Poster 73.3 / EE23

EEG spectral modulations involved in self-regulation of independent component alpha power

Julie Onton and Scott Makeig

{julie,scott}@sccn.ucsd.edu

Swartz Center for Computational Neuroscience

University of California, San Diego, USA

http://sccn.ucsd.edu

Background

Learned control over various aspects of the EEG power spectrum has potential uses for communication and prosthetic control and is being explored for several therapeutic applications.

Objectives

1) Demonstrate feasibility of gaining control over spectral power of an independent component (IC) process as opposed to power arriving at a single scalp electrode.

2) Determine whether independent modulators (IMs) of contribute to successful control of EEG spectral power of a single IC source.

Task/Methods

Procedure:

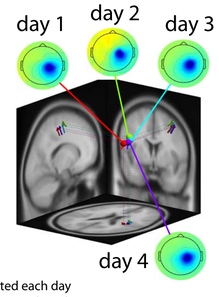
>> 10 minutes of 60-channel EEG were collected to learn a subject source unmixing matrix

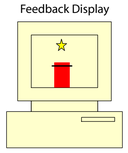
>> a right mu component was selected as the feedback component on all 4 days (see dipole models at right)

>> Raw EEG was filtered on-line using the channel weights returned by ICA for the right mu component. (Due to a technical problem, the control signal was not rereferenced before filtering. Thus, the spatial filtering was most likely suboptimal. Future sessions may demonstrate even stronger evidence of successful control over ICA component power.)

>> Mu/alpha band power (9-12 Hz) was calculated using an AR filter and smoothed over 1.6 seconds.

>> Mu/alpha power was represented to the subject as the height of a red bar (see figure below)





>> The alpha threshold was calculated each day using power from a preliminary session when the subject watched a mock feedback animation while instructed to simply watch the bar move, but not attempt to exert any control over the bar. Threshold was set at the mean power over a 3-min block of mock feedback.

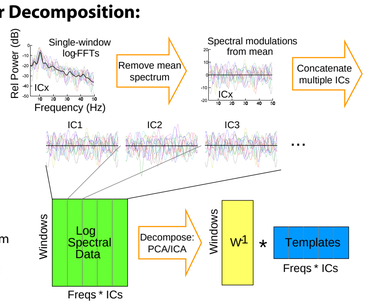
>> During the test sessions, the subject was instructed to keep the red bar above or below the black threshold line, depending on whether the 3-min test block was 'enhance' or 'inhibit'.

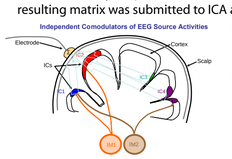
>> While alpha power was appropriately above or below threshold, a yellow star appeared above the bar to signal success to the subject that the current brain activity was optimal (see figure at left).

>> On each test day, the subject performed 4 sessions of alpha 'enhance' consisting of 60 seconds silent rest, 3 minutes of active feedback, 30 seconds rest and another 3 min active feedback block. Interspersed with the alpha enhance sessions were 4 alpha 'inhibit' sessions with the same rest and active blocks as enhance.

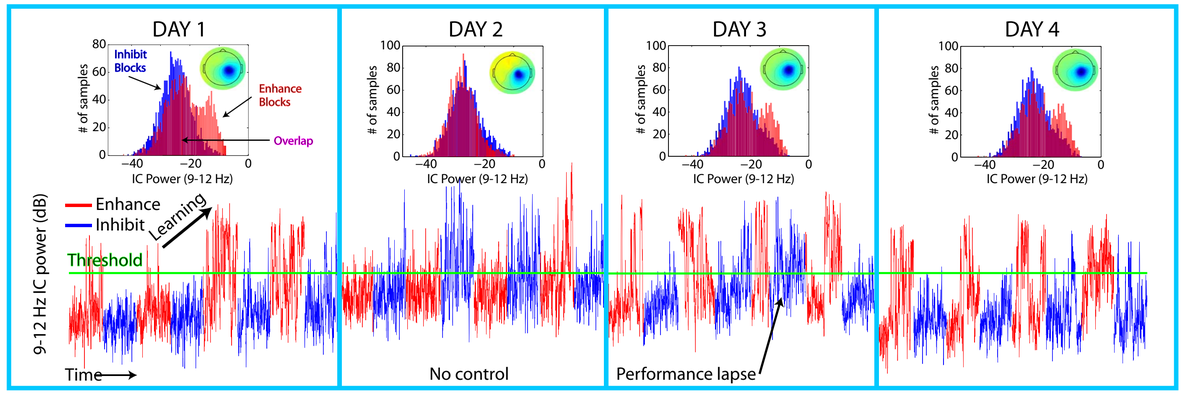
Independent Modulator Decomposition:

