A method for detecting statistically significant differences in EEG data

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Introduction

- EEG data is highly multivariate.
- Application of statistical tests is limited by EEG data dimensionality.
- A technique for performing statistical tests on highly multivariate data has been recently proposed (Fachada et al., 2016).
- We apply this technique to EEG data from schizophrenia patients and healthy controls while performing a Visual Backward Masking (VBM) task.

Methods

Experimental setup

- EEG data was collected using 64 electrodes from 22 schizophrenia patients and 20 healthy controls during a VBM task.
- The data was preprocessed for artifact removal using the processing pipeline described by da Cruz et al. (2016).
- The task comprises a Vernier target – two vertical bars that are slightly offset in the horizontal direction. Observers had to judge the offset of the lower line.
- After the target, a mask follows – observers have to discriminate the offset direction by pushing the corresponding button.
- Two VBM conditions – long and short inter-stimulus intervals (ISI) – were randomly presented with target only and mask only control conditions, in a total of four stimulus conditions.

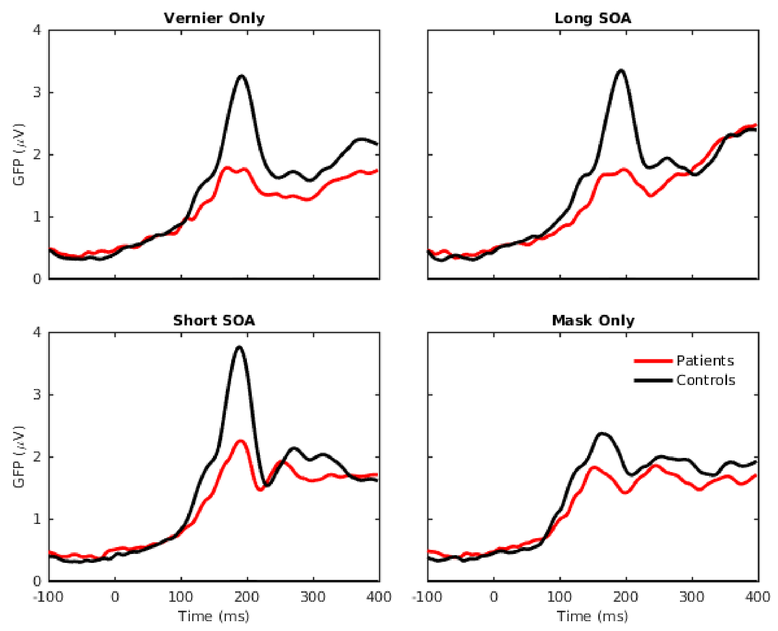
Data processing and statistical testing

- For each subject, EEG epochs were extracted from 100ms before the stimulus onset to 400 ms after stimulus onset.
- The grand averages across all trials for each stimulus condition were computed.
- The global field power (Lehmann and Skrandies, 1980), i.e. the standard deviation across all channels at any given time point, was determined.
- Principal component analysis (PCA) was used to convert multivariate observations into a set of linearly uncorrelated statistical measures.
- The first two principal components (PCs) – explaining at least 60% of the variance – were selected.
- Data from the two groups – schizophrenia patients and healthy controls – are now 2D points.
- The MANOVA test was then used for comparing the two groups and the respective p-value was reported.

Results

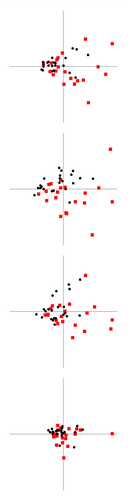
- GFP grand averages for patients and controls are shown in Figure 1.
- Patients had decreased GFP amplitudes around 200 ms after stimulus onset for all conditions with a Vernier target.

Figure 1 – GFP grand averages for patients and controls.



- Significant differences were found between patients and controls ($\alpha = 0.01$) for the Vernier and long ISI conditions.
- Significant differences were found between patients and controls ($\alpha = 0.05$) for the short ISI condition.
- No differences were found in the data from the mask only condition.
- Table 1 shows the p-values and respective PCA score plots for the different stimulus conditions.

Table 1 – P-values and score plots for the different stimulus conditions.

Stimulus condition	p-value	Score plot
Vernier only	0.0083	
Long ISI	0.0018	
Short ISI	0.0120	
Mask only	0.1525	

Conclusions

- This study shows that this technique is able to detect significant differences between schizophrenia patients and controls, reproducing previous results using conventional statistical tests (Plomp et al., 2013).
- A preliminary data analysis as performed here can be useful for rapidly assessing if the factors of interest are expressed in the data, and if more complex studies, e.g., involving classification, are justifiable.
- The utilized multivariate comparison technique is independent of the distributional properties of samples and automatically selects features that best explain their differences.
- The procedure is appropriate for comparing samples of time series, images, spectrometric measures or similar high-dimension multivariate observations, such as EEG data.

References

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