

## Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Research policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

### Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

- |     |           |
|-----|-----------|
| n/a | Confirmed |
|-----|-----------|
- The exact sample size ( $n$ ) for each experimental group/condition, given as a discrete number and unit of measurement
  - A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
  - The statistical test(s) used AND whether they are one- or two-sided  
*Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
  - A description of all covariates tested
  - A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
  - A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
  - For null hypothesis testing, the test statistic (e.g.  $F$ ,  $t$ ,  $r$ ) with confidence intervals, effect sizes, degrees of freedom and  $P$  value noted  
*Give  $P$  values as exact values whenever suitable.*
  - For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
  - For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
  - Estimates of effect sizes (e.g. Cohen's  $d$ , Pearson's  $r$ ), indicating how they were calculated

*Our web collection on [statistics for biologists](#) contains articles on many of the points above.*

### Software and code

Policy information about [availability of computer code](#)

- |                 |  |
|-----------------|--|
| Data collection | Data used in this study were obtained from the Parkinson's Progression Markers Initiative (PPMI) database ( <a href="https://www.ppmi-info.org">https://www.ppmi-info.org</a> ), accessed in March of 2018.  |
| Data analysis   | All code used for data processing, analysis, and figure generation is available on GitHub ( <a href="https://github.com/netneurolab/markello_ppmisnf">https://github.com/netneurolab/markello_ppmisnf</a> ). Analyses were conducted in Python 3.6.7; the exact computing environment used to perform all analyses is packaged into a Singularity container, available on OSF ( <a href="https://osf.io/h6jwx/">https://osf.io/h6jwx/</a> ). |

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research [guidelines for submitting code & software](#) for further information.

### Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

Data used in this study were obtained from the Parkinson's Progression Markers Initiative (PPMI) database (<https://www.ppmi-info.org>), accessed in March of 2018. Processed data used in the reported analyses are available on GitHub via [https://github.com/netneurolab/markello\\_ppmisnf](https://github.com/netneurolab/markello_ppmisnf) or via Zenodo at <https://doi.org/10.5281/zenodo.3731252>.

## Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

Life sciences       Behavioural & social sciences       Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](https://www.nature.com/documents/nr-reporting-summary-flat.pdf)

## Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	No sample size calculations were performed for the current analysis as we relied on the one-of-a-kind, open-access PPMI database. The 273 subjects (87 healthy controls and 186 patients with Parkinson's disease) were those who met inclusion criteria (see below).
Data exclusions	Refer to <a href="https://www.ppmi-info.org/study-design/research-documents-and-sops/">https://www.ppmi-info.org/study-design/research-documents-and-sops/</a> for documentation regarding exclusion criteria for subject enrollment. Subjects were excluded from data analysis if they (1) did not have at least one T1-weighted MRI scan or (2) were missing >20% of features from any data modality.
Replication	Analyses were not replicated as the authors are unaware of other Parkinson's disease datasets that contain all modalities of data collected by the PPMI for a similarly-sized (or larger) cohort (i.e., structural MRI, dopamine active transporter scans, biospecimen assays from cerebrospinal fluid, and broad clinical-behavioral assessments).
Randomization	Patients were allocated into experimental groups based on PD diagnosis made during study enrollment. Refer to <a href="https://www.ppmi-info.org/study-design/research-documents-and-sops/">https://www.ppmi-info.org/study-design/research-documents-and-sops/</a> for documentation describing diagnostic procedures.
Blinding	Investigators were not blind to experimental group as the analyses were focused solely on one of the groups (i.e., PD patients).

## Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

### Materials & experimental systems

n/a	Included in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> Antibodies
<input checked="" type="checkbox"/>	<input type="checkbox"/> Eukaryotic cell lines
<input checked="" type="checkbox"/>	<input type="checkbox"/> Palaeontology and archaeology
<input checked="" type="checkbox"/>	<input type="checkbox"/> Animals and other organisms
<input type="checkbox"/>	<input checked="" type="checkbox"/> Human research participants
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Dual use research of concern

### Methods

n/a	Included in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> ChIP-seq
<input checked="" type="checkbox"/>	<input type="checkbox"/> Flow cytometry
<input type="checkbox"/>	<input checked="" type="checkbox"/> MRI-based neuroimaging

## Human research participants

Policy information about [studies involving human research participants](#)

Population characteristics	Healthy individuals with no history of neurological illness (n = 87; ages 30-83, 32F/55M) and individuals diagnosed with Parkinson's disease (n = 186; ages 36-82, 78F/108M).
Recruitment	Refer to <a href="https://www.ppmi-info.org/study-design/research-documents-and-sops/">https://www.ppmi-info.org/study-design/research-documents-and-sops/</a> for documentation describing recruitment of subjects for the PPMI.
Ethics oversight	Central ethics oversight for the PPMI was provided by UCSF and additional oversight by individual research sites participating in the PPMI.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

## Magnetic resonance imaging

### Experimental design

Design type	No task was run during scanning as all MRI scans used were structural images.
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Design specifications

Behavioral performance measures

## Acquisition

Imaging type(s)

Field strength

Sequence & imaging parameters https://www.ppmi-info.org/."/>

Area of acquisition

Diffusion MRI  Used  Not used

## Preprocessing

Preprocessing software

Normalization

Normalization template

Noise and artifact removal

Volume censoring

## Statistical modeling & inference

Model type and settings

Effect(s) tested

Specify type of analysis:  Whole brain  ROI-based  Both

Anatomical location(s)

Statistic type for inference (See [Eklund et al. 2016](#))

Correction

## Models & analysis

n/a  Involved in the study

Functional and/or effective connectivity

Graph analysis

Multivariate modeling or predictive analysis

Multivariate modeling and predictive analysis