Inter-subject Functional Connectivity Alignment

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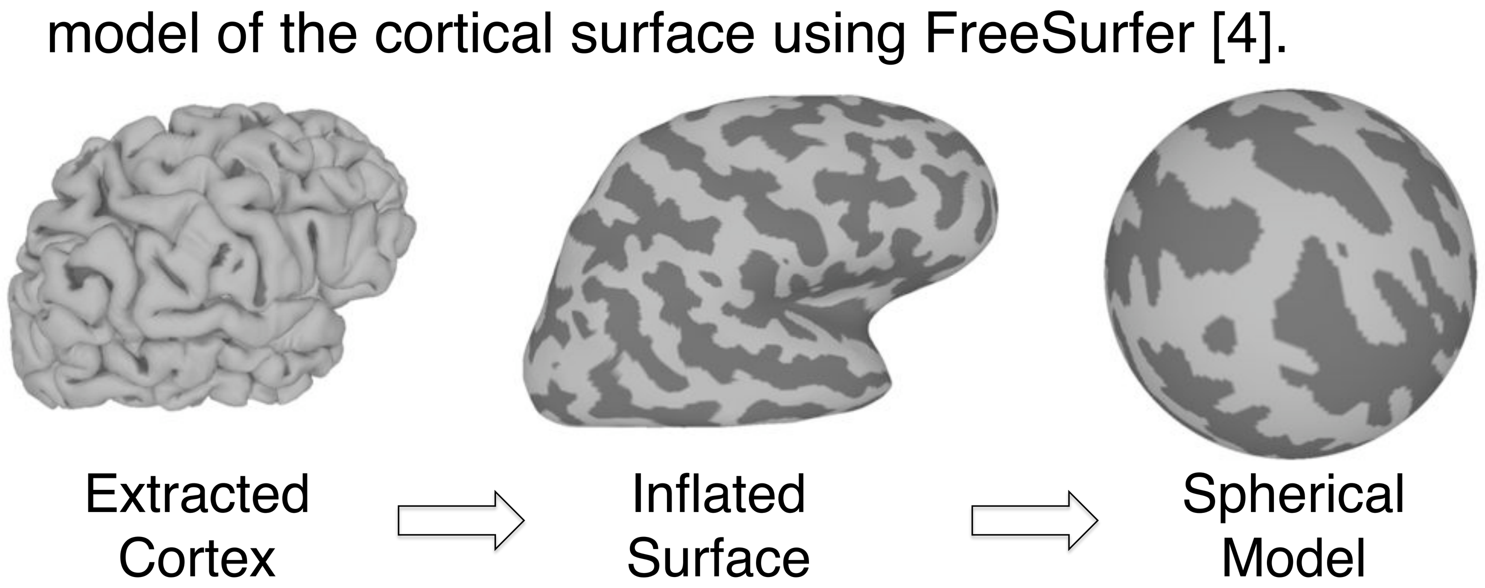
Introduction / Motivation

- Inter-subject alignment of functional MRI (fMRI) data is an important pre-processing technique for improving the statistical power of fMRI group analyses.
- Recent work [1] has shown that functionally-defined areas of the brain can be registered by maximizing the inter-subject correlation of fMRI time-series elicited by a movie viewing.
- This approach requires that functional response is time-locked with the experimental stimulus in a consistent way across subjects.
- This assumption is not always valid, as areas in the intrinsic [2] or default [3] system fail to exhibit strong correlations across repeated stimulus trials.

- **Our approach** to functional alignment seeks to improve inter-subject correspondence within the extrinsic and intrinsic networks by aligning cortical nodes with similar patterns of cortical functional connectivity.
- The use of functional connectivity for alignment is inspired by studies showing that the spatial patterns of connectivity in the intrinsic network are consistent across subjects [2], [5].

Methods

- Data were collected from 10 subjects while (a) viewing the first- and second-half of the action movie *Raiders of the Lost Ark* in 2 sessions, and (b) viewing still images in a face and object perception experiment.
- Functional time-series of cortical voxels were placed on a regular mesh on an anatomically-normalized, spherical model of the cortical surface using FreeSurfer [4].



- Within each subject, we calculated a high-dimensional connectivity vector for each cortical node that was comprised of the correlation of that node's time-series with the time-series of all other cortical nodes.
- Our algorithm then optimizes a local non-rigid spatial warp that minimizes the sum-of-squares difference between functional connectivity vectors across subjects.
- Regularization terms penalizing cortical folding ensure that mesh topology is preserved.

References

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3. Raichle ME, et al. (2001). **A default mode of brain function**. Proc. Natl. Acad. Sci. 98(2):676-682.
4. Fischl B, Sereno MI, Tootell RBH, Dale AM (1999). **High-resolution inter-subject averaging and a surface-based coordinate system**. Human Brain Mapping. 8(4):272-284.
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Results

- The first-half of the movie dataset was used by the functional connectivity registration algorithm to derive the inter-subject alignment.

