

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	Video data for the lesion datasets was acquired using Campy (https://github.com/ksseverson57/campy), and Pylon 1.2.0 (Basler). Camera calibration was performed using the MATLAB Camera Calibration App (Mathworks). Behavioral data for the electrophysiology dataset was acquired using a Motion Capture system (Kestrel 4200), with FLIR video cameras. Electrophysiological data was acquired using custom software described in Dhawale et al. 2017. Lever-pressing data was acquired using custom software described in Poddar et al. 2013.
Data analysis	We estimated the 3D pose from multi-camera videos using DANNCE as in Dunn et al. 2021 (https://github.com/spoonsso/dannce). Network training was implemented in Python 3.7.9. Behavioral classification for both datasets was performed using a custom MATLAB implementation of MotionMapper (Berman et al. 2014, https://github.com/gordonberman/MotionMapper) using MATLAB 2019b. Analysis of behavioral data using Keypoint-Moseq analysis was performed using code (https://github.com/dattalab/keypoint-moseq). Electrophysiological data was spike-sorted and clustered using custom software described in Dhawale et al. 2017 (https://github.com/Olveczky-Lab/FAST). Custom analysis code was developed in MATLAB 2019b and is available upon request.

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](#)

All data are available upon request to the corresponding authors. Data for the amphetamine dataset are publicly available at <https://doi.org/10.7910/DVN/4X8GTB19>.

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	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

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	No statistical methods were used to pre-determine the number of subjects in our study. Our sample sizes for the lesioned dataset are similar to prior publications (e.g. Markowitz et al., 2018: n = 3 sham and n = 5 lesioned animals). Our sample sizes for the electrophysiology dataset are similar to prior publications (Dhawale*, Wolff*, et al., n = 3 animals with DLS recordings).
Data exclusions	Days with recording sessions in which the number of lever taps fell below the threshold of <150 were excluded from analysis. The excluded sessions mainly consisted of early exposures to the CAPTURE environment following initial training (1 day for animal 2, 3 days for animal 3, 1 day for animal 4). One DLS-implanted animal did not sufficiently perform the lever-pressing task in the open arena and was thus excluded.
Replication	Major lesion results and electrophysiology results were analyzed and reproduced across animals (n = 7 lesion animals, n = 4 implanted animals)
Randomization	Animals were randomly chosen to be in the DLS-lesion or sham-lesion group.
Blinding	Experimenters were not blind to the experimental condition during data collection or analysis. This is most relevant in the assignment of animals to lesion or sham control groups. This was not done blindly to allow for appropriate monitoring of animal recovery.

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

Methods

- 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

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

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	Experimental subjects were female Long Evans rats 2-6 months old at the start of experiments.
Wild animals	The study did not involve wild animals.
Reporting on sex	The study only used female rats.
Field-collected samples	The study did not contain samples collected from the field.
Ethics oversight	The care and experimental manipulation of all animals were reviewed and approved by the Harvard Institutional Animal Care and Use Committee.

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

Plants

Seed stocks	N/A
Novel plant genotypes	N/A
Authentication	N/A