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Corresponding author(s): Andreas Lüthi, Andrew Holmes

Last updated by author(s): Apr 10, 2021

Reporting Summary

Nature Research 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 Research policies, see Authors & Referees 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

Omniplex (Plexon)
CinePlex Studio (Plexon)
nVista HD (Inscopix)
pClamp (Axon/Molecular Devices)
PrairieView (Bruker)
Doric Neuroscience Studio (Doric)
AXIOSCAN.Z1 (Carl Zeiss)
Imaris (Bitplane)
Brainrander
System 3 RP2.1 (Tucker-Davis Technologies)
RPvdsEx (Tucker-Davis Technologies)
Radiant (Plexon)
Plex Control Software (Plexon)
Med-PC IV (Med Associates)

Data analysis	Matlab 2015a/2017b (Mathworks) CinePlex Studio 3.5.0 (Plexon) ImageJ 2.0.0-rc-49/1.51a (NIH) ZEN Blue 2012 Cineplex Editor (Plexon) MosaicAPI (Inscopix) Python 3.7 (Anaconda distribution) IgorPro (Wavemetrics) Prism 7.02/8 (GraphPad)

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/reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research 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 list of figures that have associated raw data
- A description of any restrictions on data availability

The data that support the findings of this study are available at: https://data.fmi.ch/PublicationSupplementRepo/
Custom-written codes used to analyse data from this study are available upon reasonable request from the corresponding authors.

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

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	No statistical methods were used to predetermine sample size. Sample sizes were chosen based on prior publications involving similar methods that have shown samples sizes we chose provided sufficient statistical power (Bloodgood et al., 2018; Grundemann et al., 2019)
Data exclusions	All exclusion criteria were established prior to data collection: In imaging experiments, mice were post-hoc excluded from the analysis if the GRIN lens was placed outside of the region of interest. In chemogenetic manipulation experiments, mice were post-hoc excluded from the analysis if the virus expression spreaded outside of the target structure. Data exclusion criteria are also described in detail in the Methods.
Replication	The exact number of repetitions (individual data points from separate cells and/or animal) are indicated in figures or figure legends. Averaging across multiple trials per neuron/animal is indicated where applicable and n/N numbers refer to data from individual neurons/animals. All protocols used for the experiments are described in detail in the Methods section and supplementary material, and further information can be requested from the corresponding authors to ensure replication in other laboratories.
Randomization	Randomization was not performed because all mice with a given manipulation (e.g., Cre genotype, or virus injection) were all assigned to a single group, and not to multiple experimental groups, which would require randomization.
Blinding	Manual scorings of behaviour in chemogenetic manipulation experiments were performed by observers blind to genotype.

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
☐	☒ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data

Methods

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

Antibodies

Antibodies used	Anti-FoxP2(rabbit, Abcam, ab16046); anti-GFP (chicken, Abcam cat#13970); Living Colors® DsRed (polyclonal, Clontech Labs cat# 632496); Alexa 488 (goat anti-chicken IgG, Abcam cat#150169); Alexa 555 IgG (goat anti-rabbit , Abcam cat# A21428); Goat-anti-GFP polyclonal (GeneTex, GTX26673), Donkey-anti-goat-Alexa488 (Invitrogen, A-11055), Donkey-anti-rabbit-Alexa555 (Invitrogen, A-31573)
Validation	Reactivity with mouse in fluorescent immunohistochemistry was confirmed by the manufacture and by several previous publication (Busti et al., 2011; Bukalo et al., 2015).

Animals and other organisms

Policy information about studies involving animals; ARRIVE guidelines recommended for reporting animal research

Laboratory animals	Mus musculus, males C57/Bl6J (Envigo), aged 2-3 months at the time of injection (2-7 months at time of the experiment) were used. Following genetically modified lines (Bl6j backcrossed) were used: FoxP2-Cre (Jax#030541), Arc-CreER (Jax#021881), Ai14 (Jax#007908), and D1-Cre (Jax#037156), aged 1.5-5 months old at the time of injection (2-7 months at the time of experiment).
Wild animals	This study did not involve wild animals.
Field-collected samples	This study did not involve samples collected from the field.
Ethics oversight	All animal procedures were performed in accordance with institutional guidelines and with current European Union guidelines, and were approved by the Veterinary Department of the Canton of Basel-Stadt, Switzerland, by the local government authorities for Animal Care and Use (Regierungspräsidium Tübingen, State of Baden-Württemberg, Germany), and by the NIAAA Animal Care and Use Committee.

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