Inter-subject correlation of time-series

- On the second-half of the movie dataset, the alignment improved the mean correlation between the time-series for each subject and the mean for the other nine subjects by 29%, from 0.068 to 0.088 (Figure 1).

Inter-subject correlation of functional connectivity vectors

- On the second-half of the movie dataset, the alignment improved the mean inter-subject correlation of the functional connectivity vectors by 39%, from 0.18 to 0.25 (Figure 2).
- Functional connectivity alignment improved inter-subject alignment in intrinsic regions, including the temporoparietal junction, the precuneus, and the medial prefrontal cortex.

Inter-subject overlap of functionally-defined areas

- Using the face and object perception experiment, we identified face-selective nodes in the ventral temporal (VT) cortex of each individual subject as those that were activated more by faces than by objects ($p < 0.0001$).
- To measure inter-subject overlap of the face-selective area, we computed the number of subjects that were face-selective at each VT node. We then calculated the percentage of face-selective nodes that overlapped for two or more subjects.
- Functional connectivity alignment improved the average percentage overlap of face-selective cortex by 22%, from 21.6% to 26.4% (Figure 3).

Inter-subject correlation of time-series

Lateral View, Right Hemisphere

Anatomical Registration | Functional Connectivity Registration

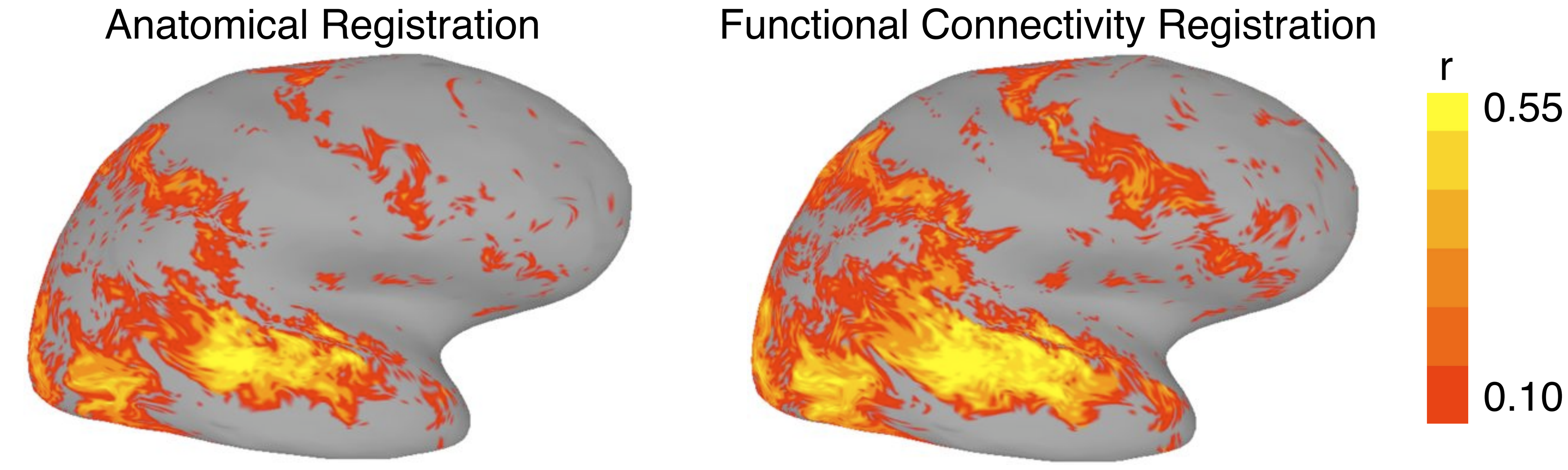

Figure 1: Average correlation of functional time-series between each subject and the mean of all other subjects in the second-half of the movie dataset

