SUPPLEMENTARY DATA

SUPPLEMENTARY FIGURES

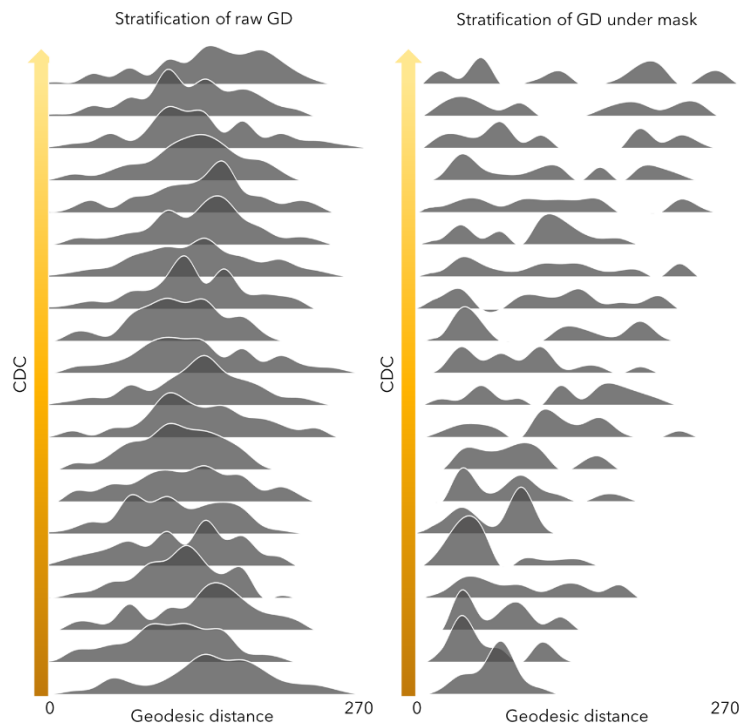Stratification of regional geodesic distance

Fig. S1. Stratification of regional geodesic distance. Left panel: Parcel-wise group-average geodesic distance was re-sorted by CDC and divided into twenty equal bins. Stratification of raw geodesic distance of the first parcel in each bin was shown. Right panel: Stratification of geodesic distance under mask (top 10% of functional connectivity) was shown. Abbreviation: GD, geodesic distance.

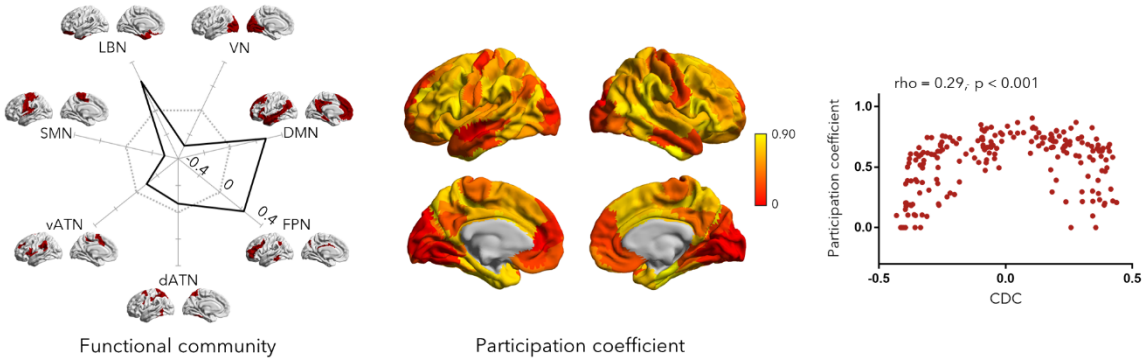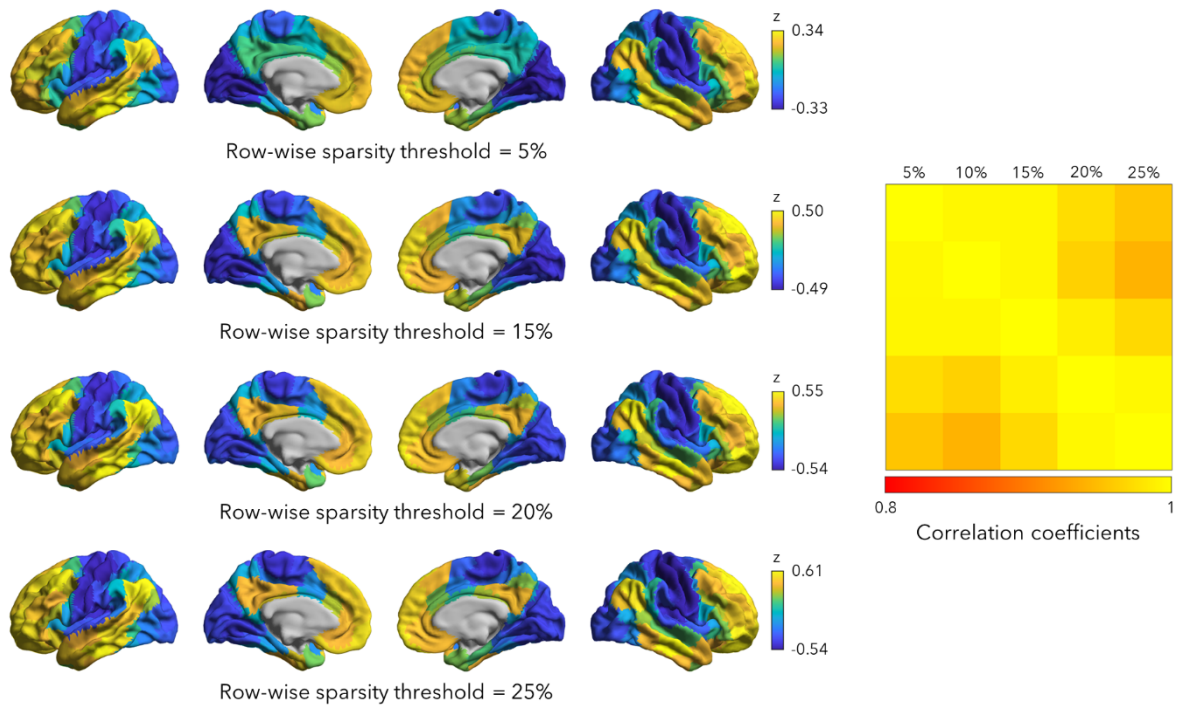Associations to macroscale functional communities

