**Supplementary method**

**Neuropsychological assessment**

The Seoul Neuropsychological Screening Battery (SNSB) covers five cognitive domains: attention (forward/backward digit span task and letter cancellation); language and related functions (the Korean version of the Boston Naming Test [K-BNT], calculation, and praxis); visuospatial function (the Rey Complex Figure Test [RCFT] copy), verbal and visual memory (immediate recall/delayed recall/recognition test using the Seoul Verbal Learning Test [SVLT] for verbal memory; immediate recall/delayed recall/recognition test using the RCFT for visual memory); and frontal/executive function (contrasting program and go/no-go test, the Controlled Oral Word Association Test [COWAT], and the Stroop test). The scores on each cognitive domain were classified as abnormal when they were below the 16th percentile (1SD) of the age-, sex-, and education-specific norms of 447 normal subjects.

**MRI and 18F-FP-CIT PET acquisition**

MRI scans were acquired using a Philips 3.0 T scanner (Philips Intera; Philips Medical Systema, Best, The Netherlands) with a SENSE head coil (SENSE factor=2) as described in our previous work.1-3 The high-resolution axial T1-weighted MRI data were obtained using a 3D T1-TFE sequence with the following parameters: 224 × 224 axial acquisition matrix; 256 × 256 reconstructed matrix with 170 slices; voxel size, 0.859 × 0.859 × 1 mm3; field of view, 220 mm; echo time, 4.6 msec; repetition time, 9.8 msec; flip angle, 8°. The diffusion-weighted MRI data were acquired using a single-shot echo-planar acquisition with the following parameters: 45 non-collinear, non-coplanar diffusion-encoded gradient directions; 128 × 128 acquisition matrix with 70 slices; voxel size, 1.75 × 1.75 × 2 mm3; field of view, 220 mm; b-factor, 600 s/mm2; echo time, 70 msec; repetition time, 7.663 sec; flip angle, 90°. The resting-state functional magnetic resonance imaging (fMRI) data were obtained using a T2\* weighted single shot echo planar imaging sequence with the following parameters: 80 × 80 matrix; 31 slices (interleaved); slice thickness, 3.0mm; gap, 1.0mm; voxel size, 2.8 × 2.8 × 3.0 mm3; field of view, 200 mm; echo time, 30 msec; repetition time, 2000 msec; flip angle, 90°. Each 330-s scan produced 165 fMRI images to obtain low frequency oscillation for the resting-state functional connectivity.4 The subjects were instructed to stay awake with their eyes closed without focusing on a specific thought and without moving during performing the fMRI.

The 18F-FP-CIT PET scans were acquired using a GE PET-CT DSTe scanner (GE Discovery STE, GE Healthcare Technologies; Milwaukee, WI), which obtains images with three-dimensional resolution of 2.3-mm FWHM. All subjects were instructed to be fasting for at least 6 hours before PET scan and 5mCi (185 MBq) of 18F-FP-CIT was injected intravenously. After 90 min following the injection, images were acquired for 20 min with three-dimensional mode at 12 KVp and 380 mAs.

**Analysis of cortical thickness**

The analyses were performed using high-resolution T1-weighted MRI data, which have been described in detail elsewhere.5-14 We visually validated the quality of T1 weighted MRI before extracting cortical surface model and cortical thickness. Structural MR images were registered into a standardized stereotaxis space using linear transformation.5 The N3 algorithm was used to correct images for intensity nonuniformity resulting from inhomogeneity in the magnetic field.6 The non-brain tissues of registered and corrected images were removed using Brain Extraction Tool (BET)7 and then classified into gray matter (GM), WM, CSF, and background using the Intensity-Normalised Stereotaxic Environment for Classification of Tissues (INSECT) algorithm.8 The surfaces of the inner and outer cortices which consisted of 40,962 vertices were automatically extracted using the Constrained Laplacian-based Automated Segmentation with Proximities (CLASP) algorithm, which reconstructs the inner cortical surface by deforming a spherical mesh onto the WM/GM boundary and then expanding the deformable model to the GM/CSF boundary.9,10 Cortical thickness was defined using the t-link method, which captures the Euclidean distance between the linked vertices of the inner and outer cortical surfaces.9,11 Each individual cortical thickness map was smoothed with 20mm full-width half-maximum Gaussian smoothing kernel to increase the signal to noise ratio,11,12 and aligned to unbiased interative surface template using vertex-wise sphere-to-sphere nonlinear surface registration.13,14

