nature portfolio

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Last updated by author(s): 19/12/25

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	The behavioral data were acquired using Matlab (Version 2016, The MathWorks Inc.) and the Psychophysical toolbox (Brainard, 1997). The EEG data were acquired using Brain Vision Recorder software from Brain Products (https://brainvision.com/).
Data analysis	Software and algorithms: - Matlab (version 2021a) - Jasp (JASP Team (2024). JASP (Version 0.19.3)) - EEGlab v2019 (https://doi.org/10.1016/j.jneumeth.2003.10.009) - Traveling waves analysis (https://github.com/artipago/travellingWaveEEG)

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 data that support the findings of this study are available from the corresponding author upon reasonable request.

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	The identified results were aggregated across both genders. Gender was determined based on participants' self-reports. In the paper, we reported the number of males and females comprising the total sample. We did not conduct separate analyses by gender because previous literature did not report a gender effect on the neural markers (i.e., Traveling waves, Alpha power), nor on the detection task we focused on.
Reporting on race, ethnicity, or other socially relevant groupings	We did not utilize the constructs of race and ethnicity as they were not relevant to the study objectives. All participants were white university students residing in Italy.
Population characteristics	The participants were drawn from the general population and did not have any neurological/psychiatric diagnoses. The participants ranged in age from 18 to 35 years old. All participants had normal or corrected-to-normal visual acuity in both eyes.
Recruitment	The participants were recruited on a voluntary basis. Participants were recruited through a combination of printed and electronic advertisements displayed on notice boards at different University of Bologna sites.
Ethics oversight	Bioethics Committee of the University of Bologna.

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 sample size of N=80 was determined a priori to ensure sufficient statistical power for detecting the main effects of interest in our within- and between-subject EEG analyses. In addition to examining condition-level effects, the study also aimed to capture interindividual variability in neural dynamics (e.g., traveling waves), which required a sample large enough to yield reliable estimates across participants. This number balances practical feasibility with the need for robust and generalizable findings.
Data exclusions	No participants were excluded from the analysis. All individuals who completed the experimental protocol were included in the final dataset.
Replication	While the results have not yet been replicated in an independent sample, the robustness of the findings is supported by the relatively large sample size (N = 80), which enhances statistical reliability and the stability of individual-level estimates. Moreover, the main effects were validated through a rigorous multimethod approach, including time-resolved analyses of alpha-band traveling waves, control comparisons across hemispheres, and mediation analyses linking neural dynamics to behavioral bias. These converging methods strengthen the confidence in the reproducibility of the effects.
Randomization	Randomization was not a central aspect of the study since there were no distinct experimental groups involved. The design mainly relied on within-subject statistics. The between-group analyses were exclusively conducted on groups delineated by an objective, physiological criterion (i.e., groups categorized by alpha amplitude modulation) This approach inherently avoids biases, as it relies solely on data-driven distinctions rather than subjective researcher decisions.
Blinding	Since there were no experimental groups involved, participant/researcher blinding was not pertinent to the study.

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

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.