Fig. S2. Associations to macroscale functional communities. Stratification of functional connectivity distance across macroscale functional communities [41], and associations to the functional participation coefficient.
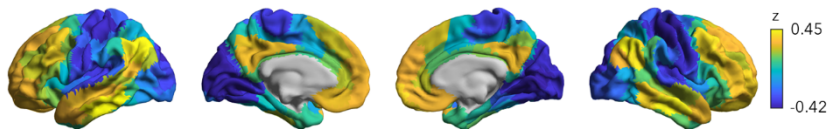
Fig. S3. Robustness analysis on CDC. (A) CDC computation across different functional connectome thresholds. High correlations (rho>0.95) between CDC across different thresholds were observed. **(B)** Functional connectivity distance after additional global signal regression (GSR).
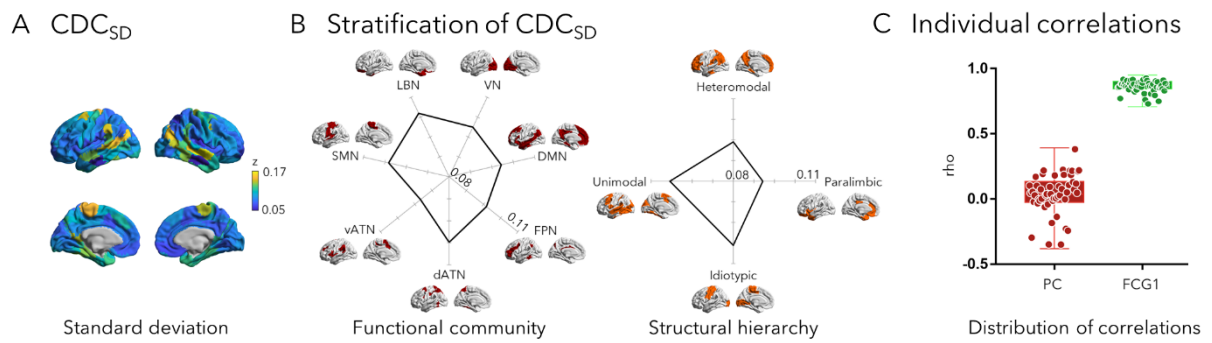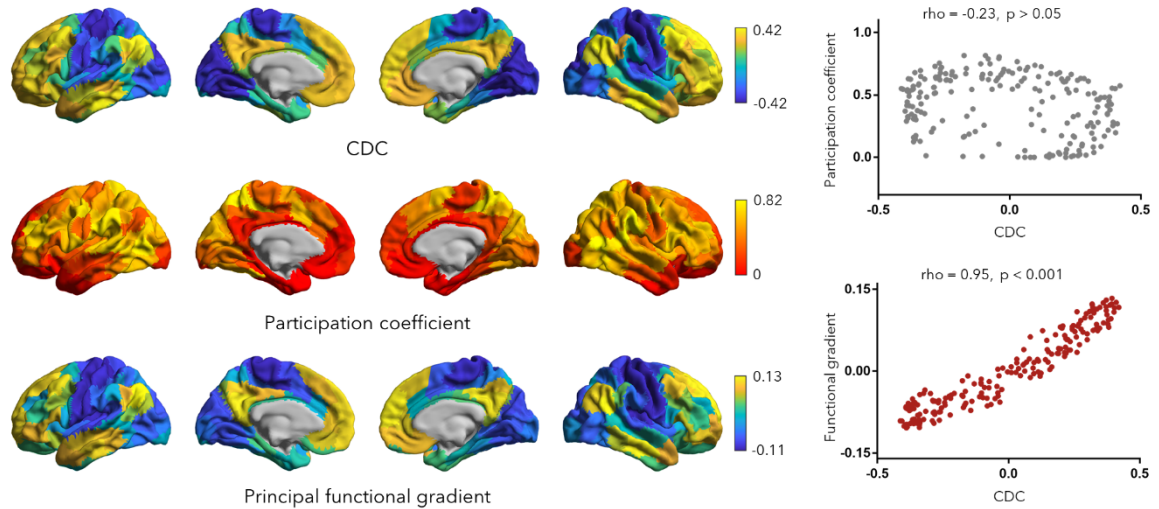
Fig. S4. Individual-level functional connectivity distance characteristics. (A) Standard deviation of functional connectivity distance (FCD$_{SD}$) across all individuals. **(B)** Stratification of FCD$_{SD}$ on functional communities and structural hierarchies. **(C)** Distribution of correlations between functional connectivity distance and other features (participation coefficient and principal gradient of functional connectome) on individual level. *Abbreviation*: PC, participation coefficient; FCG1, principal gradient of functional connectome.

