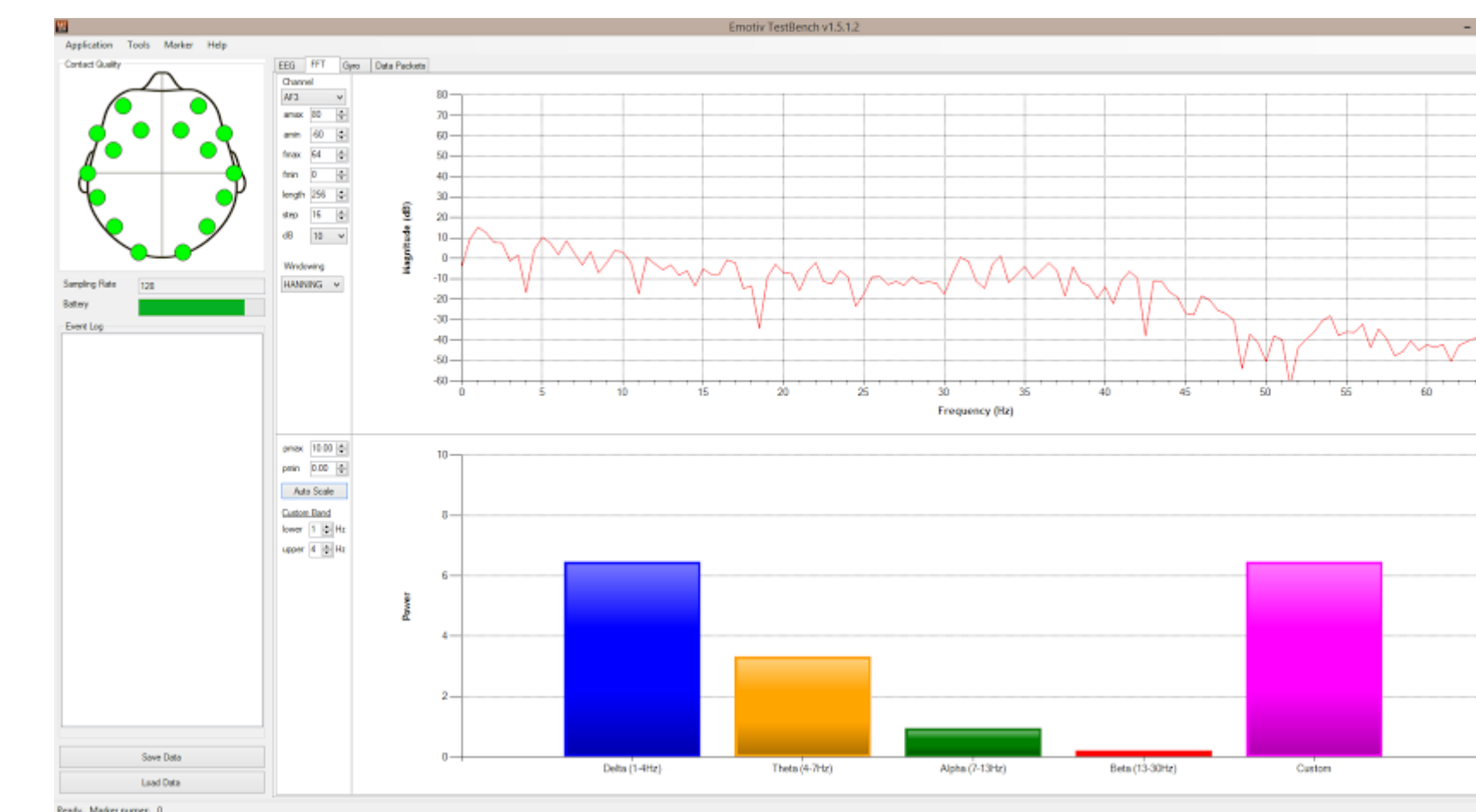
**The N-Back task** measures participants’ capacity to identify information held in working memory. It requires participants to press a button when the current visual stimulus matches the previous visual stimulus presented  $n$  steps back. The task can be made more difficult by increasing the load,  $n$ . Brain activity can be detected from EEG in the premotor and prefrontal cortices.

**Additional variables:** Participants fill out an intake form with demographic information and answers to questions that may result in different EEG signatures. Among these are diagnostic history of ADHD and associated medication, processing disorders, and traumatic brain injury. Additional information about sleep patterns, drug use, and stress level are also requested.

