Comparison of induced motor responses in fMRI and intrinsic motor networks in ICA

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Introduction: Pre surgical planning using functional magnetic resonance imaging (fMRI) is a helpful tool when removing brain tumors close to vital brain regions [1], such as the primary and pre motor cortex. However, this method relies on a patient being able to perform motor tasks in a controlled manner. This is not always the case, e.g. in children or patients suffering from cognitive impairment or paresis. In these cases it could be advantageous to use independent component analysis (ICA) to survey the intrinsic networks corresponding to motor function and use this information for the pre surgical planning.

The purpose of this study is to compare brain activation maps from bilateral movement of the hands to the intrinsic motor networks found using ICA.

Methods: 7 volunteers were scanned using a whole body 3T scanner (Tim-TRIO, Siemens Medical Solutions, Erlangen, Germany) equipped with a 12-channel head coil. After a 3D anatomical scan the intrinsic state was examined using echo planar imaging (EPI) in 300 time points (TR/TE = 2000/30 ms, 3^3 mm^3 spatial resolution) covering the whole brain. Induced motor activation was then studied using a block designed fMRI experiment (EPI; 96 time points of alternating rest and finger-clenching; TR/TE = 2660/30 ms, 2^3 mm^3 spatial resolution). Both sessions were motion corrected, normalized, co-registered to the anatomical data and smoothed by an 8 mm kernel using Brainvoyager QX 1.10 software (Brain Innovation B.V., The Netherlands). The motor activation data was also filtered using a high pass filter. A preset of 30 individual components was used in the ICA analysis. The induced motor activation was thresholded at $p < 10^{-5}$ uncorrected for multiple comparisons and the ICA data was thresholded at $z > 3.5$. The intrinsic motor network was chosen as the one network best corresponding to bilateral activation of pre, primary and supplementary motor regions that also contained blood oxygen level dependent (BOLD) characteristic data (high power in the band 0.01-0.1 Hz, high degree of clustering and high spatial and temporal entropy [2]). The activation correspondence was calculated as $(A_{ICA} \cap A_{IM}) / A_{IM}$, where A_{ICA} is the intrinsic network volume defined by ICA and A_{IM} is the volume of motor induced activation.

Results: An intrinsic motor network was found in five out of seven volunteers. In these subjects an average of 41% (range 31-53%) of the motor induced activated voxels were also activated in the ICA motor network (figure 1 and 2). The intrinsic motor network included additional inferior cortical motor areas in three volunteers. However, medial regions (supplementary motor regions) and posterior regions (parietal motor areas) were not present in three respectively two volunteers when mapping the intrinsic motor network (figure 3).

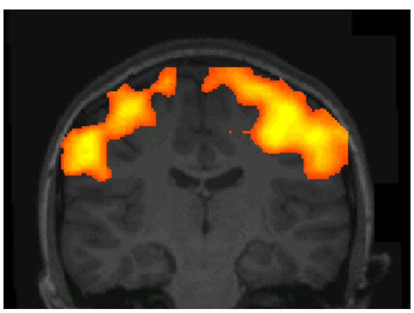

Fig. 1 – Induced motor activation in volunteer 1 using traditional block designed fMRI

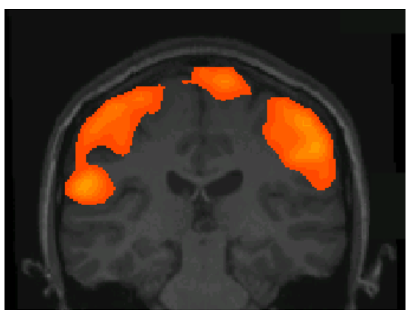

Fig. 2 – Intrinsic motor network from ICA in volunteer 1.

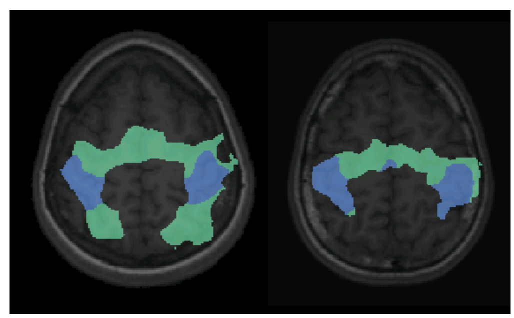

Fig. 3 – Intersection of induced bilateral motor activation and intrinsic motor network (blue) and induced bilateral motor activation not covered by the intrinsic motor activation (green). Individual data (volunteer 1 and 6).

Discussion: Mapping intrinsic motor networks could potentially be used as an alternative source of information in pre surgical planning of tumour removal when the patient is unable to cooperate in motor paradigms. Actually, the intrinsic motor network gives additional information from the whole somatotopic motor area. However, several impediments are obvious. The induced motor activation sometimes includes additional regions not represented in ICA data, such as the parietal motor association cortex or supplementary motor regions (figure 3). This could be due to the rather strong BOLD effect typically seen during induced motor activation. It could also be hazardous to properly compare the mapped motor areas in these two techniques. First of all the intrinsic network is likely to cover the whole motor somatotopy and not just the hand. Secondly, the activation threshold is difficult to equalise in the two different techniques. In conclusion we found both regional overlap and structured mismatches between induced bilateral motor activation and intrinsic motor networks found from ICA data. This shows that mapping of intrinsic motor networks has a potential as an alternative strategy in pre surgery planning of tumour removal in uncooperative patients, but that the method should be performed with caution.

References:

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2. De Martino, F., et al., *Classification of fMRI independent components using IC-fingerprints and support vector machine classifiers.* Neuroimage, 2007. **34**(1): p. 177-94.