

## 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  |
|-------------------------------------|--|
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> The exact sample size ( $n$ ) for each experimental group/condition, given as a discrete number and unit of measurement  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> The statistical test(s) used AND whether they are one- or two-sided<br><i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>   |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A description of all covariates tested  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> 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) |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> For null hypothesis testing, the test statistic (e.g. $F$ , $t$ , $r$ ) with confidence intervals, effect sizes, degrees of freedom and $P$ value noted<br><i>Give <math>P</math> values as exact values whenever suitable.</i>                            |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> 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

Commercial softwares licensed by microscopy companies was utilized: Olympus Fluoview (version 4.2a), Zeiss ZEN 2012(for LSM 710). Digitized analog signals at 10 kHz were obtained with Digidata (version 1550B) and pClamp(version 10.0) software.

Data analysis

Western blotting image analysis was performed with Fiji (version: 2.0.0-rc-69/1.52p). Med Associates Animal Behavior Analysis System (Med Associates Inc.) was used to automatically analyze freezing behavior. We used Mini 60 to analyze the frequency and amplitude of sEPSCs. Graph Pad Prism (version 8.0) was used for statistical 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 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](#)

Data availability statement :

The data used to support the findings of this study are available from the corresponding author upon request.

## 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

This information was not collected as no human was involved in this study.

Reporting on race, ethnicity, or other socially relevant groupings

This information was not collected as no human was involved in this study.

Population characteristics

This information was not collected as no human was involved in this study.

Recruitment

This information was not collected as no human was involved in this study.

Ethics oversight

This information was not collected as no human was involved in this study.

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

Pilot experiments, as well as previous work in our laboratories, were used to predict effect size and indicated n=6-10 per group to be sufficient to detect biologically and statistically significant results. No sample size calculation was performed.

Data exclusions

No data were excluded from the data set.

Replication

The data were repeated on multiple independent animals, all replicates are true biological (rather than technical) replicates. All replication were successful.

Randomization

Animals were randomly allocated to control or treatment groups.

Blinding

The investigators were blinded to group allocation during data collection 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 &amp; experimental systems

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

## Methods

n/a	<input type="checkbox"/>	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

For western blotting, we used anti-rabbit c-Fos antibody ( #2250, lot:12 Cell Signaling Technology), anti-mouse  $\beta$ -actin antibody ( #AC004, lot:35001000, Abclonal).  
For immunohistochemistry, we used anti-rabbit c-Fos antibody ( #2250, lot:12 Cell Signaling Technology), anti-mouse Vglut2 antibody ( #ab79157, lot:GR3205581-1, Abcam), anti-mouse GAD67 antibody ( #ab26116, lot:GR3357286-2, Abcam), Alexa Fluor594 goat anti-mouse antibody ( #ab150116, lot:1001006139, Abcam), Alexa Fluor594 goat anti-rabbit antibody ( #ab150080, lot:GR3440097-1, Abcam), Alexa Fluor488 goat anti-mouse antibody ( #ab150113, lot:GR3419505-1, Abcam), Alexa Fluor488 goat anti-rabbit antibody ( #ab150077, lot:GR3442008-1, Abcam), Alexa Fluor647 goat anti-mouse antibody ( #ab150115, lot:GR3399166-5, Abcam).

## Validation

Validation information of each antibody is as follows: anti-rabbit c-Fos antibody (Gui Y, Qian X, et al., Cell Death Dis. 2024 Jan 17;15(1):61. doi: 10.1038/s41419-024-06451-w). anti-mouse  $\beta$ -actin antibody (Yin Y, Lu JY, et al., Nature. 2020 Apr;580(7801):147-150. doi: 10.1038/s41586-020-2105-3), anti-mouse Vglut2 antibody (Velasco ER, Florido A, et al., Nat Commun. 2022 Jul 28;13(1):4374. doi: 10.1038/s41467-022-31442-w), anti-mouse GAD67 antibody (Forsthofer M, Straka H. J Neurol. 2023 Jan;270(1):57-70. doi: 10.1007/s00415-022-11311-8), Alexa Fluor594 goat anti-mouse antibody and Alexa Fluor488 goat anti-rabbit antibody (Liu TT, Shi X, et al., Cell Death Dis. 2023 Oct 7;14(10):654. doi: 10.1038/s41419-023-06176-2), Alexa Fluor594 goat anti-rabbit antibody and Alexa Fluor488 goat anti-mouse antibody (Li L, Chen W, et al., Histol Histopathol. 2024 Jan;39(1):67-77. doi: 10.14670/HH-18-613), Alexa Fluor647 goat anti-mouse antibody (Chen X, Yao J, et al., Int J Gen Med. 2023 May 8;16:1713-1733. doi: 10.2147/IJGM.S398908).

## 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

C57BL/6J mice were obtained from the Experimental Animal Center of Xuzhou Medical University. Vglut2/Vgat-cre and Vgat-ChR2-EYFP mice were originally sourced from Jackson Laboratory (USA) and bred at Xuzhou Medical University Laboratory Animal Center. Both male and female mice (6 to 8 week-old) were used in the experiments (each group included an equal number of male and female mice). Experiments were approved by the Animal Care and Ethics Committee of Xuzhou Medical University and conformed to the National Research Council's Guide for the Care and Use of Laboratory Animals.

## Wild animals

No wild animals were used in this study.

## Reporting on sex

Both male and female mice were used in the study, and no difference was observed between the sexes, therefore we combine them together for statistical analysis.

## Field-collected samples

The study involved no samples collected from the field.

## Ethics oversight

The study complied with the Declaration of Basel and was approved by the Animal Care and Use Committee of Xuzhou Medical University (approval number: 202112A255).

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

## Plants

## Seed stocks

This information was not collected as no plant was involved in this study.

## Novel plant genotypes

This information was not collected as no plant was involved in this study.

## Authentication

This information was not collected as no plant was involved in this study.