For each day, the data over all sessions were divided into 1-sec windows. For each selected independent component (IC) process, a fast fourier transform (FFT, Welch method) was performed on each 1-sec window between 1 Hz and 50 Hz. The result of this decomposition was transformed into log power (dB = 10*log10(power)). For each component, the mean power spectrum was removed from each window, leaving only variations from the mean spectrum (see diagram at right). Power variations for 10-20 selected components were then concatenated to yield a matrix of size (windows by frequencies * ICs). The resulting matrix was submitted to ICA after restriction to the first 15 principal dimensions by principal component analysis (PCA). ICA then found 15 maximally independent modulation (IM) modes or templates, as well as the strength of each IM in each time window (see diagram above). The rationale for this method is that several multiplicative process influences (independent modulators) may be able to affect the activity spectra one or more cortical areas simultaneously (see left).

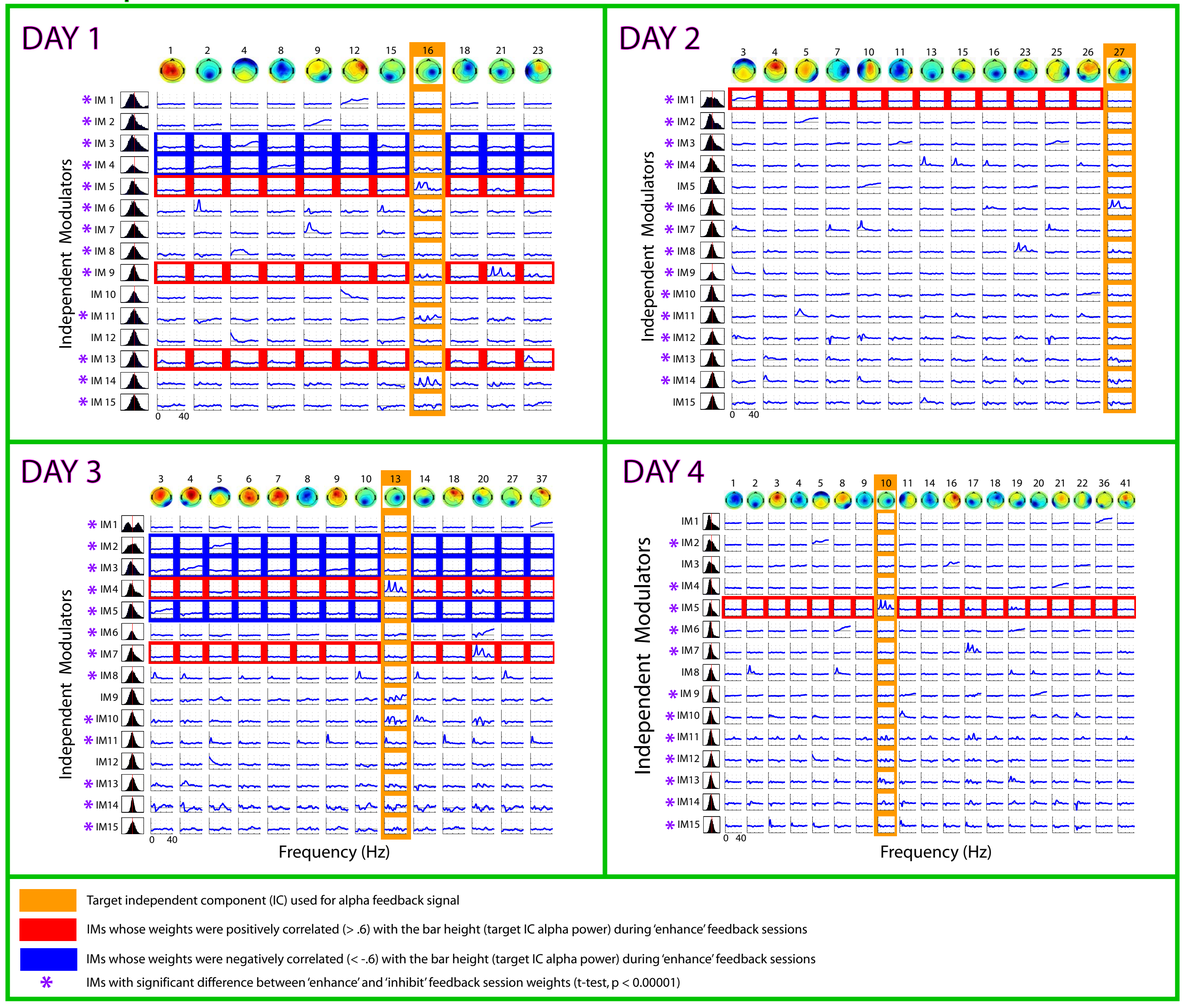




1. Performance



