

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 LAS X for Leica confocal microscope
Prairie View for Bruker two-photon microscope

Data analysis ImageJ/Fiji for image visualization and analysis
MATLAB for data analysis

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

The mouse lines described in this protocol can be obtained from JAX and the rest upon request from the developer (see Materials - Animals). All the images presented in the figures are derived from raw data with minor contrast modifications. For the calcium time lapse imaging the raw movies can be obtained from supplementary data in (Hill et al. 2015). All data is available upon 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](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	Described in the figure legend
Data exclusions	No data has been excluded
Replication	Described in the figure legend
Randomization	N/A
Blinding	N/A

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
<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 type="checkbox"/>	<input checked="" type="checkbox"/> Animals and other organisms
<input checked="" type="checkbox"/>	<input 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	Involved in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> ChIP-seq
<input checked="" type="checkbox"/>	<input type="checkbox"/> Flow cytometry
<input checked="" type="checkbox"/>	<input type="checkbox"/> MRI-based neuroimaging

Animals and other organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research

Laboratory animals	<ul style="list-style-type: none"> • Transgenic mice that express the Cre recombinase under the mural cell NG2 (Cspg4) promoter, NG2-Cre (JAX# 008533). • BAC transgenic mice that express a tamoxifen inducible Cre recombinase under the NG2 (Cspg4) promoter, NG2-CreERTM (JAX# 008538). • Transgenic mice that express the Cre recombinase under the mural cell PDGFRβ promoter, PDGFRβ-Cre (Courtesy of Dr. Volkhard Lindner, Maine Medical Center Research Institute, Maine) (Cuttler et al., 2011)40. Alternative mice: PDGFRβ-P2A-CreERT2 (JAX# 030201). • Transgenic mice that express mCherry under the Acta2 promoter, αSMA-mCherry (Courtesy of Dr. Karen Hirschi, Yale University; Armstrong et al., 2010)37. Alternative mice: SMMHC-CreERT2 (JAX#019079). • Floxed GFP mice, Z/EG (JAX# 003920) • Floxed stochastic multicolor labeling mice, R26R-Confetti (JAX# 017492) • Alzheimer's-like mice 5xFAD (JAX#006554). • Floxed GCaMP6f calcium-sensor expressing mice, Ai95(RCL-GCaMP6f)-D (JAX# 028865). • Floxed Channelrhodopsin-2/EYFP mice, Ai32(RCL-ChR2(H134R)/EYFP) (recommended strain JAX# 024109). • Floxed Archaelrhodopsin-3/EGFP mice, Ai40(RCL-ArchT/EGFP)-D (JAX# 021188).
Wild animals	N/A
Field-collected samples	N/A
Ethics oversight	All Procedures using rodents in this protocol were approved by the Yale University IACUC

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