

Reporting Summary

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Statistical parameters

When statistical analyses are reported, confirm that the following items are present in the relevant location (e.g. 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
- ☐ ☒ An indication of 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 statistics 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
- ☐ ☒ Clearly defined error bars
State explicitly what error bars represent (e.g. SD, SE, CI)

Our web collection on [statistics for biologists](#) may be useful.

Software and code

Policy information about [availability of computer code](#)

Data collection

Imaging data was acquired using Scanimage 5 by Vidrio. Extraction of cell fluorescence was performed using the open-source software Suite2p. The odor library used for designing stimulus sets was obtained from www.thegoodscentscompany.com. Physicochemical descriptors were calculated using Dragon 7.0, KODE Inc.

Data analysis

Standard analyses were performed in Matlab and Python. The package "Pyrcca" (<https://github.com/gallantlab/pyrcca>) was used for multi-set canonical correlation analysis. Simulated annealing was performed using the open-source package simanneal 0.4.2 (<https://pypi.org/project/simanneal/>).

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 upon request. 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 data that support the findings of this study are available from the corresponding author upon reasonable request.

Field-specific reporting

Please select 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/authors/policies/ReportingSummary-flat.pdf](https://www.nature.com/authors/policies/ReportingSummary-flat.pdf)

Life sciences study design

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

Sample size	Data collected from 18 animals was included in the study: each of three odor sets described in the study was presented to three animals such that each animal was exposed once to a single odor set for piriform imaging, the tiled odor set was presented to 3 additional mice for cortical imaging in the TeLC experiment, and six additional mice for the bouton imaging experiment. We found that due to the consistency in the structure of odor representations apparent across individuals, three animals sufficed for each condition.
Data exclusions	Data exclusion criteria are described in the Methods. Briefly, exclusion criteria were pre-established to select for experiments where imaging volumes spanning both Piriform cortical layers 2 and 3 (or in the case of the bouton experiment, Layer 1a) could be imaged continuously for at least 2.5 hours with minimal drift and motion artifacts, where a sufficient fraction of cortical neurons was labeled with GcAMP6s and where odor-evoked activity could be detected over the course of the entire imaging session.
Replication	The principal findings in this study were present in each individual and are reported in the main text.
Randomization	Not relevant. Animals were not assigned to different conditions based on whether they originated from the same breeding, litter, or housing cage, as all mice were derived from different cages and different breedings. In addition, the consistency in the structure of odor representations described in this study suggests that the observations are robust to these variables.
Blinding	Not relevant. The main findings in this study are not contingent on blind comparison of two or more experimental conditions, except for the scoring of the behavioral experiment, which was carried out in a blinded fashion.

Reporting for specific materials, systems and methods

Materials & experimental systems

n/a	Involved in the study
☒	☐ Unique biological materials
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☐	☒ Animals and other organisms
☒	☐ Human research participants

Methods

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

Animals and other organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research

Laboratory animals

Male 8-16 week old C57/BL6J mice; for cortical imaging, mice harboring the Vgat-ires-Cre (Jackson Stock No. 028862) and ROSA26-LSL-TdTomato reporter alleles (Jackson Stock No. 007914) were used, and for bulb imaging, mice harboring the Tbet-Cre

allele (Jackson Stock 024507) were used.

Wild animals

This study did not involve the use of wild animals.

Field-collected samples

This study did not involve samples collected from the field.