Figures and figure supplements

Visual field map clusters in human frontoparietal cortex

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Figure 1. Topographic mapping and population receptive-field modeling. (A) The discrimination task used for topographic mapping. Subjects fixated at the center of the screen while attending covertly to a bar composed of three apertures of moving dots incrementally traversing the screen. Subjects

Figure 1 continued on next page
indicated on each trial which aperture (left, right, top, or bottom) was comprised of dots whose motion direction matched that of the dots in the middle sample aperture. Motion coherence was staircased in order to tax attention constantly. The white outlines around each of the three apertures are shown here for clarity, but were not visible to subjects. (B) Schematic of the nonlinear population receptive-field modeling procedure. Trial sequences were converted into 2D binary contrast apertures and projected onto a 2D Gaussian representing a predicted pRF. A static non-linearity was applied to account for compressive spatial summation. (C) Example model fits from single voxels in multiple visual field maps. pRF model predictions are shown in red, actual data for an individual voxel for a given visual field map are shown in black. Stimulus sweep direction and bar width are shown above and below the model fits. Estimated pRF size and variance explained for each voxel are shown to the right.

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Figure 2. Visual field maps in early visual cortex. The color of each voxel indicates the best fit pRF parameter for the data being displayed. (A) Eccentricity (top) and polar angle (bottom) maps in the left hemisphere of an example subject projected onto a flattened representation of the cortical surface, where dark gray denotes sulci and light gray denotes gyri. V1, V2, and V3 share a confluent fovea while V3A and V3B share another. (B) Eccentricity (top left) and polar angle (bottom left) maps, along with variance explained (top right) and pRF size (bottom right) of an example subject projected onto an inflated cortical surface. (C) Relationship between pRF size and eccentricity. pRF sizes of voxels in V1, V2, V3, and V3AB increase with eccentricity. Error bars represent ±1 SEM across subjects.

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Figure 2—figure supplement 1. Individual subject visual cortex data. For both hemispheres of each individual subject, we show eccentricity, polar angle, pRF size, and variance explained projected onto the inflated cortical surface. Areas V1, V2d, and V3d are depicted.

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Figure 3. Visual field maps in parietal cortex. Maps of polar angle and eccentricity on an inflated cortical surface (top) and on a flattened representation of the cortical surface (bottom) for an example subject. IPS0/IPS1 form one visual field map cluster, while IPS2/IPS3 form another. Each cluster consists of two angle maps that share a confluent foveal representation. White lines denote the boundaries at the upper vertical meridian (UVM) and black lines denote the lower vertical meridian (LVM); asterisks denote foveal representations.

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Figure 3—figure supplement 1. Individual subject parietal cortex data. For both hemispheres of each individual subject (S1–S5), we show pRF size, variance explained, polar angle and eccentricity projected onto the inflated cortical surface.

Figure 3—figure supplement 1 continued on next page
Figure 4. Representation of fovea in sPCS map. Left (top) and right (bottom) hemispheres for each individual subject are shown. Top and bottom rows mark the anatomical locations of the superior frontal sulcus (SFS: white line) and the superior precentral sulcus (sPCS: black line) on an inflated cortical surface representation of each hemisphere. For clarity, black squares represent a zoomed in view of the anatomical intersection of the SFS and sPCS. The location of the fovea (asterisk) is shown both on the anatomy (left) and on the eccentricity map (right) for each individual subject. Notice how the fovea lies at the intersection of the SFS and sPCS for each subject. DOI: 10.7554/eLife.22974.008
Figure 5. Visual field maps in frontal cortex. Maps of eccentricity and polar angle are displayed for an example subject projected on both inflated (inside) and flattened (outside) cortical surfaces. In order to demonstrate the systematic organization of each map clearly, each pair of flattened cortical surfaces depicts a cartoon schematic of the organization of each map (left flat patch) next to actual map data (right flat patch). sPCS1 and sPCS2 form a visual field map cluster, sharing a foveal representation that sits at the intersection of the PCS and the SFS. White lines denote the boundaries at the upper vertical meridian (UVM) and black lines denote the lower vertical meridian (LVM). The foveal representation in iPCS sits at the intersection of the PCS and the IFS.

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Figure 5—figure supplement 1. Individual subject superior precentral sulcus (sPCS) maps. For both hemispheres of each individual subject, we show eccentricity, variance explained, polar angle and pRF size, projected onto the inflated cortical surface.

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Figure 5—figure supplement 2. Individual subject inferior precentral sulcus (iPCS) maps. For both hemispheres of each individual subject, we show eccentricity, variance explained, polar angle and pRF size projected onto the inflated cortical surface.

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Figure 6. Visual field map coverage, laterality, and model comparison. (A) Visual field map coverage plots. While all visual field maps primarily represent the contralateral hemifield, maps in association cortices also begin to represent small portions of the ipsilateral hemifield perifoveally. This is Figure 6 continued on next page
due to the fact that pRFs are less eccentric and larger in frontal and parietal cortex than in early visual cortex. (B) Visual field coverage plots for the PCS in individual subjects. Each small black dot represents the center of a voxel’s pRF. (C) Laterality index (means ± SEM across subjects). The index ranges from 0 (completely ipsilateral) to 0.5 (no laterality) to 1 (completely contralateral). All areas are highly contralateralized. (D) Comparison of cross validation results by model (means ± SEM across subjects). For every visual field map, the non-linear model explained the largest amount of variance, followed by the linear model, and finally the contralateral model.

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Figure 7. Cross-session stability of frontal and parietal visual maps. For two subjects, we show the visual maps in the intraparietal and precentral sulci derived from two independent scanning sessions. Both the eccentricity and angle representations are shown for both subjects and both hemispheres. Note the striking similarity of the maps, demonstrating that the visual map structure is stable over time and our measurement methods are reliable.

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Figure 7—figure supplement 1. Grid fit and search fit comparison. (A) For both PCS (top) and IPS (bottom), we compare eccentricity and polar angle solutions for both the grid fit (with smoothing) and search fit (without smoothing). As demonstrated in each figure comparison, the solutions for both fits not only have the same structure to each gradient, but are nearly identical. (B) We cross-validated both the grid and search fits to compare how well their solutions fit new data. In each ROI, the grid fit solutions performed as well as or better than the search fit solutions on new data. DOI: 10.7554/eLife.22974.014
Figure 8. Visual maps in reference to other anatomical designations. We projected a probabilistic map of visual topography (PMVT; Wang et al., 2015; black outlines) and a multi-modal parcellation of brain areas (MMP; Glasser et al., 2016; white outlines) onto the brains of our subjects to compare.
these locations with those of our retinotopically defined visual maps. The PMVT includes IPS0-3 from posterior to anterior in parietal cortex, and ‘FEF’ in frontal cortex. The MMP covers the entire cortex, but here we only show the areas near or overlapping our visual maps, labeled on the images for Subject 2 (S2).

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