

## 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

- |                                     |                                     |  |
|-------------------------------------|-------------------------------------|--|
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | The exact sample size ( $n$ ) for each experimental group/condition, given as a discrete number and unit of measurement  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | The statistical test(s) used AND whether they are one- or two-sided<br><i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>   |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | A description of all covariates tested   |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 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) |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | For null hypothesis testing, the test statistic (e.g. $F$ , $t$ , $r$ ) with confidence intervals, effect sizes, degrees of freedom and $P$ value noted<br><i>Give <math>P</math> values as exact values whenever suitable.</i>                            |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings   |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes   |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 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	Clampex 9.2, PatchControl v2.1, Yokogawa CQ1 1.0, Powerlab 8/35, Myocyte online Contraction Analysis (MoCA), RHX, Digital Lynx 4S, MATLAB 2012a
Data analysis	python 3.12.2, numpy 1.26.4, pandas 2.2.1, scipy 1.12.0, pingouin 0.5.4, scikit-learn 1.4.1, napari 0.4.19, MATLAB 2021b, Origin 9, Clampfit 10.7, LabChart 8.1.16, PsychoPy, kilosort3, phy, Bonsai, Origin 9, Clampfit 10.7, ImageJ 1.52p, GraphPad Prism 8, ZEN 2.6, custom software is available on Zenodo: <a href="https://doi.org/10.5281/zenodo.15210800">https://doi.org/10.5281/zenodo.15210800</a>

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](#)

The manuscript does include a data availability statement and data is available on Zenodo <https://doi.org/10.5281/zenodo.15210800>

## 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 For most experiments no particular statistical method was used to predetermine sample sizes. Sample sizes were chosen on the basis of previously published experimental designs whenever disclosed in the manuscript. For some of the animal studies sample size was calculated using power analysis.

Data exclusions No data were excluded from the analyses.

Replication The number of replicated or independently performed experiments is provided in the manuscript. Wherever applicable, the number of unsuccessful attempts is clearly stated in the manuscript.

Randomization Randomization was not performed.

Blinding Experimenters were blinded to the experimental group for the optogenetic stimulation of the auditory pathway in the common marmoset. Experimenters were blinded for histological assessment of cochlea tissue.

## 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 For cardiomyocytes: cardiac troponin I (ab47003, Abcam: 1:800); Cy5 (711-175-152, JacksonLab, U.S., 1:400);

## Antibodies used

For retinæ: rabbit Proteintech, 50430-2-AP; AlexaFluor 488 (Invitrogen, A32970);  
 For rodent cochleæ: chicken anti-GFP (1:500, ab13970 Abcam, USA); guinea pig anti-parvalbumin (1:300, 195004 Synaptic Systems, Germany); goat anti-chicken 488 IgG (1:200, A-11039 Thermo Fisher Scientific, USA); goat anti-guinea pig 568 IgG (1:200, A-1107 Thermo Fisher Scientific, USA);  
 for rodent brainstem slides: chicken-anti-GFP (1:500, Abcam, Berlin, Germany), guinea-pig-anti-vGLUT1 (1:1000, Synaptic Systems GmbH, Göttingen, Germany); goat-anti-chicken 488 (1:200, Thermo Fisher Scientific, Waltham, USA) goat-anti-guinea-pig 568 (1:200, Thermo Fisher Scientific, Waltham, USA); for gebril brain histology: antibodies for parvalbumin (1:300, guinea pig, Synaptic Systems, Goettingen, Germany) and GFP (1:500, chicken, Abcam, Cambridge, UK);  
 Marmoset histology: chicken anti-GFP (1:500, ab13970 Abcam, USA); guinea pig anti-parvalbumin (1:300, 195004 Synaptic Systems, Germany); mouse anti-NF200 (1:400, Sigma, St. Louis, USA); goat anti-chicken 488 IgG (1:200, Invitrogen Scientific, USA), goat anti-guinea pig 568 IgG (1:200, Invitrogen, USA); anti-mouse 633 (1:200, Invitrogen); guinea pig anti-parvalbumin (1:200; Synaptic systems, Germany), rabbit anti-Otoferlin (1:500; SySy); chicken anti-GFP (1:500; Abcam); anti-chicken 488 (1:1000; Invitrogen), anti-guinea pig 568 (1:1000; Invitrogen); anti-rabbit 633 (1:1000; Thermo Fisher)

## Validation

Validation was provided by companies.

## Eukaryotic cell lines

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

## Cell line source(s)

HEK293T cells (DSMZ, Braunschweig, Germany), NG108-15 (ATCC, HB-12377TM, Manassas, USA), Human cardiomyocyte like cells were differentiated from the induced pluripotent stem cell line UMGi014-A clone 2, which was created from peripheral mononuclear blood cells from a healthy male donor using integration-free Sendai virus.

## Authentication

The authentication of HEK293T cells and NG108-15 cells were performed by the cell line sources. All cell lines were checked for their morphology and only used in early passage.

## Mycoplasma contamination

The HEK293T cells and NG108-15 cells were tested negative for mycoplasma contamination.

Commonly misidentified lines  
(See [ICLAC](#) register)

No commonly misidentified cell lines were 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

Only laboratory animals were used: Mus musculus (C3HeB/FeJ, JAX 000658; C57B/6J), Mongolian gerbils (Rj:MON), Common marmoset (bred at the German Primate Center)

## Wild animals

The study did not involve wild animals.

## Reporting on sex

For all animal studies both sex were used as no impact of the sex was expected.

## Field-collected samples

No field-collected samples were used for this study.

## Ethics oversight

Electrophysiology studies in the visual system were approved by the An"Regierung von Oberbayern". Behavior experiments to test for vision restoration were approved by the Neuro Animal Care Committee (ACC) of the McGill University. Animal studies in the auditory system were approved by "Niedersächsisches Landesamt für Verbraucherschutz und Lebensmittelsicherheit".

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

## Plants

## Seed stocks

*Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.*

## Novel plant genotypes

*Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.*

## Authentication

*Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosaicism, off-target gene editing) were examined.*