

## 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 & References](#) 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

### Data analysis

The following programs were used in this analysis:  
 BWA-MEM v0.7.15  
 htlib v1.9  
 Genome Analysis Toolkit v3.8 and v4.0  
 Integrative Genomics Viewer (IGV) v2.4.5  
 Varsseq v1.4.7  
 Lumpy v0.2.13  
 Manta v1.2.2  
 SMRT Link software v5.1.0  
 NGS-LR v2.1.5  
 Sniffles v1.0.7  
 Canu v1.7  
 Circular consensus calling software v3.2.1  
 MinkNOW Core 1.11.5  
 Albacore v2.1  
 ExpansionHunter v2.5.5  
 exSTRa v0.88.3 with Bio-STR-exTRa v1.0.1  
 HISAT2 v2.1  
 StringTie v1.3.3  
 R v3.4.3  
 edgeR

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

Source data for figures are provided in Supplementary and Source Data files with this manuscript. Whole genome sequencing data and RNA-seq data are available from the corresponding author on request, subject to human research ethics approval and patient consent.

### 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/fr-reporting-summary-flat.pdf](https://nature.com/documents/fr-reporting-summary-flat.pdf)

### Life sciences study design

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

- Sample size
- Data exclusions
- Replication
- Randomization
- Blinding

### 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
- Recruitment
- Ethics oversight

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