Generalization in data driven models of primary visual cortex

ICLR 2021

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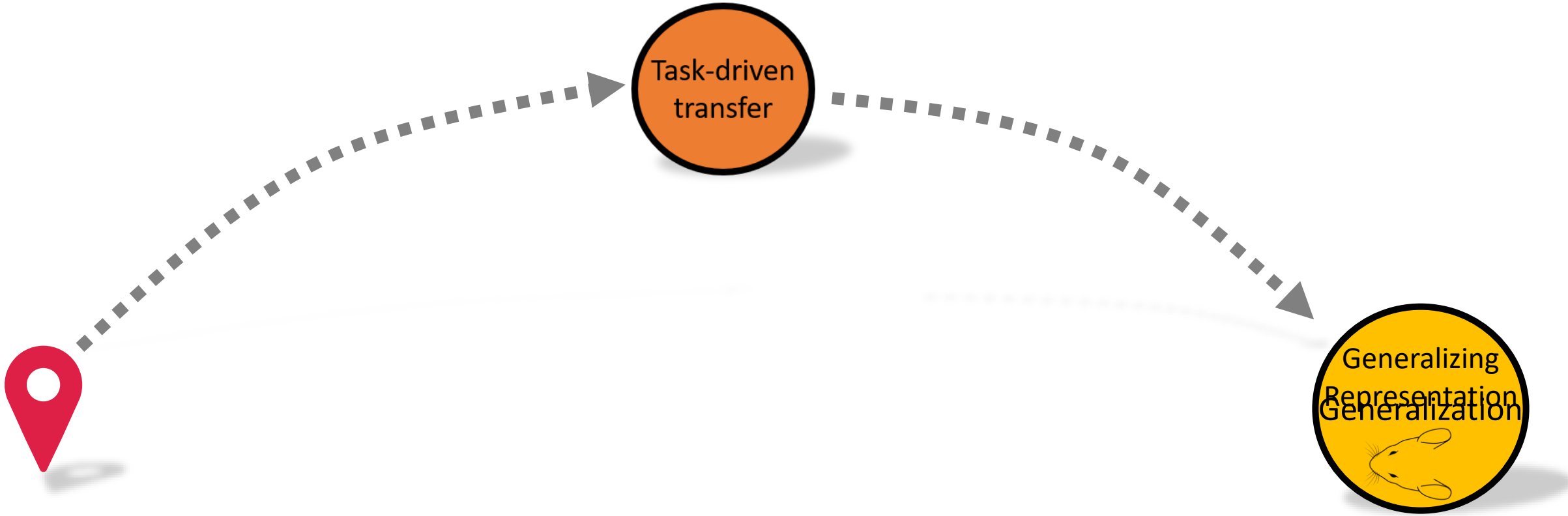
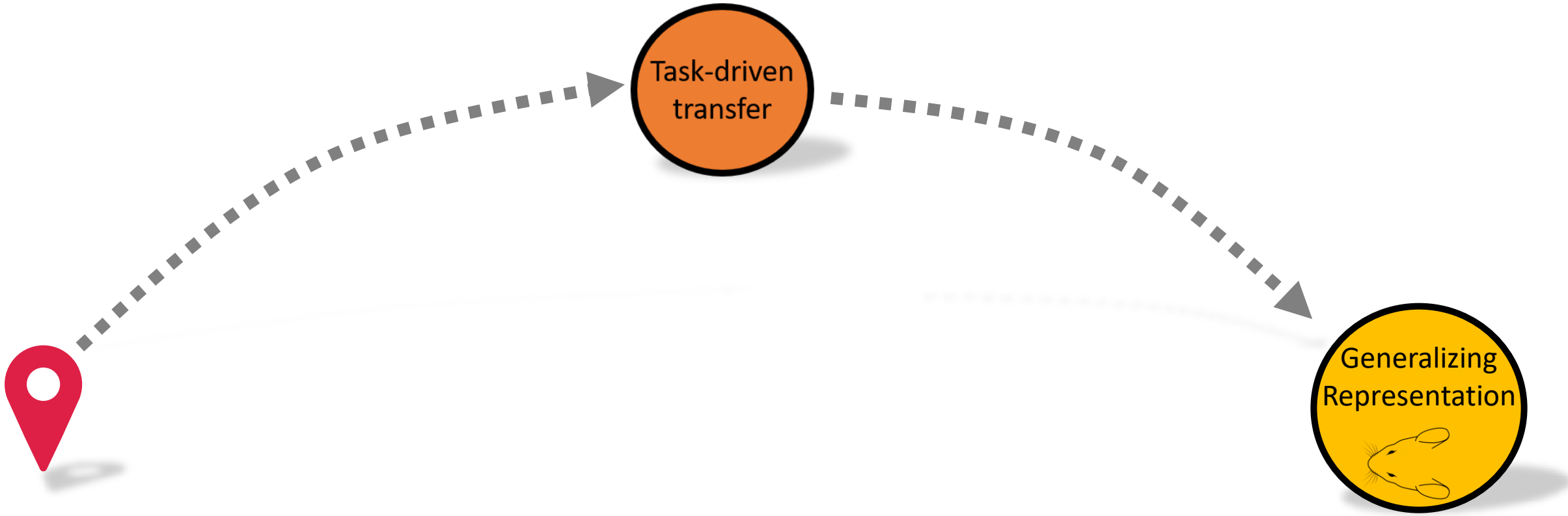
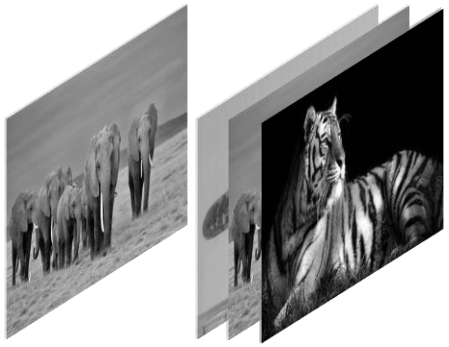
[1]University of Tübingen

[2]Baylor College of Medicine

[3]University of Göttingen


Task-driven transfer
Generalizing Representation
Generalization

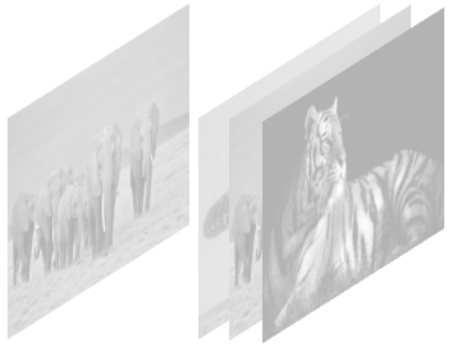

Task-driven
transfer
Generalizing
Representation



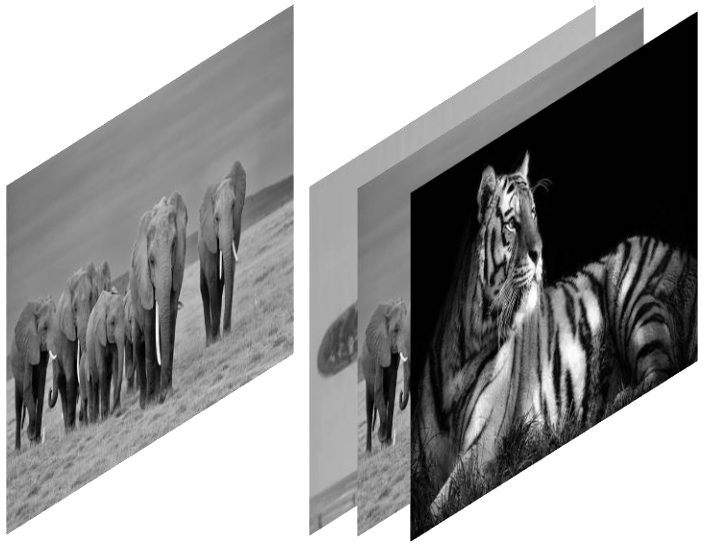
Elephant ••• Tiger

VGG16

Simonyan K, Zisserman A. Very deep convolutional networks for large-scale image recognition. ICLR 2015

