Group Analysis Reproducibility of Block and Event-Related fMRI Designs using Language Tasks

F. Lazeyras[1], M. L. Seghier[1,2], S. Simon[3], A. J. Pegna[4], and K. Asaid[4]

[1]Radiology, University Hospital of Geneva, Geneva, Switzerland, [2]Welcome Trust Center for Neuroimaging, Institute of Neurology, UCL, London, United Kingdom, [3]Radiology, University of Geneva, Geneva, Switzerland, [4]Laboratory of Experimental Neuropsychology, Neurology, University Hospital of Geneva, Geneva, Switzerland

Introduction

The use of functional MRI as clinical tool allows for non-invasive localization of eloquent cortex, especially involved in language functions. However little work has been devoted to the evaluation of reproducibility and reliability of fMRI language paradigms. In order to identify typical and atypical activations in brain-damaged patients, and to assess recovery and reorganisation processes, a normative database on control subjects must be established [1]. Here, we evaluate the reproducibility of the activation map obtained during block (BL) and event-related (ER) designs using semantic language paradigm performed by the same subjects at 3 months interval.

Material and Methods

MR acquisition 12 right-handed healthy subjects participated to the fMRI study at two occasions separated by 3 months. FMRI data was obtained at 1.5 Tesla (Intera, Philips Medical Systems, Best, The Netherlands) using GRE EPI sequence (TR/TE/flip angle = 2 s/40 ms/ 80 degrees). For the ER acquisition, TR was 1.3 sec. The FOV was 250 mm, with a matrix of 128x128 and 19 slices of 5 mm. Language paradigm consisted of a semantic categorisation task. The block paradigm alternated 5 "activation" and "control" sequences. During the "activation" period, 12 pairs of high frequency concrete French words were presented for 600 ms every 2 sec. The words in each pair were either semantically related (2/3) or not (1/3). The subject performed a go/nogo task and responded whenever the two words belonged to the same category. During the "control" condition, the subjects were asked to visually compare two sets of Greek-letter strings presented in the same way. The ER task used the same paradigm, with the pair of words followed by two pairs of Greek-letter strings presented every 6 seconds. Thirty words and sixty symbols were presented for a total scan time of 9 min 20 sec.

Data Analysis Processing and statistical analysis were performed with SPM2 software [2]. All functional volumes were realigned, normalized, smoothed (6-mm FWHM) and filtered (1/128 Hz cutoff) in the time domain. For each session (BL and ER), the data were analyzed by fixed-effect, including the six covariates of no interest representing the motion parameters. Figures 1 and 2 represent the fixed-effects analysis of the two visits obtained with BL and ER paradigms respectively. A laterality index based on regions of interest in frontal and temporal cortex was computed as follows: $LI=(N_{left}-N_{right})/(N_{left}+N_{right})$. Reliability was defined as the ratio between the number of voxels surviving the test-retest conjunction and the number of voxels activated in one OR the other visit. The conjunction implies that the region is commonly activated in the test AND in the retest session [3]. $R_{size} = N_{conj}/N_{all}*100$. $P< 0.001$ uncorrected was considered as significant for all tests.

Results

Area of activation Figure 1 (BL) and figure 2 (ER) show very similar pattern of activation. The typical language regions including the frontal cortex (inferior gyrus, mid-dorsolateral and posterior prefrontal cortex), the temporal gyrus (superior and middle), the parietal lobule and SMA are highly reproducible in both BL and ER paradigms. Secondary area, such as the right superior parietal gyrus or the occipital lobe are not consistent through the sessions. Table 1 summarises these area with their size for the 2 visits (V1 and V2).

