# Parkinson's disease may disrupt overlapping subthalamic nucleus and pallidal motor networks

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**Supplementary materials**

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**Supplementary figures and tables**

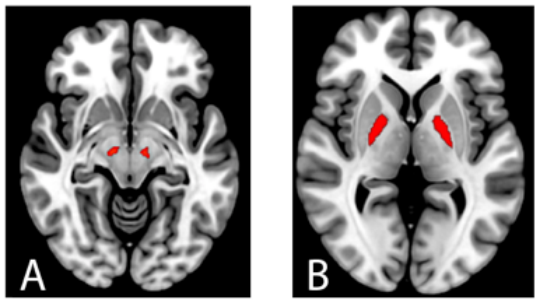


**Figure S1**: mSTN and GPi regions-of interest projected onto a MT saturation map in standard Montreal Neurological Institute space.

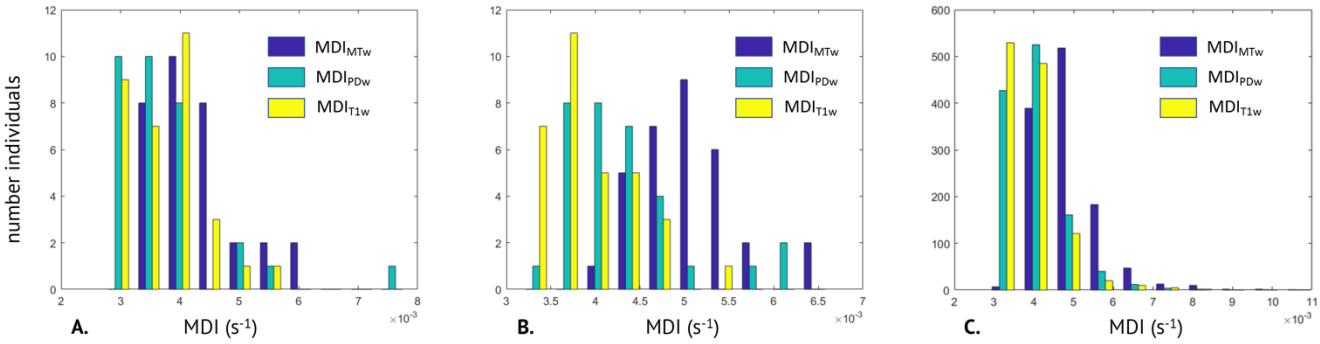


**Figure S2.** Motion Degradation Index (MDI in s-1) estimated for each contrast: MT-weighted (MTw), PD-weighted (PDw) and T1-weighted (T1w) in A. patients with Parkinson's disease (n = 32); B. healthy controls – reduced matched cohort (n = 32); C. healthy controls – entire cohort (n = 1184).

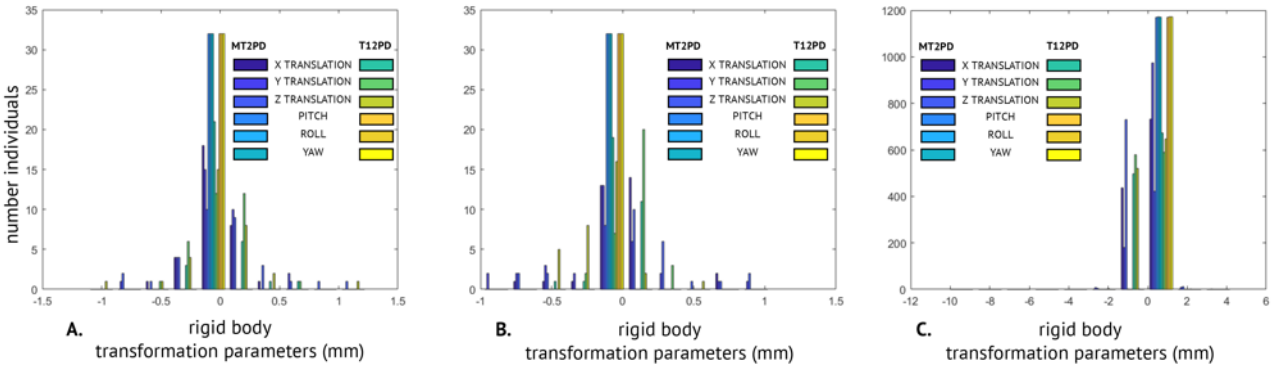


**Figure S3.** Rigid body transformation parameters (x,y, z translation; pitch roll yaw in mm) estimated for co-registration between MT-weighted and PD-weighted (MT2PD), and between T1-weighted and PD-weighted (T12PD) in A. patients with Parkinson's disease (n = 32); B. healthy controls – reduced matched cohort (n = 32); C. healthy controls – entire cohort (n = 1184).


