

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
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☐ | ☒ | 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
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ | 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 This study enrolls 40 participants, from ABIDE II-Indiana University site

Data analysis The custom code is available at <https://github.com/Yiminghh/VertexEntanglement>

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](#)

Data about Autism spectrum disorders (ASD) and typical control (TC) participants are downloaded from the second iteration of Autism Brain Imaging Data Exchange (ABIDE II, http://fcon_1000.projects.nitrc.org/indi/abide/abide_II.html).

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	20 with ASD and 20 with TC. The age range of the ASD participants is 17-54 years, and that of the TC participants is 19-37 years
Reporting on race, ethnicity, or other socially relevant groupings	not available
Population characteristics	Supplementary Note 5: Brain network construction and analysis
Recruitment	Autism Brain Imaging Data Exchange (ABIDE II)
Ethics oversight	In accordance with HIPAA guidelines and 1000 Functional Connectomes Project / INDI protocols, all datasets are anonymous, with no protected health information included.

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	<i>Describe how sample size was determined, detailing any statistical methods used to predetermine sample size OR if no sample-size calculation was performed, describe how sample sizes were chosen and provide a rationale for why these sample sizes are sufficient.</i>
Data exclusions	<i>Describe any data exclusions. If no data were excluded from the analyses, state so OR if data were excluded, describe the exclusions and the rationale behind them, indicating whether exclusion criteria were pre-established.</i>
Replication	<i>Describe the measures taken to verify the reproducibility of the experimental findings. If all attempts at replication were successful, confirm this OR if there are any findings that were not replicated or cannot be reproduced, note this and describe why.</i>
Randomization	<i>Describe how samples/organisms/participants were allocated into experimental groups. If allocation was not random, describe how covariates were controlled OR if this is not relevant to your study, explain why.</i>
Blinding	<i>Describe whether the investigators were blinded to group allocation during data collection and/or analysis. If blinding was not possible, describe why OR explain why blinding was not relevant to your study.</i>

Behavioural & social sciences study design

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

Study description	We introduce vertex entanglement (VE), an entanglement-based metric capable of quantifying the perturbations caused by individual vertices on spectral entropy, residing at the intersection of quantum information and network science.
Research sample	40 (20 with ASD and 20 with TC)
Sampling strategy	This study enrolls 40 participants, from ABIDE II-Indiana University site, 20 with ASD and 20 with TC
Data collection	Participants used in this study comes from the second iteration of Autism Brain Imaging Data Exchange (ABIDE II)
Timing	openly released to the scientific community in June 2016
Data exclusions	Contraindications to MRI were exclusionary for all participants. We also excluded participants with full-scale IQ < 80 or self-report or clinical impression of comorbid schizophrenia, past history of Major Depression with attempted suicide, history of traumatic brain injury, and various medical conditions unrelated to ASD (e.g., muscular dystrophy, uncorrectable vision impairment).

Non-participation

Analyses only included those participants who completed the MRI functional scans

Randomization

Non-randomization as cross-sectional study

Ecological, evolutionary & environmental sciences study design

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

Study description

Briefly describe the study. For quantitative data include treatment factors and interactions, design structure (e.g. factorial, nested, hierarchical), nature and number of experimental units and replicates.

Research sample

Describe the research sample (e.g. a group of tagged *Passer domesticus*, all *Stenocereus thurberi* within Organ Pipe Cactus National Monument), and provide a rationale for the sample choice. When relevant, describe the organism taxa, source, sex, age range and any manipulations. State what population the sample is meant to represent when applicable. For studies involving existing datasets, describe the data and its source.

Sampling strategy

Note the sampling procedure. Describe the statistical methods that were used to predetermine sample size OR if no sample-size calculation was performed, describe how sample sizes were chosen and provide a rationale for why these sample sizes are sufficient.

Data collection

Describe the data collection procedure, including who recorded the data and how.

Timing and spatial scale

Indicate the start and stop dates of data collection, noting the frequency and periodicity of sampling and providing a rationale for these choices. If there is a gap between collection periods, state the dates for each sample cohort. Specify the spatial scale from which the data are taken

Data exclusions

If no data were excluded from the analyses, state so OR if data were excluded, describe the exclusions and the rationale behind them, indicating whether exclusion criteria were pre-established.

Reproducibility

Describe the measures taken to verify the reproducibility of experimental findings. For each experiment, note whether any attempts to repeat the experiment failed OR state that all attempts to repeat the experiment were successful.

Randomization

Describe how samples/organisms/participants were allocated into groups. If allocation was not random, describe how covariates were controlled. If this is not relevant to your study, explain why.

Blinding

Describe the extent of blinding used during data acquisition and analysis. If blinding was not possible, describe why OR explain why blinding was not relevant to your study.

Did the study involve field work? ☐ Yes ☒ No

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

NA as not a clinical trial

Study protocol

NA

Data collection

Reported

Outcomes

Reported

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.

Magnetic resonance imaging

Experimental design

Design type

Functional MRI with network analysis

Design specifications

use the resting-state fMRI data while no task is performed

Behavioral performance measures

provide a short form of the Wechsler Abbreviated Scale of Intelligence (WASI), which is a brief and reliable measure of cognitive ability in various settings. In this study, we used the performance intelligence quotient (IQ) in ABIDE, which is a component of an individual's overall cognitive profile and plays an important role in assessing their intellectual abilities.

Acquisition

Imaging type(s)

resting-state fMRI

Field strength

3T

Sequence & imaging parameters

Number of Slices = 42; Repetition Time (TR) = 813 ms; Echo Time (TE) = 28 ms; Slice thickness = 3.4 mm; Voxel size: 3.4 * 3.4 * 3.4 mm; Field of View = 220 * 220 mm. While lying in the scanner, participants were asked to keep their eyes open and stay awake. There is only one set of 433 images (roughly 6 minutes) from the full fMRI acquisition available for sharing.

Area of acquisition

Whole Brain

Diffusion MRI

☐ Used☒ Not used

Preprocessing

Preprocessing software

spm12

Normalization

spatial normalization to the Montreal Neurological Institute (MNI) template with EPI (3 * 3 * 3 mm voxel size)

Normalization template

MNI template

Noise and artifact removal

denoising: 24HMP+8Phys+Spikereg, the 24HMP indicates 24 column head motion parameters (i.e., the 6 rigid-body parameter time-series, their backwards-looking temporal derivatives, plus all 12 resulting regressors squared); The 8Phys indicates 2 averaged WM and CSF signals, their temporal derivatives, plus all 4 resulting regressors squared; The Spikereg indicates spike regression.

Volume censoring

volumes were marked as contaminated if FDJenK > 0.25 mm.

Statistical modeling & inference

Model type and settings

resting-state fMRI data

Effect(s) tested

Shepherd's pi correlation is performed

Specify type of analysis:

☒

Whole brain

☐

ROI-based

☐

Both

Statistic type for inference

correlation analysis

(See [Eklund et al. 2016](#))

Correction

NA

Models & analysis

n/a

Involvement in the study

☒

☐

Functional and/or effective connectivity

☐

☒

Graph analysis

☒

☐

Multivariate modeling or predictive analysis

Graph analysis

whole brain network with brain hub disruption index