A Functional features and analyses based on HCP

CDC

Participation coefficient

Principal functional gradient

rho = -0.23, p > 0.05

rho = 0.95, p < 0.001

B Cognitive representations on HCP

multisensory
auditory
pain
motor
visual perception
eye movement
action
face
visual attention
visuospatial
attention
reading
episodic memory
working memory
inhibition
affective
verbal
semantics
language
cognitive control
reward
autobiographical
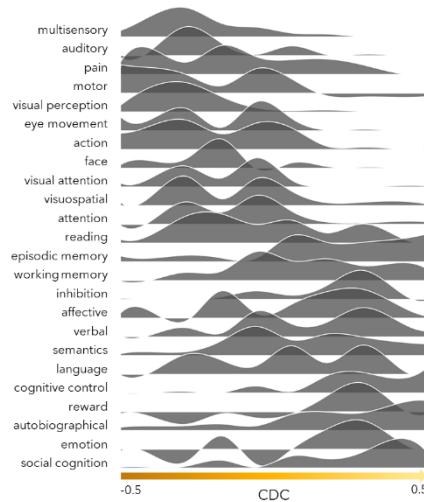emotion
social cognition

CDC

Fig. S5. Replication analyses based on HCP. (A) Functional features and analyses based on the HCP dataset. *Left panel*: Group-level functional connectivity distance, participation coefficient, and principal functional gradient. *Right panel:* Associations between participation coefficient, principal functional gradient, and functional connectivity distance. **(B)** Cognitive associations. Distributions of meta-analytical task-related fMRI activation across cortical regions relative to functional connectivity distance.