**Figure S4.** Statistical parametric maps (SPMs) of structural covariance. mSTN and GPi covariance maps of regional grey matter volume estimates across the whole brain in healthy controls at $p_{UNCORR}<.001$.


**Figure S5.** Statistical parametric maps (SPMs) of structural covariance. mSTN and GPi covariance maps of regional magnetization transfer saturation estimates across the whole brain in healthy controls at $p_{UNCORR}<.001$.

**GPi seed**

| | Anatomical region | | MNI-coordinates | | | z-score | t-value |
|---|---|---|---|---|---|---|---|
| | | | x | y | z | | |
| **VBM - GM** | | | | | | | |
| | *Precentral gyrus* | **R** | 33 | -23 | 66 | inf | 8.23 |
| | | **L** | -33 | -24 | 66 | Inf | 7.18 |
| | *Thalamus* | **R** | 9 | -14 | 6 | Inf | 20.75 |
| | | **L** | -11 | -17 | 6 | Inf | 19.28 |
| | *GPe* | **R** | 21 | -2 | -6 | Inf | 69.12 |
| | | **L** | -21 | -3 | -2 | Inf | 52.69 |
| | *Putamen* | **R** | 26 | -2 | -5 | Inf | 42.99 |
| | | **L** | -26 | -2 | -5 | Inf | 34.72 |
| | *Entorhinal area* | **R** | 26 | 0 | -18 | Inf | 7.57 |
| | | **L** | -26 | 1.5 | -21 | Inf | 4.74 |
| | *Caudate* | **R** | 15 | 18 | 5 | Inf | 5.72 |
| | | **L** | -12 | 11 | 17 | 6.51 | 6.57 |
| | *Accumbens* | **R** | 15 | 18 | -8 | Inf | 7.47 |
| | | **L** | -12 | 18 | -6 | Inf | 6.95 |
| | *Posterior Insula* | **R** | 42 | -2 | -3 | Inf | 8.35 |
| | | **L** | -41 | -12 | 2 | Inf | 8.67 |
| | *Anterior Insula* | **R** | 44 | 0 | -5 | Inf | 6.42 |
| | | **L** | -36 | 5 | 0 | Inf | 8.93 |
| | *Substantia nigra* | **R** | 8 | -20 | -18 | Inf | 13.64 |
| | | **L** | -8 | -18 | -17 | Inf | 16.08 |
| | *Red nucleus* | **R** | 8 | -21 | -12 | Inf | 16.11 |
| | | **L** | - 6 | -20 | -12 | Inf | 17.42 |
| | *Periaqueductal grey* | | 0 | -32 | -14 | Inf | 9.16 |
| | *mSTN* | **R** | 8 | -15 | -5 | Inf | 19.83 |
| | | **L** | -6 | -15 | -6 | Inf | 17.67 |
| **VBM - WM** | | | | | | | |
| | *Corona radiata* | **R** | 20 | 14 | 26 | 7.41 | 7.50 |
| | | **L** | -20 | 9 | 27 | Inf | 8.12 |
| | *Splenium corpus callosum* | | 2 | -14 | 29 | 6.18 | 6.23 |
| **MTsat - GM** | | | | | | | |
| | *Precentral gyrus* | **R** | 33 | -15 | 57 | Inf | 7.88 |
| | | **L** | -35 | -23 | 56 | Inf | 8.21 |
| | *Thalamus* | **R** | 9 | -11 | 11 | Inf | 16.70 |
| | | **L** | -8 | -20 | 8 | Inf | 14.71 |
| | *GPe* | **R** | 21 | -3 | -2 | Inf | 39.59 |
| | | **L** | -20 | -5 | 0 | Inf | 39.13 |
| | *Putamen* | **R** | 30 | -5 | 2 | Inf | 15.87 |
| | | **L** | -32 | -5 | 0 | Inf | 16.91 |
| | *Hippocampus* | **R** | 21 | -14 | -15 | Inf | 7.66 |
| | | **L** | -33 | -20 | 15 | Inf | 6.59 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Entorhinal area* | **R** | 27 | 2 | -24 | Inf | 8.59 |
| | | **L** | -30 | 2 | -24 | Inf | 7.19 |
| | *Caudate* | **R** | 18 | 12 | 14 | Inf | 7.67 |
| | | **L** | -17 | 6 | 17 | Inf | 7.49 |
| | *Posterior Insula* | **R** | 38 | 8 | 2 | Inf | 6.96 |
