

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 For imaging on LSM900 and ELYRA PS.1, ZEN 3.1 (Blue edition) software is used. For imaging on FV1000, FluoView (FV10-ASW Ver1.7) software is used. For taking electron microscopy on Tecnai Spirit G2, FEI software is used.

Data analysis For image quantification analysis, Fiji ImageJ (v1.53) is used. For statistical analysis and graphing, GraphPad Prism7 and R (version 4.2.2) are used. All images of this study were processed for publication using Fiji ImageJ (v1.53) and Adobe illustrator (2019).

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](#)

Mass spectrometry data have been deposited the Japan ProteOme STandard Repository (jPOST) under the ID JPST002268. Source data have been provided in Source Data. All other data supporting the findings of this study are available from the corresponding author on 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 N/A

Reporting on race, ethnicity, or other socially relevant groupings N/A

Population characteristics N/A

Recruitment N/A

Ethics oversight N/A

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](https://www.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 No statistical method was used to pre-determine the sample size, but our sample sizes are similar to those reported in previous publications (Wang et al., Nat. Cell Biol., 2018; Yamazaki et al., Mol. Cell, 2018; Yamazaki et al., EMBO J., 2021).

Data exclusions No data was excluded from this study.

Replication All of the experiments were successfully replicated with at least two independent biological samples. The number of replicates were specified in the methods and individual figure legends.

Randomization For all experiments, randomization was not performed because samples depended upon specific genetic cell lines so randomization was not appropriate.

Blinding For all experiments, blinding was not performed.

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

Antibodies

Antibodies used For immunostaining: anti-SC35 (mouse monoclonal, Sigma, S4045, Clone: SC-35, dilution 1:1000, IF),

anti-SON (rabbit, polyclonal, Abcam, ab121759, dilution 1:1000, IF),
 anti-NONO (mouse monoclonal, BD Biosciences, 611279, Clone: 3/p54nrb, dilution 1:500, IF),
 anti-FUS (mouse monoclonal, Santa Cruz, sc-47711, Clone: 4H11, dilution 1:500, IF),
 anti-SFPQ (mouse monoclonal, MBL, RN014MW, Clone: C23, dilution 1:500, IF),
 anti-HNRNPH1 (rabbit polyclonal, Bethyl, A300-511A, dilution 1:500, IF),
 anti-BRG1 (rabbit polyclonal, Bethyl, A300-813A, dilution 1:500, IF),
 anti-HNRNPF (rabbit polyclonal, GeneTex, GTX114476, dilution 1:200, IF),
 anti-PSPC1 (rabbit polyclonal, MBL, homemade, dilution 1:500, IF),
 anti-HNRNPH3 (rabbit polyclonal, Abcam, ab6663, dilution 1:100, IF),
 anti-RBM14 (rabbit, Bethyl, A300-331A, dilution 1:500, IF),
 anti-TDP43 (rabbit polyclonal, Proteintech, 10782-2-AP, dilution 1:500, IF),
 anti-HNRNPA1 (rabbit polyclonal, MBL, RN014PW, dilution 1:100, IF),
 anti-DDDDKtag (rabbit polyclonal, MBL, PM020, dilution 1:400, IF),
 anti-FLAG M2 (mouse monoclonal, Sigma, F3165, Clone: M2, dilution 1:1000, IF),
 anti-MS2 coat protein (rabbit polyclonal, Sigma, ABE76-I, dilution 1:250, IF),
 anti-SF3B1 (mouse monoclonal, Santa Cruz, sc-514655, Clone: B-3, dilution 1:500, IF),
 anti-Coilin (mouse monoclonal, Abcam, ab11822, Clone: Pdelta, dilution 1:1000, IF),
 anti-PML (mouse monoclonal, Santa Cruz, sc-966, Clone: PG-M3, dilution 1:500, IF),
 anti-NPAT (mouse monoclonal, Transduction Laboratories, N91820, dilution 1:100, IF).
 Goat Anti-Rabbit IgG H&L Cy2 (Abcam, ab6940, dilution 1:100, IF),
 Goat Anti-Mouse IgG Antibody, Cy3 conjugate (Sigma, AP124C, dilution 1:100, IF),
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 405 (Thermo Fisher Scientific, A-31556, dilution 1:500, IF),
 Goat anti-Mouse IgG (H+L) Alexa Fluor Plus 405 (Thermo Fisher Scientific, A-48255, dilution 1:500, IF),
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 488 (Thermo Fisher Scientific, A-11034, dilution 1:500, IF),
 Goat anti-Mouse IgG (H+L) Alexa Fluor 488 (Thermo Fisher Scientific, A-28175, dilution 1:500, IF),
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 568 (Thermo Fisher Scientific, A-11036, dilution 1:500, IF),
 Goat anti-Mouse IgG (H+L) Alexa Fluor 568 (Thermo Fisher Scientific, A-11031, dilution 1:500, IF),

