

Motion Artefact Decorrelation in FMRI Analysis using ICA

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Abstract Stimulus-correlated motion is a particular problem in Functional MRI studies as it is very hard to discriminate between true activation and closely-matched artefact. We show that spatial and temporal maps generated by Independent Component Analysis (ICA) on FMRI data can be used to identify stimulus-correlated motion. Furthermore we incorporate components corresponding to motion estimates (generated by MCFLIRT motion correction) to generate a statistical analysis which discerns between true and artefactual intensity changes. The resulting activation patterns more accurately resemble the expected response.

Introduction Previous research [1,3] has demonstrated the usefulness of ICA as an exploratory data tool in FMRI analysis, allowing the characterization of different forms of spatially and temporally-localized noise and improving the detection of task-related activation in the data. The goal of ICA is to express a set of measurements as a linear combination of statistically independent components (or 'sources'). The spatial and temporal maps produced by an ICA can be used either to subtract an estimate of a 'noise data set' from the original measurements or can be embedded into a model-based approach for artefact removal [3]. In [1] we used ICA in conjunction with synthetic data where the level and direction of motion was known to show that correlations were evident between the motion parameters and the IC timecourses. Furthermore we were able to show that after correcting the data for subject motion using MCFLIRT [2], these correlations were significantly reduced and in some cases completely eliminated. ICA as implemented in MELODIC provides us with both spatial and temporal maps of each Independent Component. In the case of some noise sources it may be easier to identify the associated artefact by its temporal characteristics; in other cases the spatial maps may yield more meaningful information.

ICA and Motion Correction We have shown in previous work [1] that ICA spatial and temporal maps can be compared with motion estimates generated by MCFLIRT to validate the quality of motion correction. Specifically we showed that before motion correction, ICA yielded a number of temporal maps which strongly correlated to the six motion parameter estimates generated by MCFLIRT. Furthermore the corresponding spatial maps from the ICA exhibited characteristics such as edge intensity changes which we expect from motion artefacts. We then went on to show that after motion correction these ICs were significantly reduced and in some cases removed altogether. In this analysis we were presented with data containing artefacts which prevented accurate activation detection having applied conventional pre-processing steps including motion correction. The z-statistic for the visual stimulation component of the study revealed itself as shown in Fig 1 (left). It is clear that the thresholded activation is distributed over a large area of the brain and not at all localised around the visual cortex. Note that all analysis was carried out using FEAT [4]. We ran ICA on the corrected data in order to identify residual confounds and discovered that there were two independent components at the experimental frequency: one was the visual paradigm itself while the other was classed as stimulus-correlated motion after the spatial map was found to exhibit the same characteristics seen in other motion artefacts. Both are shown in Fig 2. The next stage of the analysis was to re-run FEAT but to incorporate the 6 motion parameter estimates from MCFLIRT as regressors of no interest in the General Linear

Model. This yielded more localised spatial maps as shown in Fig 1 (right) but does not account for the fact that the signal-space itself is confounded by the stimulus-correlated motion. Thus we need an activation model which is specific to the activation of interest and less specific to the stimulus-correlated motion. This model is found by using the ICA timecourses themselves yielding the spatial maps shown in Fig 3.



Fig 1: (left) z-statistic of visual activation on corrected data without incorporating ICA information, (right) z-statistic of visual activation on corrected data using motion estimates as regressors of no interest

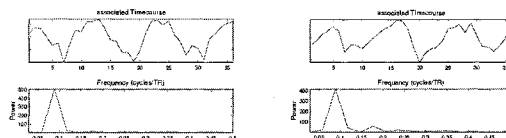


Fig 2: ICA timecourses and spatial maps corresponding to (left) the experimental visual paradigm and (right) the stimulus-correlated motion

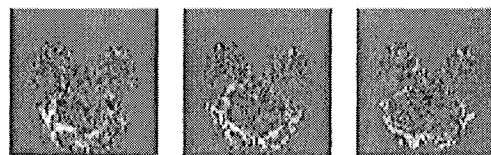


Fig 3: ICA Spatial map corresponding to visual stimulus response

Conclusions Based on previous work where we identified a strong link between ICA of FMRI data and the spatio-temporal characteristics of artefacts, we have extended our approach to feed back artefact estimates into the data analysis. By using an estimate of the true experimental paradigm (rather than an assumed design) alongside estimates of major confounds, specifically motion, we can more accurately identify confounds in the data. This approach lends itself to many scenarios in FMRI analysis where we either know or can estimate the characteristics of a confound in the data but may not necessarily understand the way in which it distorts the experimental design.

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- [1] Bannister et. al. Proc. HBM 2001
- [2] Bannister and Jenkinson Proc. HBM 2001
- [3] Beckmann et. al. Proc. HBM 2001
- [4] <http://www.fmrib.ox.ac.uk/fsl>