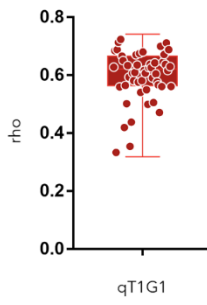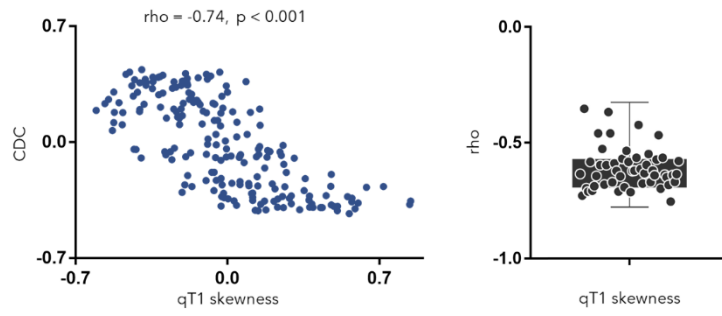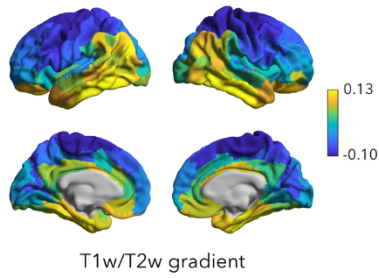
Fig. S6. Correlations between functional connectivity distance and in vivo microstructural features. (A) Individual-level correlations between functional connectivity distance and microstructural gradients derived from qT1. **(B)** Association between functional connectivity distance and microstructure skewness derived from qT1 at a group and individual level. *Abbreviation*: qT1G1, microstructure gradient derived from qT1.
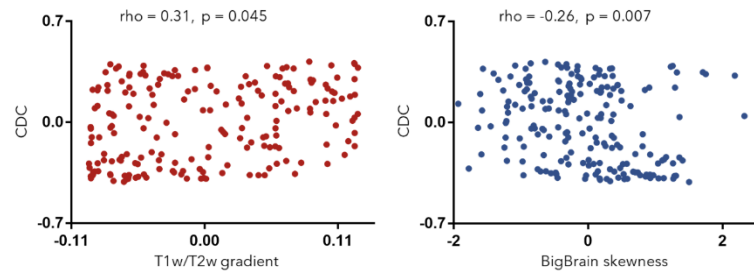
Fig. S7. Structure-function association in the HCP dataset. (A): Principal microstructural gradient estimated based on T1w/T2w ratios. **(B)** Association between functional connectivity distance and microstructure gradients derived from T1w/T2w, and BigBrain skewness feature.
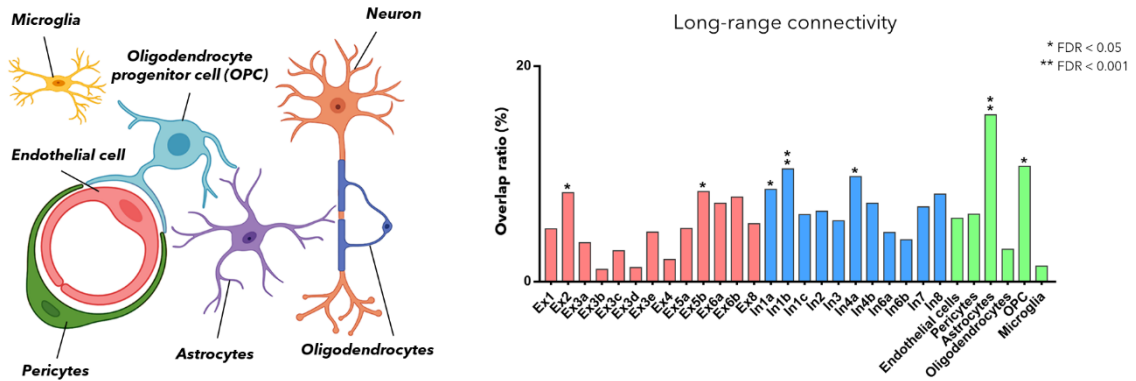