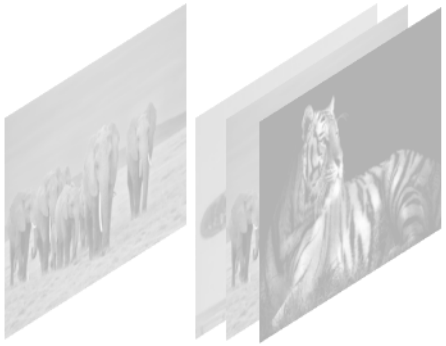


Elephant ••• Tiger

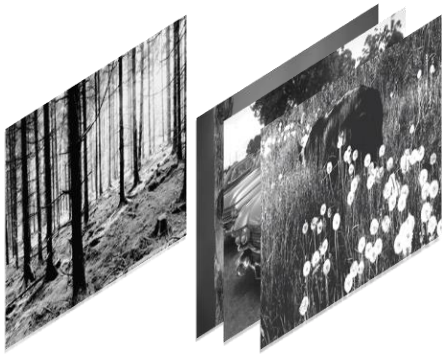


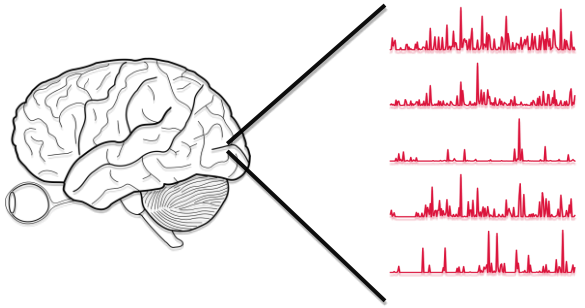
VGG16

Tig



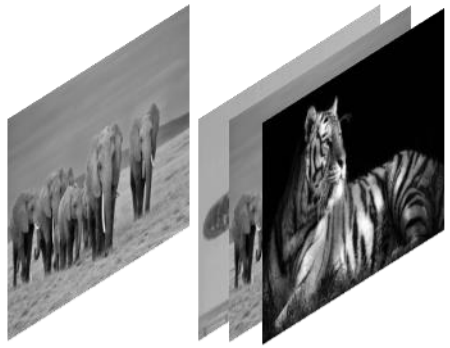
Elephant ••• Tiger





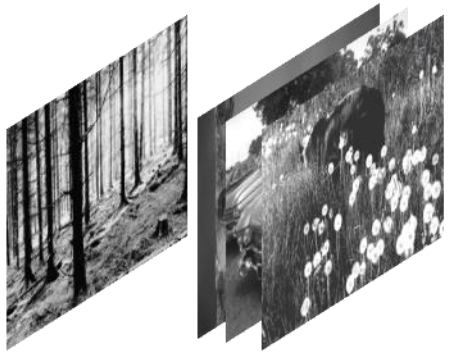
VGG16

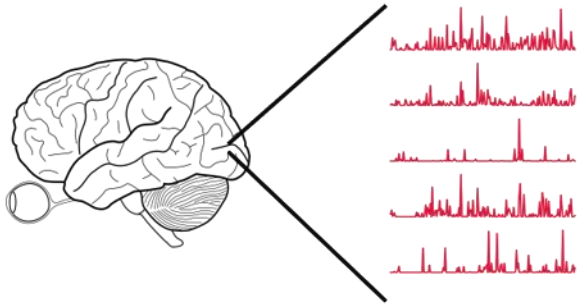
Representation dataset

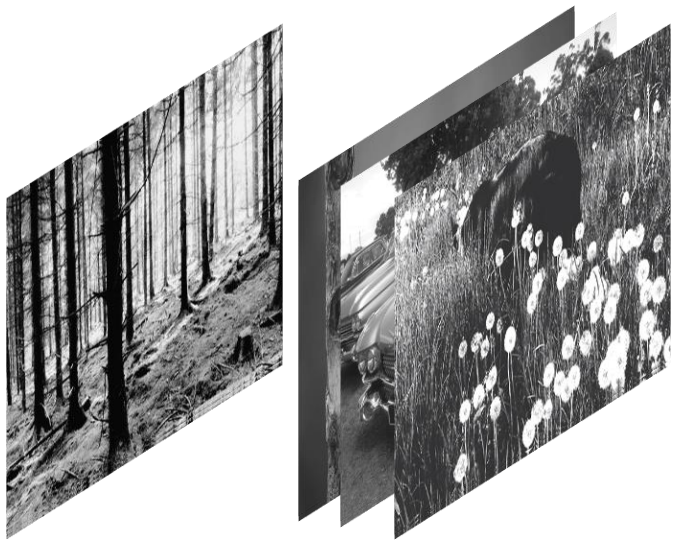


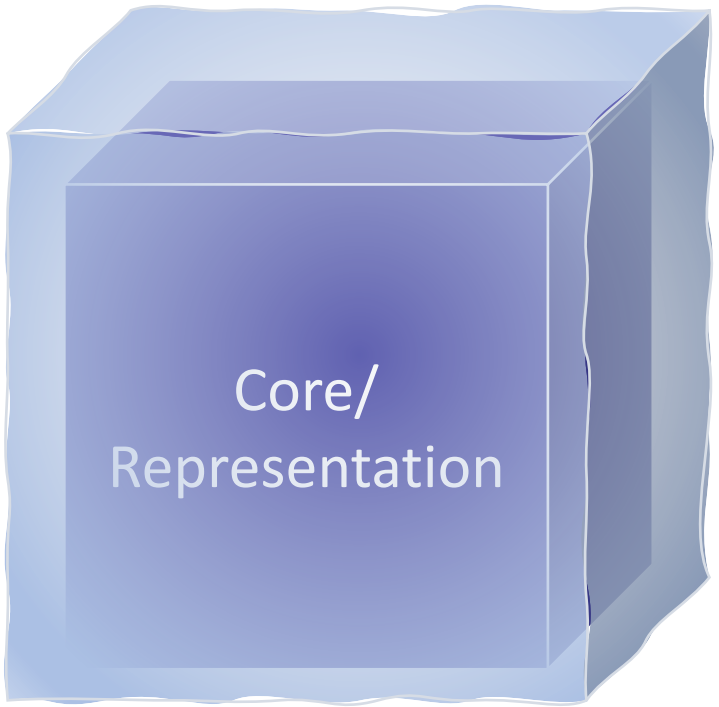
Elephant ••• Tiger

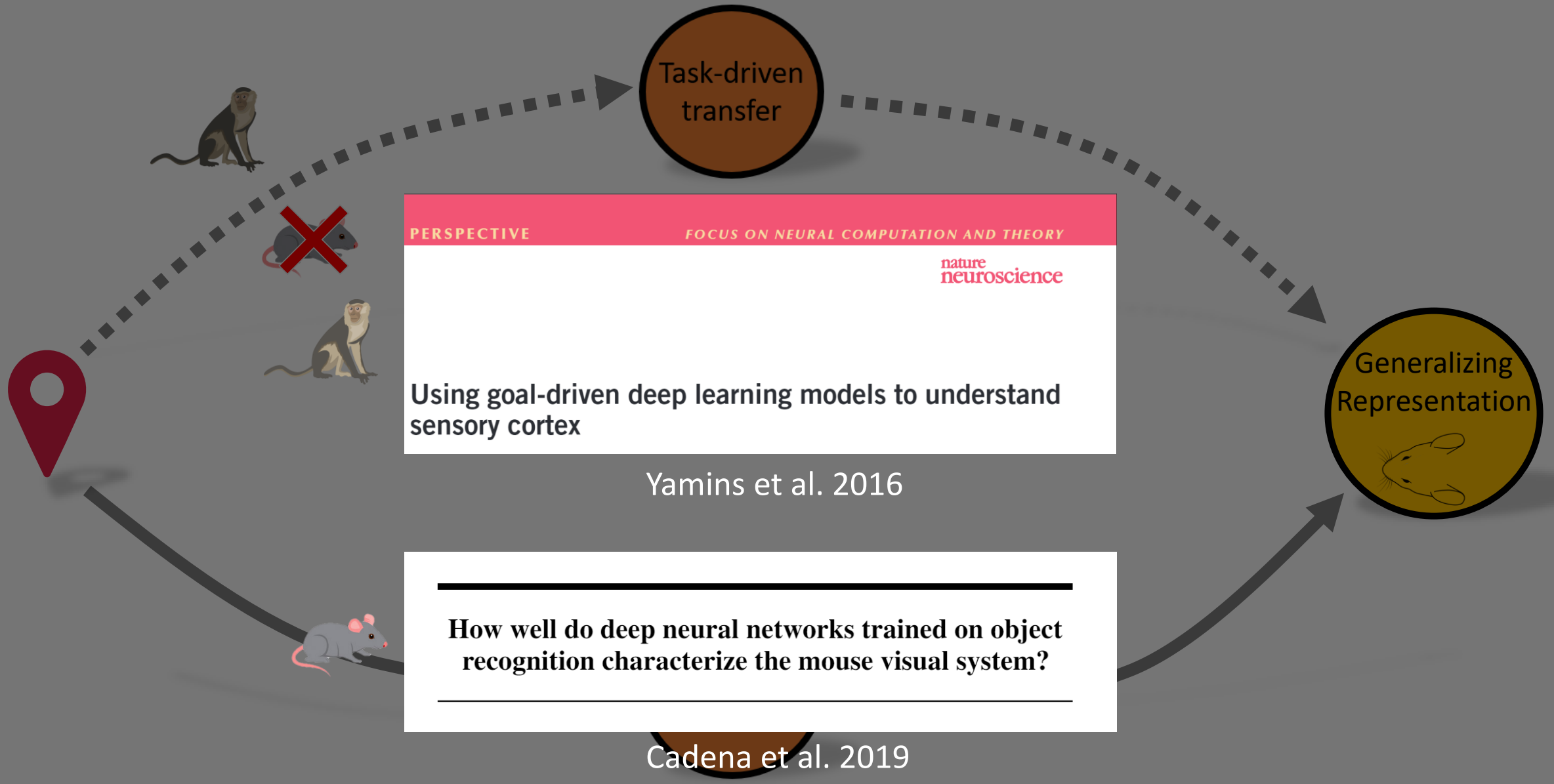
Transfer dataset

