

Reporting Summary

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Statistical parameters

When statistical analyses are reported, confirm that the following items are present in the relevant location (e.g. 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
- ☐ ☒ An indication of 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 statistics 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
- ☐ ☒ Clearly defined error bars
State explicitly what error bars represent (e.g. SD, SE, CI)

Our web collection on [statistics for biologists](#) may be useful.

Software and code

Policy information about [availability of computer code](#)

Data collection

Custom MATLAB programs and Arduino codes were used to drive hardware and collect data in the behavioral experiments. The MATLAB program used in the head-restrained licking preference tests was as described by Peng, Y. et al. Nature 527, 512-515, (2015). All custom MATLAB programs and Arduino code are available upon request.

Data analysis

ImageJ 1.51n and Advanced Normalization Tools 1.91x were used to analyze imaging data. MATLAB 2016a, Igor Pro 6.37 and Prism 7.0a were used in statistic 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/reviewers upon request. 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

All data supporting the findings of this study are available upon request.

Field-specific reporting

Please select the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences

For a reference copy of the document with all sections, see nature.com/authors/policies/ReportingSummary-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 calculate the sample size. Sample size was determined based on our experience and the sample size used in similar studies.
Data exclusions	Animals in which post-hoc histological examination showed that viral targeting or the position of implanted fiber / cannulas were in the incorrect location were excluded from analysis.
Replication	All attempts at replication were successful.
Randomization	Stimuli were presented in random order (as described in the manuscript), otherwise no randomization was used.
Blinding	Investigators were not blinded to group allocation.

Materials & experimental systems

Policy information about [availability of materials](#)

n/a	Involved in the study
☒	☐ Unique materials
☐	☒ Antibodies
☒	☐ Eukaryotic cell lines
☐	☒ Research animals
☒	☐ Human research participants

Antibodies

Antibodies used	Goat anti-c-Fos antibody (Santa Cruz, sc-52-G), Lot: I0315, 200ug/ml, 1:500.
Validation	Goat anti-c-Fos antibody (Santa Cruz, sc-52-G) has been validated extensively, eg, by immunostaining on mouse brain sections (Choi, et al. Cell, 146, 1004-1015, (2011)).

Research animals

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research

Animals/animal-derived materials	Mus musculus, C57BL/6J and B6.Cg-Gt(ROSA)26Sortm9(CAG-tdTomato)Hze/J male mice were used. All animals used were younger than 8 months old. When performing viral injections, we generally used 7-9 weeks old animals.
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Method-specific reporting

n/a	Involvement in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ Magnetic resonance imaging