**Tract-based spatial statistics (TBSS) analysis**

Diffusion tensor imaging (DTI) data were preprocessed using the Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library (FSL) program (http://www.fmrib.ox.ac.uk/fsl/). Eddy current distortions and motion artifacts were corrected by normalization of each directional volume to the non-diffusion-weighted volume (b0) with 6 degrees of freedom, using the FMRIB Linear Image Registration Tool (FLIRT). Then the diffusion tensor was calculated using a simple least-squares fit of the tensor model. The fractional anisotropy (FA or index of directional selectivity of water diffusion) and mean diffusivity (MD or average diffusivity of three dimensions) for each voxel were determined using the standard methods of the DTIFIT program in FSL.

Voxel-wise statistical analyses of FA images were performed using TBSS which together with various processing tools.15 First, all FA images were aligned to the standard FMRIB58 FA template using ANTS-SyN algorithm and resampled to 1 ×  1 ×  1 mm3.16 The FA images were averaged following registration step and thinned to represent the skeleton of fiber tracts. Each subject’s aligned FA images filled this skeleton with the highest FA values from the nearest relevant center of fiber tracts. A threshold FA value of 0.2 was determined to exclude voxels of adjacent GM or CSF. The MD images were also processed using the same methods as the FA images by aligning them with a nonlinear registration algorithm and projecting them onto the skeleton.

**Preprocessing of resting-state fMRI data**

Preprocessing of resting-state fMRI data was performed using Analysis of Functional NeuroImages (<http://afni.nimh.nih.gov/afni>) software.17 The first five volumes from each image were discarded to allow for stabilization of the magnetic field. Images were despiked, and then corrected for slice time acquisition differences and head motion.17 At the motion-correction stage, displacement due to head motion was estimated using the motion-correction parameters of the *x*, *y*, and *z* translations and three rotation axes. In all subjects, estimated displacement due to head motion was less than 1 mm between successive time-series volumes and less than 2 mm in any of the three translation directions or less than 2.0° maximum rotation around any of the axes during the resting-state scans. The slice-timing and motion corrected functional images were performed using the anatomy based correlation corrections (ANATICOR) method.18 Data were regressed as follows: (1) by six parameters obtained by rigid body correction of head motion, (2) by the signal from the eroded large ventricle mask, and (3) by the signal from a region of the local WM erosion mask (*r* = 15 mm). Hardware artifacts were modeled with eroded local WMN and erode large ventricle masks. The registered and nonuniformity corrected T1 images were classified into WM, GM, CSF, and background using an advanced neural-net classifier to obtain the large ventricle masks and WM mask.8 In addition, four large ventricles were automatically identified using automated nonlinear image matching and anatomical labeling, a well-established nonlinear warping algorithm using a multi-scale approach to deform one image to match previously labeled template.19

Then, the anatomical T1 image was coregistered to the functional images using the affine registration with Local Pearson Correlation cost function,20 and all masks were transformed to echo planar imaging space. To reduce partial volume effects, the WM mask and the large ventricle mask were eroded by one voxel. Subsequently, data were temporally band-pass filtered (0.009 < *f* < 0.08) to remove scanner drift and physiological noise. Data were then masked out using the GM mask to reduce the inclusion of unwanted blood oxygen level-dependent (BOLD) or other physiological signals that occur due to large draining vessels that tend to course on the outer surface of GM. Images were normalized to a standard MNI152 template and resampled at an isotropic voxel size of 2 mm before spatial smoothing was carried out with a 6-mm full width at half maximum (FWHM) Gaussian kernel.

**Quantitative analysis of the 18F-FP-CIT PET**

Quantitative analyses were based on volumes of interests (VOIs), which were defined based on automated anatomical labeling (AAL) template.21 All reconstructed PET images were aligned to the corresponding structural MRI using a rigid body transformation and the AAL template. The VOIs of striatal subregions (caudate and putamen) and one occipital VOI (calcarine sulcus) were selected for the analyses. The anatomical boundaries of anterior and posterior putamen were defined based on 131st coronal slice in AAL template. Dopamine transporter (DAT) activity was calculated by the non-displaceable binding potential, which was defined as follows: (mean standardized uptake value [SUV] of the posterior putaminal VOI – mean SUV of the occipital VOI) / (mean SUV of the occipital VOI).22

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