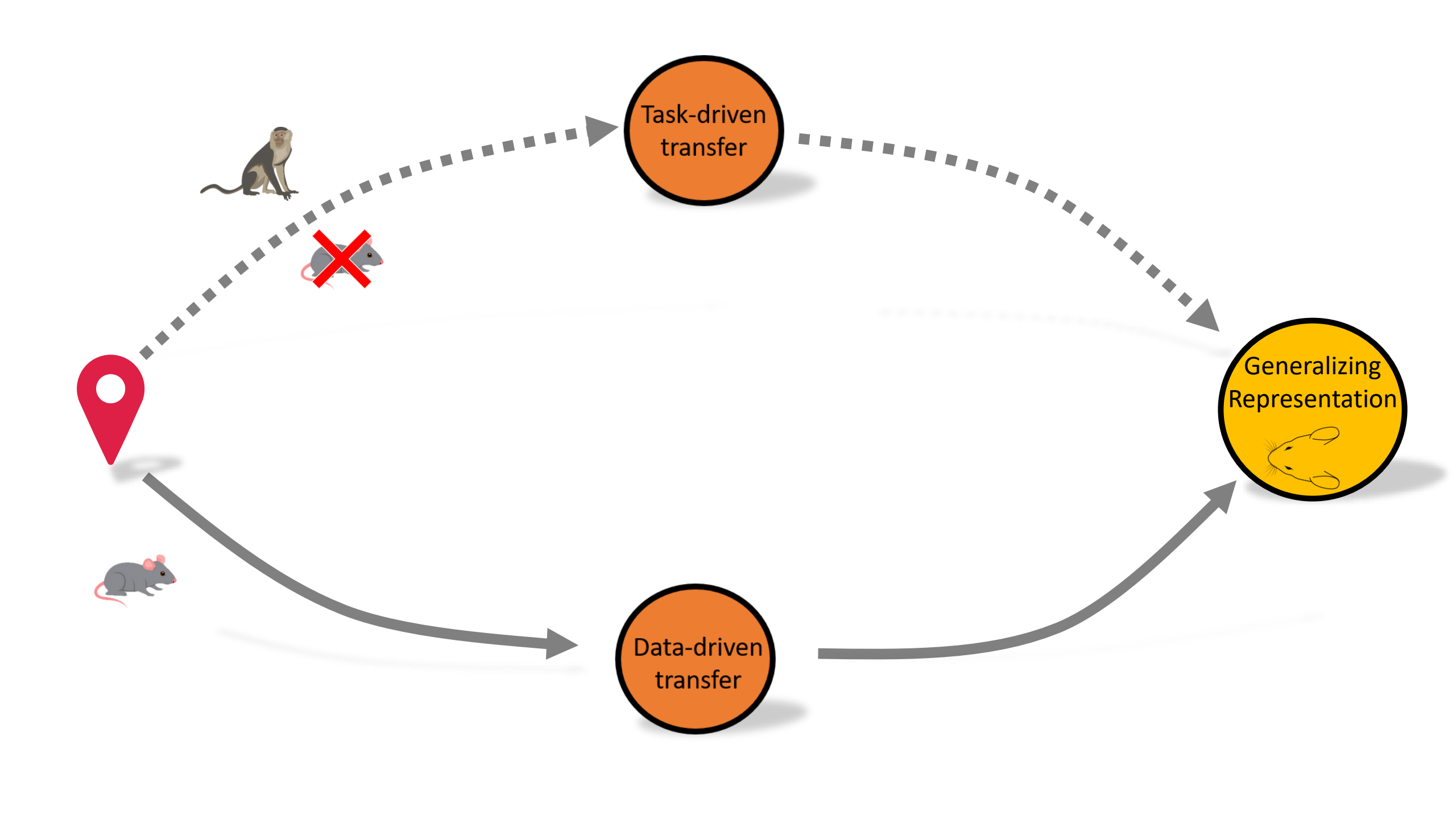


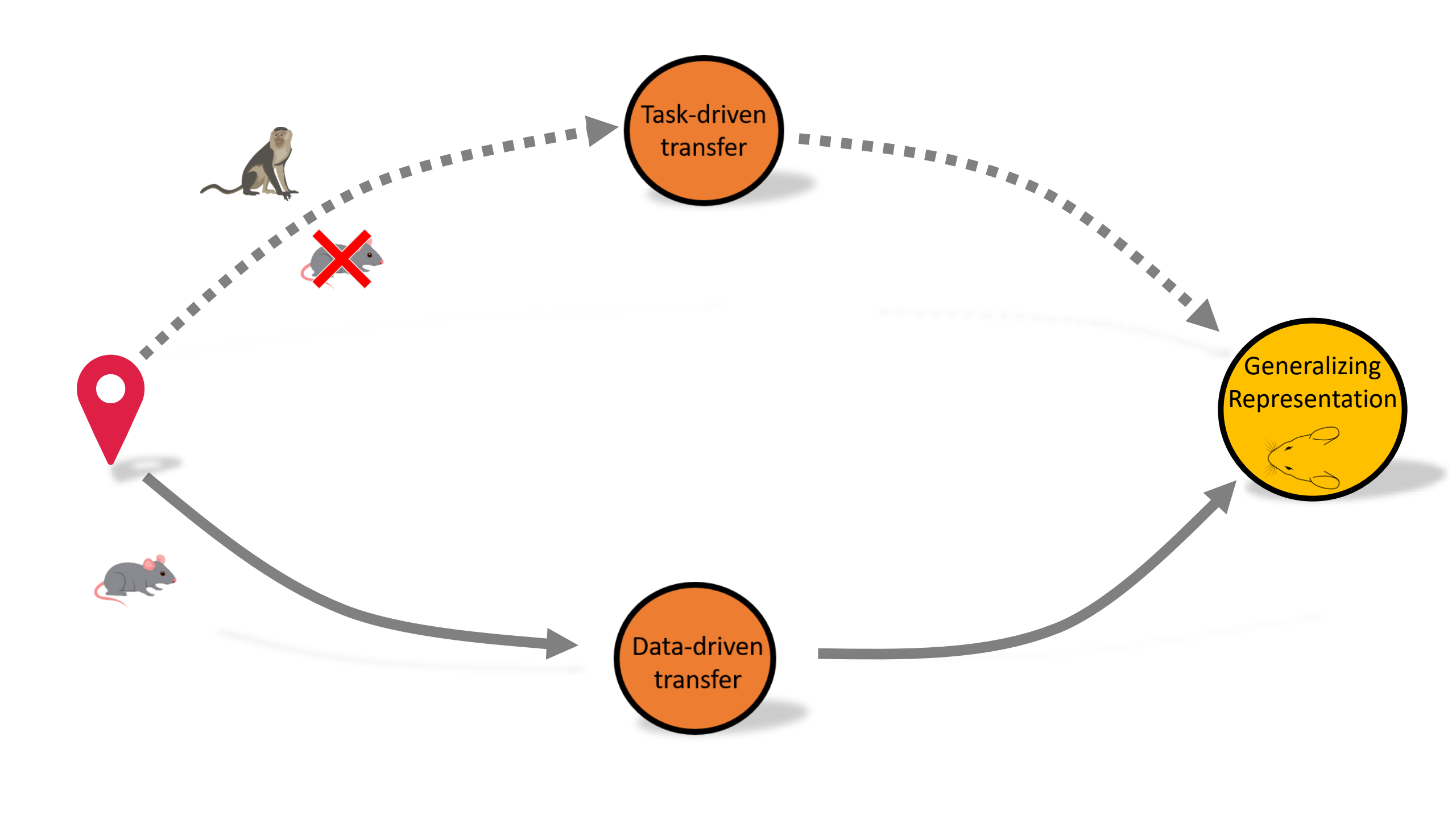




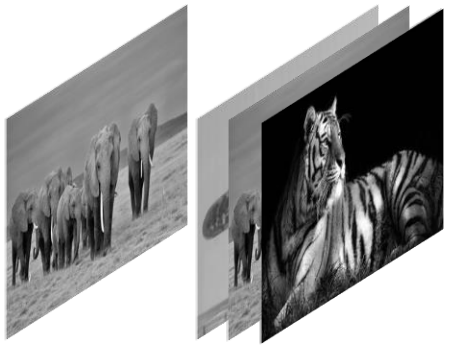


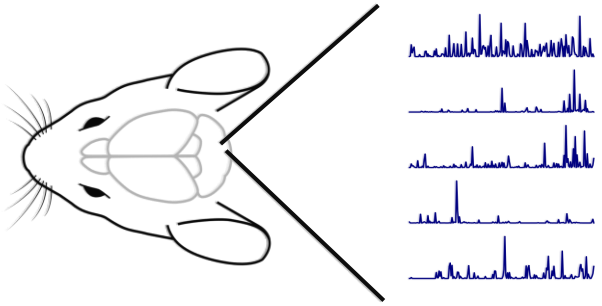

Task-driven transfer
PERSPECTIVE
FOCUS ON NEURAL COMPUTATION AND THEORY
nature neuroscience
Using goal-driven deep learning models to understand sensory cortex
Yamins et al. 2016
Generalizing Representation
How well do deep neural networks trained on object recognition characterize the mouse visual system?
Cadena et al. 2019