Fig. S8. Cell-type specific gene expression analysis. *Left*: Schema of different cell types. *Right*: The overlap ratio between genes positively related to functional connectivity distance (long-range connectivity) and cell-type specific genes. Supragranular neurons: Ex1, Ex2, Ex3a, Ex3b, Ex3c, Ex3d, Ex3e, In1a, In1b, In1c, In2, In3; infragranular neurons: Ex4, Ex5a, Ex5b, Ex6a, Ex6b, Ex8, In4a, In4b, In6a, In6b, In7, In8. *Abbreviation*: FDR, false discovery rate; Ex, excitatory neuron; In, inhibitory neuron.
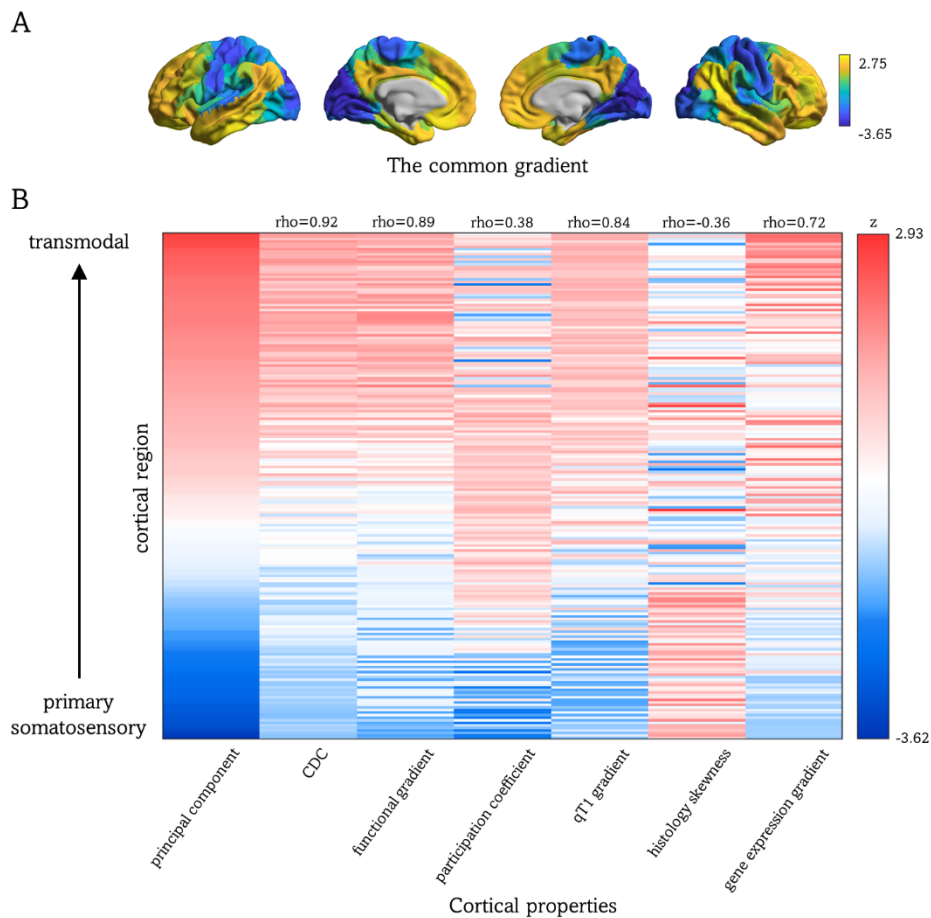
Fig.S9. A common gradient of cortical variation. (A) A common gradient across measures was estimated using principal component analysis. All measurements were z-normalized separately. (B) Regions (rows) were reordered according to the first principal component. Spearman's rank correlation coefficients between the common gradient and each individual measure are also presented.
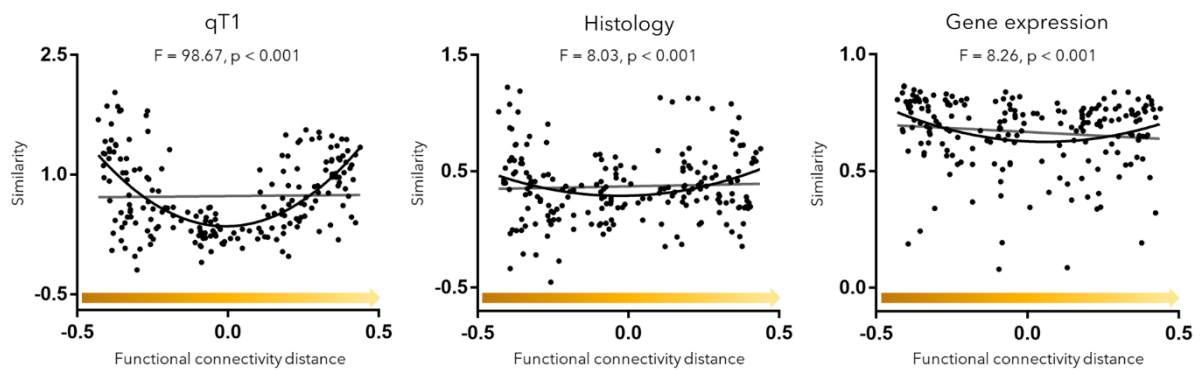
Performance of linear model and quadratic model

