

## Supplemental methods

All magnetic resonance imaging (MRI) datasets were quality controlled and visually inspected prior to being preprocessed and analyzed. All imaging data were processed using FMRIB Software Library.

Diffusion weighted imaging (DWI) data was motion and eddy current corrected, skull stripped using BET, and then diffusion tensors were fit to the data using *dtifit* in FMRIB Software Library (FSL). Tract-Based Spatial Statistics (TBSS) was used to generate a WM skeleton comprised of white matter (WM) voxels shared by all participants (20). This WM skeleton was applied to each participant's individual diffusion tensor imaging (DTI) maps and mean fractional anisotropy (FA), axial (AD), radial (RD) and mean (MD) diffusivity were extracted from various regions of interest (ROIs) based on the intersection between the TBSS skeleton and labels defined in probabilistic anatomical atlas in addition to a global average across the skeleton (20). This atlas included twenty ROIs from which DTI metrics were extracted: anterior thalamic radiation, corticospinal tract, cingulate bundle, white matter underlying the hippocampus, inferior longitudinal fasciculus, inferior fronto-occipital fasciculus, superior longitudinal fasciculus, arcuate fasciculus, forceps major, forceps minor and the uncinate fasciculus. DTI metrics were also calculated from the entire white matter skeleton.

Magnetic resonance spectroscopy (MRS) data was processed using Osirix (<https://www.osirix-viewer.com/osirix/osirix-md/>) and Tarquin (<http://tarquin.sourceforge.net/>) in order to calculate neurotransmitter specific peak heights from which neurotransmitter comparison ratios [e.g., N-acetylaspartate to glutamine (NAA/Gl)] were computed. MRS values were creatine adjusted to improve the likelihood that data was derived from tissue and not CSF. For seeds acquired in the frontal lobe and the precuneus, N-acetylaspartate to glutamine (NAA/Gl) ratio, glutamate-glutamine (Glx) ratio and choline/creatine (Cho/Cr) ratio were calculated.

These DTI and MRS metrics are provided for review in *Table S1*.

**Table S1** Diffusion tensor imaging metrics used for group classification by trained raters

Group	Healthy aging		Alzheimer's disease		Parkinson's disease dementia	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Left Ant Thal Rad FA	0.5163	0.02533	0.4610	0.05801	0.5010	0.04864
Right Ant Thal Rad FA	0.5171	0.01829	0.4490	0.06367	0.5000	0.05142
Left Corticospinal Tract FA	0.5513	0.02346	0.4910	0.06839	0.5470	0.07364
Right Corticospinal Tract FA	0.5442	0.01976	0.4780	0.07099	0.5410	0.07578
Left Cingulate Gyrus FA	0.4817	0.02681	0.4220	0.05391	0.4520	0.05412
Right Cingulate Gyrus FA	0.4763	0.02856	0.4100	0.06360	0.4490	0.04999
Left Hippocampus FA	0.4538	0.02481	0.4050	0.05255	0.4310	0.05065
Right Hippocampus FA	0.4604	0.02116	0.4170	0.05638	0.4470	0.05034
Forceps Major FA	0.5254	0.02484	0.5220	0.05308	0.5540	0.04402
Forceps Minor FA	0.5108	0.02376	0.5420	0.04940	0.5340	0.04881
Left IFOG FA	0.4829	0.02136	0.4160	0.07619	0.4630	0.06343
Right IFOG FA	0.4888	0.02401	0.4380	0.06143	0.4660	0.05441
Left ILF FA	0.4658	0.02535	0.4040	0.06168	0.4410	0.05782
Right ILF FA	0.4613	0.02007	0.4070	0.04498	0.4440	0.04326
Left SLF FA	0.4742	0.02358	0.4290	0.04483	0.4710	0.05259
Right SLF FA	0.4813	0.02708	0.4420	0.05138	0.4820	0.04780

