White Matter Integrity Correlations with Coactivation of Resting State fMRI

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Introduction

Functional connectivity has previously been shown to correlate with structural (anatomical) connectivity. Structural connectivity of brain white matter is quantified using diffusion tensor imaging to calculate fractional anisotropy (FA). In this study, we looked specifically at the superior longitudinal fasciculus (SLF) due to its anatomical relevance to the attention network. The correlation between functional coactivation of the attention network and SLF FA was investigated using independent component analysis (ICA) and dual regression. We hypothesize that this coactivation within the nodes of the network are positively correlated to SLF FA because the structural integrity of this neural pathway has importance to the neural communication between the nodes.

Methods

Subjects: The subjects included 34 healthy volunteers: 20 females and 14 males, aged 21-43 years (mean age = 26.0, SD = 4.76).

Image Acquisition: Imaging was performed using a Philips 3T Gemini MRI. High resolution T1 anatomical scans were acquired using a sequence with the parameters: TR = 2.5s, TE = 3.5ms, FOV = 22.4cm, matrix size = 224x224, 172 slices with thickness 1mm. EPI BOLD scans were acquired using a sequence with the parameters: TR = 4000ms, TE = 27ms, FOV = 21cm, matrix size = 96x96, 38 slices with 2.5mm thickness, 0.75mm skip. The resting state protocol acquired 120 measurements (~8 minutes). DTI was acquired with TR = 5.7s, TE = 70ms, matrix size = 128x128, 54 slices, FOV = 21cm, b-factor = 1200s/mm^2, and number of directions = 32.

Image Analysis: Preprocessing of the functional images was performed in FSL and included motion correction (MCFLIRT), co-registration to the high resolution T1 images (FLIRT) and non-linearly registration to the standard MNI T1 template (FNIRT). Multi-subject independent component analysis (ICA) was used to identify 18 unique networks of resting state activity using MELODIC (Beckmann and Smith 2004) as implemented in FSL. Raw diffusion images were eddy-current corrected, diffusion tensors were calculated and FA maps were generated using FSL (Smith 2004). FA images were then skeletonized and transformed into template space using tract-based spatial statistics (TBSS). Tract specific FA values were computed at the union of the FA skeleton with the SLF region from the John Hopkins University (JHU) white matter tract labels in MATLAB. Dual-regression analysis was carried out on the attention network, using the normalized regional mean FA as a covariate in the permutation tests. The dual regression was limited to areas designated by the ICA to be within the attention network using a network specific mask derived from the MELODIC network maps ($t > 2.6$).

Results

Coactivation of the attention network showed positive correlation (Figure 1A; red; $p < .005$) with the FA of the SLF bilaterally in the anterior lateral regions of the network (Figure 1A). The supplementary motor area (SMA) showed a negative correlation with the FA of the SLF (Figure 1A; blue; $p < .005$). To test for a laterality effect, the FA of the left and right SLF were calculated separately and entered into two dual regressions to assess correlation between FA and coactivation. Figures 1B and 1C show the dual regression with FA values from the left and right SLF respectively. Results are highly similar between left, right, and bilateral SLF.

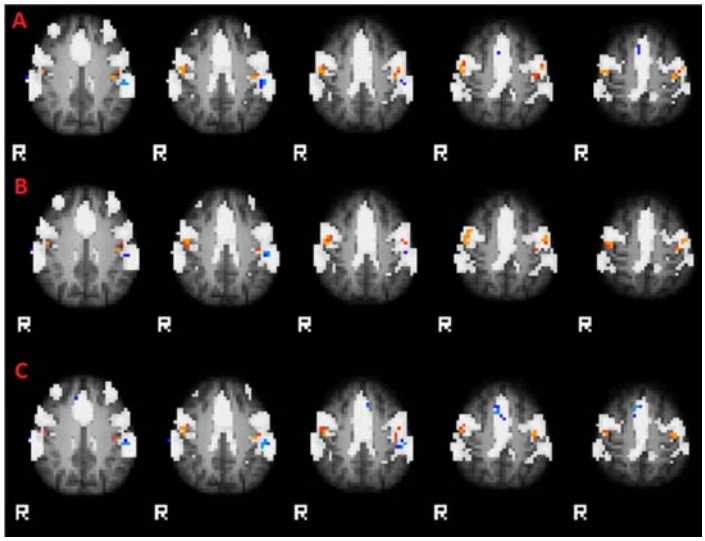

Figure 1: Correlation maps of bilateral SLF FA **(row A)**, right SLF FA **(row B)**, and left SLF FA **(row C)** with coactivation in attention network (p<.005).

Discussion

The results presented here partially support the hypothesis that white matter integrity correlates with functional coactivation of resting state networks. Due to the anterior-posterior gradient of the coactivation correlations with SLF FA it will be interesting to follow up with investigations of how increased integrity of association fibers, such as the SLF, might shift the attention network to be more dominated anteriorly. In other words, we aim to follow up with an investigation of how the degree of frontality of networks (networks driven more so by frontal regions) is associated with the integrity of association fibers. The effects of gender on the results are not yet known, but this should be an area of investigations due to known differences in the connectivity patterns of males and females (Tang 2010).

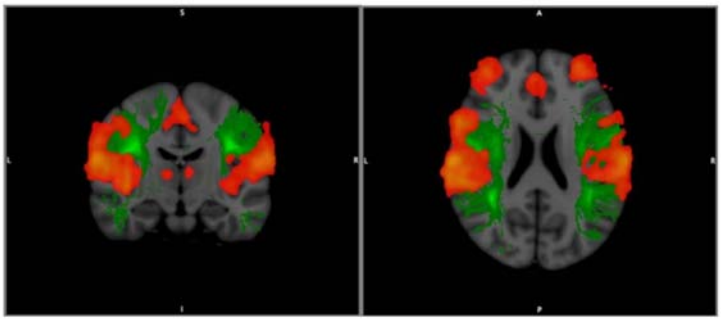

Figure 2: Attention Network (orange) and SLF (green) overlay.

References

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