For western blotting:

anti-NONO (mouse monoclonal, BD Biosciences, 611279, Clone: 3/p54nrb, dilution 1:2000, WB),
 anti-SFPQ (mouse monoclonal, MBL, RN014MW, Clone: C23, dilution 1:2000, WB),
 anti-HNRNPH1 (rabbit polyclonal, Bethyl, A300-511A, dilution 1:2000, WB),
 anti-BRG1 (rabbit polyclonal, Bethyl, A300-813A, dilution 1:2000, WB),
 anti-HNRNPF (rabbit polyclonal, GeneTex, GTX114476, dilution 1:1000, WB),
 anti-PSPC1 (rabbit polyclonal, MBL, homemade, dilution 1:1000, WB),
 anti-TDP43 (rabbit polyclonal, Proteintech, 10782-2-AP, dilution 1:2000, WB),
 anti-GAPDH (mouse monoclonal, Abcam, ab8245, Clone: 6C5, dilution 1:10000, WB),
 anti-GAPDH (rabbit polyclonal, Abcam, ab37168, dilution 1:10000, WB),
 anti-FLAG M2 (mouse monoclonal, Sigma, F3165, Clone: M2, dilution 1:5000, WB)
 anti-HA (mouse monoclonal, BioLegend, 901513, Clone: 16B12, dilution 1:1000, WB),

For electron microscopy

anti-NONO (mouse monoclonal, BD Biosciences, 611279, Clone: 3/p54nrb, dilution 1:20, EM)
 anti-SFPQ (mouse monoclonal, Sigma, P-2860, Clone: B92, dilution 1:50)
 anti-mouse IgG antibody coupled to 10 nm gold particles (BBI, EM.GAM10/2, dilution 1:25).

Validation

Antibodies obtained from the commercial source were validated by the suppliers, and detailed validation analyses are provided on the company website for the products used in this study.

anti-SON (rabbit, polyclonal, Abcam, ab121759): validation shown in (<https://www.abcam.co.jp/sondbp5-antibody-ab121759.html?productWallTab=ShowAll>)
 anti-NONO (mouse monoclonal, BD Biosciences, 611279, Clone: 3/p54nrb): validation shown in (<https://www.bdbiosciences.com/ja-jp/products/reagents/microscopy-imaging-reagents/immunofluorescence-reagents/purified-mouse-anti-p54-nrb.611279>).
 anti-FUS (mouse monoclonal, Santa Cruz, sc-47711, Clone: 4H11): validation shown in (<https://www.scbt.com/ja/p/fus-tls-antibody-4h11>).
 anti-SFPQ (mouse monoclonal, MBL, RN014MW, Clone: C23): validation shown in (<https://ruo.mbl.co.jp/bio/dtl/A/?pcd=RN014MW>).
 anti-SFPQ (mouse monoclonal, Sigma, P2860, Clone: B92): validation shown in (<https://www.sigmaaldrich.com/JP/ja/product/sigma/p2860>)
 anti-HNRNPH1 (rabbit polyclonal, Bethyl, A300-511A): validation shown in (<https://www.citeab.com/antibodies/655162-a300-511a-rabbit-anti-hnrnp-h-antibody-affinity-puri>)
 anti-BRG1 (rabbit polyclonal, Bethyl, A300-813A): validation shown in (<https://www.fortislife.com/products/primary-antibodies/rabbit-anti-brg1-smarca4-antibody/BETHYL-A300-813>)
 anti-HNRNPF (rabbit polyclonal, GeneTex, GTX114476): validation shown in (<https://www.genetex.com/Product/Detail/hnRNP-F-antibody-N1N3/GTX114476>)
 anti-HNRNPH3 (rabbit polyclonal, Abcam, ab6663): validation shown in (<https://www.abcam.co.jp/hnrph3-antibody-ab66663.html>)
 anti-RBM14 (rabbit, Bethyl, A300-331A): validation shown in (<https://www.fortislife.com/products/primary-antibodies/rabbit-anti-coaa-antibody/BETHYL-A300-331>)
 anti-TDP43 (rabbit polyclonal, Proteintech, 10782-2-AP): validation shown in (<https://www.ptglab.co.jp/products/TARDBP-Antibody-10782-2-AP.htm>)
 anti-HNRNPA1 (rabbit polyclonal, MBL, RN014PW): validation shown in (<https://ruo.mbl.co.jp/bio/dtl/A/index.html?pcd=RN114PW>)
 anti-DDDDKtag (rabbit polyclonal, MBL, PM020): validation shown in (<https://ruo.mbl.co.jp/bio/dtl/A/?pcd=PM020>)
 anti-FLAG M2 (mouse monoclonal, Sigma, F3165, Clone: M2): validation shown in (<https://www.sigmaaldrich.com/JP/ja/product/sigma/f3165>)
 anti-MS2 coat protein (rabbit polyclonal, Sigma, ABE76-I): validation shown in (https://www.merckmillipore.com/JP/ja/product/Anti-Enterobacterio-Phage-MS2-Coat-Protein,MM_NF-ABE76-I)
 anti-SF3B1 (mouse monoclonal, Santa Cruz, sc-514655, Clone: B-3): validation shown in (<https://www.scbt.com/ja/p/sap-155->

