

## 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 | The LSM700 laser-scanning confocal microscope and the AXIO IMAGER Z1 microscope were used for histochemistry image collection; the Tecan Microtiter plate reader was used for measuring serum cytokines' and catecholamines' concentrations; amplifier (BMA-400 amplifier, CWE) and digitizer (Micro3 1401; CED) were used for vagal efferent nerve discharge data collection; Axon 700B amplifier (Molecular Devices, Sunnyvale, CA, USA) and digidata (1440A) were used for whole-cell DRG recording data collection; the Docris Neuroscience Studio (4.1.5.2) and custom codes written in Bonsai (2.3.1) and Arduino (1.8.7) software were used for optical stimulation. |
| Data analysis   | SigmaStat 3.5 and Graph Pad Prism 7 were used for statistical analysis; Adobe Photoshop (CS6) and Image J (2.0.0-rc-69/1.52p) were used for image processing; Spike 2 (v8.08; CED) was used for vagal recording data analysis; Clampex 10.4 and Clampfit 10 were used for whole-cell electrophysiological recording 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

All data is included in the manuscript and available from the corresponding author on 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](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 statistical methods were used to predetermine sample sizes. Sample sizes were based on previous studies from our lab and others (Liu et al., Neuron, 2020, PMID: 32791039; Torres-Rosas et al., Nat Med, 2014, PMID: 24562381).                                                                                                                                                                                                         |
| Data exclusions | No data exclusions                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Replication     | Experiments were performed with multiple animals. All attempts at replication were successful in terms of qualitative histochemical analyses. For quantitative analyses, the numbers of biological replications used for statistical analyses (in terms of the number of animals used for every experiment) are described in the figure legends, and for each experimental group, mice were derived from at least two independent litters. |
| Randomization   | The animals were littermates and randomly assigned to the experimental group and control group.                                                                                                                                                                                                                                                                                                                                            |
| Blinding        | Experimenters were blinded to genotypes for animal survival analyses and for quantitative histochemical analyses. The levels of cytokines and catecholamines were measured by machines; as such, blinding was not relevant.                                                                                                                                                                                                                |

## 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 type="checkbox"/>            | <input checked="" 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 |

## Antibodies

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Antibodies used | Rabbit anti-Tuj1 (1:1000, ab52623, Abcam), rabbit anti-c-Fos (1:500, ABE457, Millipore), goat anti-ChAT (1:500, AB144P, Millipore), rabbit anti-GFP (1:500, A11122, Invitrogen), chicken anti-GFP (1:500, A10262, Invitrogen), rat anti-TRKA (1:200, AF1056, R&D), chicken anti-NF200 (1:500, NFH, Aves labs), rabbit anti-CGRP (1:1000, Millipore, PC205, 1:1000), rabbit anti-PV (1:1000, PV 27, swant), Alexa Fluor 488 conjugated IB4 (1:500, I21411, Invitrogen), rabbit anti-S100 (1:500, Sigma, SAB4502708), goat anti-mCherry (1:500, AB0040-200, Acris), Alexa Fluor 405, 488, 594 donkey anti-goat, rabbit, rat, chicken IgG (1:500; 711-545-152, 705-585-003, 705-545-003, 705-475-147, 711-585-152 and 712-476-150; Jackson ImmunoResearch)                                                                                                                                                                                                                                                                                                             |
| Validation      | For rabbit anti-Tuj1, see Zeng et al. Nature. 2019 May;569(7755):229-235;<br>for rabbit anti-c-Fos, see Wang et al., Pharmacol Biochem Behav. 2015;135:31-9 and Liu et al. Neuron. 2020 Nov 11;108(3):436-450;<br>for goat anti-ChAT, see Liu et al. Neuron. 2020 Nov 11;108(3):436-450;<br>for rabbit anti-GFP, chicken anti-GFP and chicken anti-NF200, see Li et al. Cell. 2011 Dec 23;147(7):1615-27;<br>for rat anti-TRKA and Alexa Fluor 488 conjugated IB4, see Arcourt et al. Neuron. 2017 Jan 4;93(1):179-193;<br>for rabbit anti-CGRP, see Yang et al., Neuropharmacology. 2017, 125:284-294;<br>for rabbit anti-PV, see Yeong et al. Nature. 2017 Sep 28;549(7673):482-487;<br>for rabbit anti-S100, validated by manufacturer ( <a href="https://www.sigmaaldrich.com/US/en/product/sigma/sab4502708">https://www.sigmaaldrich.com/US/en/product/sigma/sab4502708</a> );<br>for goat anti-mCherry, see Abaira et al., Cell, 2017.<br>All secondary antibodies used in this study have been commercial validated and widely used/validated by the field. |

## Animals and other organisms

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

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Laboratory animals      | Mice were handled and housed accordance with the ptotocols approved by the Institutional Animal Care and Use Committee at Dana-Farber Cancer Institute and followed NIH guidelines. Mice were kept in a temperature- and humidity-controlled room with a 12-hour light/dark cycle and had ad libitum access to standard laboratory mouse pellet food and water. The Prokr2Cre transgenic mouse line was generated by the Gene Expression Nervous System Atlas (GENSAT) project <sup>31</sup> and acquired from MMRRRC, University of California, Davis (MMRRRC_034700-UCD). C57BL/6J male mice (000664), Rosa26-loxp-stop-loxp-frt-stop-frt-tdTomato mice (Ai65, 021875), Rosa26-loxp-stop-loxp-tdTomato reporter mice (Ai14, 007908), and Rosa26-loxp-stop-loxp-frt-stop-frt-CatCh-EYFP mice (RC::FL-CatCh, 025109) were acquired from the Jackson Laboratory (JAX). The AdvillinFlpo mice were acquired from the David D. Ginty lab. Tau-loxp-stop-loxp-frt-stop-frt-DTR mice were acquired from the Martyn Goulding group. |
| Wild animals            | This study did not involve wild animals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Field-collected samples | Study did not involve field-collected samples.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Ethics oversight        | All animal experiments were performed with protocols approved by the Institutional Animal Care and Use Committee at Dana-Farber Cancer Institute and followed NIH guidelines.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

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