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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	MATLAB v2021a, SCR_001622
Data analysis	MATLAB v2021a, SCR_001622

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 conditions of ethics approval and consent procedures do not permit the public archiving of the participants' anonymized study data. These data are available upon request to the corresponding author in consultation with the cantonal ethics committee of the Swiss canton Zurich. Preprocessed numerical data are available at https://github.com/caneuro/skullwhistle, and functional brain maps are available at https://identifiers.org/neurovault.collection:18295.

Human research participants

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

Reporting on sex and gender	The sex of the participants is reported for each sample for each experiment. Sex and gender were not included as a factor in any of the analyses, because none of our hypothesis was related to participants' sex and gender.
Population characteristics	The study included 8 different laboratory experiments with human participants. Experiment 1: n=70 human participants, 43 female, mean age 25.01y, SD 4.55 Experiment 2: n=40 human participants, 25 female, mean age 24.60y, SD 3.43 Experiment 3: n=7 human participants, 4 female, mean age 33.57y, SD 7.25 Experiment 4: n=76 human participants, 52 female, mean age 24.17y, SD 4.46 Experiment 5: n=58 human participants, 41 female, mean age 25.60y, SD 6.29 Experiment 6: n=47 human participants, 34 female, mean age 23.91y, SD 4.21 Experiment 7: n=47 human participants, 33 female, mean age 25.02y, SD 3.91 Experiment 8: n=33 human participants, 18 female, mean age 26.00y, SD 5.47
Recruitment	All participants in the studies were recruited by public announcements and volunteered to participate.
Ethics oversight	All experiments were approved by the cantonal ethics committee of the Swiss canton of Zürich.

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

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Quantitative acoustic, behavioral, and brain data
Research sample	Human participants sampled from the general population by public announcements
Sampling strategy	See above; exclusion criteria were having hearing and visual impairments as well as psychiatric or neurological disorders in life history
Data collection	Laboratory experiments, PC controlled experiments, sounds delivered by high-quality headphones
Timing	01/2021 - 11/2022
Data exclusions	No data were excluded from the data analysis. Seven participants took part in the different laboratory experiments, but because of hardware failures of the response devices, their behavioral responses were not recorded, and no data could be included in the data analysis.
Non-participation	n/a
Randomization	No group allocation of participants

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

Magnetic resonance imaging

Experimental design

Design type	task-based, event-related
Design specifications	This experiment included 200 sounds. The experiment consisted of 4 different runs, and each run presented all 200 sounds in random order as single trials. Each run also contained a random selection of 20 trials, in which sounds of the previous trial were repeated.
Behavioral performance measures	The task of participants was to detect sound repetitions (~10% of all trials) and indicate the detection of a repeated sound by a button press with their right index finger. Participants were asked to listen attentively to the sounds, and the sound repetition task ensured that participants kept an attentive listening state. All repetition trials were excluded from all further analyses.

Acquisition

Imaging type(s)	functional, structural
Field strength	3T
Sequence & imaging parameters	Structural and functional brain data were recorded on a 3T Philips Ingenia MR scanner by using a standard 32-channel head coil. A high-resolution structural image was acquired by using a T1-weighted scan (301 contiguous 1.2mm slices, repetition time [TR]/echo time [TE] = 1.96s/3.71ms, field of view [FOV] = 256mm, in-plane resolution 1x1mm2). Functional whole-brain images were recorded by using a T2*-weighted echo-planar pulse imaging (EPI) sequence (TR 1.6s, TE 30ms, flip angle [FA] 82°; in-plane resolution 220×114.2mm, voxel size 2.75×2.75×3.5mm3; slice gap 0.6mm) covering the whole brain.
Area of acquisition	whole-brain

Diffusion MRI ☐ Used ☒ Not used

Preprocessing

Preprocessing software	SPM12, v7487; SCR_007037
Normalization	based on segmentation of the T1 image
Normalization template	ICBM152
Noise and artifact removal	motion correction (realignment), moothing 8mm kernel; motion parameters as regressors of no interest in the 1-level GLM
Volume censoring	n/a

Statistical modeling & inference

Model type and settings	first-level GLM design as fixed-effects model, second-level GLM design as random-effects model; gPPI connectivity models; MVPA analysis
Effect(s) tested	Contrasts between conditions; functional connectivity; MVPA to RSA analysis using a correlation approach

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

Statistic type for inference (See Eklund et al. 2016)	combined vowel and cluster analysis; strength of functional connectivity; RSA patterns to predict patterns of brain activaity
Correction	FWE correction

Models & analysis

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

Functional and/or effective connectivity	general psycho-physiological interaction (gPPI)
Multivariate modeling and predictive analysis	MVPA analysis as searchlight analysis; MVPA discrimination in single-trial data