

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 (<i>n</i>) 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
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☐ | ☒ 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ 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 <i>d</i> , Pearson's <i>r</i>), 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	Miniscope imgaing data was collected by an open source DAQ software(https://github.com/Aharoni-Lab/Miniscope-DAQ-QT-Software). Fiber photometry recording data was collected by an commercial software ThinkerTechFiberPhotometry(Thinker Tech Nanjing Bioscience Inc.)
Data analysis	Statistical analysis was conducted using GraphPad Prism(v10.6), MATLAB (R2018a, MathWorks), and Python (v3.5.6). All thermal images were read and processed using AnalyzIR software (AnalyzeIR_Venus 6.1.12, Fortric, Shanghai). The software used for miniscope imaging data analysis is open source and available on GitHub (https://github.com/etterguillaume/MiniscopeAnalysis , https://github.com/zhoup/CNMF_E , and https://github.com/flatironinstitute/NoRMCorre).

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](#)

Source data are provided for all figures. Additional data relating to the paper are available upon reasonable request to the corresponding author.

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

The sample size was based on the variation of the measure, and the requirement for statistical tests.

Data exclusions

For any data excluded from the analysis, exclusion criteria were clearly stated in the methods.

Replication

All results in this study, including behavioral testing, calcium imaging recording, and chemogenetic experiments, were replicated in multiple animals, independently.

Randomization

The genotype and age of animal was clearly stated in the methods.

Blinding

Experiments and data analysis were not double-blind and were performed by different experimenters using the same standards and methods.

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

1. Rabbit anti-c-fos (1:500; Cell Signaling Technology, Catalog # 2250s)
2. Alexa Fluor 555 goat anti-rabbit IgG (1:1000; Abcam, Catalog # ab150078)

Validation

The specificity and application of all the antibodies are validated by companies.
 Rabbit anti-c-fos (Cell Signaling Technology, Catalog # 2250s)
 Validation for IF- <https://www.cellsignal.cn/products/primary-antibodies/c-fos-9f6-rabbit-mab/2250>
 Alexa Fluor 555 goat anti-rabbit IgG (Abcam, Catalog # ab150078)
 Validation for IF- <https://www.abcam.cn/Goat-Rabbit-IgG-HL-Alexa-Fluor-555-ab150078.html>

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

Male chow-fed C57BL/6J, diet-induced obese (DIO) (SPF Biotechnology, Beijing, China), and transgenic Fos2A-iCreER (TRAP, JAX# Stock No. 030323), TIGRE2-jGCaMP8m (JAX# Stock No. 037718), vGluT2-ires-Cre (JAX# Stock No. 016963), ChAT-Cre (JAX# Stock No. 006410), Ai14 (JAX# Stock No. 007914) mice were used in this study. All transgenic mice were backcrossed to C57BL/6J to generate a breeding colony. All DIO mice were maintained on a high-fat diet (consisting of 60% fat) for 16- weeks, with free access to food and water before randomization by weight and stereotaxic surgery. Animals were housed under a 12 h light–dark cycle, with food and water available ad libitum. The housing facility had a temperature of 21–23°C and a humidity of 40–60%.

Wild animals

No wild animals were used in this study.

Reporting on sex

Only male mice were used in this study.

Field-collected samples

No field-collected samples were used in this study.

Ethics oversight

All experimental procedures were approved by the Animal Care and Use Committee at the Southern Medical University.

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

Plants

Seed stocks

N.A.

Novel plant genotypes

N.A.

Authentication

N.A.