SPM12 fMRI and EEG Analysis Documentation

NMDA SS 2023

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Contents

1 Introduction

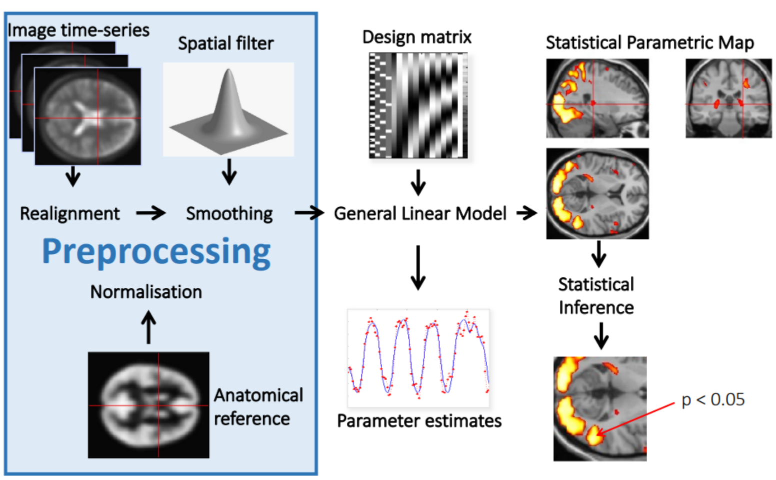
The following document contains important aspects of the processing and analysing steps of fMRI and EEG data using the statistical analysis pipeline SPM12 based on matlab functions. The first part of this documentation will describe the steps of preprocessing and analyzing fMRI data. EEG data will be covered in the second part.

2 fMRI Analysis

2.1 Preprocessing

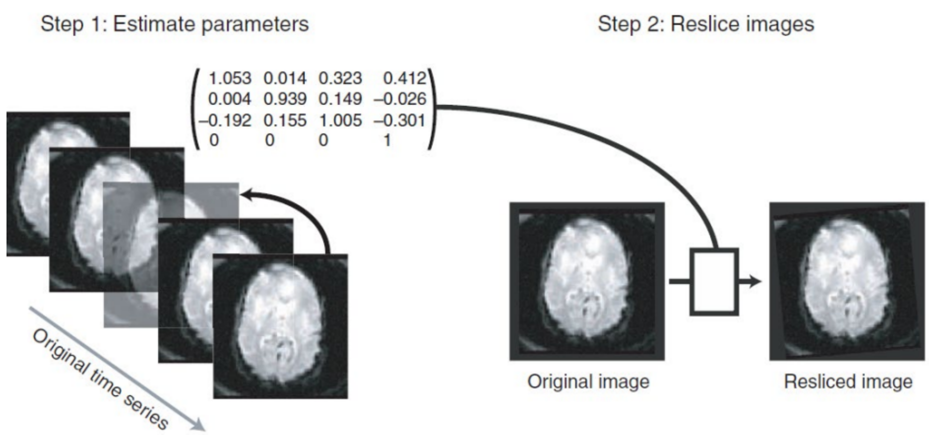
Preprocessing of fMRI images prior to statistical analysis allows to ensure that the data has sufficient quality and reduces the influence of disruptive factors to ensure reliable results.
Preprocessing of fMRI data consists of four different steps:

1. Realignment
2. Slice Time correction
3. Normalization
4. Smoothing



2.1.1 Realignment

Realignemnt in fMRI preprocessing is basically motion correction. Because it is not possible to completely avoid minimal motion in the scanner, some images of the time-series are tilted against each other due to motion artifacts. This will lead to a distortion in the recording of a particular neuronal structure.
In fMRI, especially task related motion is a huge problem. Example: If pushing a response-button induces head motion, a strong signal change will be artificially induced into the data. This signal change will be time-locked to the event of button-pressing and might overwrite any effect of interest.
To reduce the influence of these motion artifacts on statistical results, all fMRI data is realigned. For that, differences in brightness between the single images are used. As the shape of the head is not changing, an algorithm can determine optimal spinning/turning of the images to minimize these differences. The algorithmic calculations result in motion parameters, which are then used to interpolated and rewrite the images.



2.1.2 Slice Time Correction

Preprocessing also includes slice time correction. FMRI volumes are typically acquired in a slice-wise manner and not all at once. Because of that, the time delay of image acquisition between the first and the last slide is almost 1xTR. These slice-time acquisition differences can be compensated by temporal interpolation of the data (= Slice time correction).

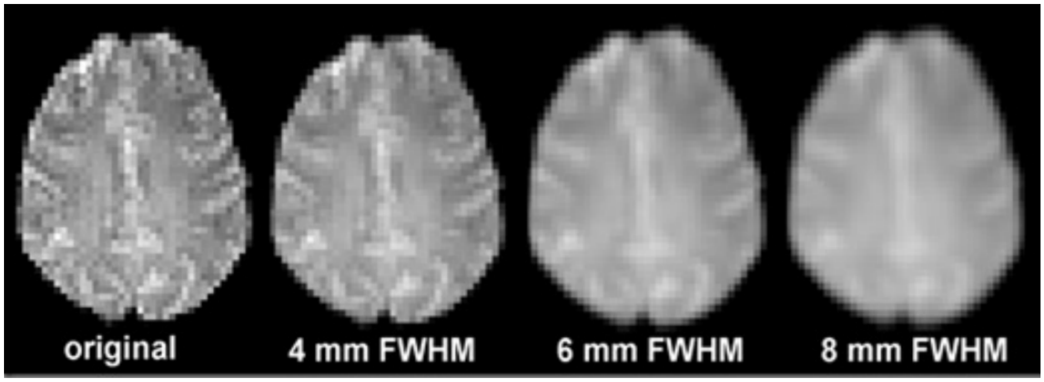
2.1.3 Normalization

Normalization is based on the problem that every head (and brain) has a different shape. To allow the calculation of group statistics with spatial information, all individual brains need to be transformed to a standard space, for example the MNI space. For that the fMRI images need to be segmented into gray and white matter maps based on differences in bightness of different tissues in the T1 and probability maps.

After this step, so called Warping of the data is perfomed, where optimal transformation parameter are determined to map every individual brain to a standard-shape (= mapping onto the MNI standard template).

2.1.4 Smoothing

But even after motion correction, normalization and transforming each brain into MNI-space, inter-individual spatial differences remain. To resolve these and to allow reasonable group-statistics, the data is smoothed using Gaussian Filter Windows. Smoothing eliminates small outliers, pronounces main effects that are present in multiple neighbouring voxels and affects the significance threshold of consecutive testing.



2.2 Statistical Analysis on subject level