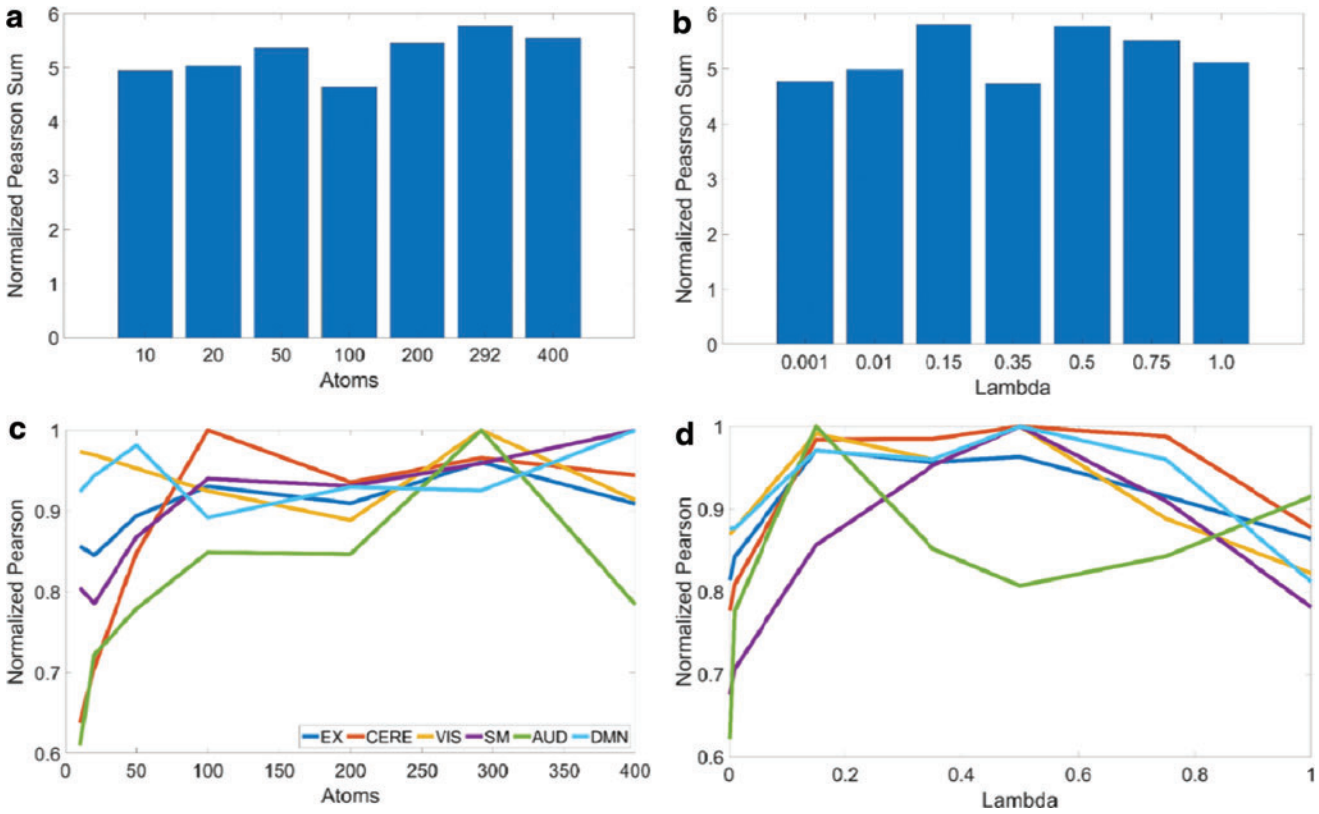
Supplementary Data

Sparse Dictionary Learning Parameter Optimization

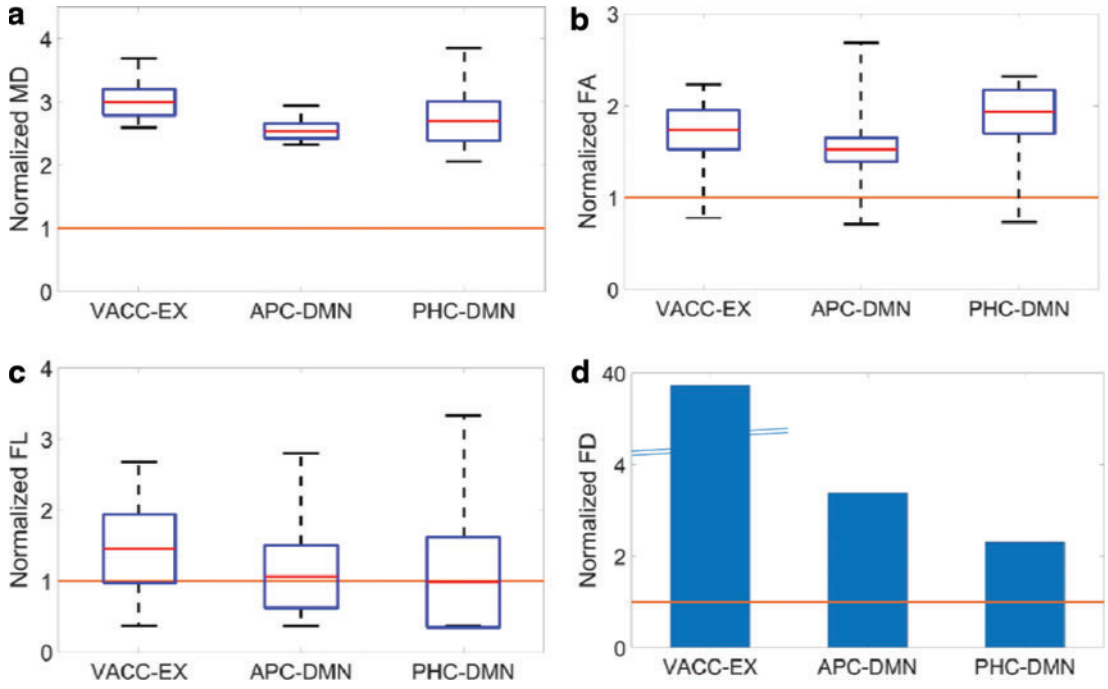
Sparse dictionary learning (sDL) was performed by minimizing Equation (1) in the main text, which includes two free parameters: the number of atoms (n) and the sparsity parameter (λ). First, n was optimized by using a fixed λ of 0.15; whereas n was varied between 10 and 400. Then for the optimally determined value of n, λ was optimized by varying its value between 0.001 and 1.0.

Optimization of the parameters was performed by using the following procedure. For each variable parameter value, activation maps were generated, and the activation maps that produced the maximum Pearson spatial coefficients with each reference pig resting-state network (RSN) atlas were determined. The Pearson values were then normalized (divided by the maximum) across the variable parameter and summed across the six RSNs. The parameter value that produced the maximum normalized Pearson sum was considered optimal.

Supplementary Figure S1a and c show the normalized Pearson sum values and the normalized Pearson values for each individual RSN, respectively, as a function of n. The optimal value of n was determined to be 292 (Supplementary Fig. S1a), and for this value, all RSNs produce maximal or near maximal Pearson values (Supplementary Fig. S1c). When performing sDL, it is typical to use a complete or over-complete dictionary matrix, or in other words, n is generally equal to or greater than the length of the time series being decomposed. The overall length of the time series for the group dataset is 3592; however, since similar RSN fluctuations are expected across pigs, a complete dictionary matrix is considered as $n = 292$, which is the length of the shortest time series associated with the pig whose last eight volumes were removed due to motion.

