Resting State fMRI head movements in Multiple Sclerosis patients: evaluation of the MCFLIRT correction algorithm

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Introduction

Resting-state functional-MRI (rs-fMRI) is widely used to investigate the brain architecture networks though the BOLD response. The technique represents an interesting and reliable approach, but its elaboration results to be prone to noise due to confounding factors. In particular, head motion has become a particularly challenging problem in recent studies using rs-fMRI [1]. The work aim was to evaluate in Multiple Sclerosis (MS) patients a well-known motion correction algorithm from FMRIB's Software Library – MCFLIRT [2] - that could be applied to minimize head motion distortions, allowing to correctly interpret rs-fMRI results.

Methods

Eighteen early-MS patients (mean-age=37.42±8.11, 9 females) were recruited according to McDonald and Polman criteria [3], and matched for demographic variables with 19 healthy-controls (mean-age=37.55±14.76, 10 females). All rs-fMRI were pre-processed using FMRIB's Software Library v5.0 and they were motion corrected through MCFLIRT algorithm for extracting six motion parameters: three translation measures of axes x(left/right), y(anterior/posterior) and z(superior/inferior) and three rotations measures around the axes phi, theta and psi. Two motion estimators have been calculated from translational and rotational displacements: the root-mean-square (RMS) from the x, y and z parameters and the Euler-Angle (EA) from phi, theta and psi angles. We performed an outlier analysis comparing each subject's RMS/EA with the sum of its group mean and two standard deviations (S). The subject represented an outlier if its value exceeded this sum, and its movement could distort the fMRI analysis.

Results

Analysis showed two outliers in healthy-control (EA=2.8819, S=2.73; RMS=0.0083, S=0.0061) and in MS-patients (EA=2.9532, S=2.7951; RMS=0.022, S=0.0137). However, the differences were minimal, thus they could be not considered as real outliers. Moreover, a t-test was realized to investigate the differences between the two groups. No statistical significant differences ($p<0.05$) were found in RMS values (MS-mean=0.0040mm and healthy-mean=0.0026mm) and in EA (MS-mean=1,7201° and healthy-mean=1,5731°).

Conclusions

Head motion have significant effects on rs-fMRI network measures and it is usually associated with decreased functional in Default and Frontoparietal Networks. Strategies application to reduce this distortion is fundamental for a correct data interpretation. We analyzed one of the most used motion correction algorithm, MCFLIRT, and our evaluation showed that it is able, in MS patients, to minimize effects of head motions, correcting any movements artefacts. Its application allows to have similar movements within subjects, excluding outliers and consenting the correct network function interpretation.

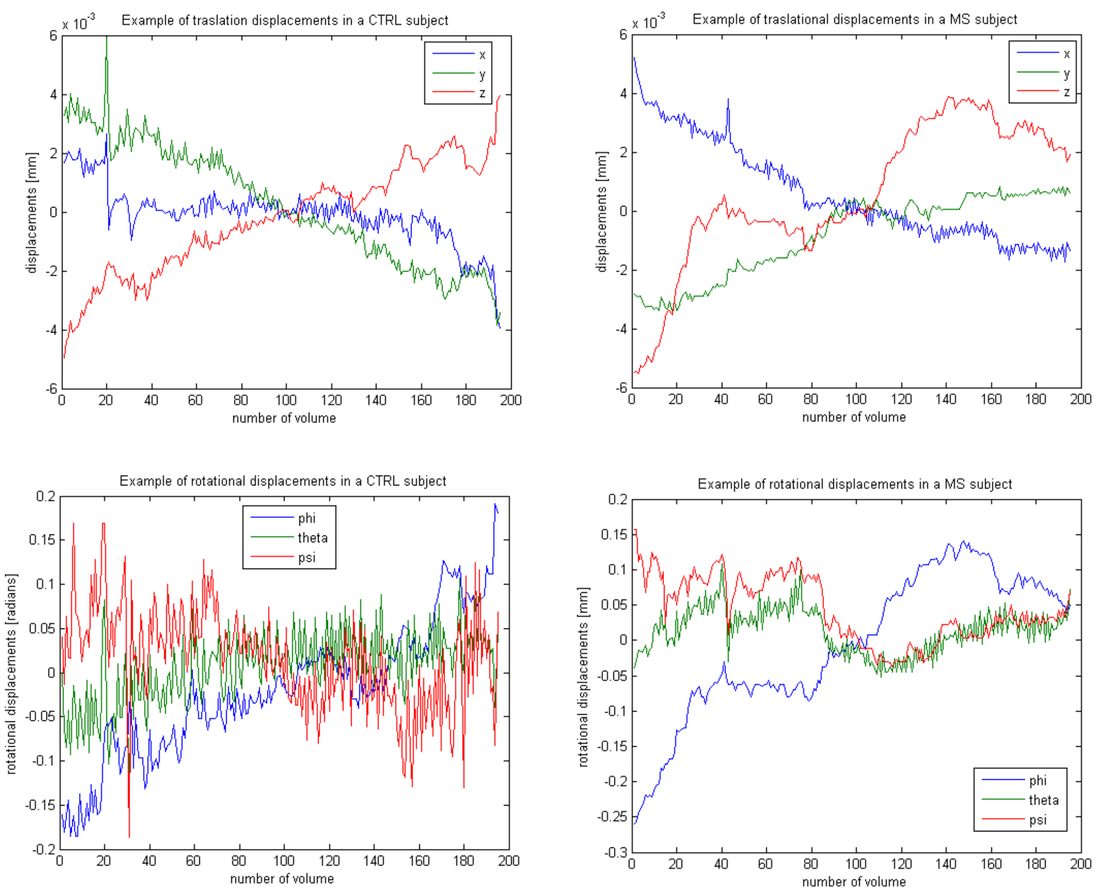

Fig.1: Examples of translational and rotational movements in a CTRL subject and in a MS subject.

Table 1: Parameters of outlier estimators in CTRL subjects.

Displacement	Estimator	Outlier analysis form	Outlier analysis value	Any outliers
Translational [mm]	Root mean squared – rms	Mean rms + 2*std rms	0.0061	0.0083
Rotational [grades]	Euler Angle – EA	Mean EA + 2*std EA	2.73	2.88

Table 2: Parameters of outlier estimators in MS subjects.

Displacement	Estimator	Outlier analysis form	Outlier analysis value	Any outliers
Translational [mm]	Root mean squared – rms	Mean rms + 2*std rms	0.0137	0.022
Rotational [grades]	Euler Angle - EA	Mean EA + 2*std EA	2.7951	2.9532

Bibliography

[1] Van Dijk, Koene RA, Mert R. Sabuncu, and Randy L. Buckner. "The influence of head motion on intrinsic functional connectivity MRI." Neuroimage 59.1 (2012): 431-438.
[2] Jenkinson, M., Bannister, P., Brady, J. M. and Smith, S. M. Improved Optimisation for the Robust and Accurate Linear Registration and Motion Correction of Brain Images. NeuroImage, 17(2), 825-841, 2002.
[3] Polman, C. H., Reingold, S. C., Banwell, B., Clanet, M., Cohen, J. A., Filippi, M., et al., (2011). Diagnostic criteria for multiple sclerosis: 2010 revisions to the McDonald criteria. Annals of neurology, 69(2), 292-302.