

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	Electrophysiology: Axon multiclamp 700B + Digidata 1440 (MC700A commander and Clampex 10.2) Fluorescence: Olympus BX61 microscope and OrcaFlash C11440 (HCImageLive) Animal behavior: EthoVision
Data analysis	Analysis of electrophysiology and fluorescence: Igor Pro 7.21 Analysis of animal behavior: Ethovision Matlab code for CA3 network modelling (Figure 7-8) could be obtained from the corresponded author upon request (leesukho@snu.ac.kr)

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 of numerical data and statistical values in this article are presented as a separate Microsoft Excel file.

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

Reporting on race, ethnicity, or other socially relevant groupings

Population characteristics

Recruitment

Ethics oversight

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](https://www.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

1. <https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/JP288350>
2. <https://onlinelibrary.wiley.com/doi/full/10.1002/hipo.23400>
3. <https://doi.org/10.1523/JNEUROSCI.2130-18.2019>
4. <https://physoc.onlinelibrary.wiley.com/doi/10.1113/JP270372>

Data exclusions

Replication

Randomization

Blinding

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
☒	☐ Plants

Methods

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	Rat: SD rat / Mouse: B6.Cg-Tg(Fos-EGFP*)1Mmay/J, <Kcna2tm1a(EUCOMM)Wtsi>, rotamine-FLPe, C57BL/6-Tg(Grik4-cre)G32-4Stl/J,
Wild animals	No wild animals were used.
Reporting on sex	There is no sexual differences among animals.
Field-collected samples	Animals were maintained under the specific-pathogen free standard environmental conditions (temperature: 25°C ± 2°C, humidity: 60% ± 5%, dark/light cycle: 12/12 h) and monitored by veterinary supervision by Institute for Experimental Animals, Seoul National University College of Medicine until the experiment. Animals had unrestricted access to food and water during maintenance.
Ethics oversight	All experimental and animal manipulation protocols outlined ⁴⁹⁶ in this article were conducted under the approval from the Institutional Animal Care and Use Committee of Seoul National University (IACUC, Approval #: SNU-220121-2-3 and SNU-230524-1-2) and the IACUC Standard Operating Guidelines (Animal and Plant Quarantine Agency Ordinance of Korea, No. 2023-47). All authors are aware of the ethical principles upheld by the IACUC and confirm that their work adheres to animal ethics.

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

Plants

Seed stocks	No plants were used
Novel plant genotypes	No plants were used
Authentication	No plants were used