| | | **L** | -38 | -6 | -6 | Inf | 11.79 |
| | *Anterior Insula* | **R** | 33 | 3 | 12 | Inf | 10.86 |
| | | **L** | -36 | 11 | -6 | Inf | 7.19 |
| | *Substantia nigra* | **R** | 11 | -18 | -12 | Inf | 9.75 |
| | | **L** | -8 | -18 | -15 | Inf | 12.17 |
| | *Red nucleus* | **R** | 6 | -23 | -15 | Inf | 7.87 |
| | | **L** | -8 | -21 | -15 | Inf | 11.16 |
| | *Periaqueductal grey* | | 0 | -32 | -14 | Inf | 8.26 |
| | *mSTN* | **R** | 8 | -17 | -5 | Inf | 14.67 |
| | | **L** | -11 | -17 | -5 | Inf | 13.20 |
| | | | | | | | |
| **MTsat - WM** | | | | | | | |
| | *Temporal pole* | **R** | 41 | 12 | -35 | Inf | 6.86 |
| | | **L** | -36 | 6 | -41 | 5.55 | 5.59 |
| | *PLIC* | **R** | 17 | 0 | -6 | Inf | 24.05 |
| | | **L** | -17 | 0 | -6 | Inf | 21.05 |
| | *Fronto-temporal WM* | **R** | 38 | 29 | 30 | Inf | 7.92 |
| | *Pre- and postcentral WM* | **L** | -60 | -18 | 23 | 4.18 | 4.20 |
| | | | | | | | |
| **PD* - GM** | | | | | | | |
| | *GPe* | **R** | 18 | -5 | 0 | Inf | 41.75 |
| | | **L** | -17 | -9 | -3 | Inf | 47.77 |
| | *Putamen* | **R** | 33 | -3 | -2 | Inf | 7.59 |
| | | **L** | -32 | -6 | 0 | Inf | 10.56 |
| | *Posterior Insula* | **R** | 44 | -8 | 3 | Inf | 7.82 |
| | | **L** | -35 | -11 | 14 | Inf | 6.16 |
| | *Anterior Insula* | **R** | 42 | -3 | 3 | Inf | 8.71 |
| | | **L** | -38 | -1.5 | 6 | Inf | 6.24 |
| | *Middle temporal gyrus* | **R** | 59 | -23 | -8 | 7.77 | 7.88 |
| | *Parietal operculum* | **L** | -51 | -38 | 21 | 7.68 | 7.78 |
| | *Cingulate gyrus* | **R** | 3 | 12 | 41 | 5.64 | 5.68 |
| | | **L** | -5 | 6 | 42 | 5.74 | 5.78 |
| | | | | | | | |
| **R2* - GM** | | | | | | | |
| | *GPe* | **R** | 20 | 0 | -6 | Inf | 84.79 |
| | | **L** | -20 | -2 | -2 | Inf | 74.62 |
| | *Putamen* | **R** | 26 | 0 | -2 | Inf | 31.20 |
| | | **L** | -29 | -2 | 3 | Inf | 18.79 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Thalamus* | **R** | 8 | -8 | 8 | Inf | 10.89 |
| | | **L** | -12 | -18 | 9 | Inf | 7.24 |
| | *Caudate* | **R** | 15 | 13 | 11 | Inf | 12.32 |
| | | **L** | -12 | 12 | 12 | Inf | 11.65 |
| | *Substantia nigra* | **R** | 9 | -12 | -14 | Inf | 24.14 |
| | | **L** | -9 | -12 | -14 | Inf | 25.71 |
| | *Red nucleus* | **R** | 9 | -23 | -17 | Inf | 13.64 |
| | | **L** | -3 | -23 | -17 | Inf | 8.23 |
| | *mSTN* | **R** | 11 | -21 | -12 | Inf | 16.33 |
| | | **L** | -5 | -21 | -14 | Inf | 14.10 |
| | *Dentate nucleus* | **R** | 14 | -59 | -35 | Inf | 8.74 |
| | | **L** | -12 | -59 | -35 | Inf | 8.86 |
| | *Cerebellum* | **R** | 14 | -86 | -38 | 5.99 | 6.04 |
| | | **L** | -20 | -86 | -41 | 5.57 | 5.61 |
| | | | | | | | |
| **R2* - WM** | | | | | | | |
| | *PLIC* | **R** | 12 | 2 | 5 | Inf | 16.39 |
| | | **L** | -12 | 0 | 0 | Inf | 24.65 |
| | *Cerebral peduncle* | **R** | 8 | -9 | -12 | Inf | 25.98 |
| | | **L** | -8 | -12 | -18 | Inf | 15.13 |
| | *Dentate nucleus* | **R** | 12 | -59 | -35 | Inf | 10.28 |
| | | **L** | -11 | -59 | -36 | Inf | 10.99 |