Task-driven transfer
Generalizing Representation
Data-driven transfer

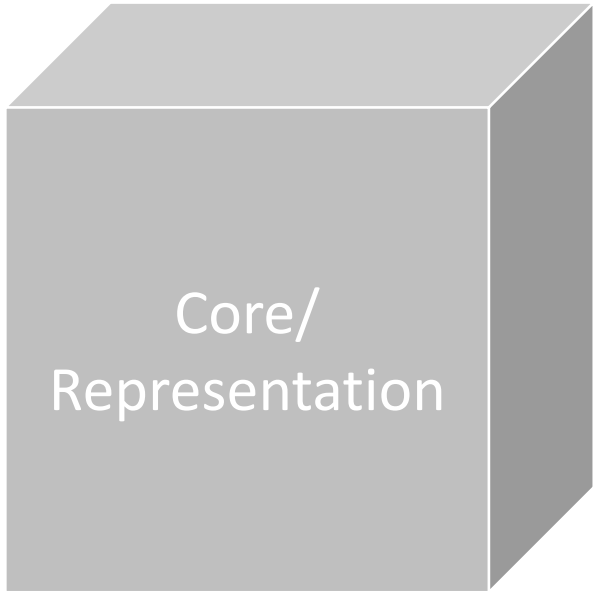

Task-driven transfer
Generalizing Representation
Data-driven transfer

Representation dataset

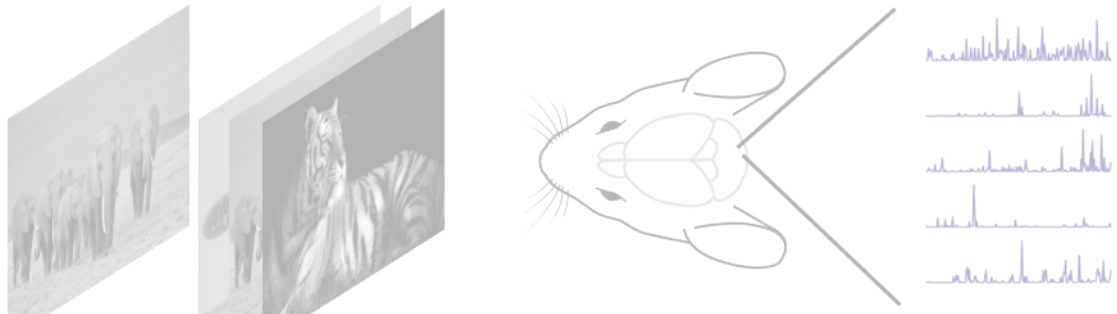




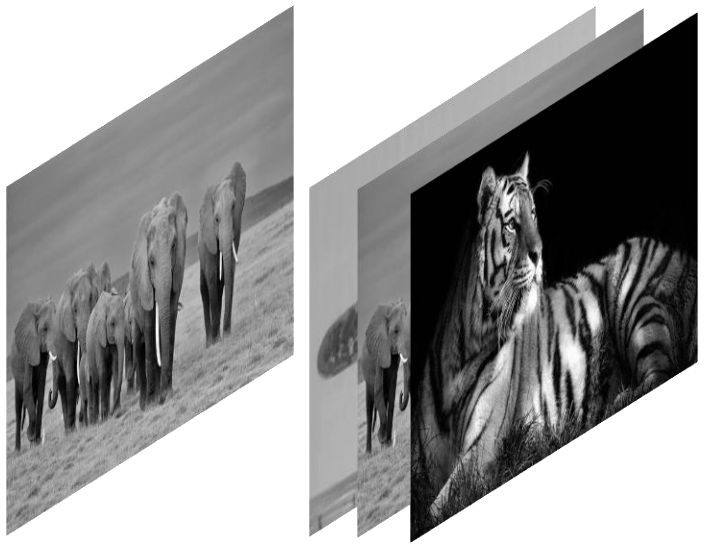
Mouse 1



Representation dataset



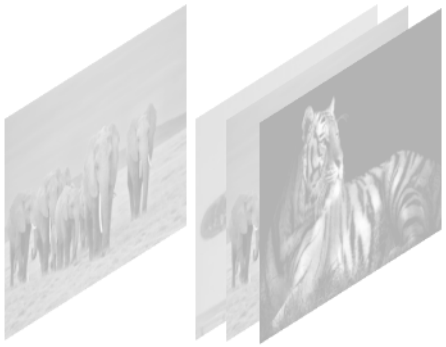
Mouse 1

