

In Vivo Estimation of Structural Connectivity in the Acoustic Radiation with Diffusion Imaging: Method and Validation

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Introduction

The Acoustic Radiation (AR) is a crucial white matter pathway that traverses from the Medial Geniculate Body (MGB) to the Primary Auditory Cortex (PAC). The AR is vital in the relay of inbound auditory information to PAC where high-level processing such as speech and music perception are executed^{1,2}. Having the ability to accurately characterize the AR *in vivo* has many clinical applications yet accurate techniques for mapping the AR *in vivo* have remained elusive³

Objectives

There are two goals for this study:

- 1) Produce an automated procedure to accurately map connectivity of the AR *in vivo* using Diffusion Weighted Imaging (DWI) and probabilistic tractography
- 2) Validate this procedure by examining: (a) the overlap of the reconstructed AR with a probabilistic atlas; (b) the relationship between estimated structural connectivity in the AR and functional activation in PAC.

Procedure

- Diffusion-weighted and functional magnetic resonance images from the Human Connectome Project (HCP)⁴ database in 20 randomly selected healthy subjects
- Use constrained spherical deconvolution and probabilistic fiber tracking to reconstruct AR.
- Estimate volume (Vol) and cross-sectional area (CSA) of AR in terms of apparent fiber density
- Compute overlap of reconstructed AR with the Juelich probabilistic AR atlas
- Compute correlation between Vol/CSA and auditory evoked BOLD activation in PAC

References

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Results

- Reconstructed AR tracts overlapped 63% ($\pm 2\%$ SEM; left hemi) and 71% ($\pm 2\%$ SEM; right hemi) with voxels showing $\geq 50\%$ probability in Juelich AR atlas
- Figure 1 shows the overlap of AR generated via probabilistic tractography with AR as defined by the Juelich atlas