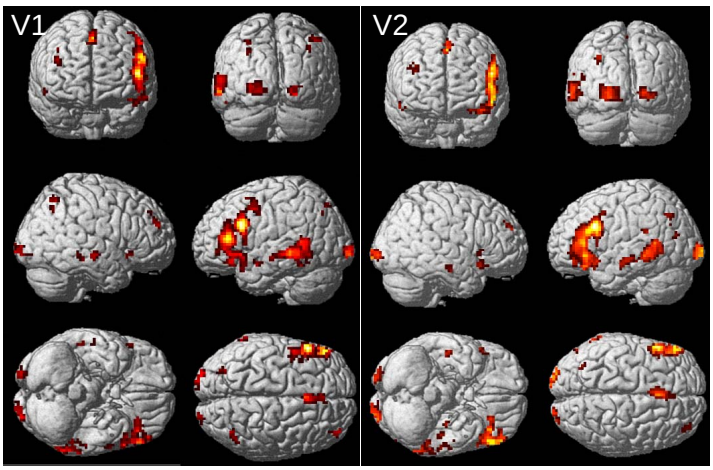

Figure 1: Group analysis of the block design fMRI obtained at two times (V1 and V2) separated by 3 months.

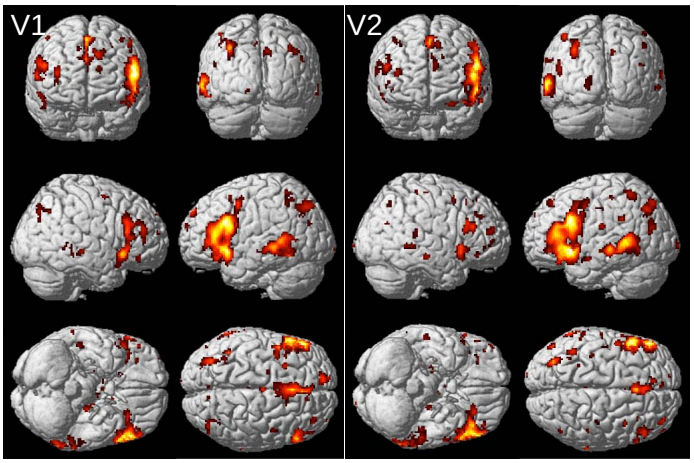

Figure 2: Group analysis of the ER design fMRI obtained at two times (V1 and V2) separated by 3 months.

Activated regions	BL Size 1	BL Size 2	BL R_{size} [%]	ER Size 1	ER Size 2	ER R_{size} [%]	BL LI 1	BL LI 2	ER LI 1	ER LI 2
Left Frontal	579	670	**43.27**	2949	3848	**48.46**	91.02	90.91	54.27	75.65
Left Temporal	304	232	**29.71**	866	1173	**40.28**				
Left Parietal	28	46	**1.33**	426	409	**21.69**				
Right Frontal	21	19	**11.76**	980	537	**16.20**				
Right Temporal	22	19	**2.39**	50	104	**1.33**				
Right Parietal	29	10	**0**	79	23	**12.33**				
SMA	80	114	**26.9**	1253	727	**9.49**				

Table 1: Reliability and lateralisation indices obtained for the block (BL) and event-related (ER) paradigms in the two visits (1 and 2).

Size of activation Table 1 reports the reliability indices of the different regions of interest. On average, good reproducibility was found for left frontal and temporal activation in both tasks. Activation of the right hemisphere show much less consistency, specially in the temporal lobe. The lateralisation index shows an overall very strong consistency in block design (91.02% and 90.91 for V1 and V2), and somewhat less pronounced in ER (54.27% and 75.65% for V1 and V2) reflecting more involvements of the right hemisphere.

Discussion and Conclusion

Conjunction analysis provides a simple and direct means to assess reproducibility of fMRI findings. Here, we show that language fMRI gives reproducible reference maps and laterality index for both BL and ER paradigms that can be reliably used for clinical investigations.

References [1] Seghier ML *et al*, Human Brain Mapping 2007, in press. [2] Wellcome Department of Imaging Neuroscience, London, UK, http://www.fil.ion.ucl.ac.uk/spm [3] Nichols T *et al*, Neuroimage 2005, 25:653-660.