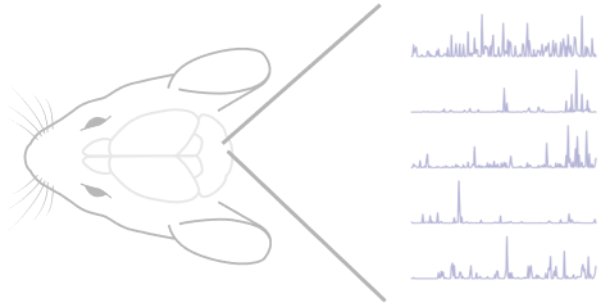


Core/
Representation

Readout

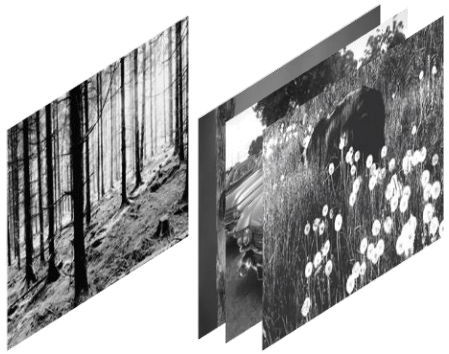
Representation dataset

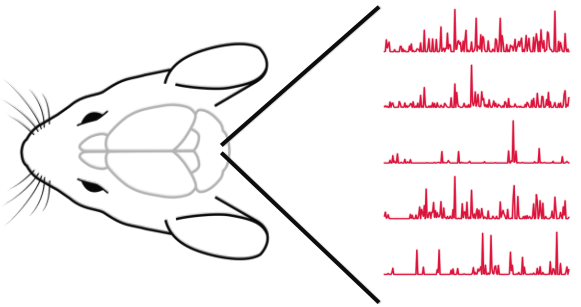




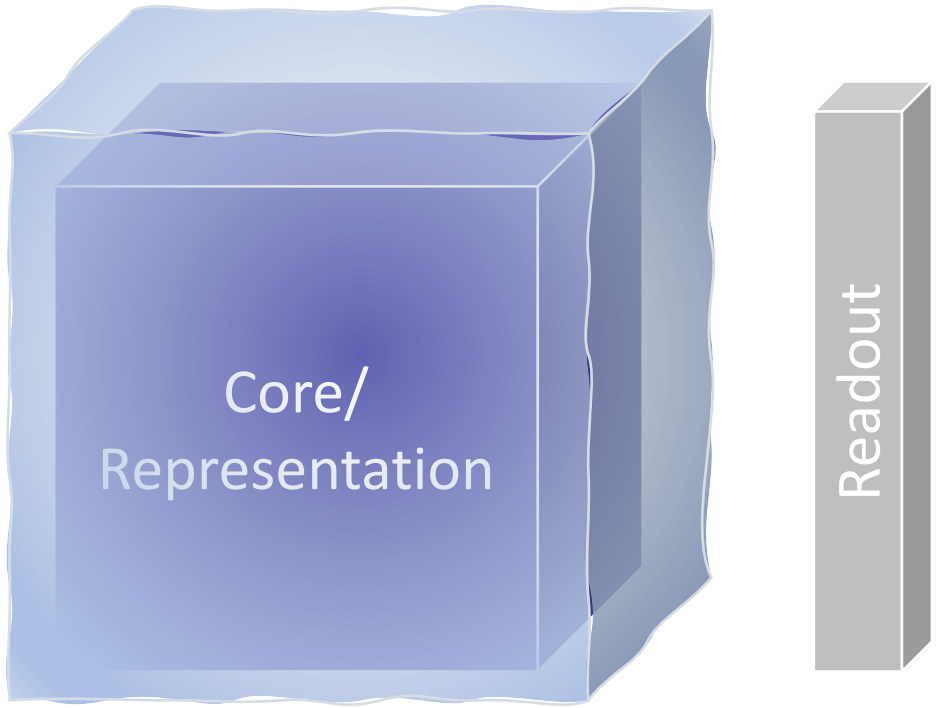
Mouse 1

Transfer dataset

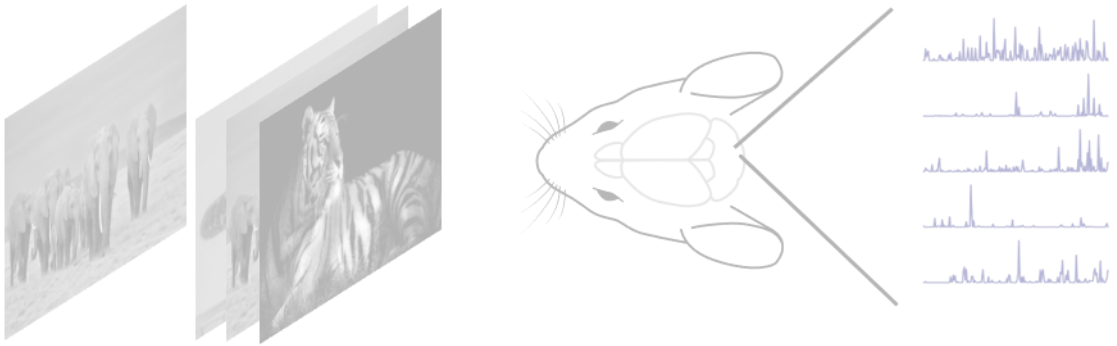




Mouse 2

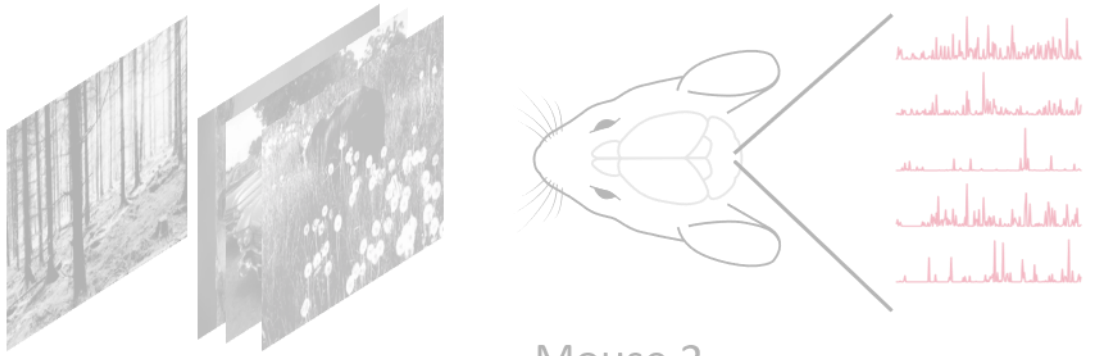


Representation dataset

