

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

RZ5P (Tucker-Davis Technology) processor running Synapse software (Tucker-Davis Technology) was used to collect fiber photometry data. Freezing behaviors with patchcord attachment were analyzed using Adobe Premiere Pro software. Freezing behaviors without patchcord attachment were analyzed using Freeze frame 3. Images were taken at 405 nm, 488 nm, and 561 nm using a Nikon C2 laser scanning confocal microscope.

Data analysis

GraphPad Prism 10, Freeze frame 3, Adobe Premiere Pro

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 data generated or analyzed during this study are included in this published article (and its supplementary information files). Source data are provided with 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	-
Reporting on race, ethnicity, or other socially relevant groupings	-
Population characteristics	-
Recruitment	-
Ethics oversight	-

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	Power analysis was performed to confirm adequate sample size.
Data exclusions	All the mice that had viral expression in the region of interest were included in the data. Mice that had no viral expression or misplaced optical fibers due to a mistake in surgery were excluded from the data.
Replication	To ensure that experimental findings can be easily reproduced, we included detailed methods and sources of all reagents and protocols for the experiments included in the manuscript. All behavioral experiments were repeated with the number of mice specified in the manuscript. Individual data points and error bars were presented in the figures. All histological and microscopic analysis were repeated with at least 5-8 mice. Exact sample sizes are provided in the figure legends.
Randomization	All subjects were randomly assigned to groups.
Blinding	Investigators were blinded to group allocation during data acquisition and analysis.

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
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

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

Antibodies

Antibodies used	Primary antibodies: anti-TH (mouse monoclonal, Sigma-Aldrich, MAB314, 1:2000 dilution), c-Fos (rabbit polyclonal, Synaptic Systems, sysy226008, 1:3000 dilution) Secondary antibodies: Alexa 647-conjugated donkey anti-mouse IgG (Jackson immunoresearch, 1:1000 dilution), Alexa 647-conjugated donkey anti-rabbit IgG (Jackson immunoresearch, 1:1000 dilution)
Validation	The specificity of the primary antibodies was validated by the manufacturer for IHC applications in mouse tissue and/or by previous work. mouse monoclonal anti-TH (MAB314, Sigma-Aldrich): https://www.merckmillipore.com/KR/ko/product/Anti-Tyrosine-Hydroxylase-Antibody-clone-LNC1,MM_NF-MAB318?ReferrerURL=https%3A%2F%2Fwww.google.com%2F&bd=1 rabbit c-Fos (sysy226008, Synaptic Systems): https://www.sysy.com/product/226008 secondary Alexa 647-conjugated donkey anti-mouse IgG (Jackson immunoresearch) : https://www.jacksonimmuno.com/catalog/products/715-607-003

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	Mice had free access to food and water and were maintained under a 12-hour light/dark cycle at 20–26°C with 40–60% humidity, with the light cycle beginning at 08:00 AM. All mice were housed 2-5 animals per cage and were maintained in a controlled vivarium under a 12/12-hour light/dark cycle (light on: 08:00 AM, light off: 08:00 PM). All protocols for animal experiments were approved by the Institutional Animal Care and Use Committee (IACUC) of the Institute of Basic Science (Daejeon, Korea). The THCre/+(Strain #008601) and C57Bl/6J (Strain #000664) mouse lines were obtained from the Jackson laboratory.
Wild animals	This study did not involve wild animals
Reporting on sex	Only male mice were used in all studies.
Field-collected samples	This study did not involve samples collected from the field.
Ethics oversight	All protocols for animal experiments were approved by the Institutional Animal Care and Use Committee (IACUC) of the Institute of Basic Science (Daejeon, Korea).

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

Plants

Seed stocks	-
Novel plant genotypes	-
Authentication	-