

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	Carl Zeiss LSM 700 and 800 were operated by ZEN black and ZEN blue, respectively (confocal imaging); Pulse/Pulse Fit (current recording); ECLIPSE Ti2-E (Nikon) (TIRF)
Data analysis	Igor Pro 6.0 (WaveMetrics Inc.): data analysis of confocal imaing and patch clamp; imageJ-figi (win64): Image analysis of TIRF microscopy; Zeiss ZEN 2.3 SP1 (Zen balck): image analysis; Microsoft Office Excel 365: calculating the average and SEM of all data; GraphPad Prism 7.02: statistical analysis; ImageJ-figi : image 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 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](#)

Source data are provided with this paper. All other data supporting the findings of this study are available from the corresponding author.

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](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	Sample size calculations were not performed. For all imaging experiments, the number of single cell samples was selected to be at least five based on the localization pattern of expressed proteins throughout each cell
Data exclusions	In confocal imaging, cells showing shape instability or membrane disruption were excluded. Electrophysiological recordings excluded cells that exhibited high noise, instability, or current amplitudes that were too large or too small for analysis.
Replication	The results of this study were successfully reproducible. All experiments were repeated independently at least three times on different days with similar results.
Randomization	Samples were not randomly drawn for the experiment. In all experiments, similar expression levels of fluorescently tagged proteins were visually confirmed in each cell.
Blinding	Investigators were not blinded during data collection and analysis. All experiments were conducted utilizing machinery, and the data obtained are quantitative.

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

Antibodies

Antibodies used	rabbit-anti HA (Bethyl) & rabbit IgG (R&D systems) primary antibody (mouse anti-GFP 1:100, Santacruz sc-9996; mouse anti-HA 1:100 (M1R-HAx3) and 200 (EGFR-HAx3 and PDGFR-HAx3), Santacruz sc-7392; rabbit anti-GAPDH 1:25,000, Cell signaling technology #2955) secondary antibody (anti-mouse IgG 1:10,000, Thermo Fisher Scientific; anti-rabbit IgG 1:10,000, Thermo Fisher Scientific)
Validation	rabbit-anti HA: https://www.fortislife.com/cms/files/A190-108A-8.pdf rabbit IgG (R&D systems): https://resources.rndsystems.com/pdfs/datasheets/ab105c.pdf?v=20240214&_ga=2.62869674.769202176.1707903092-1241818898.1707903092 mouse anti-GFP 1:100, Santacruz sc-9996: https://datasheets.scbt.com/sc-9996.pdf mouse anti-HA 1:200, Santacruz sc-7392: https://datasheets.scbt.com/sc-7392.pdf rabbit anti-GAPDH 1:25,000, Cell signaling technology #2955: https://www.cellsignal.com/datasheet.jsp?productId=2955&images=0&size=A4

Eukaryotic cell lines

Policy information about [cell lines and Sex and Gender in Research](#)

Cell line source(s)	HEK293T cell line (RRID: CVCL_2737) was obtained from Bertil Hille (University of Washington School of Medicine, Seattle, Washington). The original source for this cell line is European Collection of Authenticated Cell Cultures (ECACC) (Cat# 96121229).
Authentication	Microscopic examination (HEK293T cells are easily distinguished by their morphology. Before performing any work with the cells, check their morphology through optical observation.)
Mycoplasma contamination	No testing for mycoplasma contamination was performed.
Commonly misidentified lines (See ICLAC register)	Cell lines that are commonly misidentified were not used.

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	Primary-neuron culture was performed with Sprague-Dawley rats from P5 to P6
Wild animals	Using non-transgenic WT Sprague-Dawley rats from P5 to P6.
Reporting on sex	Used Sprague-Dawley rats regardless of gender (P5 to P6)
Field-collected samples	Field-collected samples were not used.
Ethics oversight	All procedures were performed according to the ethical guidelines of the Laboratory Animal Resource Center, DGIST approved.

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