Diagnostic accuracy of cerebral metabolic imaging in disorders of consciousness

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Introduction

The high rate of misdiagnosis [1] reflects the difficulty of correctly diagnosing different states of consciousness like minimally conscious state (MCS) and vegetative state/unresponsive wakefulness syndrome (VS/UWS). We here aim to develop an evaluation method by teaching a machine to detect the state of consciousness using fluorodeoxyglucose PET (18F-FDG-PET) scans.

Data

Data:

PET images with computed tomography attenuation correction:

- 140 patients with different states of consciousness (50 Minimally Conscious State (MCS), 46 Unresponsive Wakefulness State (UWS), 4 Locked in Syndrome, 13 Emerged- MCS, 7 in coma and 20 ambiguous patients.
- 35 healthy subjects
- Mean age 34.82 years old, ± 14.7 SD

Each patient's state of consciousness was evaluated with repeated assessments of Coma Recovery Scale – revised [2].

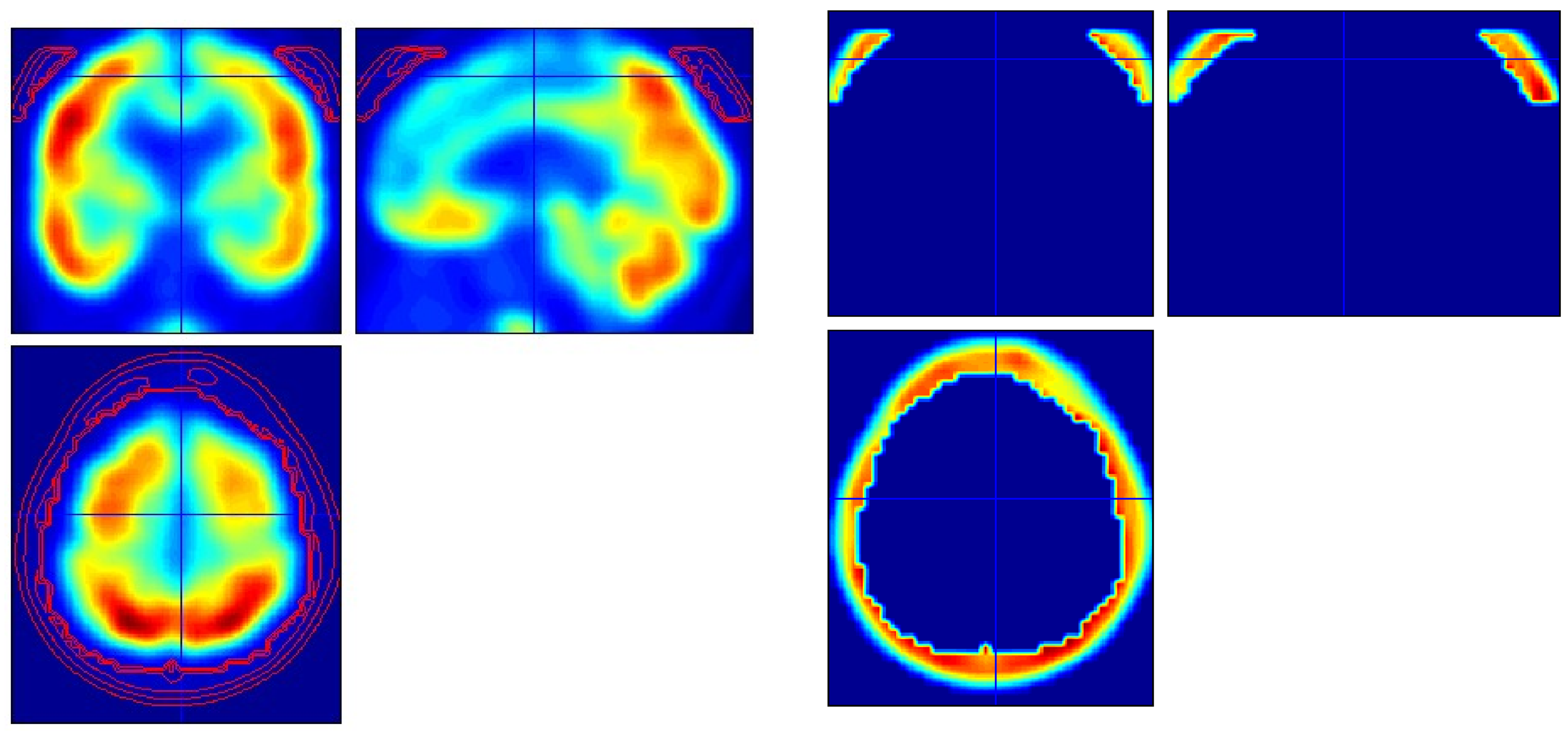
Preprocessing

In the preprocessing all patients and controls were used in order to create a study specific template [3].