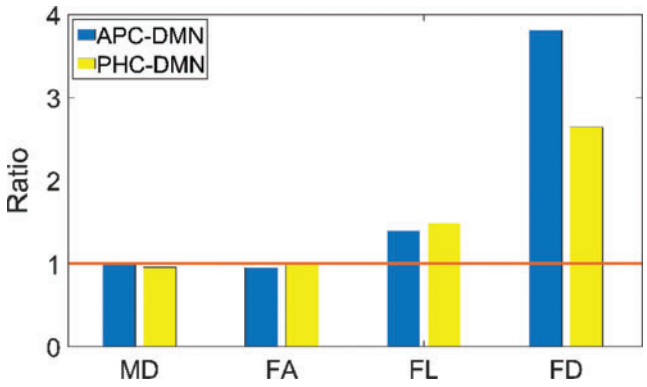


SUPPLEMENTARY FIG. S1. Normalized Pearson sum as a function of the number of atoms using a fixed sparsity parameter of 0.15 **(a)** and as a function of lambda using a fixed number of atoms of 292 **(b)**. The number of atoms and lambda value that produced the maximum normalized Pearson sum was considered optimal, and these values were determined to be 292 and 0.15, respectively. Normalized Pearson values for each individual RSN are also given as a function of the number of atoms **(c)** and lambda **(d)**. AUD, auditory; CERE, cerebellar; DMN, default mode; EX, executive control; RSN, resting-state network; SM, sensorimotor; VIS, visual.



SUPPLEMENTARY FIG. S2. Normalized *MD* **(a)**, *FA* **(b)**, *FL* **(c)**, and *FD* **(d)** measurements for the fibers intersecting with three anatomical volumes from the reference atlas. The lower and upper whiskers of the boxplots represent the minimum and maximum measurements, respectively. The central red line in each box represents the mean of the measurements, and the box represents one standard deviation from the mean. All measurements were normalized by their respective whole-brain averages, represented as the brown line across the three anatomies. FA, fractional anisotropy; FD, fiber density; FL, fiber length; MD, mean diffusivity.

Supplementary Figure S1b and d show the normalized Pearson sum values and the normalized Pearson values for each individual RSN, respectively, as a function of λ. The optimal value of λ was determined to be 0.15 (Supplementary Fig. S1b); however, a value of 0.5 performed almost equally as well. For $\lambda = 0.15$, five of the six RSNs produce maximal or near maximal Pearson values, whereas the sensorimotor RSN produces a relatively low Pearson value (Supplementary Fig. S1d). This is also the case for $\lambda = 0.5$, where only the auditory RSN is the lone RSN to produce a relatively low Pearson value. Since the normalized Pearson value, as well as the absolute Pearson value, of the sensorimotor RSN for $\lambda = 0.15$ was greater than the values of the auditory RSN for $\lambda = 0.5$, the optimal value for λ was still considered to be 0.15. By choosing the smaller λ value, the activation maps have less of a sparsity constraint.



