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# Reporting Summary

Nature Research 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 Research policies, see Authors & Referees 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<br>*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<br>*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 temporal segment network was used to self-learn the video-level features of the behavioural phenotypes. Technical details are shown in the Supplementary Information. |
| Data analysis | Our code is derived from the open-source code of the temporal segment network, available at https://github.com/yjxiong/temporal-segment-networks. All implementation details are described in sufficient detail in Methods and in the Supplementary Information. |

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/reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research 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 list of figures that have associated raw data
- A description of any restrictions on data availability

The authors declare that the main data supporting the results in this study are available within the paper and its Supplementary Information. The datasets generated during the study and representative videos for each behaviour are available for research purposes from the corresponding authors on reasonable request. The raw videos are not publicly available due to restrictions of portrait right and patient privacy.

# 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 | Previous studies on the mannerisms of visually impaired humans were fairly limited owing to sample size (small groups or case studies), and to the paucity of representative situations (adults with less plasticity). Reference: Molloy A. et al. Strabismus 19, 77–84 (2011).<br>We focused on a group of 4,196 human infants (largest-to-date study population) who suffered from varying degrees of early-stage visual-stimuli deficiencies while their behavioural systems remained sensitive (the infants retained high behavioral plasticity). |
| Data exclusions | All the infants were younger than 3 years of age, and 2,272 participants (54.1%) were male. Infants were excluded if they had brain and mental illnesses or other known illnesses that could affect their behavioural patterns. These data exclusion criteria were pre-established. |
| Replication | Our findings of behaviours and visual functions are derived from both statistical analysis (comparison and correlation) and modelling (dominance analysis), and also validated by artificial-intelligence algorithms (signals deciphered from the trained networks and specific patterns in visually impaired infants). |
| Randomization | After functional examinations of visual acuity and structural examinations of ocular conditions, all infants were divided into three groups on the basis of a range of visual conditions: a total of 571 (13.61%) infants were included in the 'healthy' group; 1,913 (45.59%) were included in the 'mild' impairment group; and 1,712 (40.80%) were included in the 'severe' impairment group. There was therefore no randomization in group allocation. |
| Blinding | The clinicians who were responsible for the evaluation of visual conditions were blind to the study design.<br>The investigators and experts who were responsible for the labelling of behaviours were blind to group allocation. |

# 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 |
| ☒ | ☐ Animals and other organisms |
| ☐ | ☒ Human research participants |
| ☒ | ☐ Clinical data |

## Methods

| n/a | Involved in the study |
|---|---|
| ☒ | ☐ ChIP-seq |
| ☒ | ☐ Flow cytometry |
| ☒ | ☐ MRI-based neuroimaging |

## Human research participants

Policy information about studies involving human research participants

| | |
|---|---|
| Population characteristics | All the infants were younger than 3 years of age, and 2,272 participants (54.1%) were male. Infants were excluded if they had brain and mental illnesses or other known illnesses that could affect their behavioural patterns. |
| Recruitment | All 4,196 infants were recruited from 3 populations with various settings: The National Visual Screening Project, a population-based study focused on children in communities, the Childhood Blindness Project of South China, a multicentre collaboration consisting of tertiary hospitals and primary clinics, and the Vision of Infants in Guangzhou, conducted at Zhongshan Ophthalmic Center, the largest specialized eye hospitals in China. |
| Ethics oversight | The research protocol was approved by the Institutional Review Board and Ethics Committee of Sun Yat-sen University (Guangzhou, China). Informed written consent was obtained from at least one family member of each infant, and the tenets of the Declaration of Helsinki were followed throughout this study. This trial was registered with the Clinical Research Internal Management System of Zhongshan Ophthalmic Center and retrospectively registered in ClinicalTrials.gov (NCT03431207). This study was part of the trial and it only used data from the trial. |

Note that full information on the approval of the study protocol must also be provided in the manuscript.