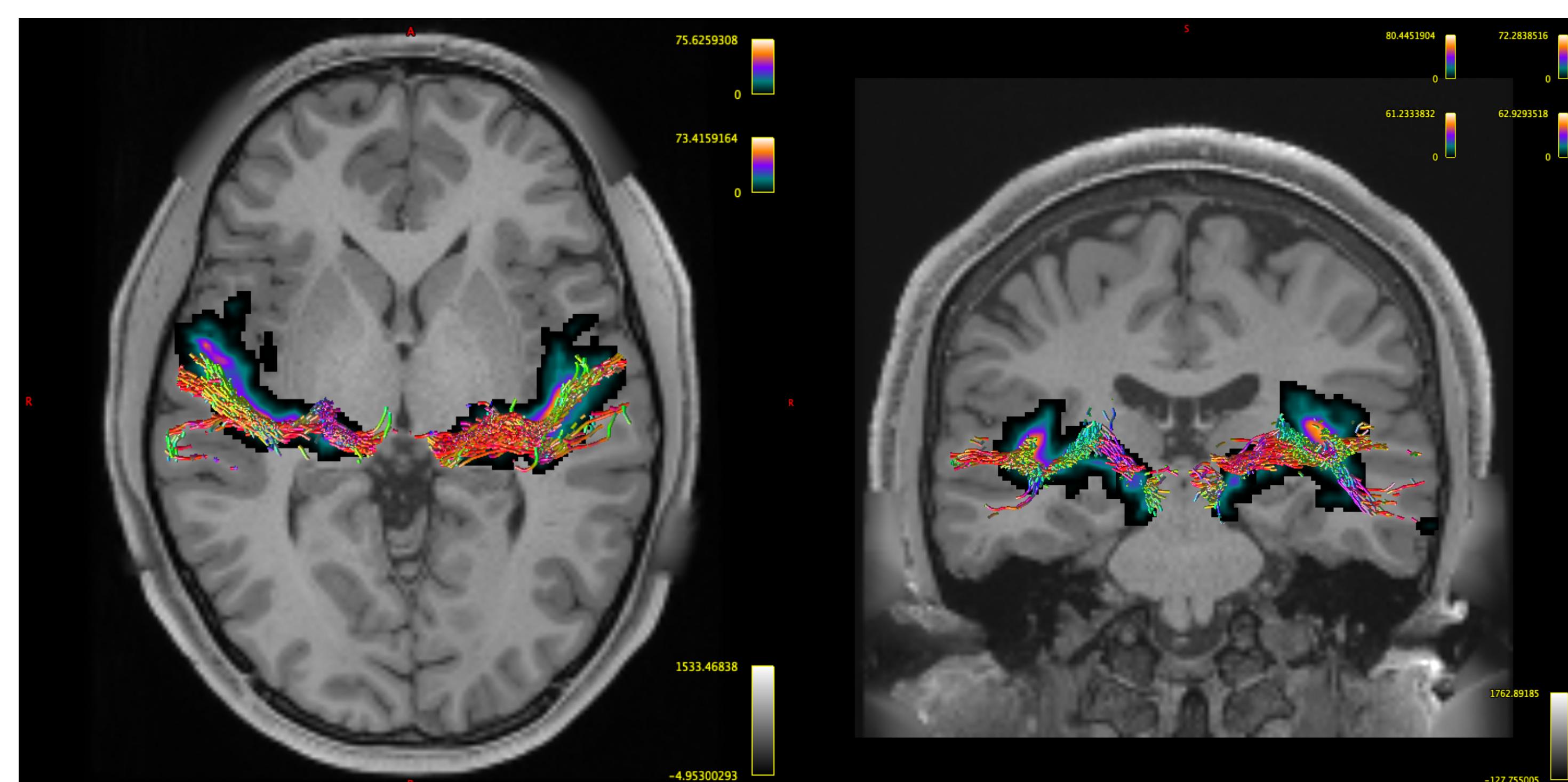


Figure 1 (Above). Examples of two subjects' *in vivo* probabilistic tractography reconstruction of the AR overlapped with the Juelich AR atlas after warping to native image space. Colormap indicates the probability that a given voxel belongs to the Juelich atlas for the AR and MGB (only in coronal view, right).

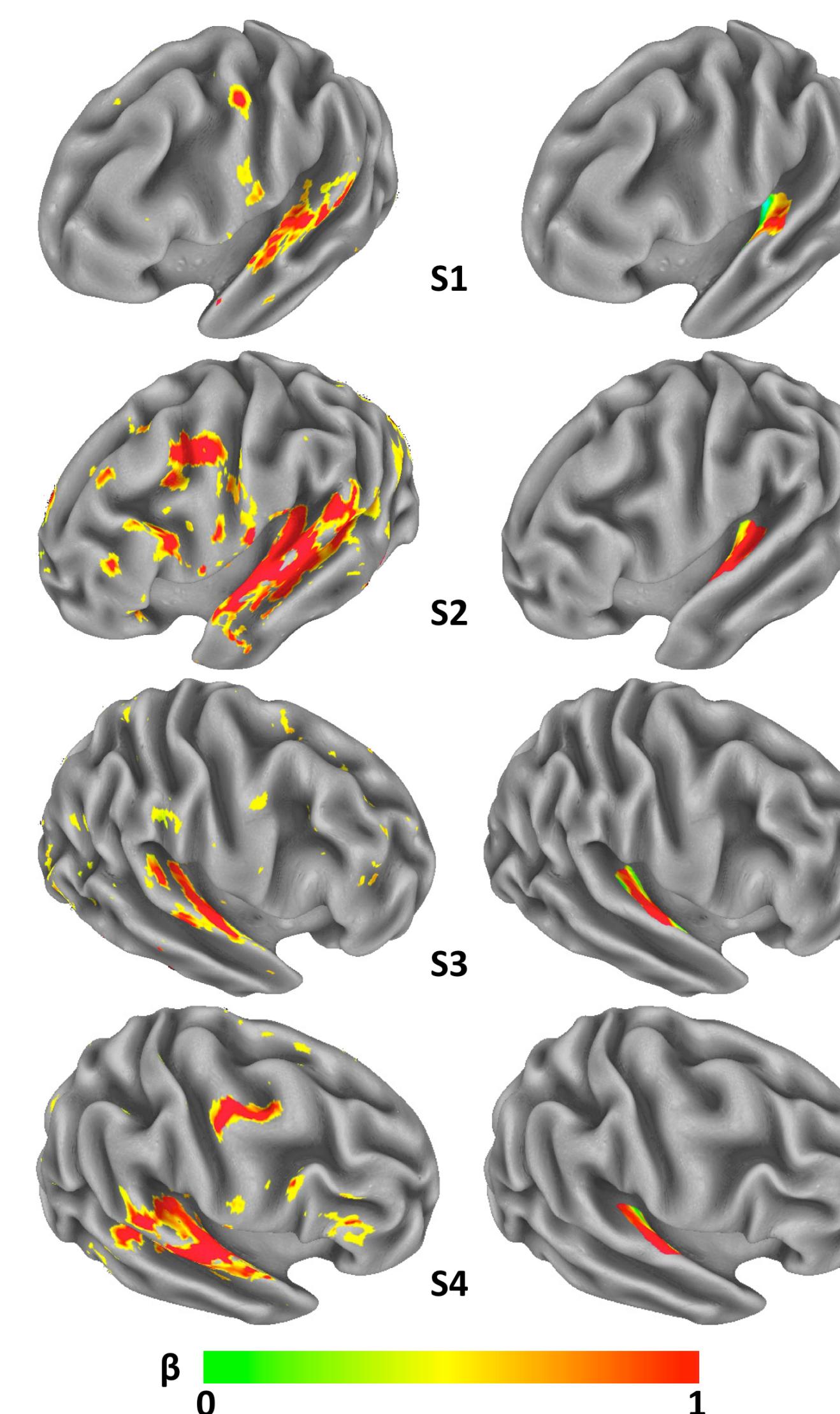


Figure 2 (Left). Example of auditory-evoked fMRI activation maps. Subjects chosen at random and labeled S1-S4. Left column: whole-brain activation maps, Right column: activation restricted to PAC grey matter regions of interest, i.e. terminus of the AR. Activation was estimated for a task in which subjects listened to aurally-presented stories and math problems. Data were analyzed following a standard general linear model approach. Colormap reflects average activation to all auditory events versus a silent baseline. Voxel-wise statistical threshold is $p < 0.001$, uncorrected.

