

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

Fiber photometry: commercialized software from Biolink Optics Technology
Whole cell recording: commercialized software Clampex 10.2 from Molecular Devices
Single unit recording: commercialized software, NeuroPhys Acquisition System from Neurosys2.8.0.8, USA and NeuroLego System from Jiangsu Brain Medical Technology Co.ltd
Behavior data: EthoVision XT

Data analysis

MatLab 2009a
MatLab 2014b
MClust 4.4
ImageJ 1.48
GraphPad Prism 7
EthoVision XT
Custom code to analyze fiber photometry and single unit recording data which is available upon request
<https://github.com/xulab2022/AHN>

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 with this paper and publicly available at <https://github.com/xulab2022/AHN> and <http://atlas.brain-map.org/>

Human research participants

Policy information about [studies involving human research participants and Sex and Gender in Research](#).

Reporting on sex and gender	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	No sample size calculation was performed. The sample size were similar to those reported in previous publications, PubMed 34980925, PubMed 27641503 and PubMed 29397273.
Data exclusions	Mice that were mis-hits for viral injection or optic fiber placement were excluded from further analysis unless noted in the text.
Replication	All attempts at replication were successful. Experiments and data analysis were done by different experimenters blindly. And all data related behavior were collected from more than one batch mice. And all the histological experiments and images were collected from at least 3 mice, except for 2 mice in fig 4c fox urine-object group and at least two batches except for verification of Vgat-IRES-Cre mouse line, the ratios of vgat+ and vglut2+ neurons in AHN and c-fos staining in fig 4a-c.
Randomization	All animal were randomly assigned to different groups
Blinding	The investigators were blinded to group allocation during data collection and analysis in fiber photometry and optogenetic experiments. WT mice tested in OF+Object (fig 1a), OF (fig 1b) and in c-fos staining (fig 4a-c) were only analyzed blindly, because group allocation was clear during data collection.

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	Included 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"/> Clinical data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Dual use research of concern

Methods

n/a	Included 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	<p>Chicken anti-GFP: Abcam, Cat# ab13970, dilution 1:300</p> <p>Goat anti-chicken, Alexa Fluor 488: Jackson Immuno Research Laboratories, Cat# 103-545-155, dilution 1:300</p> <p>Guinea pig anti-c-Fos : Synaptic Systems, Cat #226004, dilution 1:1000</p> <p>Rabbit anti-c-Fos: Synaptic Systems, Cat #226003, dilution 1:20000</p> <p>Goat-anti-guinea pig Alexa Fluor 647 : Jackson Immuno Research Laboratories, Cat #106-605-003, dilution 1:1000</p> <p>Biotin-conjugated goat-anti-rabbit secondary antibody : Jackson Immuno Research Laboratories, Cat #111-065-003, dilution 1:1000</p>
Validation	<p>Chicken anti-GFP: RRID:AB_300798</p> <p>Goat anti-chicken: RRID:AB_2337390</p> <p>Guinea pig anti-c-Fos : RRID:AB_2619946</p> <p>Rabbit anti-c-Fos: RRID:AB_2231974</p> <p>Goat-anti-guinea pig Alexa Fluor 647 : RRID:AB_2337446</p> <p>Biotin-conjugated goat-anti-rabbit secondary antibody: RRID:AB_2337959</p>

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	All animals used in the study were adult males aged between 8-30 weeks, including C57BL/6J, Vgat-IRES-Cre and Vglut2-IRES-Cre. The animals were housed with ad libitum food and water under a reversed 12:12 hr light-dark cycle with temperature controlled between 21 and 23°C and humidity-controlled between 40–70%.
Wild animals	No wild animals were used
Reporting on sex	only male mice were used
Field-collected samples	No field-collected samples were used
Ethics oversight	Experiment protocols were approved by the Animal Care and Use Committee of the Institute of Neuroscience, Chinese Academy of Sciences, Shanghai, China (IACUC No. NA-01602016) or by the Hubei Provincial Animal Care and Use Committee and the Animal Experimentation Ethics Committee of Huazhong University of Science and Technology (IACUC No.844F) or by the Administrative Panel on Laboratory Animal Care at the National Institute of Biological Sciences.

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