**Table S1** (continued)

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Group	Healthy aging		Alzheimer's disease		Parkinson's disease dementia	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Left Uncin Fasc FA	0.4813	0.02610	0.4120	0.06763	0.4400	0.06944
Right Uncin Fasc FA	0.4821	0.02813	0.3860	0.07905	0.4550	0.04378
Left Arcuate FA	0.5079	0.03741	0.4250	0.10804	0.4390	0.10651
Whole Skeleton FA	0.4846	0.02126	0.4430	0.04448	0.4770	0.03945
Left Ant Thal Rad MD	0.0006	0.00004	0.0007	0.00011	0.0007	0.00008
Right Ant Thal Rad MD	0.0006	0.00004	0.0007	0.00011	0.0007	0.00007
Left Corticospinal Tract MD	0.0006	0.00004	0.0007	0.00006	0.0006	0.00007
Right Corticospinal Tract MD	0.0006	0.00004	0.0006	0.00008	0.0006	0.00007
Left Cingulate Gyrus MD	0.0006	0.00005	0.0007	0.00008	0.0007	0.00007
Right Cingulate Gyrus MD	0.0006	0.00005	0.0007	0.00008	0.0007	0.00010
Left Hippocampus MD	0.0006	0.00005	0.0007	0.00008	0.0007	0.00007
Right Hippocampus MD	0.0006	0.00005	0.0007	0.00007	0.0007	0.00007
Forceps Major MD	0.0007	0.00005	0.0007	0.00005	0.0007	0.00006
Forceps Minor MD	0.0006	0.00005	0.0007	0.00006	0.0007	0.00007
Left IFOG MD	0.0007	0.00005	0.0007	0.00007	0.0007	0.00007
Right IFOG MD	0.0007	0.00005	0.0007	0.00005	0.0007	0.00005
Left ILF MD	0.0007	0.00005	0.0007	0.00005	0.0007	0.00006
Right ILF MD	0.0006	0.00005	0.0007	0.00005	0.0007	0.00005
Left SLF MD	0.0006	0.00005	0.0007	0.00004	0.0006	0.00007
Right SLF MD	0.0006	0.00005	0.0007	0.00005	0.0006	0.00007
Left UncMDsc MD	0.0007	0.00005	0.0007	0.00009	0.0008	0.00013
Right UncMDsc MD	0.0007	0.00005	0.0007	0.00009	0.0007	0.00009
Left Arcuate MD	0.0007	0.00006	0.0007	0.00014	0.0007	0.00010
Whole Skeleton MD	0.0006	0.00004	0.0007	0.00008	0.0007	0.00006
Left Ant Thal Rad AD	0.0010	0.00006	0.0010	0.00012	0.0011	0.00009
Right Ant Thal Rad AD	0.0010	0.00007	0.0010	0.00010	0.0010	0.00008
Left Corticospinal Tract AD	0.0010	0.00006	0.0010	0.00007	0.0010	0.00007
Right Corticospinal Tract AD	0.0010	0.00006	0.0010	0.00007	0.0010	0.00007
Left Cingulate Gyrus AD	0.0010	0.00007	0.0010	0.00007	0.0010	0.00008
Right Cingulate Gyrus AD	0.0010	0.00007	0.0010	0.00007	0.0010	0.00011
Left Hippocampus AD	0.0010	0.00006	0.0010	0.00008	0.0010	0.00007
Right Hippocampus AD	0.0010	0.00007	0.0010	0.00006	0.0010	0.00008
Forceps Major AD	0.0011	0.00007	0.0011	0.00007	0.0011	0.00006