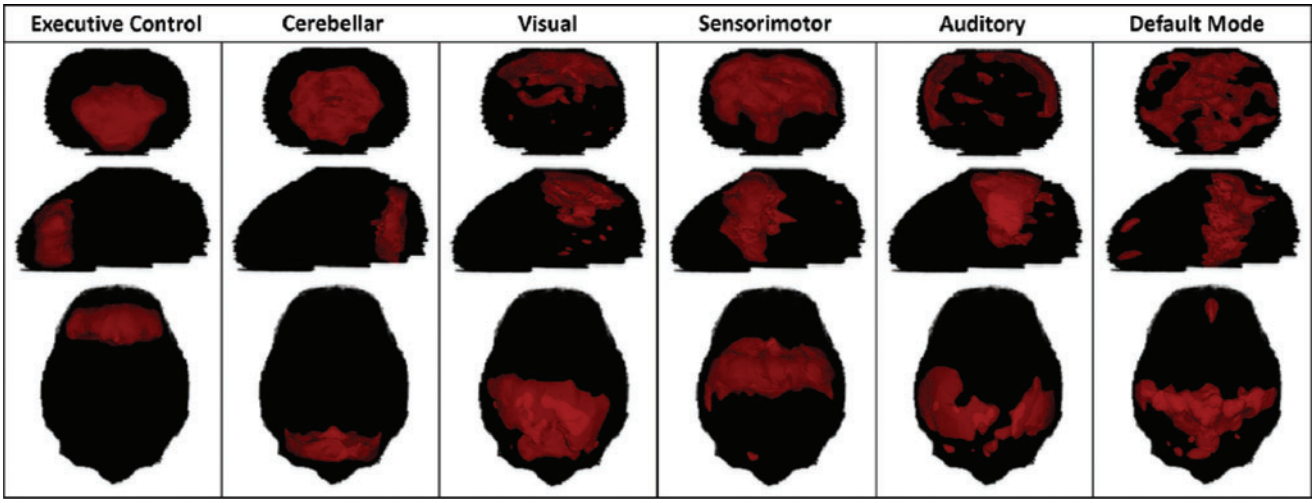
SUPPLEMENTARY FIG. S3. Ratios of the average structural connectivity measures determined for fibers intersecting with the activation volume from the averaged sDL maps that was found within each anatomical region divided by the average measures for fibers intersecting with the corresponding anatomical volume from the reference RSN atlas. sDL, sparse dictionary learning.

RSN Individual Anatomy Analysis

Using the averaged sDL activation maps (RSNs), Pearson spatial coefficients and mean ratio values were determined for each anatomical component given in Table 1 for each RSN. The volumetric percentage of each anatomical component in relation to its corresponding RSN volume was also determined from the reference pig RSN atlas. The results of this analysis are given in Supplementary Table S1. Individual anatomies (lobules, nuclei, and peduncles) of the cerebellum were not examined in this work.

When comparing anatomies of a similar RSN, a high Pearson correlation value and a high mean ratio indicate good correlation between the anatomy and RSN. However, a low Pearson value does not necessarily indicate a poor correlation between the anatomy and the RSN if the anatomy is small and the mean ratio is large. Only if both the Pearson and mean ratio values are small, then the anatomy is considered poorly correlated.

For the visual, sensorimotor, and auditory networks, all anatomies tend to correlate well with their corresponding



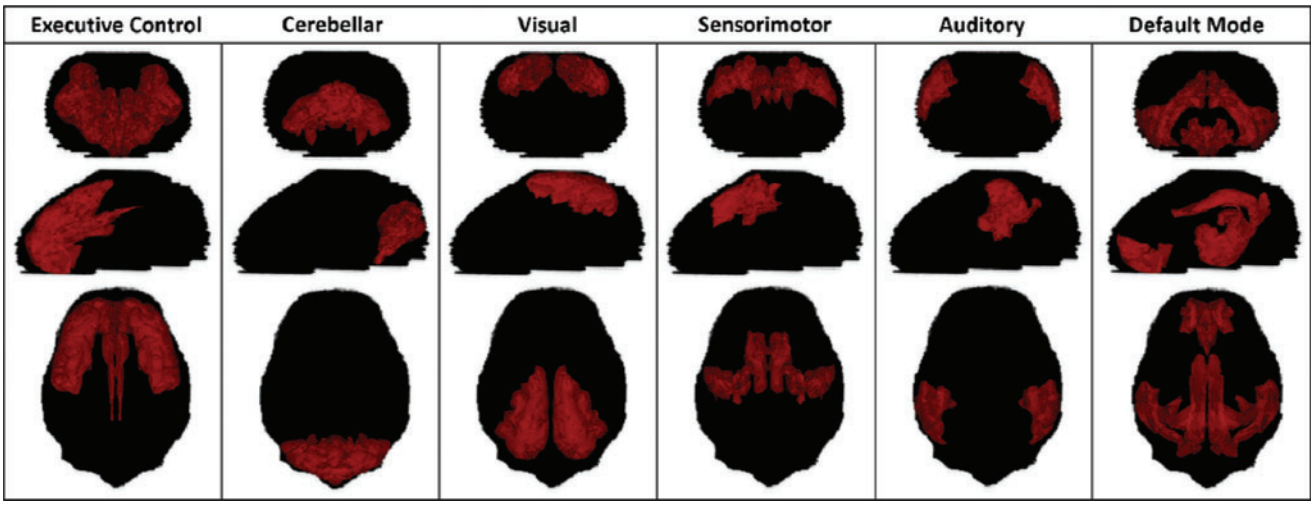
SUPPLEMENTARY FIG. S4. Three-dimensional projections of the averaged sDL activation maps for six RSNs. Coronal (top), sagittal (middle), and axial (bottom) views are projections from the front, left, and top of the brain, respectively.

