# Using independent component analysis to measure language laterality

**A. B. Waites[1], E. Johansson[1,2], D. F. Abbott[1], and G. D. Jackson[1]**

[1]Brain Research Institute, Heidelberg West, Vic, Australia, [2]Department of Medical Radiation Physics, University of Lund, Lund, Sweden

**Introduction**

The language network is lateralized in the population. Knowledge of the distribution of language can help to minimize the risk of language deficit following surgery. Assessment of language lateralization is currently performed with the Wada test or Cortical stimulation mapping (CSM), both of which are invasive approaches (Kathleen B. McDermott et al,2005). Functional magnetic resonance imaging (fMRI) offers a non invasive alternative. In subjects unable to perform a language task, such as some patient groups and small children, standard fMRI cannot image the language system. The current study aimed to use the data driven method of Independent Components Analysis (ICA) to reveal the language network and quantify language lateralization. In particular, we wished to explore the extent to which one can exploit language networks detected in the resting state to assess laterality.

**Methods**

A control group of 34 healthy patients were used in the study. Functional images acquired with a GE 3T Signa scanner using a GR - EPI sequence. For 16 of the subjects: Language task (TR/TE= 3600/40ms, Flip angle = 60°, slices =4 mm, 1mm Gap), Rest (TR/TE= 3000/40ms, Flip angle = 60°, slices =4 mm, 1mm Gap) and for the remaining 18 subjects: Language task (TR/TE= 3200/40ms, Flip angle = 75°, slices =3 mm, 1mm Gap), Rest (TR/TE= 3200/40ms, Flip angle = 75°, slices =3 mm, 1mm Gap).

Between 90 and 300 volumes of resting state data were acquired, together with a verbal fluency task (Orthographic lexical retrieval, OLR). The OLR task consisted of a block design paradigm where the subject generated words beginning with a displayed letter. The data were preprocessed using SPM 2 (www.fil.ion.ucl.ac.uk/spm ), applying slice timing, motion correction, and spatial normalization.

Simulated datasets were generated to compare the performance of SPM and ICA to a ground truth. Three Gaussian spheres (at MNI coordinates -34 20 2 L IFG, 36 28 0 R IFG, -46 0 34 L MFG) were added to the resting data of 10 subjects, with weight (1, 0.8, 0.6). Signal level was also varied from 0.5, 1, 2, 4 to 8% of the background voxel signal. Analysis was performed using SPM 2, as well as the ICA analysis tool GIFT v1.3b ( icatb.sourceforge.net) using the INFOMAX algorithm (McKeown et al,1998 and Bell et al, 1995). Prior to GIFT analysis, the data were low pass filtered (f<0.08Hz). ICA components representing "language" were selected by spatial correlation with a known language image (obtained from an independent group of 30 subjects, and made symmetric). ROC and laterality index analysis was performed to compare the two methods. LI was calculated by counting voxels within left and right hemisphere ROIs for both SPM t-maps and IC components z-maps, according to $LI = (N_L-N_R)/ (N_L+N_R)$. The OLR and Rest data of the controls were then analyzed by GIFT, whereas SPM was only used on OLR data. The data analysis was identical to the simulated data.

**Results**

Fig 1. shows the average area under the ROC curve for SPM and ICA applied to simulated data for the different CNR values 0.5,1,2,4 and 8%. Fig.2 shows the LI index as a function of number of active voxels inside the ROI for subject A. Fig.3 shows results for SPM/ICA analysis of the OLR data of subject A, thresholded at 1000 active voxels. Green indicates voxels where both SPM/ICA detect activation, blue where ICA alone shows active voxels, and red SPM alone. Fig 4 shows the same information for ICA analysis of rest data from the same subject.

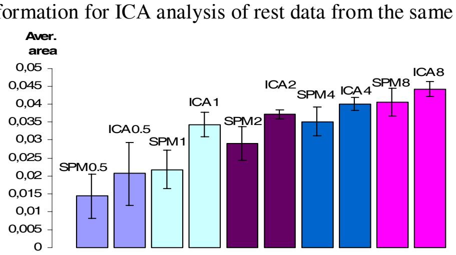


**Fig.1 area under the ROC curve for SPM/ICA analysis of simulated data at 0.5-8% CNR.**

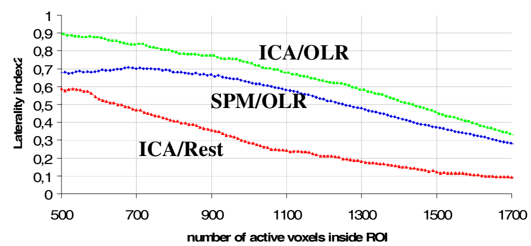


**Fig. 2. LI as a function of the number of active voxels inside ROI ICA/OLR (Green), SPM/OLR (Blue), ICA/Rest(Red) for subject A**

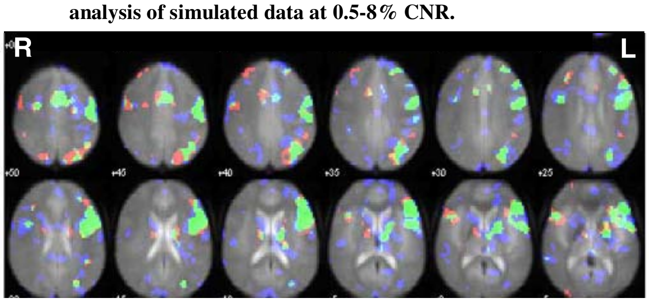


**Fig 3. shows active voxel contribution from ICA (blue), SPM( red) , both SPM and ICA (green) from analysing OLR data of subject A**

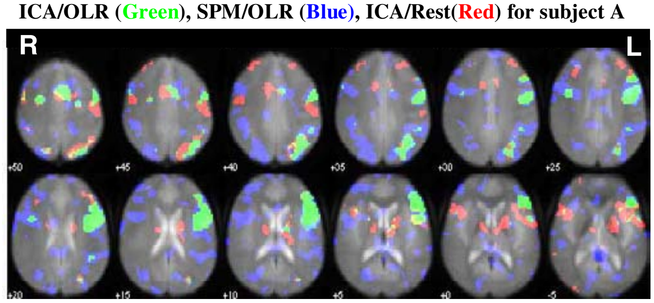


**Fig 4. shows active voxel contribution as fig 3 but with ICA analysis of the rest data of subject A**

**Discussion**

The simulated data (fig 1.) shows that ICA is more sensitive at detecting true activation when analyzing fMRI data. Fig.2 shows similar behavior in real OLR data, where ICA is sensitive to lateralization. ICA of rest data shows a more bilateral behavior, which may indicate its sensitivity to a wider network of language regions. This is supported by the activation maps of Figs.3 and 4. This study shows that ICA is as capable as SPM to identify language lateralization when evaluating fMRI data, without using a priori information about the task performed. Further we see that ICA analysis of rest data can identify the language network, albeit with a more bilateral distribution. Further work is needed to understand whether this wider network is clinically meaningful.

**References**

Bell AJ, Sejnowski (1995): An information-maximation approach to blind separation and blind deconvolution. Neural Comput 7:1129-1159(1995)

Kathleen B. McDermott et al (2005): Presurgical language mapping. Current Directions in Psychological Science 6:291-295(2005)

McKeown et al (1998) : Analysis of fMRI data by blind separation into independent spatial components. Human Brain Mapping 6:160-188(1998)