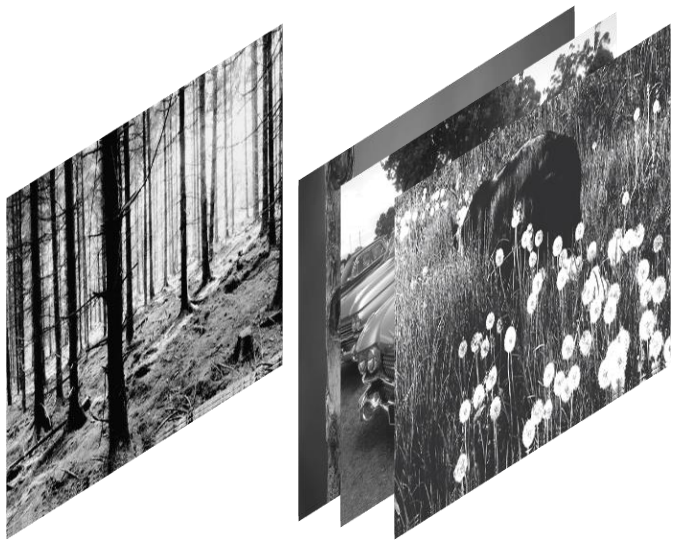


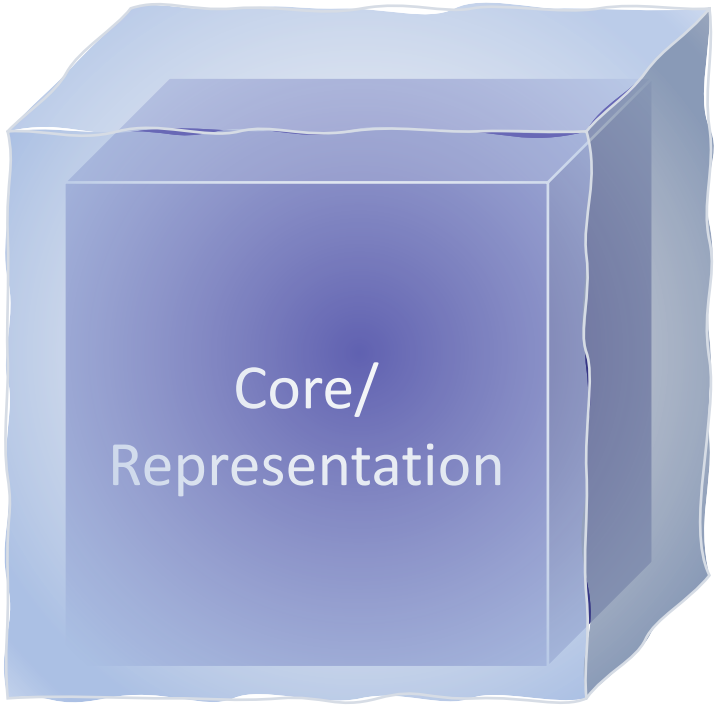
Mouse 1

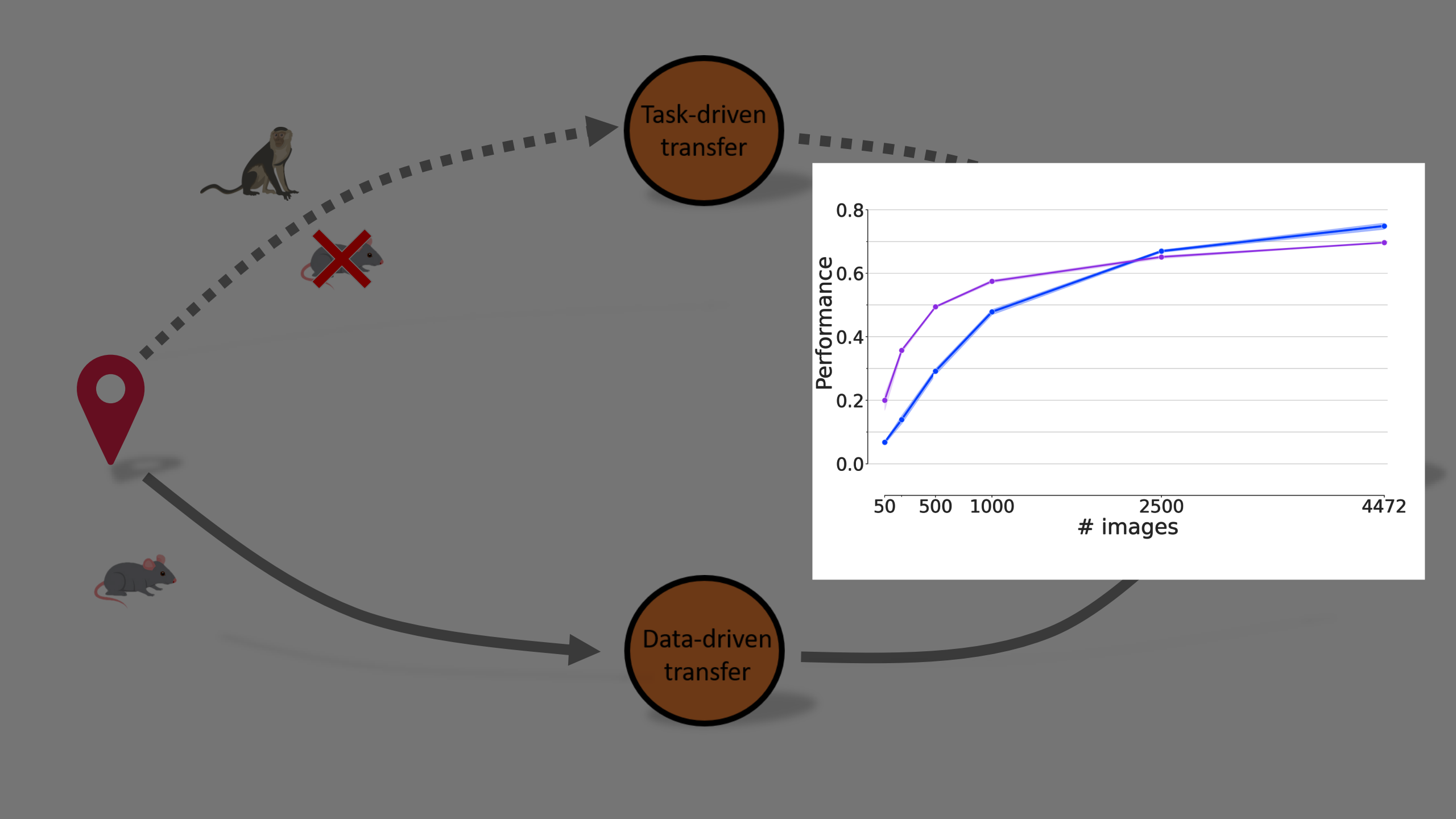
Transfer dataset

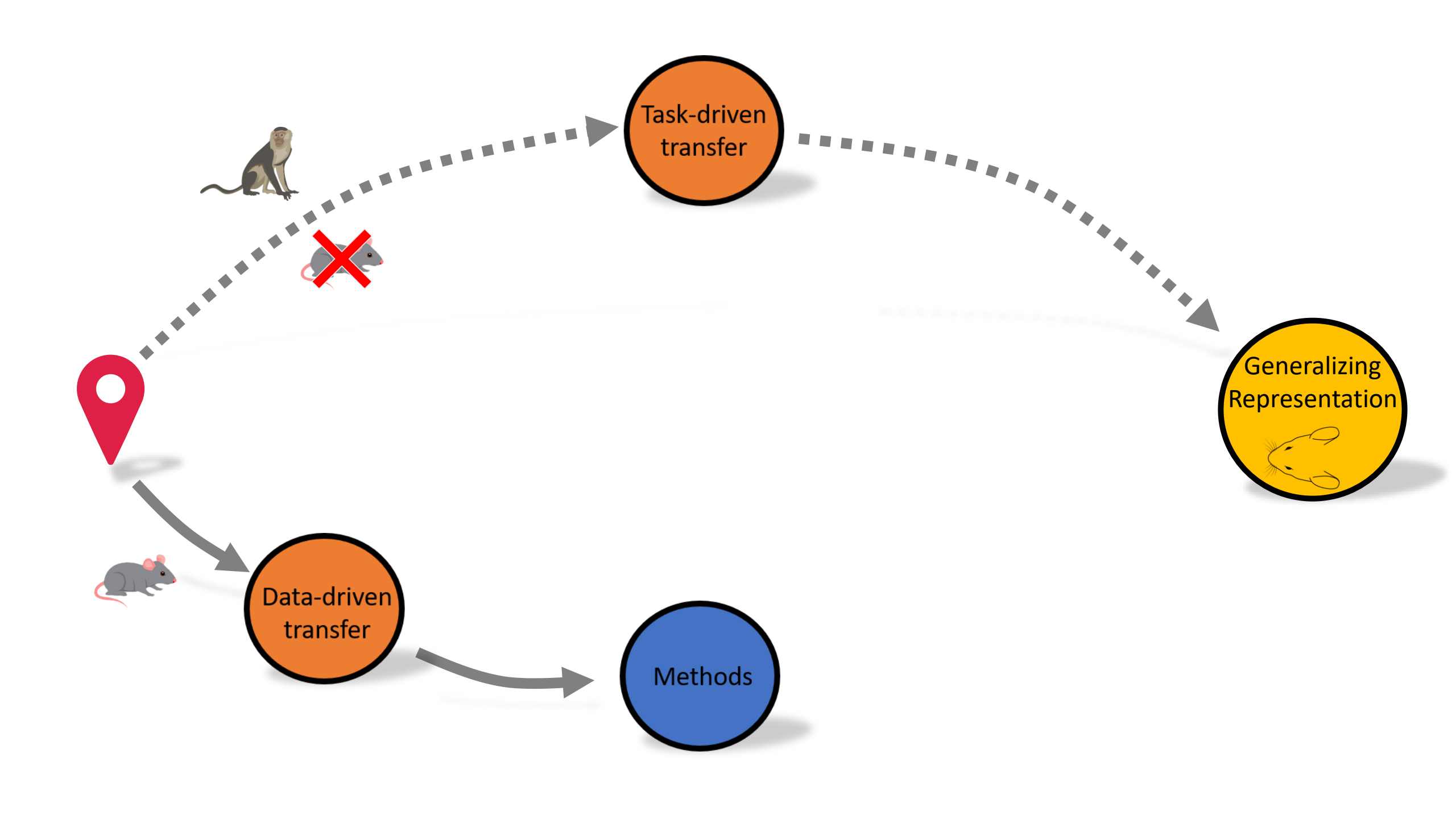


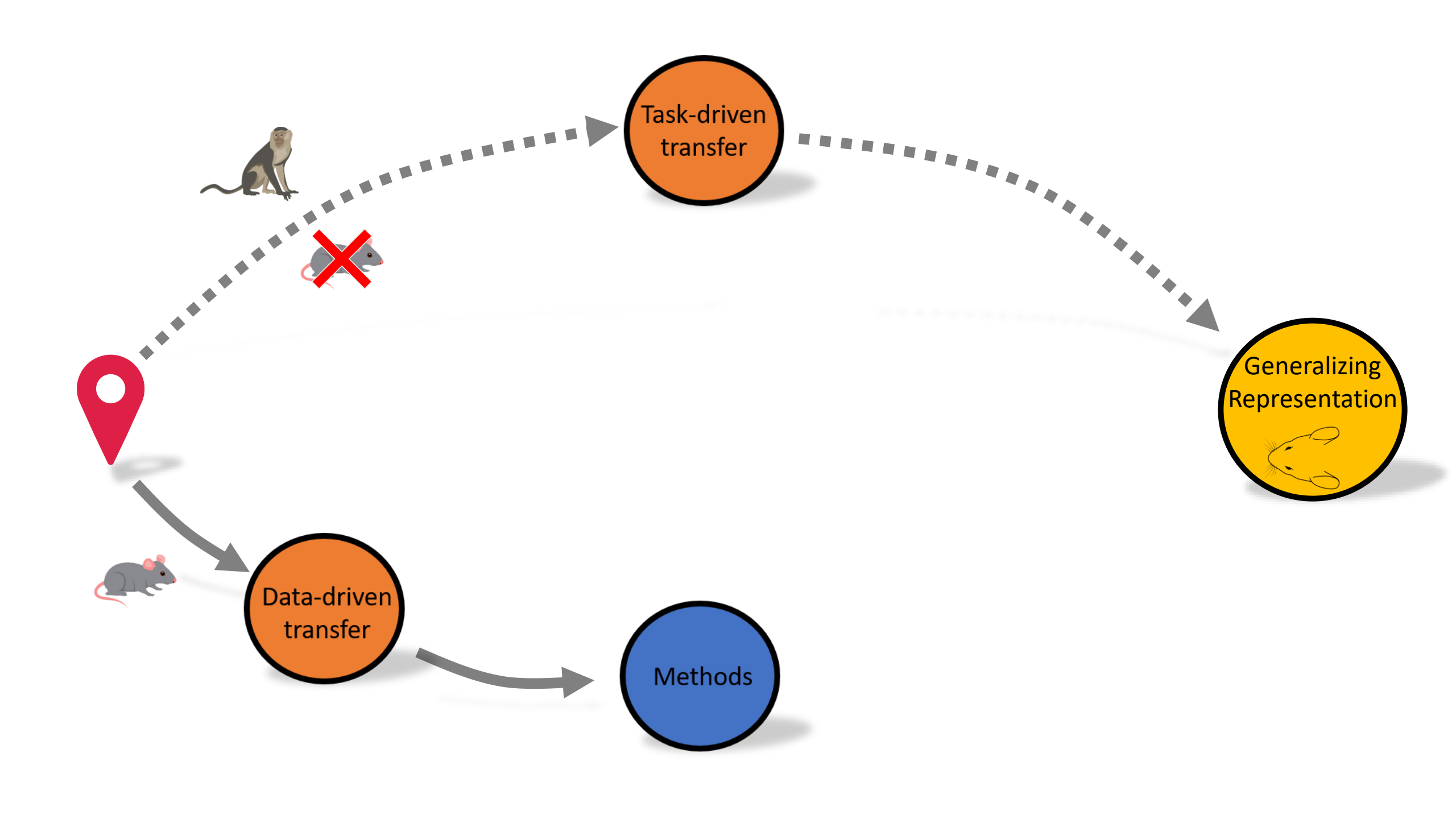
Mouse 2





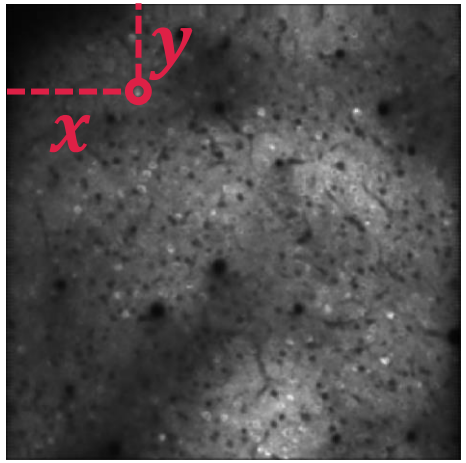

Task-driven transfer
Data-driven transfer
Performance
0.0
0.2
0.4
0.6
0.8
50
500
1000
2500
4472
images