**Table S1** Results of the whole-brain voxel-based covariance analysis across volume and parameter maps in grey and white matter of healthy controls with seeds in the GPi.

*Abbreviations: L – left, R – right, VBM – voxel-based morphometry, mSTN – motor region of the subthalamic nucleus, GM – Grey Matter, GP – globus pallidus, GPi – globus pallidus pars interna, GPe – globus pallidus pars externa, PLIC – posterior limb of the internal capsule, ALIC – anterior limb of the internal capsule, MT sat – magnetization transfer saturation, R2* – effective transverse relaxation rate, PD* – effective proton density, CC – corpus callosum*

**mSTN seed**

| | Anatomical region | | MNI-coordinates | | | z-score | t-value |
|---|---|---|---|---|---|---|---|
| | | | x | y | z | | |
| **VBM - GM** | | | | | | | |
| | *Precentral Gyrus* | **R** | 33 | -23 | 62 | Inf | 8.84 |
| | | **L** | -35 | -24 | 59 | Inf | 7.44 |
| | *Thalamus* | **R** | 14 | -18 | 11 | Inf | 23.13 |
| | | **L** | -12 | -20 | 9 | Inf | 27.91 |
| | *GP* | **R** | 21 | -6 | -6 | Inf | 21.26 |
| | | **L** | -21 | -11 | -3 | Inf | 21.26 |
| | *Putamen* | **R** | 32 | -6 | -2 | Inf | 12.37 |
| | | **L** | -32 | -11 | -2 | Inf | 11.63 |
| | *Substantia nigra* | **R** | 8 | -18 | -17 | Inf | 40.5 |
| | | **L** | -8 | -18 | -17 | Inf | 41.55 |
| | *Red nucleus* | **R** | 6 | -23 | -18 | Inf | 25.59 |
| | | **L** | -8 | -23 | -18 | Inf | 28.95 |
| | *Periaqueductal grey* | | 0 | -35 | -17 | Inf | 11.09 |
| **VBM - WM** | | | | | | | |
| | *Corona radiata* | **R** | 24 | -6 | 32 | Inf | 9.46 |
| | | **L** | -26 | -23 | 33 | Inf | 8.22 |
| | *Splenium corpus callosum* | | -3 | -26 | 27 | 6.40 | 6.46 |
| | *Genu corpus callosum* | | 6 | 30 | 3 | 5.20 | 5.23 |
| **MTsat - GM** | | | | | | | |
| | *Precentral Gyrus* | **R** | 41 | -14 | 51 | Inf | 6.22 |
| | | **L** | -32 | -23 | 56 | Inf | 5.33 |
| | *Middle Frontal gyrus* | **R** | 30 | 26 | 51 | Inf | 5.34 |
| | *Thalamus* | **R** | 9 | -14 | 0 | Inf | 33.5 |
| | | **L** | -8 | -11 | 0 | Inf | 32.10 |
| | *GP* | **R** | 21 | -9 | -3 | Inf | 18.82 |
| | | **L** | -20 | -6 | 5 | Inf | 13.69 |
| | *Putamen* | **R** | 30 | -9 | -9 | Inf | 14.31 |
| | | **L** | -30 | -11 | 3 | Inf | 12.94 |
| | *Hippocampus* | **R** | 26 | -12 | -21 | Inf | 10.02 |
| | | **L** | -26 | -14 | -23 | Inf | 13.05 |
| | *Entorhinal area* | **R** | 21 | 0 | -26 | Inf | 11.54 |
| | | **L** | -21 | 0 | -23 | Inf | 7.42 |
| | *Amygdala* | **R** | 20 | -9 | -15 | Inf | 21.41 |
| | | **L** | -21 | -9 | -17 | Inf | 15.27 |
| | *Caudate nucleus* | **R** | 16.5 | 0 | 23 | Inf | 11.07 |
| | | **L** | -12 | -2 | 17 | Inf | 8.36 |
| | *Posterior insula* | **R** | 38 | -11 | 8 | Inf | 5.99 |
