A conjunction analysis-based approach to compare the lateralizing power of fMRI responses in different language tasks

S. Simon[1], M. Seghier[2,3], F. Lazeyras[2], J-M. Annoni[4], and A. Khateb[4]

[1]Bio-Medical Imaging Center, Geneva University Hospitals, Geneva, Switzerland, [2]Department of Radiology, Geneva University Hospitals, Geneva, Switzerland, [3]Wellcome Trust Centre for Neuroimaging, Institute of Neurology, UCL, London, United Kingdom, [4]Department of Neurology, Neuropsychology Unit, Geneva University Hospitals, Geneva, Switzerland

Introduction

Current data support functional MRI as a major tool to localize language functions in the brain, before the resection of a lesion or an epileptic focus [1]. For its validation, fMRI has been mostly compared to the Intracarotid Amobarbital injection Procedure (the so called Wada test) in estimating the cortical hemispheric dominance in language function. Impressive correlations have been shown between both methods, despite of their quite different measurements [2]. However fMRI has many advantages over Wada testing, such as the possibility to perform different linguistic tasks with no time limitations. The key issue here is the choice for these tasks. In this study, we aimed at comparing four tasks in their individual ability to help making a decision about activations hemispheric asymmetry, by the means of a new approach to define functional Regions Of Interest (ROIs).

Methods

Tasks. Four block paradigms were applied on 15 right-handed healthy subjects. Two reading/matching tasks based on a go/no go judgment were used (a rhyme decision task and a semantic categorization task between two visually presented words [3]). In addition, two generation tasks based on presented drawings were used (picture naming and verb generation). Subjects were instructed to press a key response for the reading tasks, and to make overt whispered responses for the generation tasks. During the control conditions, subjects were told to perform a visual discrimination task among two sets of greek-letter strings for the reading tasks, and to merely maintain their gaze on the scrambled version of the same images for the productive tasks. All tasks have been chosen because they are easy to perform and more importantly, they offer the possibility to control on subject's cooperation, which both are essential in a clinical perspective.

MR acquisition. FMRI scanning was conducted on a 1.5T Philips Intera imager (Philips Medical Systems, Best, The Netherlands) using GRE EPI sequences (TR/TE/flip angle = 2s/40ms/80°). The FOV was 250 mm, with a 128x128 matrix. 17 slices of 5mm were acquired.

Data analysis. Processing was performed by SPM5 software [4]. All functional volumes were realigned, unwarped to minimize motion-related effects, normalized to the MNI template and smoothed (6-mm FWHM). Fixed-effects analysis was made with SPM2 to generate SPM-t activation maps for each tasks ($p<0.001$ uncorrected), as well as for the conjunction of the four tasks ($p<0.1$ uncorrected). Hemispheric dominance was estimated for each tasks by the means of a Laterality Index computed as follows ($LI=(N_{left}-N_{right})/(N_{left}+N_{right})$) on predefined bilateral ROIs. We have developed an original approach to create such ROIs by means of a functional mask, which was derived from the conjunction analysis of the four tasks (Fig.1). The ROIs were based on left AND right hemispheric activations to take into account the inter-hemispheric variability. Several subdivisions of the ROIs global mask were also defined (from local activation maxima).

Results

Conjunction analysis. The activation pattern (Fig.1) was strongly left-lateralized and is in line with current neuroimaging data [5], indicating that this analysis has revealed a very consistent network. Activations were mainly found in the ventral prefrontal cortices, in the middle and superior temporal cortices, as well as in the supplementary motor areas and some subcortical structures (not visible on Fig.1).

LI analysis. No differences in the (left-)hemispheric dominance were found between the analysis which was made without any mask and the analysis performed with the ROIs global mask (Tab.1 left part).This suggests that the present method did not actually compromise our sensitivity. The two generation tasks elicited the weaker hemispheric dominance compared to the two reading decisional tasks (Tab.1 left). The verb generation (Verb G) task however succeeded in detecting a left dominance, especially in the frontal areas. The semantic categorization (Categ) task interestingly showed stronger dominance in the temporal areas. Within the cortical lobes, Broca's area (pars opercularis) presented the strongest hemispheric dominance for every task, excepted for the picture naming (Pict Na) task. Reversely, the middle part of the superior temporal sulcus was activated more bilaterally for every task.

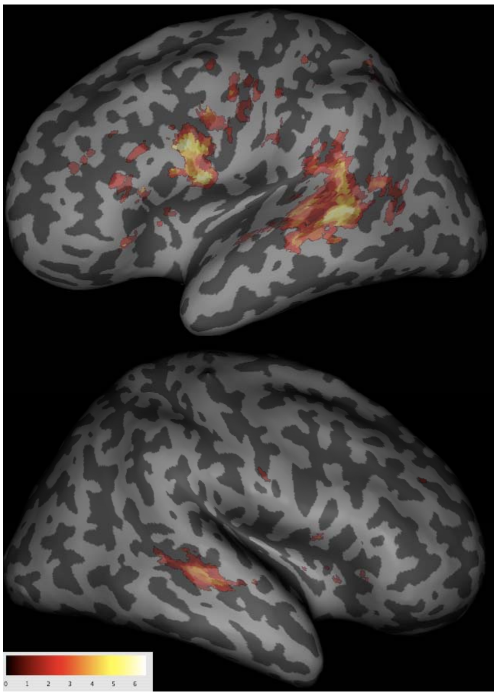

***Figure 1**. Conjunction analysis map obtained for all the tasks (ROIs global mask). Activations were superimposed on the inflated MNI template brain.*

Tasks	Without mask	ROIs mask	Frontal	Temporal	Broca's area	vIFG	STS	pSTG
Rhyme								
LI	**0.73**	**0.74**	**1**	**0.49**	**1**	**1**	**0.32**	**0.45**
N total	*1349*	*589*	*207*	*291*	*104*	*67*	*185*	*22*
Categ.								
LI	**0.85**	**0.83**	**0.68**	**0.93**	**1**	**0.31**	**0.89**	**1**
N total	*1213*	*586*	*255*	*260*	*101*	*130*	*169*	*33*
Pict.Na.								
LI	**-0.07**	**0.06**	**0.06**	**-0.09**	**0.18**	**0.01**	**-0.22**	**-0.03**
N total	*3791*	*1308*	*464*	*656*	*169*	*202*	*337*	*78*
Verb G								
LI	**0.43**	**0.41**	**0.51**	**0.22**	**0.90**	**0.20**	**-0.07**	**0.44**
N total	*2533*	*1099*	*388*	*565*	*137*	*173*	*341*	*50*

***Table 1**. ROIs-based LI computed for each tasks and number of voxels, which were retained in the calculation. Note that positive LI means left-hemispheric dominance. vIFG: Inferior Frontal Gyrus pars orbtalis and insula; STS: Superior Temporal Sulcus and middle temporal gyrus; pSTG; posterior Superior Temporal Gyrus.*

Discussion and Conclusion

Our approach allowed us to compare the LI in several areas, which were reliably activated across language tasks. The present data show strong differences in the lateralizing power of activations in the four "classical" tasks we used, depending on the cortical areas we focused on. This supports a current view [6] suggesting that, in a pre-surgical mapping context, the combination of different tasks is essential to evaluate hemispheric dominance, as well as regional hemispheric dominance. This method could also be used individually for patients, for instance to constrain the analysis on consistently activated areas.

References

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