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Reporting Summary

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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	Zen blue & black, FPulse, Igor Pro 5.01, ImageSP
Data analysis	ImageJ, Matlab (2020a), Sigmaplot, Igor Pro 5.1, Python,

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

Original data reported in this paper will be shared by the lead contact upon reasonable request. Any additional information required to reanalyze the data reported in this paper is available from the lead contact upon request.

Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

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 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.*
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

Life sciences study design

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

Sample size	In total 16 mice, 168 cells and 1075 spines were analyzed for morphological spine analysis. For DREADD related experiments 32 mice, 84 cells and 1492 spines were analyzed. For cFOS analysis 748 PVIs, 3567 GCs and 1713 MC were analyzed. For co-localization of the DREADD virus expression 437 cells were detected and analyzed. For electrophysiological in vitro recordings 35 mice, 69 cells, 67 spine and 82 shaft inputs were analyzed. Behavioral analysis was done with 66 mice. In this context 119 PVIs and 457 spines were analyzed. CFOS analysis in context of behavioral analysis was performed with 2086 PVIs, 2088 GCs and 5686 MCs. MC-PVI contacts based on eGRASP was analyzed based on 10 mice, 2171 cells, 2115 spines and 3394 eGRASP contacts and co-localization with the eGRASP virus 211 cells were analyzed. We have chosen sample sizes that are in the range of other studies using similar methodology (see for example ref. Sancho & Bloodgood 2018 and Foggetti et al. 2019).
Data exclusions	For spine analysis: cells were excluded if the dendritic tree and soma were not connected and if the dendritic tree was incomplete. For electrophysiological whole-cell recordings in vitro, cells with a more positive membrane potential than -55 mV were discarded.
Replication	Behavioural data sets as well as DREADD experiments were conducted in two rounds (for example cohort one: mice under control, enriched environment and single housing conditions; cohort two: mice under control, enriched environment and single housing conditions). Spine density and morphological spine characteristics were measured in both rounds.
Randomization	Our manuscript reports differences in spine characteristics, running time and cFos expression in relation to different behaviour conditions and DREADD stimulation. Therefore, prior to image analysis data were randomly renamed and only after completion of the blind analysis reassigned for statistical analysis.
Blinding	Blinding was performed based on randomization (see above). Otherwise no further blinding was applicable to our experiments.

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

Methods

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

Antibodies

Antibodies used: PV rabbit (PV 27) Swant , PV goat (PV 28) Swant, PV guinea pig (PV GP 72) Swant, cFos rabbit (sc-52) SantaCruz.

Validation: Validation references from the manufactures homepage for the PV rabbit antibody: 1.Kretsinger R.H. (1981) Neurosci. Res. Progr. Bull. 19/8, MIT-Press; 2.Celio M.R., Heizmann C.W. (1981) Nature 293: 300-302; 3.Celio M.R., Heizmann C.W. (1982) Nature 297:504-506; 4.Schwaller B., et al. (1999) Am. J. Physiol. 276. C395-403.
For the PV goat antibody: Schwaller B., et al. (1999) Am. J. Physiol. 276. C395-403.
For the PG guinea pig antibody: Filice F., Celio, M.R., Szabolcsi V. (2017) JCN.
For the cFos antibody: Yang et al. 2015. J. Neurosci. 35: 36-52.

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: We used a total of 150 PV-Cre mice. For the experiments the mice were aged P42 to P70, except for electrophysiology experiments mice were P20 to P45.

Wild animals: Not applicable.

Reporting on sex: In our manuscript only male mice were used to study spines of parvalbumin-positiv interneurons. The reason for this selection is that previous reports indicate that the hormone cycle in female mice influence the shape of dendritic spines of principal cells (please see Chenjian et al PNAS 2004 101:2185-90; Phan et al. Endocrinology 2011 152:1492-502).

Field-collected samples: Not applicable

Ethics oversight: All experiments involving animals were carried out according to national and institutional guidelines and approved by the 'Tierversuchskommission' of the Regierungspräsidium Freiburg (license #G20/137) in accordance with national legislation.

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