| | | **L** | -38 | -11 | 2 | Inf | 8.00 |
| | *Substantia nigra* | **R** | 8 | -17 | -15 | Inf | 27.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **L** | -8 | -17 | -15 | Inf | 31.05 |
| | *Red nucleus* | **R** | 6 | -23 | -18 | Inf | 16.52 |
| | | **L** | -5 | -21 | -18 | Inf | 21.63 |
| | *Periaqueductal grey* | | -2 | -35 | -17 | Inf | 10.6 |
| | | | | | | | |
| **MTsat - WM** | | | | | | | |
| | *Splenium Corpus Callosum* | | 2 | -20 | 23 | Inf | 10.58 |
| | *Cerebral Peduncle* | **R** | 11 | -15 | -17 | Inf | 18.18 |
| | | **L** | -9 | -12 | -15 | Inf | 20.68 |
| | *PLIC* | **R** | 17 | -8 | -6 | Inf | 28.39 |
| | | **L** | -17 | -11 | -6 | Inf | 25.91 |
| | *Fronto-temporal WM* | **R** | 48 | -6 | 18 | Inf | 5.79 |
| | *Pre- and post-central WM* | **L** | -24 | -29 | 35 | Inf | 11.17 |
| | | | | | | | |
| **PD* - GM** | | | | | | | |
| | *Thalamus* | **R** | 9 | -26 | 3 | Inf | 7.57 |
| | | **L** | -11 | -26 | 0 | Inf | 11.61 |
| | *Red nucleus* | **R** | 9 | -21 | -12 | Inf | 22.86 |
| | | **L** | -9 | -23 | -12 | Inf | 22.09 |
| | *Substantia nigra* | **R** | 7.5 | -18 | -15 | Inf | 14.95 |
| | | **L** | -6 | -18 | -15 | Inf | 15.23 |
| | | | | | | | |
| **R2*- GM** | | | | | | | |
| | *GP* | **R** | 21 | -6 | -8 | Inf | 21.12 |
| | | **L** | -21 | -9 | -5 | Inf | 22.9 |
| | *Putamen* | **R** | 27 | 5 | -8 | Inf | 14.26 |
| | | **L** | -27 | 3 | -8 | Inf | 13.49 |
| | *Thalamus* | **R** | 21 | -18 | -2 | Inf | 12.40 |
| | | **L** | -8 | -15 | 0 | Inf | 16.09 |
| | *Caudate* | **R** | 14 | 0 | 18 | Inf | 11.79 |
| | | **L** | -12 | 0 | 18 | Inf | 10.53 |
| | *Accumbens* | **R** | 9 | 8 | -12 | Inf | 6.06 |
| | | **L** | -12 | 6 | -12 | Inf | 9.30 |
| | *Substantia nigra* | **R** | 5 | -15 | -11 | Inf | 36.27 |
| | | **L** | -5 | -15 | -12 | Inf | 38.06 |
| | *Red nucleus* | **R** | 9 | -21 | -18 | Inf | 22.73 |
| | | **L** | -3 | -21 | -18 | Inf | 19.44 |
| | *Dentate nucleus* | **R** | 14 | -59 | -33 | 5.62 | 5.66 |
| | | **L** | -12 | -60 | -35 | 5.73 | 5.77 |
| | *Cerebellum* | **R** | -17 | -83 | -27 | 5.61 | 5.65 |
| | | **L** | 12 | -83 | -35 | 5.33 | 5.36 |
| | | | | | | | |
| **R2*- WM** | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *PLIC* | **R** | 18 | -8 | 3 | Inf | 18.95 |
| | **L** | -14 | -5 | 3 | Inf | 18.76 |
| *Cerebral peduncle* | **R** | 8 | -12 | -15 | Inf | 28.97 |
| | **L** | -9 | -12 | -15 | Inf | 26.64 |
| *Dentate Nucleus* | **R** | 12 | -60 | -36 | Inf | 8.01 |
| | **L** | -11 | -59 | -36 | Inf | 8.25 |

**Table S2** Results of the whole-brain voxel-based covariance analysis across volume and parameter maps in grey and white matter of healthy controls with seeds in the mSTN.