Fig. S10. Performance of linear model and quadratic model. Linear model (*gray line*) and quadratic model (*black curve*) were used to fit the association between microarchitectural similarity and functional connectivity distance. The golden arrows whose color change from darker to lighter represent the gradual increase in functional connectivity distance.
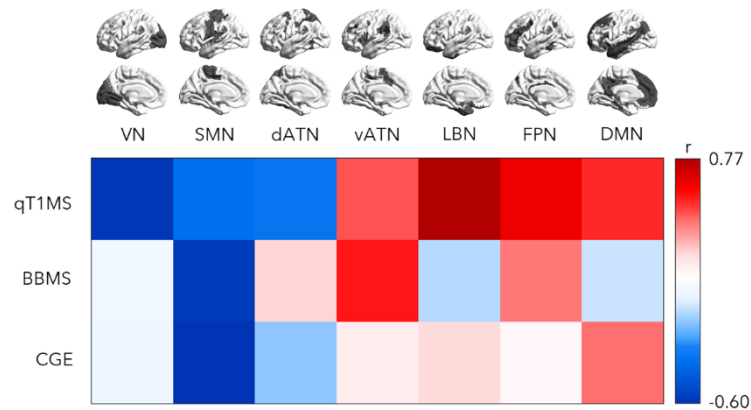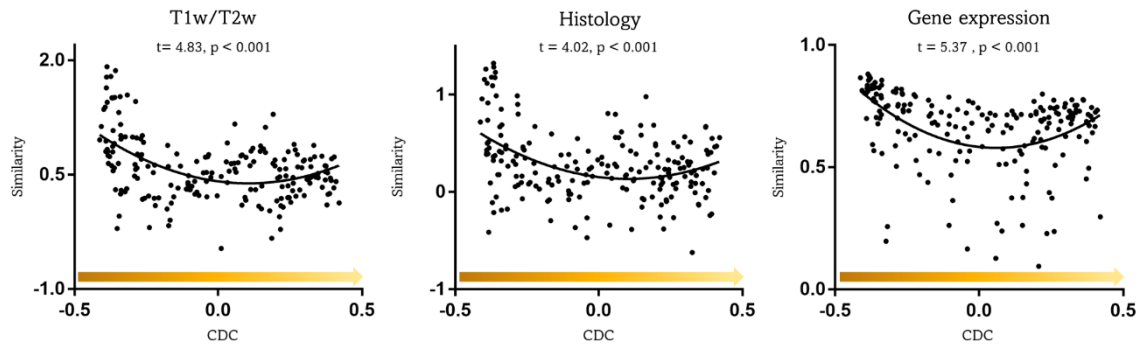
Fig. S11. Similarity-distance correlation in functional community. The correlation between microarchitectural similarity and functional connectivity distance was examined across different intrinsic functional communities. Different colors in the matrix represent correlations between distance and microstructural/genetic similarities (r values). *Abbreviation*: VN, visual network; SMN, somatomotor network; dATN, dorsal attention network; vATN, ventral attention network; LBN, limbic network; FPN, frontoparietal control network; DMN, default mode network; CGE, correlated gene expression.
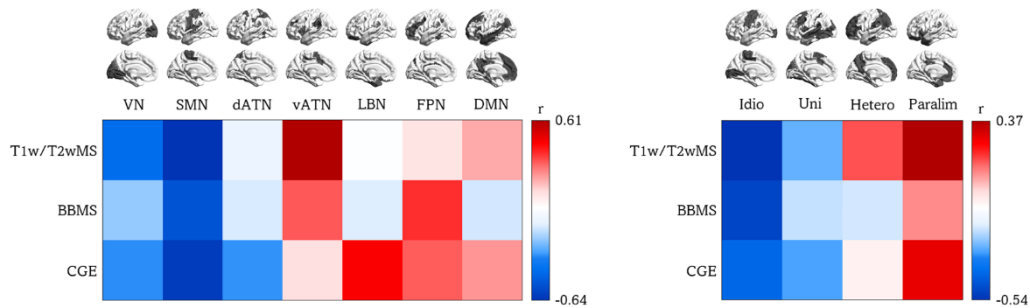
Fig. S12. Microarchitectural and genetic similarity analyses based on the HCP dataset.
(A) Quadratic relationship between microarchitectural similarity and functional connectivity distance. **(B)** Similarity-distance associations in intrinsic functional communities and levels of the cortical hierarchy. Different colors in the matrix represent correlations between functional connectivity distance and microarchitectural similarity (r values). *Abbreviation*: T1w/T2wMS, microstructural similarity derived from T1w/T2w; BBMS, microstructural similarity derived from BigBrain; CGE, correlated gene expression; VN, visual network; SMN, somatomotor network; dATN, dorsal attention network; vATN, ventral attention network; LBN, limbic network; FPN, frontoparietal control network; DMN, default mode network.