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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 (*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	Electrophysiology data were collected with Tucker-Davis Technologies (TDT) RZ2 with SYNAPSE software or EEG/EMG system from Pinnacle Technology (# 8200-K1-SL); Images were acquired using Olympus SLIDEVIEW VS200; MRI data were collected using Bruker 9.4 Tesla.
Data analysis	FIJI image (2.9.0) processing software (NIH), Prism 9 (GraphPad), MATLAB 2020a (MathWorks), ITK-SNAP (3.6.0), Kilosort 2.5, Phy GUI

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 necessary for the conclusions of the study are available in the main text, figures, and extended data. The source data for each main figure and extended data figure are all provided. Representative raw wield-field and MRI images, as well as MATLAB codes are also available in Zenodo (https://doi.org/10.5281/zenodo.10440376)

Human research participants

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

Reporting on sex and gender	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 determine the sample size in advance. The number of animals used in this study was largely based on previous studies from our lab and others (Drieu et al. 2022; Iliff et al. 2012).
Data exclusions	No data were excluded from experiments unless apparent failures, such as failure of intra-cisterna magna and intraperenchymal injections.
Replication	All experiments were replicated in at least three independent experiments for a total of at least 3 mice per group, and all attempts to replicate the data were successful.
Randomization	Animals were randomly assigned to the experimental or control group.
Blinding	The researchers were blind to the group allocation during data acquisition and analysis.

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	c-Fos (9F6) primary antibody (Cell Signaling Technology #2250), GFAP (Agilent Technologies Z033429-2)
Validation	c-Fos: Osterhout et al., Nature 606, pages 937-944(2022); GFAP: Li et al., Nature 587, pages 613–618 (2020)

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	C57BL/6J mice, 2-6 months old. Animals were housed inside a temperature (22 ºC) and humidity-controlled (33 - 39 %) environment with 12-hour light/dark cycle and provided with food and water ad libitum.
Wild animals	No wild animals were used in this study.
Reporting on sex	Male mice were used in this study.
Field-collected samples	No field-collected samples.
Ethics oversight	All experimental procedures were approved by the Institutional Animal Care and Used Committee in Washington University School of Medicine.

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

Magnetic resonance imaging

Experimental design

Design type	Evaluation of CSF infiltration across time using Dotarem and Gadospin P
Design specifications	The total acquisition time is about 1 hour per mouse (4 minutes 54 seconds X 11 sequences)
Behavioral performance measures	None

Acquisition

Imaging type(s)	Contrast-enhanced MRI
Field strength	9.4 Tesla
Sequence & imaging parameters	A series of T1 FLASH-3D weighted images were taken to visualize CSF perfusion with the following parameters: repetition time = 30 ms; echo time = 8 ms; number of echo images = 1; number of averages = 1; number of repetitions = 11; scan time = 4 minutes and 54 seconds; flip angle = 20, FOV = 1.6 x 1.6 x 0.8 cm with a 128 x 128 x 64 matrix ; spatial resolution = 125 x 125 x 125 µm (8 pixels per mm; voxel size = 0.125 mm3), number of slices = 64; receiving coil: 4-channel brain probe.
Area of acquisition	Mouse brain

Diffusion MRI ☐ Used ☒ Not used

Preprocessing

Preprocessing software	Paravision 360
Normalization	Each mouse served as its own control
Normalization template	Each mouse served as its own control (tracer infiltration over time)
Noise and artifact removal	No noise or artifact removal
Volume censoring	None

Statistical modeling & inference

Model type and settings	Tracer diffusion across time for each mouse
Effect(s) tested	Two-way repeated measure ANOVA

Specify type of analysis: ☐ Whole brain ☒ ROI-based ☐ Both

Anatomical location(s): Mouse hippocampus and its nearby perivascular pathways

Statistic type for inference (See Eklund et al. 2016): *Specify voxel-wise or cluster-wise and report all relevant parameters for cluster-wise methods.*

Correction | *Describe the type of correction and how it is obtained for multiple comparisons (e.g. FWE, FDR, permutation or Monte Carlo).*

Models & analysis

n/a	Involved in the study
☒	☐ Functional and/or effective connectivity
☒	☐ Graph analysis
☒	☐ Multivariate modeling or predictive analysis