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Corresponding author(s): Rob Wykes, Anton Guimera and Jose A. Garrido

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Reporting Summary

Nature Portfolio 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 Portfolio 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	Python 3.7 packages (Matplotlib 3.2.0, Numpy 1.17.4) and the following python library were used for electric characterization of the gSGFET arrays: https://github.com/aguimera/PyGFET. A custom simulink model was used for graphene microtransistor electrophysiological data acquisition, please contact g.tec medical engineering GmbH for code access.
Data analysis	All electrophysiological data were analysed using Python 3.7 packages (Matplotlib 3.2.0, Numpy 1.17.4, Pandas 0.25.3, seaborn 0.9.0, Neo 0.8.0, and Elephant 0.6.2) and the custom library PhyREC (https://github.com/aguimera/PhyREC/tree/PhyREC4). Custom scripts can be found at Zenodo link []. Immunohistochemical data analysis was performed using Python3.7 script (github.com/kebarr/biocompatibility_study).

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 Portfolio 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 description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All relevant data obtained to evaluate the main findings of the paper are openly available in [repository name] at http://doi.org/[doi], reference number [xxxxx]. All other raw data are available from the corresponding author upon reasonable request.

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

Life sciences study design

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

Sample size	Six wild-type adult male C57BL mice and four WAG-Rij rats were used in this study. No sample-size calculation was performed. Sample size was sufficient for proof-of-concept of gDNP technology. For the biocompatibility (histology and ELISA) studies where some prior knowledge about variability was available, we performed a power calculation indicating that groups of 3-4 animals at each time point would be required to sufficiently power these sets of experiments. For histological staining, all data sets are n=3, with the exception of 2-week graphene, which is n=4, and 12 weeks Neuronexus probes which are n=2, due to an inability to locate the probe location in histological sections for one animal implanted. For ELISA testing, gDNP with and without graphene hemisphere data sets are n=3 or 4 at all timepoints, while contralateral hemispheres were combined, giving n=7.
Data exclusions	Where statistical values are reported, no data was excluded. The exact sample size and whether data is obtained from the same or multiple subjects is mentioned in the text. Otherwise, data was selected for illustrative purposes of gDNPcapabilities.
Replication	All findings were replicated (see sample size), and the results reproducible. For histological staining, all data sets are n=3, with the exception of 2-week graphene, which is n=4, and 12 weeks Neuronexus probes which are n=2, due to an inability to locate the probe location in histological sections for one animal implanted. For ELISA testing, gDNP with and without graphene hemisphere data sets are n=3 or 4 at all timepoints, while contralateral hemispheres were combined, giving n=7. Electrophysiological signals recorded were very comparable across experimental units (animals), and transistors
Randomization	Randomization is not rellevant in our study since no conclusion is based on subject-dependent effects.
Blinding	All post-hoc biocompatibility analysis was performed by a researcher blind to the experimental condition. Electrophysiology data analysis did not require blinding as all animals were treated in the same way.

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	Involved in the study
☐	☒ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☐	☒ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Antibodies

Antibodies used	1. Rabbit anti-Iba1 (1:1000, Wako 019-19741). 2. Chicken anti-GFAP (1:2000, Abcam ab4674). Secondary antibodies: 1.Anti-rabbit Alexa Fluor (AF) 560 2. Anti-chicken AF647 (all 1:500, Thermofisher).
Validation	Iba-1 (Wako 019-19741): IHC in rats is included https://labchem-wako.fujifilm.com/us/product_data/docs/00055446_doc02.pdf GFAP (Abcam ab4674): IHC in rats is included https://www.abcam.com/gfap-antibody-ab4674.html

Animals and other organisms

Policy information about studies involving animals; ARRIVE guidelines recommended for reporting animal research

Laboratory animals	C57BL/ mice were bred (2–4-month-old males), while WAG rats were imported (Charles river, used 6-9 month-old males). Animals were housed on 12 h/12 h dark/light cycle, and food and water were given ad libitum. Humidity was kept within 45% to 65% and temperature between 20^{o}C to 24^{o}C degrees. Prior to headbar surgery, animals were group housed, but after this, animals were individually housed. For the biocompatibility studies, adult male 6-8 weeks age Sprague-Dawley rats (230-280g) were used for this study (Charles River, England).
Wild animals	No wild animals were used in this study.
Field-collected samples	No field-collected samples were used in this study.
Ethics oversight	Electrophysiological recording experiments were conducted in accordance with the United Kingdom Animal (Scientific Procedures) Act 1986 and approved by the Animals in Scientific Research Unit at the Home Office (license PPL70-13691). Biocompatibility experimental procedures were conducted in compliance with the Animal welfare act, with approval of the Home Office and local animal welfare ethical review body (AWERB), license P089E2E0A.

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