*Abbreviations: L – left, R – right, VBM – voxel-based morphometry, mSTN – motor region of the subthalamic nucleus, GM – Grey Matter, GP – globus pallidus, GPi – globus pallidus pars interna, GPe – globus pallidus pars externa, PLIC – posterior limb of the internal capsule, ALIC – anterior limb of the internal capsule, MT sat – magnetization transfer saturation, R2* – effective transverse relaxation rate, PD* – effective proton density, CC – corpus callosum*

**GPi seed**

| | Anatomical region | | MNI-coordinates | | | z-score | t-value |
|---|---|---|---|---|---|---|---|
| | | | x | y | z | | |
| **VBM - GM** | | | | | | | |
| | *Thalamus* | **R** | 20 | -24 | 12 | 3.72 | 4.33 |
| | | **L** | -21 | -23 | 9 | 3.76 | 4.38 |
| | *Accumbens nucleus* | **R** | 11 | 11 | -6 | Inf | 4.51 |
| | | **L** | -6 | 12 | -6 | 4.12 | 4.96 |
| | *Caudate* | **L** | -14 | 6 | 17 | Inf | 3.62 |
| **VBM - WM** | | | | | | | |
| | *PLIC* | **R** | 21 | -3 | -2 | 4.95 | 6.47 |
| | | **L** | -20 | -5 | -6 | 6.02 | 9.01 |
| **PD* - GM** | | | | | | | |
| | *Cingulate gyrus* | **R** | 5 | -15 | 45 | Inf | 4.51 |
| | | **L** | -2 | -15 | 33 | Inf | 4.29 |
| | *Calcarine cortex* | **R** | 8 | -63 | 11 | Inf | 4.48 |
| | | **L** | -15 | -63 | 8 | Inf | 4.66 |
| | *Precuneus* | **R** | 5 | -53 | 12 | Inf | 3.46 |
| | | **L** | -11 | -56 | 6 | Inf | 4.33 |
| | *Central operculum* | **R** | 41 | -18 | 14 | Inf | 4.05 |
| | | **L** | -44 | -21 | 14 | Inf | 5.51 |
| | *Posterior insula* | **R** | 41 | -8 | 0 | Inf | 3.74 |
| | | **L** | -41 | -8 | -2 | Inf | 4.73 |
| | *Anterior insula* | **R** | 39 | 10.5 | 0 | Inf | 3.86 |
| | | **L** | -5 | 0 | -2 | Inf | 4.64 |
| | *Temporal pole* | **R** | 38 | -18 | -42 | 5.02 | 6.61 |
| | | **L** | -42 | 12 | -44 | Inf | 4.71 |
| | *GPe* | **R** | 23 | -3 | -5 | Inf | 4.81 |
| | | **L** | -23 | -3 | -5 | Inf | 4.82 |
| | *Putamen* | **R** | 26 | 11 | -2 | Inf | 3.97 |
| | | **L** | -27 | 0 | -9 | Inf | 4.16 |
| | *Hippocampus* | **R** | 27 | -12 | -17 | Inf | 5.39 |
| | | **L** | -26 | -14 | -18 | Inf | 4.14 |
| | *Entorhinal area* | **R** | 29 | 2 | -18 | Inf | 4.01 |
| | | **L** | -24 | -2 | -18 | Inf | 3.98 |
| | *Accumbens* | **R** | 9 | 14 | -6 | Inf | 4.16 |
| | | **L** | -9 | 9 | -6 | Inf | 5.16 |
| | *Cerebellum anterior lobe* | **R** | 6 | -53 | -11 | Inf | 6.05 |
| | | **L** | -12 | -62 | -12 | Inf | 5.22 |
| | *Cerebellar tonsils* | **R** | 14 | -56 | -65 | Inf | 4.16 |
| | | **L** | -12 | -44 | -63 | Inf | 5.65 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **R2* - GM** | | | | | | | |
| | *GPe* | **R** | 23 | -6 | -3 | 5.69 | 8.15 |
| | | **L** | -23 | -5 | -3 | 5.66 | 8.07 |
| | *Putamen* | **R** | 24 | 3 | 2 | Inf | 5.61 |
| | | **L** | -29 | 3 | -3 | Inf | 4.42 |
| | *mSTN* | **R** | 11 | -15 | -11 | 4.56 | 5.72 |
| | | **L** | -11 | -14 | -9 | 4.61 | 5.81 |
| | *Substantia nigra* | **R** | 12 | -14 | -9 | Inf | 5.69 |
| | | **L** | -11 | -11 | -9 | Inf | 5.20 |
| | *Red nucleus* | **R** | 11 | -15 | -11 | 4.56 | 5.72 |
| | | **L** | -11 | -14 | -9 | 4.61 | 5.81 |
| | *Dentate Nucleus* | **R** | 18 | -57 | -36 | 3.74 | 4.36 |
| | | **L** | -15 | -56 | -35 | 4.40 | 5.42 |
| | | | | | | | |
| **R2* - WM** | | | | | | | |
| | *PLIC* | **R** | 15 | -2 | -3 | 6.83 | 11.61 |
| | | **L** | -14 | -2 | -5 | 6.49 | 10.45 |
| | *Cerebral peduncle* | **R** | 12 | -9 | -11 | 4.63 | 5.85 |
| | | **L** | -13.5 | -8 | -11 | Inf | 7.05 |