Results Continued

- The relation between Vol/CSA and PAC activation (fMRI) was examined using a Spearman rank-order correlation to account for subjects with high activation.
- A moderate, positive correlation was detected for CSA ($r_s = 0.452$, $n = 20$, $p = 0.0465$).
- There was no significant relation between Vol and PAC activation

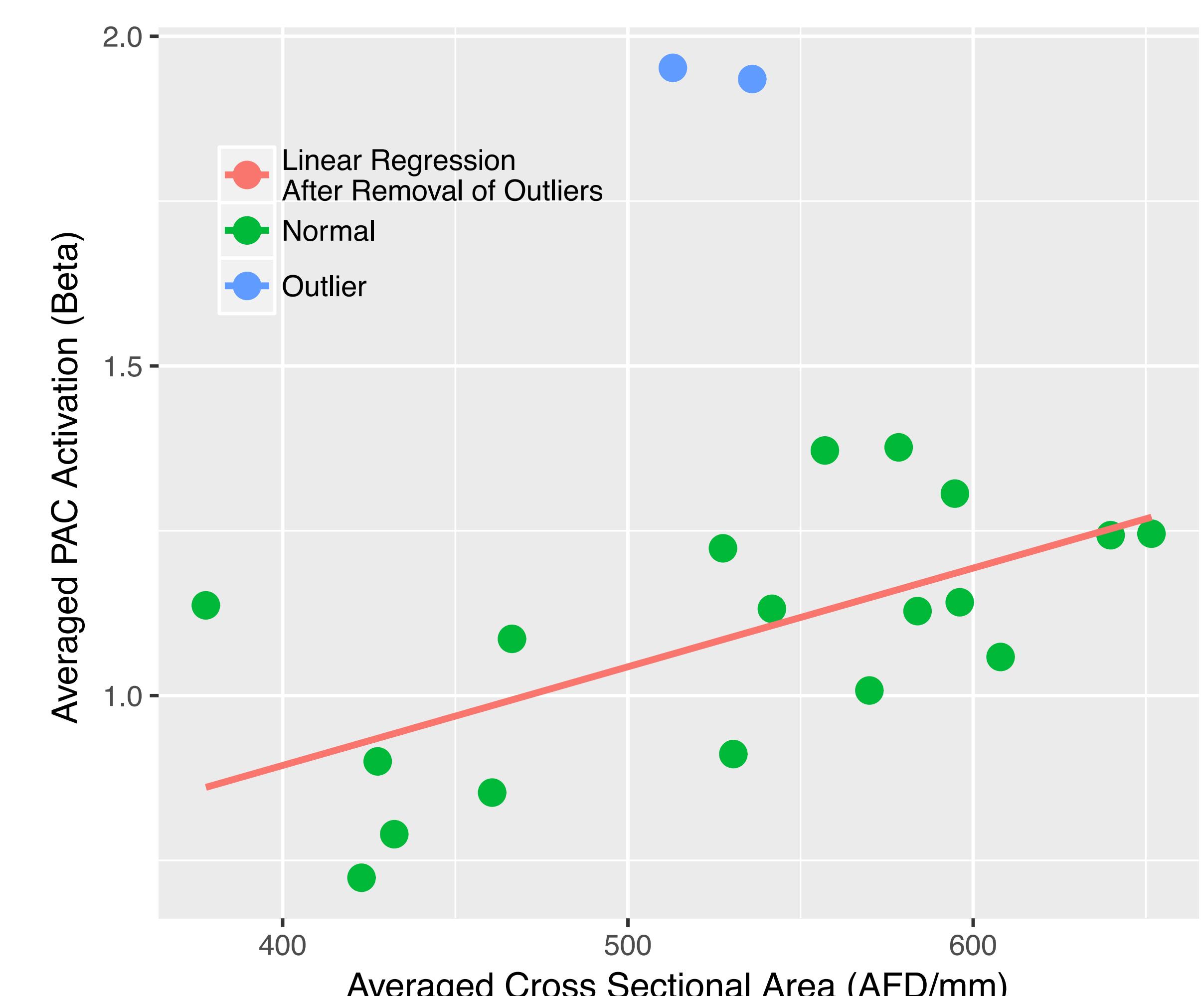


Figure 3. Scatterplot of averaged left/right hemisphere PAC activation and CSA values. Blue dots highlighted to show unusually high values of PAC activation and noted as potential outliers. A best fit line was applied after removal of outliers. With removal of potential outliers, correlation between CSA and PAC activation is $r = 0.63$, $p = 0.005$, $n = 18$.

Discussion

- The automatic method successfully completed reconstruction of AR in 20/20 subjects (40/40 hemispheres)
- Reconstructed ARs are accurate when compared to overlap of probabilistically defined atlas
- CSA estimates relate to fMRI activation; allows inference that AR structural connectivity relates to function in PAC