nature portfolio

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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	We recorded neural activity using a 96-channel array (Utah ArrayTM – Blackrock Neurotech, USA) from day 1, the day after implantation, until the day before electrode removal. The signal was digitally amplified using a Cereplex M head stage from Blackrock Neurotech, connected to a 128-channel neural signal processor (NeuroPort), and sampled at 30kHz using Central Software. We applied a 750 Hz high-pass filter to isolate spiking activity, with the multi-unit detection threshold set at -3 standard deviations of the signal. Signal quality varied during the immediate postoperative period, leading to fluctuations in the number of responsive and selective channels across recording sessions. Spike sorting was performed offline (Offline Sorter 4, Plexon, TX).
Data analysis	All data was analysed using custom-written MATLAB R2023b (Mathworks, Natick, MA, USA) scripts. The code has been made available through Code Ocean.

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 datasets generated during and/or analyzed during the current study are available from the corresponding author on request. Source data are provided with this paper.

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	We obtained invasive intracranial recordings from four patients with refractory epilepsy: male 24 years, female 55 years, female 58 years and male 29 years.
Reporting on race, ethnicity, or other socially relevant groupings	Race was not mentioned in the manuscript because we deemed it irrelevant. All patients were Caucasian. Extensive patient characteristics including medical history and medication are provided in the manuscript.
Population characteristics	We obtained invasive intracranial recordings from four patients with refractory epilepsy treated at UZ Leuven (University Hospital Leuven).
Recruitment	We obtained invasive intracranial recordings from four patients with refractory epilepsy treated at UZ Leuven (University Hospital Leuven).These patients were identified by the epileptologist as surgical candidates and underwent intracranial EEG monitoring to localize the epileptic onset zone. At our institution, all patients requiring subdural grid placement for epilepsy monitoring are invited to participate in this study and asked if they consent to the placement of a micro-electrode array. The study protocol was thoroughly discussed with each patient during a preoperative consultation held at least six weeks prior to surgery. Patients were informed of the potential risks associated with micro-electrode array implantation, including infection and hemorrhage. Importantly, no additional incisions were made for the purpose of this study. Written informed consent was obtained from all participants on the evening before their surgery.
Ethics oversight	Ethische Commissie Onderzoek UZ/KU Leuven

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	The study included four subjects. The number of participants was entirely dependent on the availability of patients requiring intracranial EEG and was further constrained by the specific electrode placement required for clinical monitoring. For instance, patients requiring only frontal electrode placement could not be included in this study.
Data exclusions	In one experiment (binocular rivalry), Patient 1 misunderstood the task instructions and failed to appropriately differentiate between the two images. As a result, it was not possible to analyze perception-related responses for this patient. This is explicitly noted in the manuscript's Results section. However, the non-perception-related activity was unaffected and was therefore included in the analysis.
Replication	We tried to replicate the findings from all experiments in all four patients by repeating all experiments in all patients.
Randomization	Not applicable.
Blinding	Not applicable. Both the patients and the research team were always fully aware of the experiments being conducted.

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

Clinical data

Policy information about clinical studies

All manuscripts should comply with the ICMJE guidelines for publication of clinical research and a completed CONSORT checklist must be included with all submissions.

Clinical trial registration	We obtained ethical approval (study number s53126) for conducting semi-chronic microelectrode recordings using the Utah array in patients undergoing invasive epilepsy monitoring.
Study protocol	Study protocol is attached to the same mail as this document.
Data collection	Data was collected in the University Hospital of Leuven, on the epilepsy ward. Patients were recruited between february 2021 and march 2022.
Outcomes	We did not have clinical outcome measures.

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, mosiacism, off-target gene editing) were examined.*