**Table S3** Results of the whole-brain voxel-based covariance analysis across volume and parameter maps in grey and white matter for patients with Parkinson's disease with seeds in the GPi.

*Abbreviations: L – left, R – right, VBM – voxel-based morphometry, mSTN – motor region of the subthalamic nucleus, GM – Grey Matter, GP – globus pallidus, GPi – globus pallidus pars interna, GPe – globus pallidus pars externa, PLIC – posterior limb of the internal capsule, ALIC – anterior limb of the internal capsule, MT sat – magnetization transfer saturation, R2* – effective transverse relaxation rate, PD* – effective proton density, CC – corpus callosum*

**mSTN seeds**

| | Anatomical region | | MNI-coordinates | | | z-score | t-value |
|---|---|---|---|---|---|---|---|
| | | | x | y | z | | |
| **VBM - GM** | | | | | | | |
| | *Thalamus* | **R** | 6 | -9 | -15 | 4.06 | 4.86 |
| | | **L** | -15 | -23 | 5 | Inf | 5.90 |
| | *Caudate* | **R** | 11 | 11 | 20 | 3.22 | 3.61 |
| | | **L** | -11 | 3 | 20 | 3.57 | 4.11 |
| | *Hippocampus* | **R** | -26 | -45 | -5 | 3.18 | 3.56 |
| | *Accumbens* | **R** | 8 | 9 | -6 | Inf | 4.17 |
| | | **L** | -8 | 6 | -9 | Inf | 5.13 |
| **VBM - WM** | | | | | | | |
| | *PLIC* | **R** | 18 | -12 | -3 | 5.70 | 8.17 |
| | | **L** | -15 | -17 | -2 | 5.32 | 7.26 |
| | *ALIC* | **L** | -21 | 11 | 6 | 4.88 | 6.32 |
| **MTsat - GM** | | | | | | | |
| | *Planum temporale* | **R** | 57 | -20 | 11 | 4.24 | 5.15 |
| | *Posterior insula* | **R** | 39 | -17 | 11 | 3.79 | 4.43 |
| | | **L** | -44 | -11 | -3 | 3.59 | 4.14 |
| | *Parietal operculum* | **L** | -53 | -24 | 12 | 3.68 | 4.26 |
| | *Thalamus* | **R** | 9 | -20 | 11 | Inf | 3.61 |
| | | **L** | -12 | -15 | 11 | Inf | 4.04 |
| | *Caudate* | **R** | 17 | 2 | 17 | Inf | 3.64 |
| | | **L** | -12 | 6 | 17 | Inf | 3.81 |
| | *Hippocampus* | **L** | -36 | -15 | -15 | 4.31 | 5.28 |
| | *Parahippocampal gyrus* | **L** | -14 | -11 | -21 | Inf | 3.58 |
| | *Periaqueductal grey* | | -2 | -36 | -11 | Inf | 4.40 |
| **PD* - GM** | | | | | | | |
| | *Caudate* | **R** | 14 | 6 | 15 | Inf | 4.43 |
| | | **L** | -17 | 11 | 18 | Inf | 4.71 |
| | *Central operculum* | **R** | 51 | -18 | 14 | Inf | 4.88 |
| | | **L** | -45 | -17 | 12 | 4.45 | 5.54 |
| | *Posterior insula* | **R** | 41 | -3 | -5 | Inf | 3.72 |
| | | **L** | -39 | -15 | 12 | Inf | 4.09 |
