

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	Data from fiber photometry recordings were collected using Doric Neuroscience Studio software (v. 5.3.3.14). Electrophysiology data was acquired with PatchMaster v2x90 software (HEKA Elektronik; Germany).
Data analysis	Data analysis were performed using Matlab (v. R2021b), Python (v. 3.10.5), FitMaster 2.15 (HEKA Elektronik; Germany), and GraphPad Prism (v. 9.3.0.) software. All custom code in Matlab and Python are freely available via the Harvard Dataverse link in the manuscript: https://doi.org/10.7910/DVN/BXCYZS

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](#)

The data generated in this study and used to produce the figures are provided in the Source Data file. The raw fiber photometry data are available under restricted

access as they are still in use at the time of publication. Data will be made available on request to the corresponding author. 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

Use the terms sex (biological attribute) and gender (shaped by social and cultural circumstances) carefully in order to avoid confusing both terms. Indicate if findings apply to only one sex or gender; describe whether sex and gender were considered in study design; whether sex and/or gender was determined based on self-reporting or assigned and methods used. Provide in the source data disaggregated sex and gender data, where this information has been collected, and if consent has been obtained for sharing of individual-level data; provide overall numbers in this Reporting Summary. Please state if this information has not been collected. Report sex- and gender-based analyses where performed, justify reasons for lack of sex- and gender-based analysis.

Reporting on race, ethnicity, or other socially relevant groupings

Please specify the socially constructed or socially relevant categorization variable(s) used in your manuscript and explain why they were used. Please note that such variables should not be used as proxies for other socially constructed/relevant variables (for example, race or ethnicity should not be used as a proxy for socioeconomic status). Provide clear definitions of the relevant terms used, how they were provided (by the participants/respondents, the researchers, or third parties), and the method(s) used to classify people into the different categories (e.g. self-report, census or administrative data, social media data, etc.) Please provide details about how you controlled for confounding variables in your analyses.

Population characteristics

Describe the covariate-relevant population characteristics of the human research participants (e.g. age, genotypic information, past and current diagnosis and treatment categories). If you filled out the behavioural & social sciences study design questions and have nothing to add here, write "See above."

Recruitment

Describe how participants were recruited. Outline any potential self-selection bias or other biases that may be present and how these are likely to impact results.

Ethics oversight

Identify the organization(s) that approved the study protocol.

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

Sample size was estimated using power analysis with power of 0.8, significance of 0.05, and effect size calculated from preliminary and previously published data.

Data exclusions

Animals showing no viral or off-target site viral expression or incorrect optic fiber placement (< 10%) were excluded from analysis.

Replication

All findings were replicated in at least 2 to 3 cohorts of animals.

Randomization

All animals were randomly allocated to experimental groups.

Blinding

Injection sites and viral expression were confirmed for all animals by experimenters blinded to behavioral outcome. All data analysis were performed by experimenters blinded to animal group conditions.

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: Goat anti-Chat (Millipore, AB144P, RRID:AB_2079751); Mouse anti-TH, (Millipore, MAB318, RRID:AB_2201528); Rabbit anti-Tph2 (Abcam, ab111828, RRID:AB_10862137); Goat anti-VIAAT (Nittobo-nmd, VGAT-Go-Af620, RRID:AB_2571623); Guinea pig anti-synaptophysin, (Nittobo-nmd, Syn-GP-Af300, RRID: AB_2571843)

Secondary antibodies: Donkey anti-goat 594 (Life Technologies, A11058, RRID:AB_2534105); Goat anti-guinea pig 594 (Life Technologies, A11076, RRID:AB_141930); Donkey anti-mouse 594 (Life Technologies, A21203, RRID:AB_141633); Donkey anti-rabbit 594 (Life Technologies, A21207, RRID:AB_141637)

Validation

Antibodies are commercially available and have been validated in the lab, by other groups, and/or as detailed in the company manufacturer websites. Research resource identifiers (RRIDs) are listed for each antibody.

<https://www.sigmaaldrich.com/US/en/search/mab318?focus=products&page=1&perpage=30&sort=relevance&term=mab318&type=product>

<https://www.sigmaaldrich.com/US/en/search/ab144p?focus=products&page=1&perpage=30&sort=relevance&term=ab144p&type=product>

<https://www.abcam.com/products/primary-antibodies/tph2-antibody-ab111828.html>

<https://nittobo-nmd.co.jp/pdf/reagents/VGAT.pdf>

<https://nittobo-nmd.co.jp/pdf/reagents/syn.pdf>

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

Mus musculus, C57Bl/6J (Stock #000664, Jackson), GAD2-Cre (Stock #10802, Jackson), DAT-Cre (Stock #006660, Jackson), ChAT-Cre (Stock #006410, Jackson). All experiments were conducted in adult mice aged between 12-16 weeks old. For social experiments, juvenile stimuli always consisted of C57Bl/6J mice (4-7 weeks old).

Wild animals

The study did not involve wild animals.

Reporting on sex

Social behavior experiments were performed in male and female mice that interacted with male and female juvenile conspecifics, respectively. Photometry results were similar in males and females, however, female VTA dopaminergic activity responses and nucleus accumbens dopamine responses to novelty were lower than males so female data are presented separately in supplementary figures.

Field-collected samples

The study did not involve samples collected from the field.

Ethics oversight

All animal protocols were approved by the Institutional Animal Care and Use Committee of the University of Massachusetts Chan Medical School.

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

Seed stocks

Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.

Novel plant genotypes

Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.

Authentication

Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosaicism, off-target gene editing) were examined.