**Table S1** (continued)

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Group	Healthy aging		Alzheimer's disease		Parkinson's disease dementia	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Forceps Minor AD	0.0011	0.00006	0.0012	0.00011	0.0011	0.00012
Left IFOG AD	0.0010	0.00007	0.0010	0.00007	0.0010	0.00007
Right IFOG AD	0.0011	0.00008	0.0010	0.00005	0.0010	0.00009
Left ILF AD	0.0010	0.00007	0.0010	0.00007	0.0010	0.00007
Right ILF AD	0.0010	0.00007	0.0010	0.00005	0.0010	0.00007
Left SLF AD	0.0010	0.00007	0.0010	0.00003	0.0010	0.00008
Right SLF AD	0.0010	0.00007	0.0010	0.00005	0.0010	0.00009
Left UncADsc AD	0.0011	0.00009	0.0011	0.00007	0.0011	0.00011
Right UncADsc AD	0.0011	0.00009	0.0011	0.00009	0.0011	0.00012
Left Arcuate AD	0.0011	0.00009	0.0011	0.00019	0.0011	0.00016
Whole Skeleton AD	0.0010	0.00005	0.0010	0.00008	0.0010	0.00007
Left Ant Thal Rad RD	0.0004	0.00004	0.0005	0.00012	0.0005	0.00008
Right Ant Thal Rad RD	0.0004	0.00003	0.0005	0.00011	0.0005	0.00007
Left Corticospinal Tract RD	0.0004	0.00004	0.0005	0.00008	0.0004	0.00009
Right Corticospinal Tract RD	0.0004	0.00004	0.0005	0.00009	0.0004	0.00009
Left Cingulate Gyrus RD	0.0005	0.00004	0.0005	0.00009	0.0005	0.00008
Right Cingulate Gyrus RD	0.0005	0.00005	0.0005	0.00008	0.0005	0.00010
Left Hippocampus RD	0.0005	0.00004	0.0005	0.00009	0.0005	0.00007
Right Hippocampus RD	0.0005	0.00004	0.0005	0.00007	0.0005	0.00007
Forceps Major RD	0.0005	0.00005	0.0005	0.00006	0.0004	0.00006
Forceps Minor RD	0.0004	0.00005	0.0004	0.00006	0.0005	0.00006
Left IFOG RD	0.0005	0.00004	0.0005	0.00009	0.0005	0.00008
Right IFOG RD	0.0005	0.00004	0.0005	0.00007	0.0005	0.00005
Left ILF RD	0.0005	0.00004	0.0005	0.00006	0.0005	0.00007
Right ILF RD	0.0005	0.00004	0.0005	0.00005	0.0005	0.00005
Left SLF RD	0.0005	0.00004	0.0005	0.00005	0.0005	0.00007
Right SLF RD	0.0005	0.00004	0.0005	0.00006	0.0004	0.00007
Left UncRDsc RD	0.0005	0.00004	0.0006	0.00011	0.0006	0.00015
Right UncRDsc RD	0.0005	0.00005	0.0006	0.00011	0.0005	0.00009
Left Arcuate RD	0.0005	0.00006	0.0005	0.00014	0.0005	0.00009
Whole Skeleton RD	0.0004	0.00003	0.0005	0.00008	0.0005	0.00006
Frontal_NAA	30.708	10.4569	27.500	5.3955	27.550	3.7227
Frontal_Cr	20.354	7.6307	18.500	4.6845	19.150	2.3339

**Table S1** (continued)

**Table S1** (continued)

Group	Healthy aging		Alzheimer's disease		Parkinson's disease dementia	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Frontal_Gl	8.625	4.2510	8.600	3.1252	7.750	2.3124
Frontal_NAA_Cr	1.5558	0.27407	1.5310	0.28614	1.4550	0.24305
Frontal_GLeft NAA	0.2713	0.08446	0.3150	0.10987	0.2770	0.06290
Prec_NAA	34.708	12.2420	31.200	5.4681	31.050	4.3872
Prec_Cr	20.646	7.0687	19.050	3.4274	19.500	2.5386
Prec_Gl	11.208	4.4157	10.650	3.2664	9.800	2.1370
Prec_NAA_cr	1.6783	0.17714	1.6510	0.21257	1.5930	0.10371
Prec_GLeft NAA	0.3150	0.07028	0.3470	0.10177	0.3220	0.08270