2. Independent modulators: relation to task demands



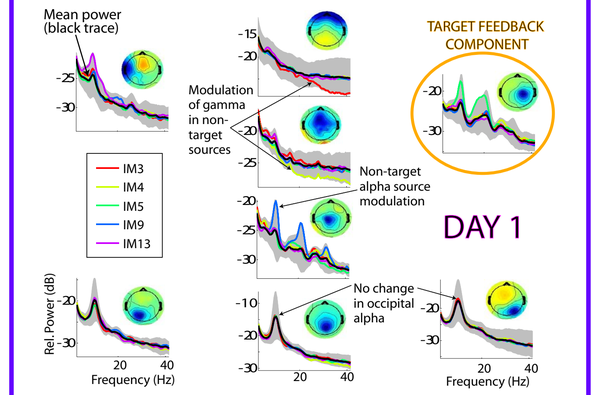
Target independent component (IC) used for alpha feedback signal

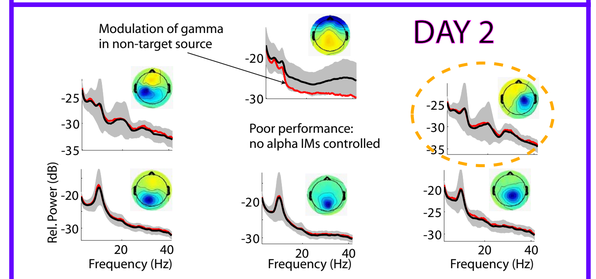
IMs whose weights were positively correlated (> .6) with the bar height (target IC alpha power) during 'enhance' feedback sessions

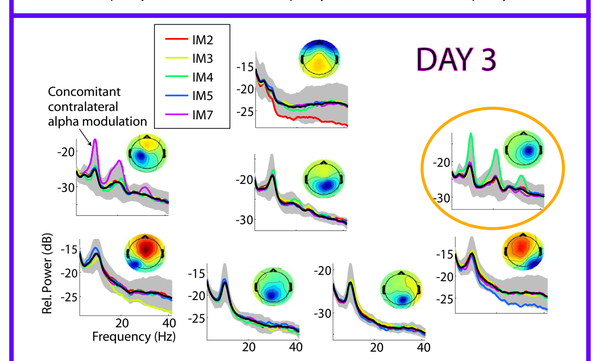
IMs whose weights were negatively correlated (< -.6) with the bar height (target IC alpha power) during 'enhance' feedback sessions

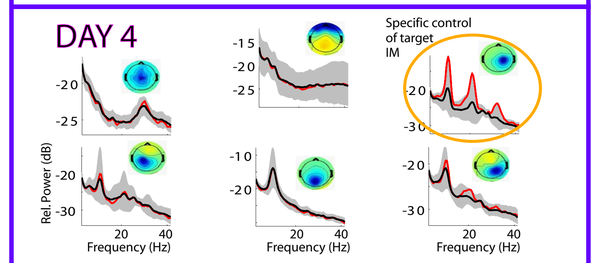
* IMs with significant difference between 'enhance' and 'inhibit' feedback session weights (t-test, p < 0.00001)

3. IMs active during alpha 'enhance'









Conclusions:

1) Gaining conscious control over activity of an independent EEG component is feasible and could possibly be of more use than single scalp channel control

2) Several independent EEG modulator processes were active during successful control of alpha band activity in a right mu component

>> However, the spectral modulations involved in this control changed over sessions

Society for Neuroscience, Atlanta, Georgia, Oct. 2006