

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 (<i>n</i>) 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> 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 <i>d</i> , Pearson's <i>r</i>), 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	Metabolic Cages (Promethion, Sable Systems), LAS X software.
Data analysis	NeuroInfo (MBF Bioscience), Rstudio, Fiji (ImageJ), Prism 10.

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](#)

In this study the Allen Brain Atlas was used as a reference for brain regions. This database is publicly available at <https://mouse.brain-map.org/static/atlas>. All data necessary for the interpretation and replication of the reported findings are contained within the manuscript and supplemental information. Raw data supporting the findings of this study are available from the corresponding author upon reasonable request. Statistical source data is provided with this paper. Detailed figure source data is also provided with this paper.

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

Life sciences study design

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

Sample size Sample sizes were estimated based on standards and credibility in the field of thermoregulation, and based on pilot metabolism data in response to real time cold exposure experiments in the research group of Lydia Lynch before conducting this study.

Data exclusions Experiments that involved stereotaxic surgery showed unsuccessful surgical targeting in under 5 % of cases, but those subjects were excluded from analysis based on histological validation. No other animals were excluded from any experiment in this study, and no extreme statistical outliers were observed for any experiment.

Replication All of the core findings of this manuscript were reproduced by two to three different investigators in our group. All technical details have been reported so that these findings can easily be replicated in any other laboratory with similar apparatus. All experiments were replicated independently between 2 and 4 times.

Randomization Animals were randomly allocated to experimental groups, and groups were counter-balanced for cage of origin.

Blinding Investigators were blind to experimental groups at all points of data collection and analysis.

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	Chicken polyclonal anti-GFP (ref# A10262, 1:1000, Invitrogen, Waltham, MA), Rabbit polyclonal IgG anti-c-Fos (ref# 226008, 1:1000, Invitrogen, Waltham, MA), Alexa 568 Anti-Rabbit IgG (ref# 11011, 1:500, Invitrogen, Waltham, MA) and Alexa 488 Anti-Chicken IgG (ref# A11039, 1:500, Invitrogen, Waltham, MA).
Validation	All antibodies were validated by the manufacturer as stated on their website. Moreover, antibody concentration was specifically validated for this study by comparing 1:1000 concentrations with 1:500 and 1:5000. The concentration that achieved optimal signal was selected.

Animals and other research organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research, and [Sex and Gender in Research](#)

Laboratory animals	Mice, C57Bl/6j, 6 - 12 weeks of age.
Wild animals	No wild animals were used in this study.
Reporting on sex	The majority of the study was conducted using only male mice. Following revision, we have included one experiment with female mice, which explicitly tests the effect of sex on cold memory formation.
Field-collected samples	No field collected samples were used in this study
Ethics oversight	All animal work was performed in compliance with the Ryan and Lynch laboratory project licenses, with ethical approval from the Trinity College Dublin ethics committee, the Animal Research Ethics Committee from the Health Products Regulatory Authority (HPRA), the Brigham and Women's Hospital Institutional Animal Care and Use Committee guidelines.

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

Plants

Seed stocks	N/A
Novel plant genotypes	N/A
Authentication	N/A