fMRI Activation Pattern Based Prediction of Psychopathological Status Using Support Vector Machines

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Background

The analysis of differences of activation between healthy control subjects and patients suffering from various psychopathological conditions is an active area of neuroscientific research. In neuroimaging those differences are traditionally investigated by means of the general linear model (GLM) in order to localize deviations of activation between groups. An alternative method of analysis is classification. Within this framework a classification algorithm tries to make a guess about the condition that generated an unknown pattern of activation. For example an algorithm "trained" with patterns of activation belonging to schizophrenic patients and healthy controls may try to infer if an unknown person is suffering from schizophrenia on the basis of corresponding activation patterns. We developed a toolbox facilitating an easy classification analysis - ***WalNUT BSC***. In a first attempt, we used it to differentiate between subjects suffering from Obsessive Compulsive Disorder (OCD) and healthy controls.

fMRI Study

- Symptom provocation study
- Subjects and Experimental Design
  - 20 subjects
    - 10 subjects suffering from OCD and 10 mentally healthy control subjects
  - TR = 3 s
  - Pictures from 4 emotional categories ('OCD', 'Fear', 'Disgust', 'Neutral'), 20 pictures each, were presented in a block design
  - Within a category each picture was presented for 3 s resulting in a total of 60 s per condition/block
  - Each category was repeated six times
  - Within a block, the pictures were shown in a randomized sequence.

Methods

- Data Preprocessing
  - fMRI volumes were realigned, acquisition corrected, normalized, and finally smoothed using SPM99
- Setting up the data matrix
  - In a first step WalNUT BSC computed standardized beta-regression coefficients (GLM) corresponding to design-correlated voxel activation of each subject
  - Each subject was then represented by a vector consisting of all voxels' beta-coefficients
- Selection of voxels appropriate to classification, training and test
  - First a subject to be classified was seperated from the data matrix
  - Then voxels exhibiting a high ratio of inter-class to intra-class variance were selected by means of two sample T-test
  - In the next step the classifier was trained with selected voxels' beta coefficients (i.e. activation patterns of subjects) and their corresponding class-labels.
  - Finally the classifier predicted the psychopathological status of the given subject
  - This procedure was repeated for each of the subjects and each experimental condition

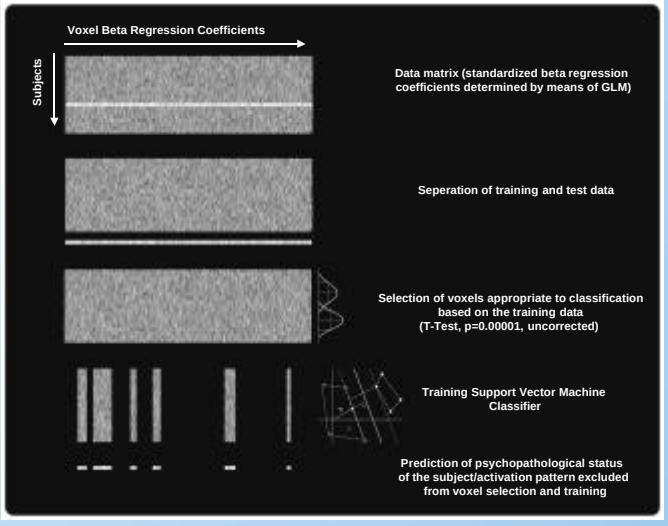

Fig. 1: Computational steps performed by ***WalNUT BSC*** in order to predict the psycho-pathological status of a single subject.

Results

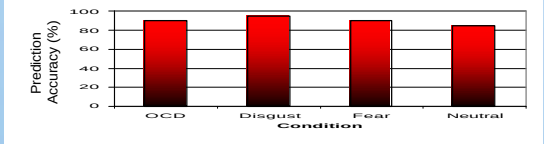

Fig. 2: Prediction accruacy across experimental conditions.

#	T	X	Y	Z	Structure	Lobe/Region	Hemi-sphere
1	9.2	-21	81	18	Superior G.	Frontal	L
2	7.2	36	-57	57	Supramarginal G.	Parietal	R
3	6.8	-42	-54	54	Supramarginal G.	Parietal	L
4	6.5	42	-30	81	Precentral G.	Central	R

Tab. 1: T-Values (two sample T-test; p < 0.00001, uncorrected) and spatial localization of voxels selected across all classification procedures within the OCD condition.

- Prediction accuracy
  - Using beta coefficients corresponding to the OCD condition, we received a prediction accuracy of 90% (p = 0.0002; binomial probability)
  - Interestingly we received an even higher accuracy using the disgust coefficients (95%; p = 0.00002; binomial probability)
  - Figure 2 summarizes the results.
- Spatial localization of voxels appropriate to classification
  - Consistent with the findings of Schienle et al. (2005), areas within frontal as well as parietal lobe differentiated maximally between the two groups and were therefore most appropriate for prediction of psychopathological status.
  - Table 1 and Figure 3 summarize the results.

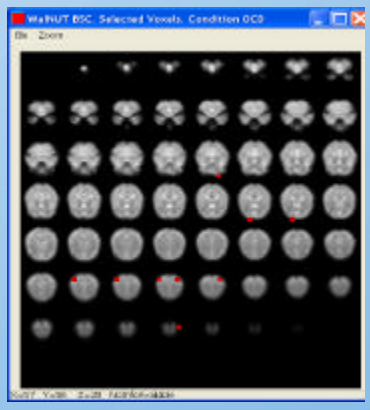

Fig. 3: Voxels selected across all single-subject classification procedures within the OCD condition

Discussion

Recently several authors (e.g. 1-2) demonstrated that classification of psychopathological status based on neuroimaging data is possible across a wide range of conditions. We developed a toolbox facilitating an easy classification analysis. The software discriminated between patients suffering from OCD and healthy controls with very high accuracy.

References

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