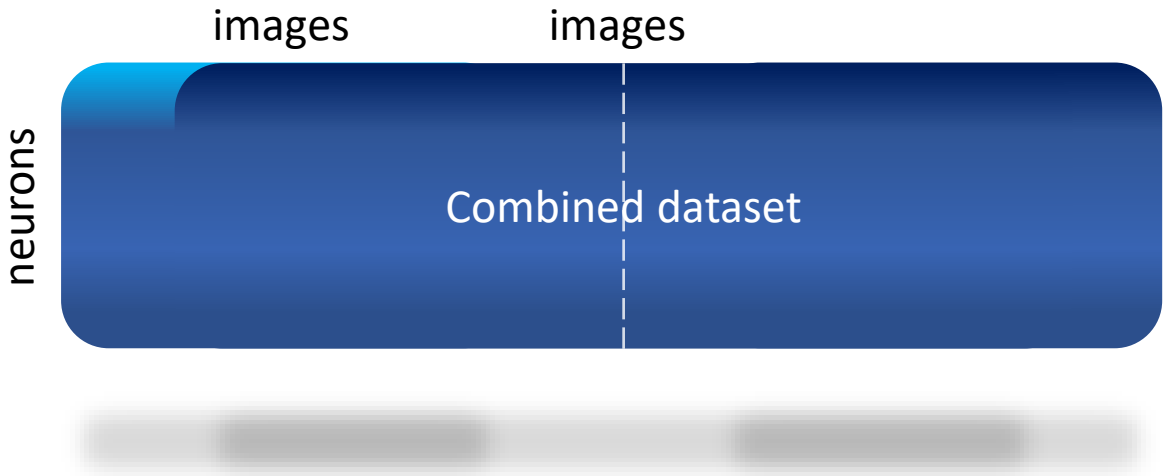

Task-driven transfer
Generalizing Representation
Data-driven transfer
Methods


Task-driven transfer
Generalizing Representation
Data-driven transfer
Methods

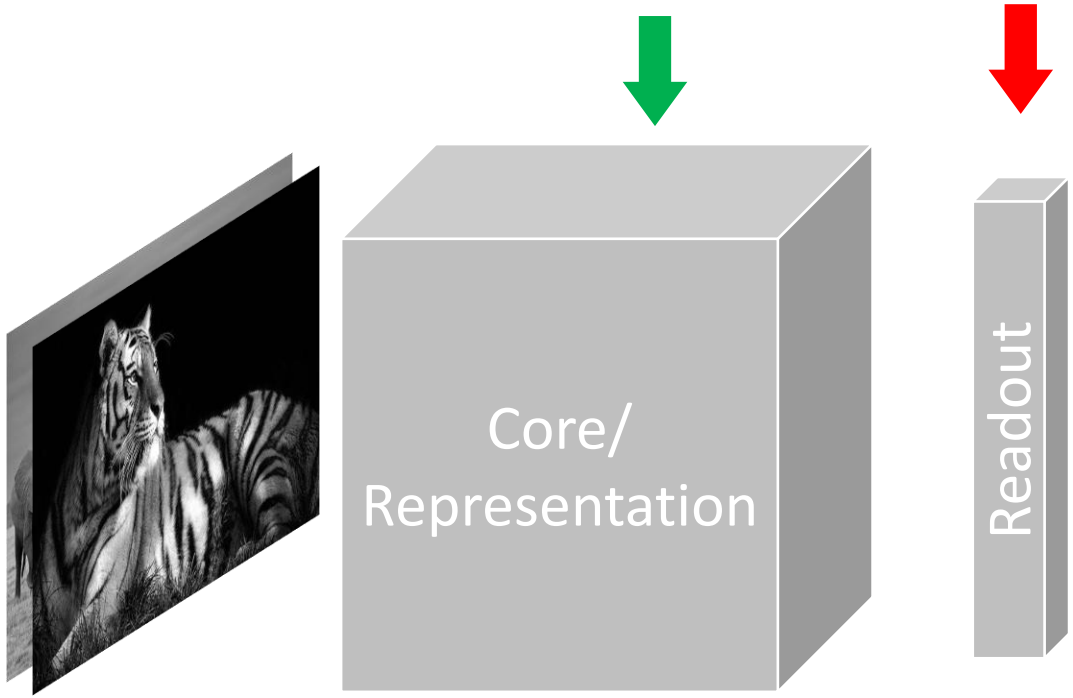
Methods

Data-stitching

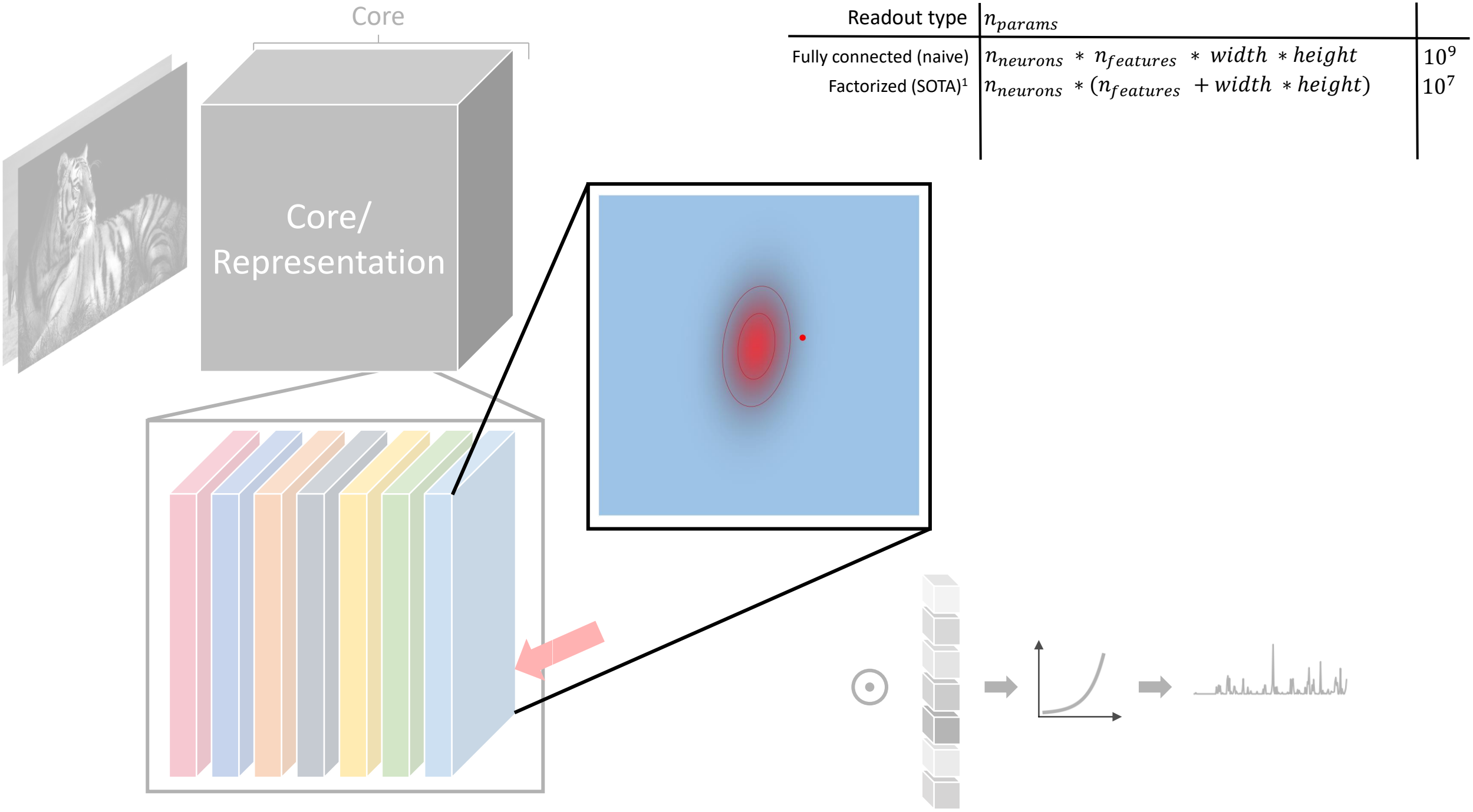




Data-efficiency

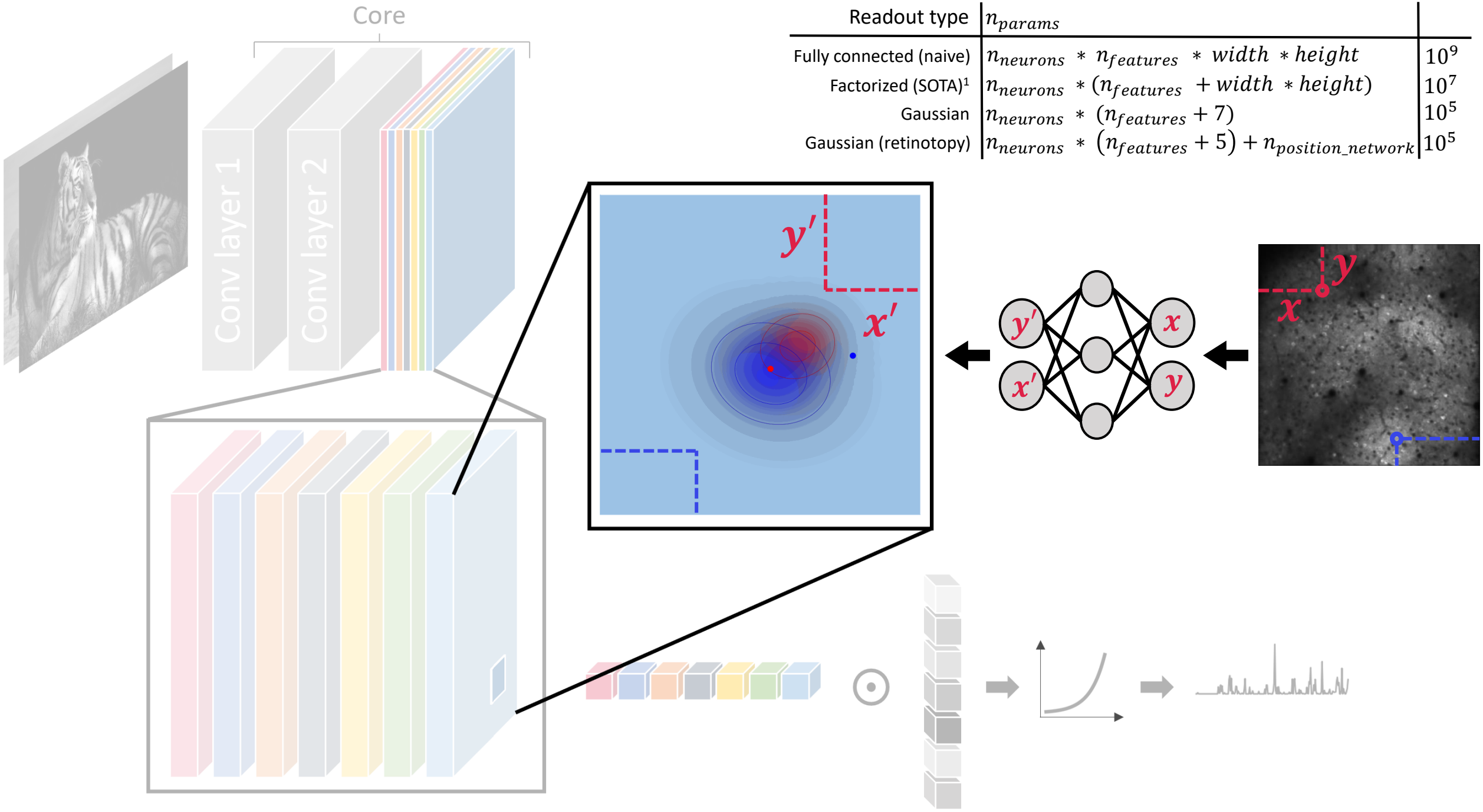


-> Reduce number of parameters in readout



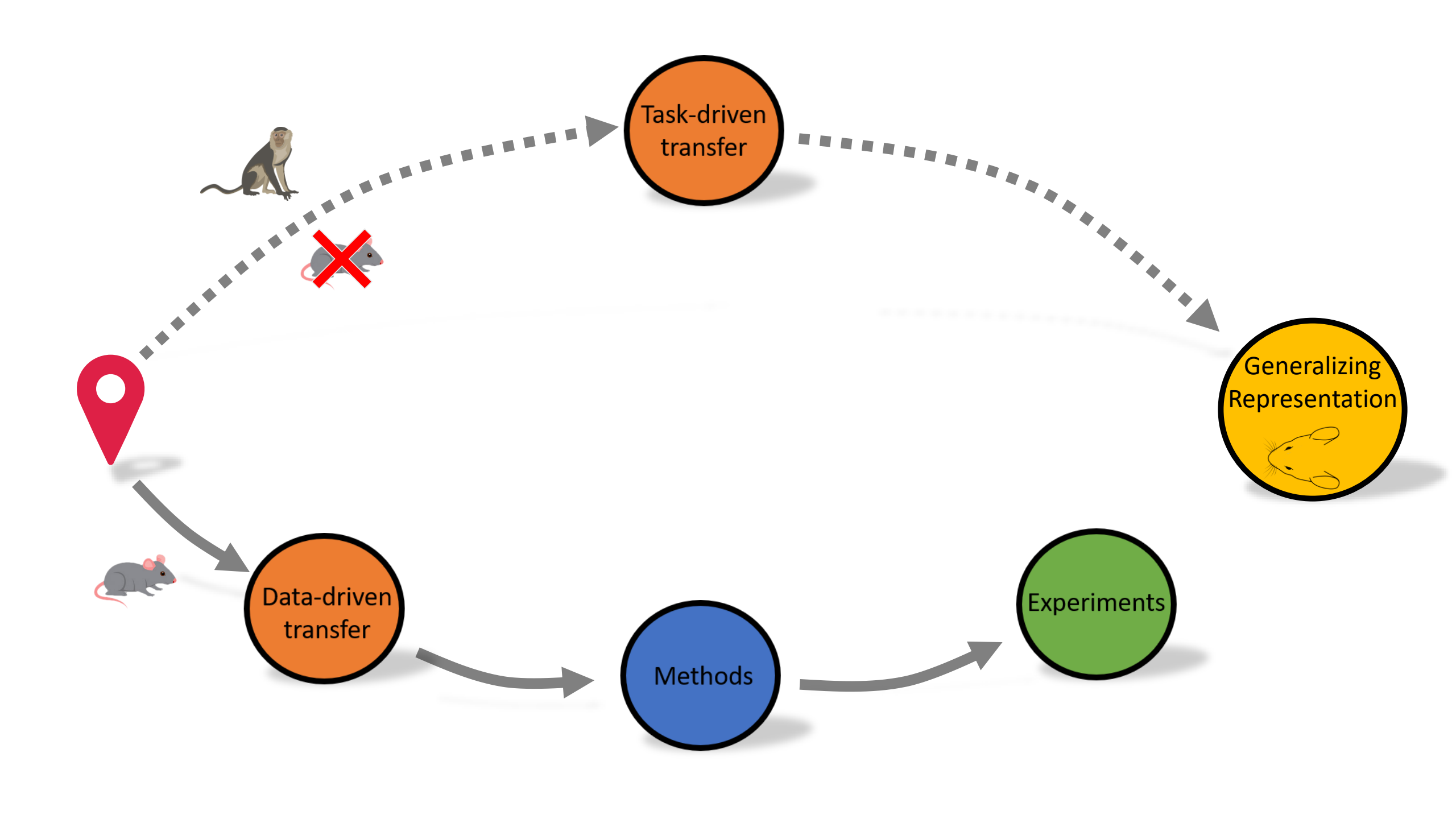
Readout type	n_{params}	
Fully connected (naive)	$n_{neurons} * n_{features} * width * height$	10^9
Factorized (SOTA)[1]	$n_{neurons} * (n_{features} + width * height)$	10^7

