

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

Blackrock Research Central Software Suite 7.04 was used to acquire electrophysiology data, available at <https://blackrockneurotech.com/research/support/software/>. Leica Application Suite X software platform 3.5.5 was used to acquire fluorescence images. EC-Lab V11.36 was used with a SP-150e single channel potentiostat from BioLogic for electrochemical impedance spectrums acquisition.

Data analysis

MountainSort 4: <https://github.com/flatironinstitute/mountainsort>
 DropSnake: <https://bigwww.epfl.ch/demo/dropanalysis/>
 Deeplabcut: <http://www.mackenziemathislab.org/deeplabcut>
 GraphPad Prism 9: <https://www.graphpad.com/>
 Matlab R2022b: <https://www.mathworks.com/products/matlab.html>
 Wolfram Mathematica: <https://www.wolfram.com/mathematica/>
 Abaqus 6.12: <https://www.3ds.com/products-services/simulia/products/abaqus/>

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](#)

Data and materials availability: All data and materials supporting the findings of this study are available within the paper and its Supplementary Information. The raw datasets generated during the study are provided within the source data. Source data are available for Figs. 1-5, Extended Data Figs. 3-8 and 10. Source data are provided within this paper.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

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

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	Sample sizes were estimated based on previous studies. [Yang, X. et al. Bioinspired neuron-like electronics. Nat. Mater. 18, 510-517 (2019).]
Data exclusions	Animals with surgical complications and that displayed health concerns during the post-surgery monitoring period were excluded based on pre-established criteria.
Replication	All the experiments were replicated. The number of repetitions for each experiment has been indicated in the manuscript. Attempts at replication were successful and the conclusion were drawn from the analysis of multiple experiments.
Randomization	Mice were randomized into different groups
Blinding	Investigators were blinded to data collection and analyses of fluorescence images. Blinding was not relevant to this long-term electrophysiological recording because the animals were not divided into control and experimental groups.

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

Methods

n/a	Involved in the study
☐	☒ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☐	☒ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

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

Antibodies

Antibodies used

Primary antibodies:

Chicken anti-glial fibrillary protein GFAP (Abcam, Catalog #ab4674, Lot #GR3281175-3)
 Goat anti-ionized calcium binding adaptor molecule 1 (Iba1) (Abcam, Catalog #ab5076, Lot #GR63420-3)
 Rabbit anti-neuronal nuclear NeuN (Abcam, Catalog #ab177487, Lot #GR3250076-7)
 GFAP (GA5) Mouse mAb (Cell Signaling Technology, #3670)
 Iba1/AlF-1 (E4O4W) XP® Rabbit mAb (Cell Signaling Technology, #17198)
 All primary antibodies were diluted 1:100-1:200

Secondary antibodies:

Alexa Fluor 647 donkey anti-chicken (Jackson ImmunoResearch, Catalog #a703605133, Lot #GR144948)
 Alexa Fluor 647 goat anti-mouse (Invitrogen, Catalog#A21236)
 Alexa Fluor 594 donkey anti-goat (Invitrogen, Catalog #A32758, Lot #TI271731)
 Alexa Fluor 555 goat anti-rabbit (Invitrogen, Catalog#A21429)
 Alexa Fluor 488 donkey anti-rabbit (Invitrogen, Catalog #A21206, Lot #2045215)
 All secondary antibodies were diluted 1:500

Validation

Validation statement on the manufacturer's website and citations such as <https://www.abcam.com/gfap-antibody-ab4674.html>, <https://www.abcam.com/neun-antibody-epr12763-neuronal-marker-ab177487.html>, <https://www.citeab.com/antibodies/2401269-a-21236-goat-anti-mouse-igg-h-l-highly-cross-adsor>.
 Yang, X. et al. Bioinspired neuron-like electronics. Nat. Mater. 18, 510-517 (2019).

Animals and other research organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research, and [Sex and Gender in Research](#)

Laboratory animals

C57BJ/6 mice (25–35g; 6–8 weeks of age). Mice were housed at a temperature is 22 ± 1 degree Celsius and humidity is 30-70%.

Wild animals

The study did not involve wild animals.

Reporting on sex

Sex was not consider in this work

Field-collected samples

The study did not involve samples collected from the field.

Ethics oversight

All procedures were approved by the Animal Care and Use Committee of Harvard University under protocols 19-03-348 and 20-05-368 .

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