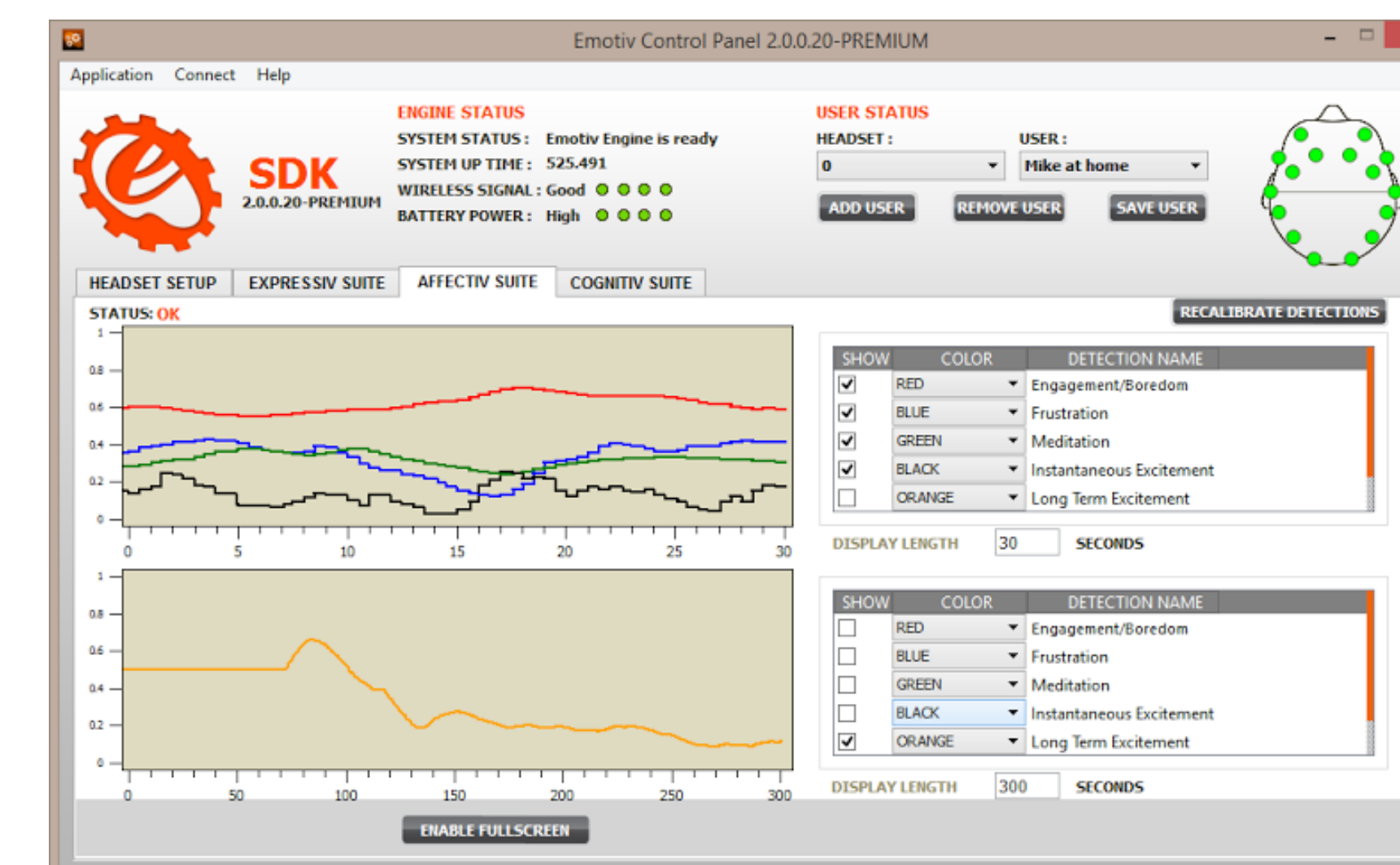
**Figure 1.** The Emotiv EPOC headset records 14 channels of scalp potential. We sacrifice occipital channels (O1, O2).



**Figure 2.** Frequency characteristics of EEG signals are categorized via Fast Fourier Transforms of data in figure 1.



**Figure 3.** Ratios of power at some frequencies to others are characteristic of concentration or relaxation.



## Conclusions

Precise timing is important for working memory tasks, but unavailable in consumer-grade headsets. By sacrificing two electrodes for the timing signal, we achieve the ability to record EEG data synchronized to behavioral data. When combined, these sources of information allow us to test far more interesting hypotheses than when they are recorded separately.

## Future Directions

This extension of our basic research gives us opportunities to form scientific hypotheses and test them by selecting from varied methods and analyses. It also allows us opportunities to gain experience with advanced methods in preparation for continued education. For example, future research will involve investigating working memory capacity by using memory span tasks.

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