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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 and Simlink r2019a.
Data analysis	Matlab r2019a for EEG analysis. Matlab r2023a for the rest. Metropolis-Hastings algorithm was implemented in an in-house manner based on Hastings, Biometrika, 1970, Zhou PRL, 2011, and Metropolis et al., J Chem Phys 1953. The codes for the energy landscape analysis were shared as supplementary material for one of our previous studies (Ezaki et al. Phil Trans Royal Soci A, 2017).

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 are available at GitHub (https://github.com/takamitsuwatanabe/PaperData01/tree/main/BDNS_ASD).

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	This study employed 50 typically developing individuals (14 females) and 50 individuals with autism spectrum disorder (11 females)
Reporting on race, ethnicity, or other socially relevant groupings	Japanese. Asian. Adults.
Population characteristics	The participants were diagnosed by a trained psychiatrist according to DSM 5, and the severity of their core symptoms was assessed using ADOS-2 Japanese edition by the psychiatrist and/or a trained psychologist. To reduce the heterogeneity of the participants, this study employed high-functioning ASD adults (Full IQ/Verbal IQ/Practice IQ ≥ 85). The IQ was quantified with the Wechsler Adult Intelligence Scale (third edition, UK). We excluded individuals with any other neuropsychiatric disorders and those taking psychiatric medicines at the time of the experiments. The age was controlled between ASD and control groups (ASD: 22.9±0.3, Control: 23.4±0.3; mean±sem).
Recruitment	We recruited the participants through online methods and from relevant clinics. These methods may have induced some selection biases: all the control and autistic participants lived in/around Tokyo; all the participants were recruited during the COVID-19 pandemic, which may result in selecting individuals who were relatively resilient to COVID-19.
Ethics oversight	This study was approved by Institutional Ethics Committees at The University of Tokyo (20-132). The protocols for transcranial magnetic stimulation (TMS) complied with the guidelines issued by the Japanese Society for Clinical Neurophysiology and the International Federation of Clinical Neurophysiology4. All the participants provided written informed consent before any experiment and were financially compensated for their participation.

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	This study was approved by Institutional Ethics Committees at The University of Tokyo (20-132). The protocols for transcranial magnetic stimulation (TMS) complied with the guidelines issued by the Japanese Society for Clinical Neurophysiology and the International Federation of Clinical Neurophysiology4. All the participants provided written informed consent before any experiment and were financially compensated for their participation.
Data exclusions	We did not exclude any data but 10 of the 50 ASD individuals dropped out during the first 12-week longitudinal experiment (Experiment 4).
Replication	Experiment 3's results were replicated in the first part of Experiment 4. Essential parts of the results seen in Experiment 4 were replicated in Experiments 5 and 6 and Additional Experiments 1-3. Essentially, the main findings were replicated twice.
Randomization	We adopted a sham-controlled cross-over design and randomly assigned the participants either to TMS-sham condition or sham-TMS condition.
Blinding	In the current BDNS sessions, only the participants were blind to the TMS condition, whereas the experimenter knew it. Conventionally, complete double-blind designs are difficult to achieve in TMS studies.

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	N/A
Novel plant genotypes	N/A
Authentication	N/A

Magnetic resonance imaging

Experimental design

Design type	Resting-state functional MRI
Design specifications	5min/run x 6 runs
Behavioral performance measures	Not applicable since we employed a resting-state functional MRI protocol.

Acquisition

Imaging type(s)	functional (EPI) and structural (T1-weighted) MRI
Field strength	3T
Sequence & imaging parameters	In this study, we recorded structural and resting-state functional MRI using a 3.0T MRI scanner (Trio, Siemens Medical Systems) with the 32-channel head coil at the International Research Center for Neurointelligence (WPI-IRCN) at The University of Tokyo. T1-weighted structure images were obtained at 1mm-cubic resolution. Functional images were recorded using an echo planar imaging (EPI) sequence (TR 0.8sec, TE 37ms, Flip angle 52 degrees, 72 slices, spatial resolution 2×2×2mm, multi-band acceleration factor 8). Phase image and magnitude images were also obtained for a fieldmap.
Area of acquisition	whole brain

Diffusion MRI ☐ Used ☒ Not used

Preprocessing

Preprocessing software	SPM
Normalization	First, the first five images were discarded, and the images underwent realignment, unwarping, slice timing correction, normalisation to the standard template (ICBM 152) and spatial smoothing (Gaussian kernel with 8mm of full-width at half maximum).
Normalization template	ICBM 152
Noise and artifact removal	Then, we removed the effects of head motion, white matter signals, cerebrospinal fluid signals and global signals before performing band-pass temporal filtering (0.01–0.1Hz).
Volume censoring	We directly examined the normalised imagesfor all the participants.

Statistical modeling & inference

Model type and settings	Energy landscape analysis. Random-effect model
Effect(s) tested	Not applicable since we mainly used energy landscape analysis.

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

Statistic type for inference (See Eklund et al. 2016)	Not applicable since we mainly used energy landscape analysis.
Correction	Bonferroni correction

Models & analysis

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