RSN map; for the executive control network, all anatomies tend to correlate well, except for the ventral anterior cingulate cortex (VACC-EX). In the default mode network, the anterior prefrontal (APC-DMN), orbitofrontal, and parahippocampal (PHC-DMN) cortices all produce poor correlations with the default mode RSN.

Further structural connectivity analysis of these poorly correlated anatomies was performed by measuring the mean diffusivity, fractional anisotropy, fiber length, and fiber density of the fibers intersecting with each anatomical volume from the reference RSN atlas (Supplementary Fig. S2), as well as for the empirically determined activation volume from the averaged sDL maps that was found within each anatomical region. A ratio of the averages of these measurements (average from activation volume divided by average from reference atlas) was also determined (Supplementary Fig. S3). Further discussion of the poorly correlated anatomies and their structural connectivity measures are given in the Discussion of the main text.

Additional Images

See Supplementary Figures S4 and S5.



SUPPLEMENTARY FIG. S5. Three-dimensional projections of the pig reference RSN atlas for six RSNs. Coronal (top), sagittal (middle), and axial (bottom) views are projections from the front, left, and top of the brain, respectively.

SUPPLEMENTARY TABLE S1. RESTING-STATE NETWORK ANATOMY STATISTICS

RSN	*Pearson*	*Mean ratio*	*Percentage*
Executive control			
Primary somatosensory cortex	0.23	4.00	38.2
Dorsolateral prefrontal cortex	0.29	10.1	9.66
Anterior prefrontal cortex	0.30	8.91	13.2
Orbitofrontal cortex	0.06	6.75	0.81
Insular cortex	0.14	2.86	29.1
Ventral anterior cingulate cortex	0.00	0.19	1.56
Dorsal anterior cingulate cortex	0.25	9.63	7.52
Visual			
Primary visual cortex	0.42	6.72	56.8
Secondary visual cortex	0.30	5.85	36.8
Associative visual cortex	0.10	4.85	6.39
Sensorimotor			
Primary motor cortex	0.18	4.79	21.2
Somatosensory associative cortex	0.32	5.31	54.6
Premotor cortex	0.15	3.71	24.2
Auditory			
Superior temporal gyrus	0.16	7.29	20.3
Auditory cortex	0.40	8.87	79.7
Default mode			
Hippocampus	0.20	5.75	12.7
Anterior prefrontal cortex	0.03	0.80	20.7
Orbitofrontal cortex	0.00	0.00	1.28
Inferior temporal gyrus	0.11	3.03	15.1
Ventral posterior cingulate cortex	0.07	9.19	0.53
Dorsal posterior cingulate cortex	0.14	3.31	18.7
Retrosplenial cingular cortex	0.06	5.59	0.48
Anterior entorhinal cortex	0.13	4.45	9.33
Parahippocampal cortex	0.05	1.14	21.2

Pearson spatial coefficients and mean ratio values calculated by using the averaged sDL activation maps and each anatomical component, and the volumetric percentage of each anatomical component in relation to its corresponding RSN volume, as determined from the reference pig RSN atlas.

RSN, resting-state network; sDL, sparse dictionary learning.