Data were preprocessed and analyzed by means of statistical parametric mapping (SPM12):

- PET images were normalized in MNI.
- A study specific template was created by averaging the normalized PET-scans. Template was smoothed with an 8mm FWHM kernel.
- Raw PET scan were normalized again in the study specific template and smoothed with an 14mm FWHM kernel.
- The voxels' intensity of Normalized PET scans were scaled down with a unique value for each image, extracted from skin voxels (skin was selected as a point that is not related to consciousness).
- All voxels that had a probability more than 60% to belong to the gray matter were selected by using the tissue probability map of SPM.

Skin Extraction



Skin voxels are selected for intensity normalization, as a reference point of glucose consumption that is not related to consciousness state.

Classification

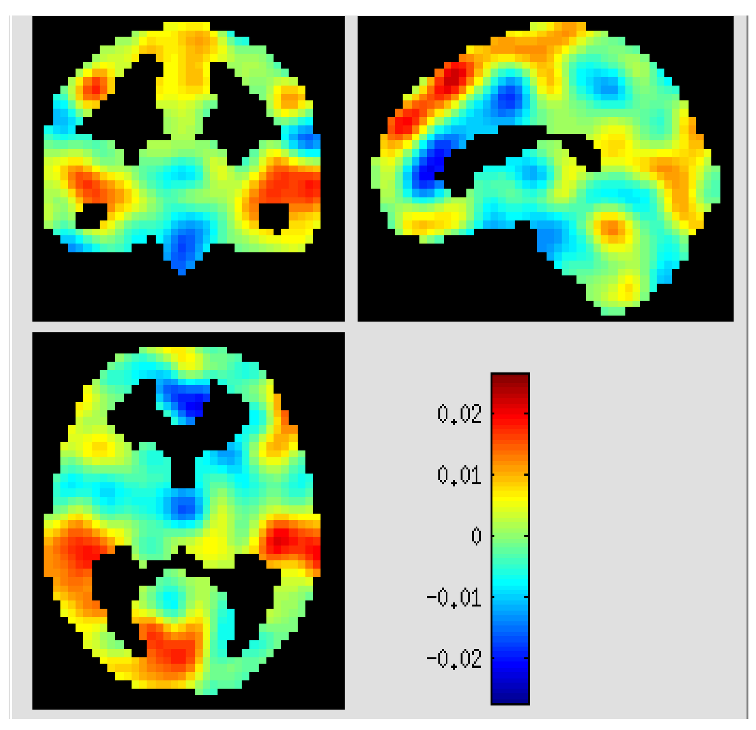
Our main goal is to discriminate the MCS patients from those being in VS/UWS.

A Gaussian Process Classifier (GPC) [4], embedded in the Pattern Recognition for Neuroimaging Toolbox [5], was chosen to classify the PET images. GPC was chosen due to the fact that gives results in terms of probabilities and that can be interpreted as a confidence level.

Besides classification GPC assigns one value to each voxel and this can be displayed as weight map.
In order to estimate the accuracy of the Classifier, Leave one out - Cross Validation scheme was used.

A total accuracy of 81.25% was achieved, MCS detection rate was 78% and UWS was 84.78%, ($p<0.002$ for both classes).

Weight Map & ROC curve



Weight map

Accuracy	MCS vs UWS (%)
total	81.25
balanced	81.39
MCS	78
UWS	84.78

Conclusion & Discussion:

Medial and lateral frontoparietal cortices and brain stem appear to play a key role in consciousness state, as shown from the weights assigned by the classifier to the voxels. Besides the absolute cortical metabolic activity [6], glucose consumption in different brain regions can affect the state of consciousness. The MCS correct classification rate is relatively low but as a critical point needs to be improved. Some of the limitations responsible for it, that we are currently working on, are the following:

- Skin mask is often not able to select skin voxels due to severe deformations of patients' brains.
- The state of consciousness of a few patients included in the study changed with the time.
- The significant size of the ventricles seem to “push” the voxels on the edge to higher weights.

References:

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