Global cerebral asymmetry correlates with motor but not language laterality

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Introduction

The presence of both global and local structural asymmetries as well as functional laterality in the human brain is well established, but the relationship between them remains unclear. We have previously reported the development of methods for automatically quantifying brain torque (leftward occipital and rightward frontal asymmetry) [1] and found no significant differences in the magnitude of torque between right and left handed healthy subjects [2]. Several groups have quantified laterality measures from fMRI data [e.g. 3], and good agreement has been found between such measures and the invasive sodium amytal task [4]. The aim of the present study is twofold; firstly to establish a method for calculating functional laterality for a language and a motor paradigm, and secondly, to investigate whether a relationship exists between brain torque and language or motor laterality in healthy subjects.

Method

Thirty-three healthy right handed subjects (16 male) underwent structural and functional MR acquisition on a 1.5T Siemens Sonata. In addition to the MR protocol, subjects also underwent behavioural assessments of verbal fluency and hand preference (Annett Pegboard test). Brain torque was measured from 3D T1-weighted volumes using the method of LowD [1]. FMRI Language laterality was assessed using a word generation task and FMRI motor laterality was assessed using finger tapping (alternating hands). Both block-design paradigms were analysed using FEAT (FMRI Expert Analysis Tool, www.fmrib.ox.ac.uk/fsl). We examined the effects of different statistical thresholds ($z > 2.3, 4.8, 7.3$) on voxel count laterality and also computed the mean percentage signal change. We also examined the effect of volume of interest (VOI) selection by extracting 1) whole hemisphere, 2) anatomically derived (middle and inferior frontal gyri for language; pre- and post- central gyri for motor) and 3) functionally derived (based on the group activation maps). In each case the laterality index was computed as: $(R-L)/((R+L)/2)$.

Results

As the threshold was increased, mean voxel count laterality increased in each VOI, but the spread of the data conformed less to a normal distribution. Both voxel counting at $z>2.3$ and percent signal change were normally distributed, but the voxel counting method gave higher laterality indices. The anatomically derived VOI gave significantly higher mean laterality indices than the whole hemisphere ($p < 0.05$) and tended to give higher values than the functionally derived VOI for each method of calculating laterality. Voxel counting at $z>2.3$ in anatomically derived VOIs were therefore used for subsequent analyses.

No significant correlations were found between fMRI language laterality and either behavioural language measures or brain torque. Average activation in these right handed subjects was significantly more lateralised when using right than left hand for finger tapping ($F=5.2$, $p<0.001$). No significant correlation was found between Annett pegboard laterality and fMRI laterality, however a significant correlation between fMRI laterality for right finger tapping and brain torque ($r=0.48$, $p=0.016$) was observed (see Figure).

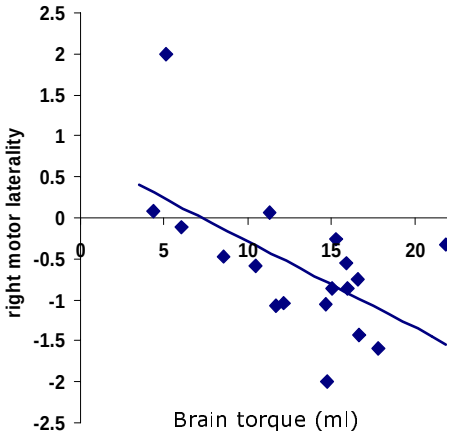

Figure. Relationship between brain torque and right motor laterality

Discussion

Sensitivity of fMRI laterality measures differs according to the method used, but further work is required to assess which provides the best reproducibility. Although there are previous reports of the relationship between planum temporale asymmetry and language function [5], we found no evidence that global brain torque is related to language laterality. Possibly language laterality is dependent upon local rather than global structural asymmetries. Taken together with our previous finding that brain torque does not differ between strongly left and right handed individuals [4], the present results suggest that although overall hand preference may not relate to structural asymmetry, the degree to which the function is lateralized in right handed subjects does.

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