Model-free fMRI group analysis using FENICA

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Introduction

Exploratory analysis of functional MRI data allows activation to be detected even if the time course differs from what is expected. Independent Component Analysis (ICA) has emerged as a powerful approach, but current extensions to the analysis of group studies suffer from a number of drawbacks: they can be computationally demanding, results are dominated by technical and motion artifacts, and some methods require that time courses are the same for all subjects or that templates be defined to identify common components. We have developed a group ICA (gICA) method which is based on single subject ICA decompositions and the assumption that the spatial distribution of signal changes in components which reflect activation is similar between subjects. FENICA was introduced in the context of group ICA methods for identifying resting-state fMRI data, and is predicated on the spatial consistency of network activity across subjects (Schöpf et al., 2010). The method is based on single-subject ICAs, followed by grouping and second-level analysis of spatially consistent components across subjects. We assessed the performance of this method by applying it to data from three experiments covering a wide range of experiment designs and stimuli, and compare it to common group approaches such as concatenation ICA (concatICA) and GLM.

Material and Methods

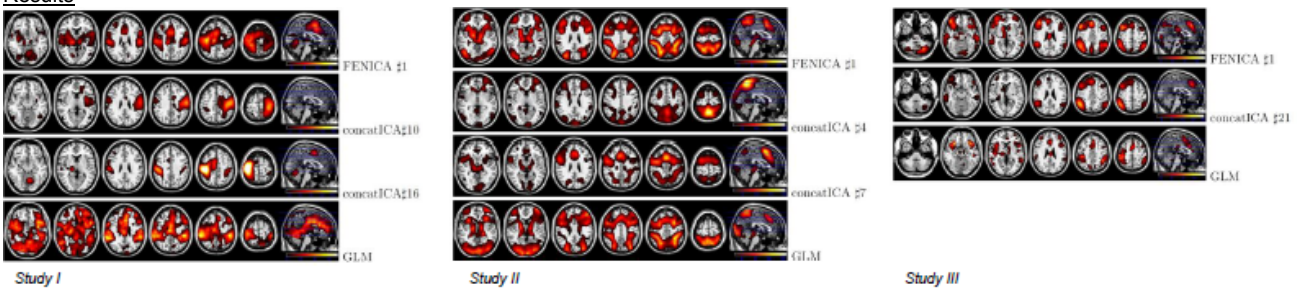
Study I: 28 subjects (16f) performed a go/no-go motor task. Interstimulus-intervals (ISI) were 15s, comprising a white crosshair for 10s followed by a yellow crosshair for 5s. The yellow crosshair indicated that a trial was imminent. A green crosshair, presented for 1s, signaled a "go" trial, for which subjects were asked to perform the button press sequence (right - left - right button) using the index and middle fingers of the right hand. "No go" trials were signalled by a red crosshair, presented for 1s. Each run consisted of 14 "go" trials and 5 "no go" trials. Images were acquired on a 3T Medspec S300 system (Bruker Biospin, Germany) using single-shot gradient recalled EPI. 14 axial slices (6mm thickness, 1mm gap) were aligned to ACPC with a matrix size of 64x96, FOV 230x190 and TE/TR 40/1000ms. 330 image volumes were acquired for each subject.

Study II: The 28 subjects who participated in Study I also took part in this experiment. The Tower of London (TOL) paradigm was presented. Subjects were asked to determine the minimum number of moves required to achieve a target configuration of balls on pegs from a given starting configuration, moving only one ball at a time. The starting and target configurations were presented simultaneously, along with two response options (the correct minimum number of moves and another plausible, but false, answer). The same measurement parameters were used for the acquisition of functional images as in *Study I*. For each subject 470 image volumes were acquired.

Study III: 22 subjects (13f) were included in the experiment. Stimuli consisted of 500ms randomized monorhinal pulses of CO_2 (50-60% v/v) which were birhinally applied using an air-dilution olfactometer (OM6b, Burghart Instruments, Wedel, Germany).
Functional images were acquired on a 3T standard clinical MRI scanner (Signa HDx, GE Healthcare, Milwaukee, WI, USA) using single-shot gradient-recalled EPI (37 slices, TE/TR 35/2100ms, FOV 240mm, voxel size 3,75x3,75x4mm^3, matrix size 64x64, 475 volumes).

Data analysis: Image preprocessing was performed using SPM5. For further artefact corrections two regions of interests (white matter and ventricles) were defined, and time courses from these regions were extracted and regressed out for each single-subject data set. Group analysis was performed using FENICA (Schöpf et al., 2010), temporal concatenated group ICA introduced as probabilistic ICA (PICA) (Beckmann et al., 2004), and GLM.

Results



Activity maps of the motor experiment (*Study I*), cognition experiment (*Study II*), and the trigeminal experiment (*Study III*) analyzed with FENICA, concatICA, and GLM projected onto a standard template (FDR corrected, $p<0.05$). Shown are axial slices in Talairach space and a saggital view indicating the position of the axial slices.

Conclusion

In all cases, the group maps identified by FENICA were the most consistent over subjects corresponding to task activation. There is good agreement between FENICA results and regions identified in prior GLM-based studies. In the chemosensory task, additional regions are identified by FENICA and temporal concatenation ICA that are related to the stimulus, but exhibit a delayed response. FENICA is a fully exploratory method that allows activation to be identified without assumptions about temporal evolution and isolates activation from other sources of signal fluctuation in fMRI. The advantage over other gICA methods is that this method is computationally undemanding, spotlights components relating to activation rather than artifacts, allows the use of familiar statistical thresholding through deployment of a higher level GLM analysis, and can be applied to studies where the stimulation paradigm is different for each subject.

References

Schöpf V, Kasess CH, Lanzenberger R, Fischmeister F, Windischberger C, Moser E.*J Neurosci Methods*. 2010 Oct 15;192(2):207-13
Beckmann CF, Smith SM. *IEEE Trans Med Imaging*. 2004 Feb;23(2):137-52.