| | *Anterior insula* | **R** | 45 | 9 | -4.5 | Inf | 5.01 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **L** | -44 | 14 | -8 | 3.82 | 4.48 |
| | *Temporal pole* | **R** | 38 | 17 | -44 | 4.22 | 5.12 |
| | | **L** | -30 | 15 | -47 | 4.36 | 5.36 |
| | *Hippocampus* | **R** | 15 | -11 | -20 | Inf | 3.87 |
| | | **L** | -18 | 11 | -23 | Inf | 3.68 |
| | *Entorhinal area* | **R** | 18 | -3 | -35 | Inf | 3.77 |
| | | **L** | -15 | -2 | -39 | 4.53 | 5.66 |
| | *Accumbens* | **R** | 8 | 12 | -2 | 5.08 | 6.74 |
| | | **L** | -5 | 14 | -3 | 5.61 | 7.94 |
| | *Transverse temporal gyrus* | **R** | 48 | -12 | 8 | Inf | 4.26 |
| | | **L** | -50 | -21 | 12 | 4.46 | 5.54 |
| | *Lingual gyrus* | **R** | 27 | -44 | -6 | 4.84 | 6.25 |
| | | **L** | -29 | -53 | -6 | 4.91 | 6.38 |
| | *Thalamus* | **R** | 23 | -32 | 3 | 5.14 | 6.88 |
| | | **L** | -17 | -33 | 5 | 5.35 | 7.33 |
| | *Cerebellum anterior lobe* | | 0 | -53 | -6 | 4.80 | 6.16 |
| | *Cerebellar tonsils* | **R** | 6 | -56 | -59 | 4.80 | 6.18 |
| | | **L** | -5 | -57 | -63 | 5.27 | 7.15 |
| | | | | | | | |
| **R2* - GM** | | | | | | | |
| | *GP* | **R** | 14 | -3 | -6 | 4.31 | 5.27 |
| | | **L** | -17 | -9 | -8 | 4.68 | 5.95 |
| | *Thalamus* | **R** | 0 | -8 | 9 | 3.88 | 4.57 |
| | *Caudate* | **R** | 21 | 9 | 21 | 3.68 | 4.27 |
| | | **L** | -15 | -12 | 23 | Inf | 3.62 |
| | *Substantia nigra* | **R** | 8 | -14 | -15 | 6.25 | 9.68 |
| | | **L** | -6 | -14 | -15 | 6.09 | 9.21 |
| | *Red nucleus* | **R** | 6 | -18 | -9 | 6.20 | 9.54 |
| | | **L** | -5 | -18 | -9 | 5.92 | 8.75 |
| | | | | | | | |
| **R2* - WM** | | | | | | | |
| | *PLIC* | **R** | 12 | 2 | 3 | Inf | 5.56 |
| | | **L** | -12 | -5 | -3 | Inf | 4.46 |
| | *Cerebral peduncle* | **R** | 11 | -14 | -8 | 6.02 | 9.03 |
| | | **L** | -9 | -12 | -8 | 6.06 | 9.13 |

**Table S4** Results of the whole-brain voxel-based covariance analysis across volume and parameter maps in grey and white matter for patients with Parkinson's disease with seeds in the mSTN.

*Abbreviations: L – left, R – right, VBM – voxel-based morphometry, mSTN – motor region of the subthalamic nucleus, GM – Grey Matter, GP – globus pallidus, GPi – globus pallidus pars interna, GPe – globus pallidus pars externa, PLIC – posterior limb of the internal capsule, ALIC – anterior limb of the internal capsule, MT sat – magnetization transfer saturation, R2* – effective transverse relaxation rate, PD* – effective proton density, CC – corpus callosum*