antibody-b-3)
 anti-Coilin (mouse monoclonal, Abcam, ab11822, Clone: Pdelta): validation shown in (<https://www.abcam.com/products/primary-antibodies/coilin-antibody-pdelta-ab11822.html>)
 anti-PML (mouse monoclonal, Santa Cruz, sc-966, Clone: PG-M3): validation shown in (<https://www.scbt.com/ja/p/pml-antibody-pg-m3>)
 anti-GAPDH (mouse monoclonal, Abcam, ab8245, Clone: 6C5): validation shown in (<https://www.abcam.co.jp/gapdh-antibody-6c5-loading-control-ab8245.html>)
 anti-GAPDH (rabbit polyclonal, Abcam, ab37168): validation shown in (<https://www.abcam.co.jp/gapdh-antibody-loading-control-ab37168.html>)
 anti-HA (mouse monoclonal, BioLegend, 901513, Clone: 16B12): validation shown in (<https://www.biolegend.com/ja-jp/products/anti-ha-11-epitope-tag-antibody-11071>)
 anti-SFPQ (mouse monoclonal, Sigma, P2860, Clone: B92): validation shown in (<https://www.sigmaaldrich.com/JP/ja/product/sigma/p2860>)
 Goat Anti-Rabbit IgG H&L Cy2 (Abcam, ab6940): validation shown in (<https://www.abcam.co.jp/products/secondary-antibodies/goat-rabbit-igg-hl-cy2--preadsorbed-ab6940.html>)
 Goat Anti-Mouse IgG Antibody, Cy3 conjugate (Sigma, AP124C): validation shown in (https://www.merckmillipore.com/JP/ja/product/Goat-Anti-Mouse-IgG-Antibody-Cy3-conjugate,MM_NF-AP124C)
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 405 (Thermo Fisher Scientific, A-31556): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Rabbit-IgG-H-L-Cross-Adsorbed-Secondary-Antibody-Polyclonal/A-31556>)
 Goat anti-Mouse IgG (H+L) Alexa Fluor Plus 405 (Thermo Fisher Scientific, A-48255): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Mouse-IgG-H-L-Highly-Cross-Adsorbed-Secondary-Antibody-Polyclonal/A48255>)
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 488 (Thermo Fisher Scientific, A-11034): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Rabbit-IgG-H-L-Highly-Cross-Adsorbed-Secondary-Antibody-Polyclonal/A-11034>)
 Goat anti-Mouse IgG (H+L) Alexa Fluor 488 (Thermo Fisher Scientific, A-28175): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Mouse-IgG-H-L-Secondary-Antibody-Recombinant-Polyclonal/A28175>)
 Goat anti-Rabbit IgG (H+L) Alexa Fluor 568 (Thermo Fisher Scientific, A-11036): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Rabbit-IgG-H-L-Highly-Cross-Adsorbed-Secondary-Antibody-Polyclonal/A-11036>)
 Goat anti-Mouse IgG (H+L) Alexa Fluor 568 (Thermo Fisher Scientific, A-11031): validation shown in (<https://www.thermofisher.com/antibody/product/Goat-anti-Mouse-IgG-H-L-Highly-Cross-Adsorbed-Secondary-Antibody-Polyclonal/A-11031>)

Some antibodies were validated in a previously published study

anti-SC35 (mouse monoclonal, Sigma, S4045, Clone: SC-35): This antibody was mischaracterized and the main target of SC35 monoclonal antibody is SRRM2. Validation shown in Ilik, et al: (doi: 10.7554/eLife.60579.)
 anti-PSPC1 (rabbit polyclonal, MBL, homemade): validation shown in Naganuma, et al: (doi: 10.1038/emboj.2012.251)
 anti-NPAT (mouse monoclonal, Transduction Laboratories, N91820): This antibody was used in Chujo et al: (doi: 10.15252/emboj.201695848) and is no longer available.

Eukaryotic cell lines

Policy information about [cell lines and Sex and Gender in Research](#)

Cell line source(s)	HAP1 cells (Horizon Discovery, Cat#C631, RRID:CVCL_Y019). Flp-In T-REx 293 Cells (Thermo Fisher Scientific, R78007)
Authentication	HAP1 cells were purchased from Horizon Discovery (https://horizondiscovery.com/ja/engineered-cell-lines/products/hap1-parental-cell-lines?catalognumber=C631) Flp-In T-REx 293 Cells were purchased from Thermo Fisher Scientific (https://www.thermofisher.com/order/catalog/product/R78007)
Mycoplasma contamination	DAPI staining did not revealed the presence of Mycoplasmas.
Commonly misidentified lines (See ICLAC register)	No commonly misidentified cell lines were used in the study.