Hierarchical general-linear modeling of EEG data in EEGLAB and LIMO extension

Ramon Martinez-Cancino1*, Scott Makeig1, Cyril Pernet2, Arnaud Delorme1,3
1Swartz Center for Computational Neurosciences, 2Division of Clinical Neurosciences, Univ. Of Edinburgh, 3CerCo, CNRS/Paul Sabatier University, Toulouse, France, * ramonmc@usc.edu

Hierarchical linear model procedure

EEGLAB is an interactive Matlab toolbox for processing continuous and event-related EEG, MEG and other electrophysiological data incorporating independent component analysis (ICA), time/frequency analysis, artifact rejection, event-related statistics, and several useful modes of visualization of the averaged and single-trial data.

LIMO EEG is a Matlab toolbox which is an extension of EEGLAB to analyze evoked responses over the space and time dimensions, while accounting for single trial variability using a two level hierarchical linear modeling of the data. LIMO provides robust parametric tests (Pernet et al., 2011).

Goal = EEGLAB + LIMO

Here we present results of integrating into EEGLAB functionality for computing general linear model (GLM) statistics leveraging functionality in the LIMO EEG Toolbox.

Setting up a design in the STUDY. We have developed in EEGLAB functionalities to define statistical contrasts, to visualize their results, and to interact with the user via intuitive graphic user interfaces (GUIs). Here we shown a validation using a publicly available data set (Wakeman and Henson, 2015) (Wakeman-Henson or WH data).

Legend

1. EEGLAB main window
2. Newly developed pop_studydesign() GUI. Complex designs are supported now with no limits on the number of independent variables or contrast.
3. Building the statistical design for the 1st level analysis by editing and/or adding independent variables to the interface in 2. In this panel, we show the selection of the first independent variable of the 2nd design.
4. Design matrices corresponding to each of the 4 designs listed under ‘Select STUDY design’ on the GUI in 2.
5. Estimating data models defined in the selected STUDY design. Channels data: When working with channels data, the measures to use in the analysis should be precomputed first.
6. ICA data: When working with components, the precomputation of the measures to use in the analysis and the clustering of the ICA components should be done before estimate the statistical model.
7. EEGLAB convert the statistical design and uses the LIMO EEG extension to estimate the GLM parameters for both the 1st level and defaults 2nd level analysis.
8. Results from Design1 on Channels data (a) Residuals of the model for subject ‘SubJ1’ as an example of 1st level analysis result. (b) WH data and EEGLAB results. (c) Trimmed means of ERPs.

Participants were asked to press one of two keys based on how symmetric they regarded each image, ‘more’ or ‘less symmetric’ than average.

More info https://openfMRI.org/dataset/ds000117

Conclusions

The integration into EEGLAB of hierarchical GLM statistics has been implemented and is currently undergoing alpha testing. In the near future, statistical analysis based on hierarchical general linear models (within subjects and between subjects) will be the default approach supported by EEGLAB.