Inter-subject correlation of functional connectivity vectors

Lateral View, Right Hemisphere

Anatomical Registration | Functional Connectivity Registration

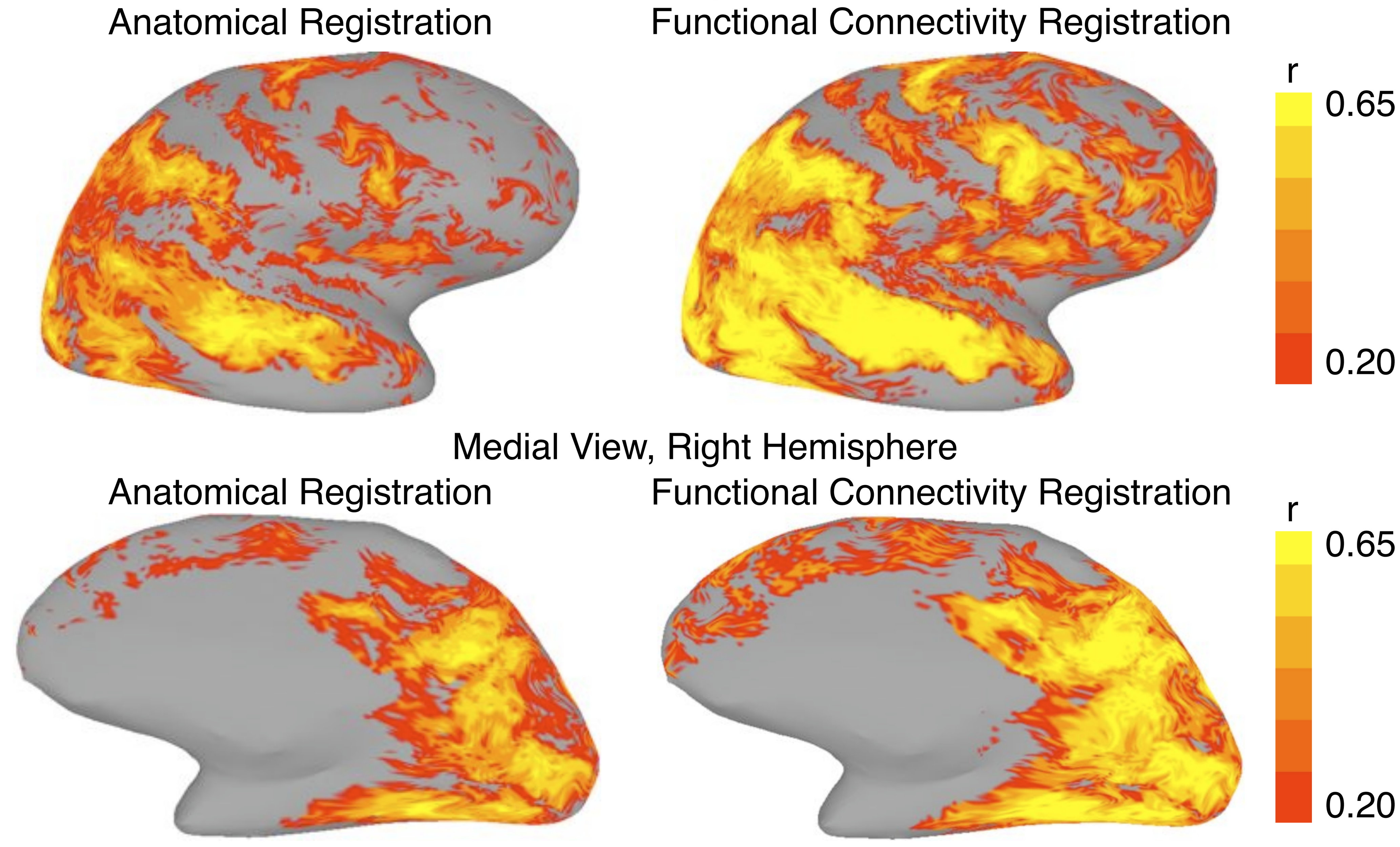

Figure 2: Average correlation of functional connectivity vectors between each subject and the mean of all other subjects in the second-half of the movie dataset

Inter-subject overlap of functionally-defined areas

Ventral View, Right Hemisphere

Anatomical Registration | Functional Connectivity Registration

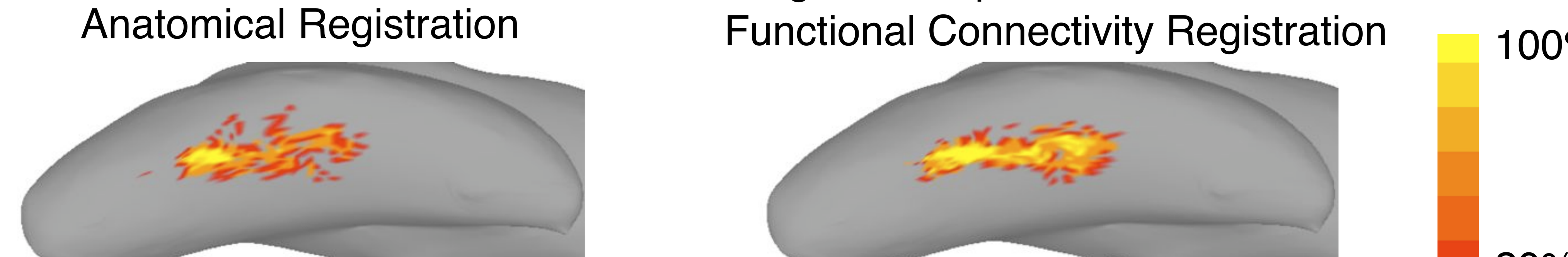

Figure 3: Percentage overlap map of the face-selective area