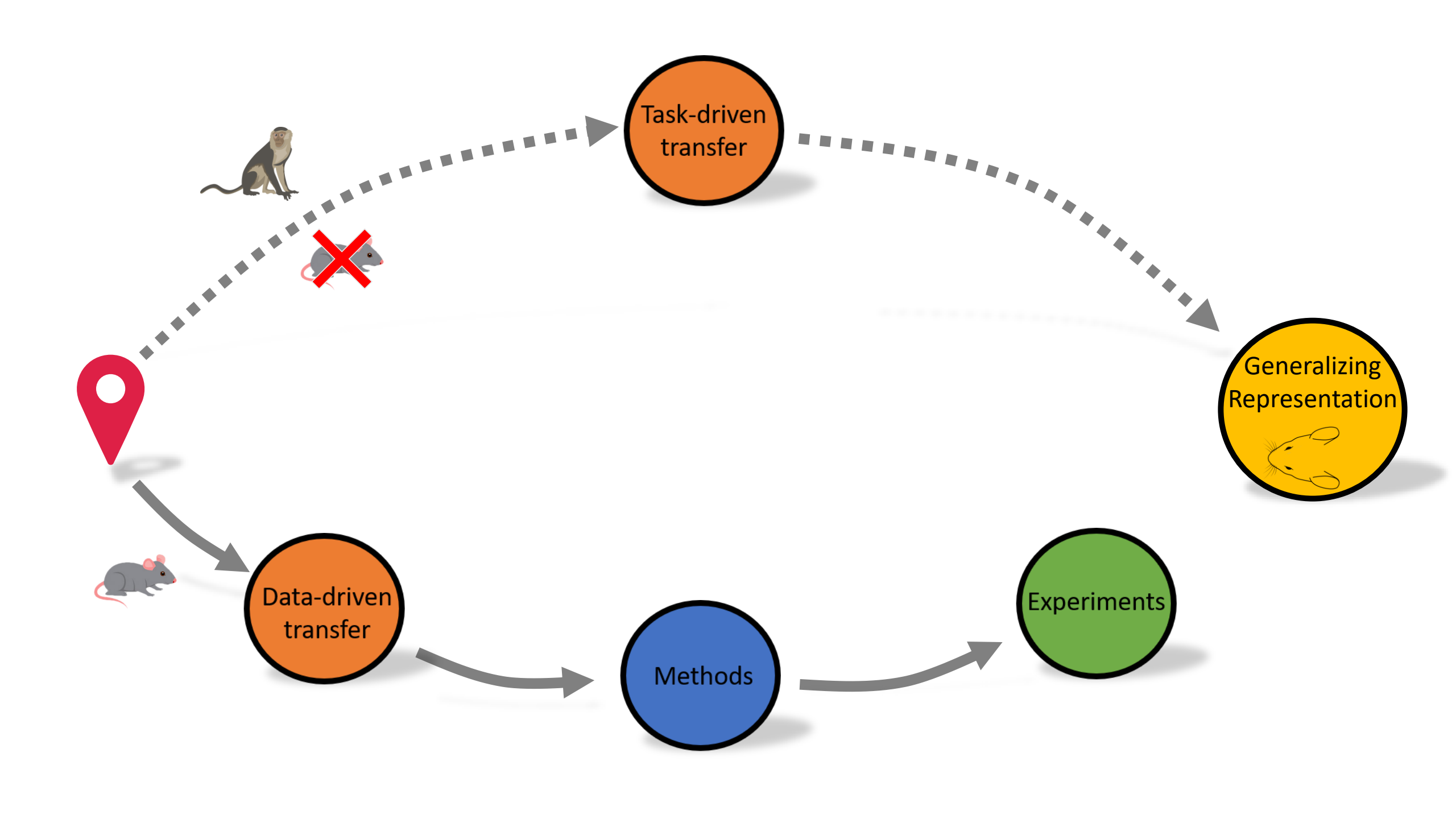
[1]D. A. Klindt et al., Neural system identification for large populations separating "what" and "where, NIPS 2017



Readout type	n_{params}	
Fully connected (naive)	$n_{neurons} * n_{features} * width * height$	10^9
Factorized (SOTA)[1]	$n_{neurons} * (n_{features} + width * height)$	10^7
Gaussian	$n_{neurons} * (n_{features} + 7)$	10^5
Gaussian (retinotopy)	$n_{neurons} * (n_{features} + 5) + n_{position\_network}$	10^5

[1]D. A. Klindt et al., Neural system identification for large populations separating "what" and "where, NIPS 2017


Task-driven transfer
Generalizing Representation
Data-driven transfer
Methods
Experiments

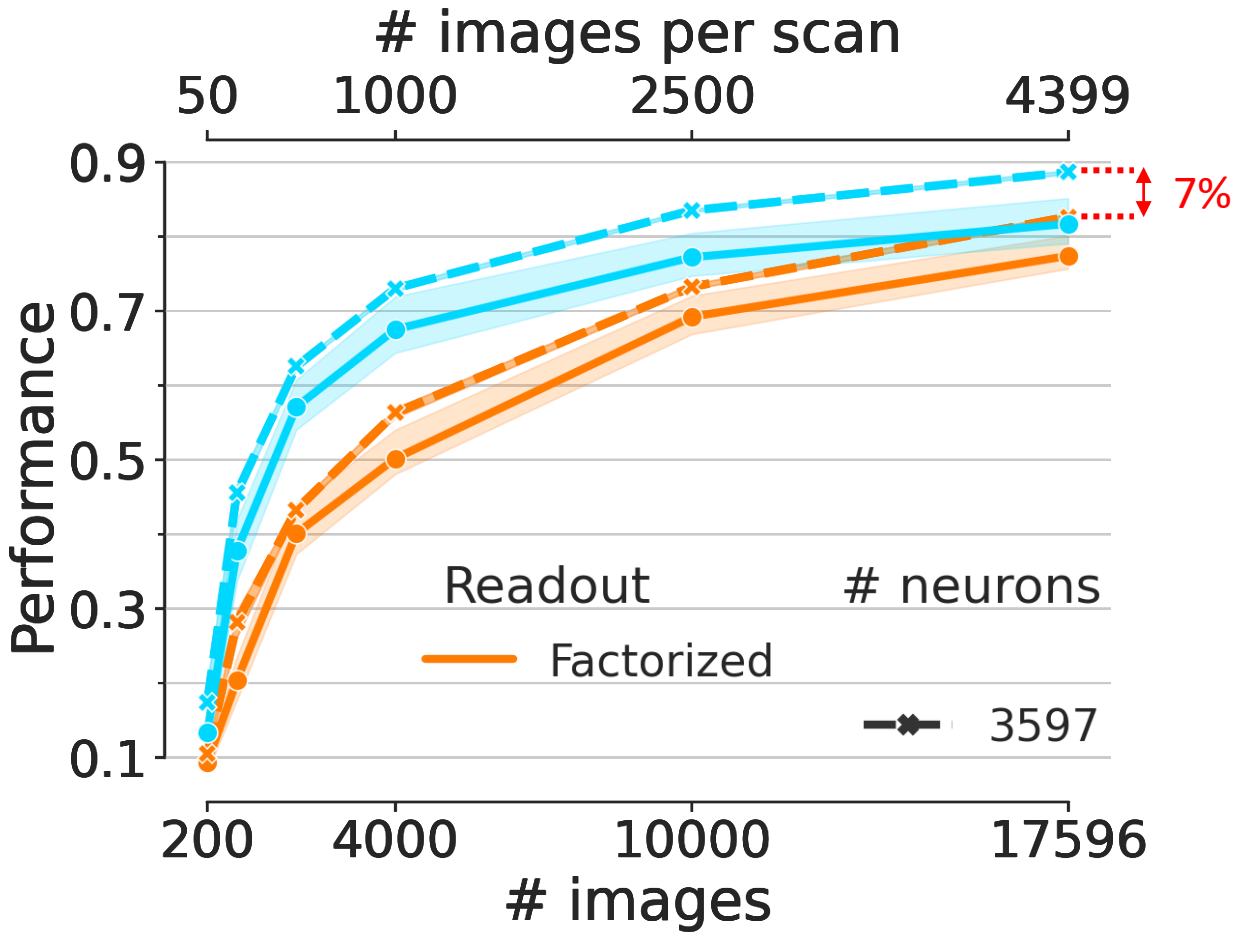

Task-driven transfer
Generalizing Representation
Data-driven transfer
Methods
Experiments

Questions

- Does the new readout generally perform well? (direct)

  Yes: 7% improvement to SOTA.

Experimental Evidence



Questions

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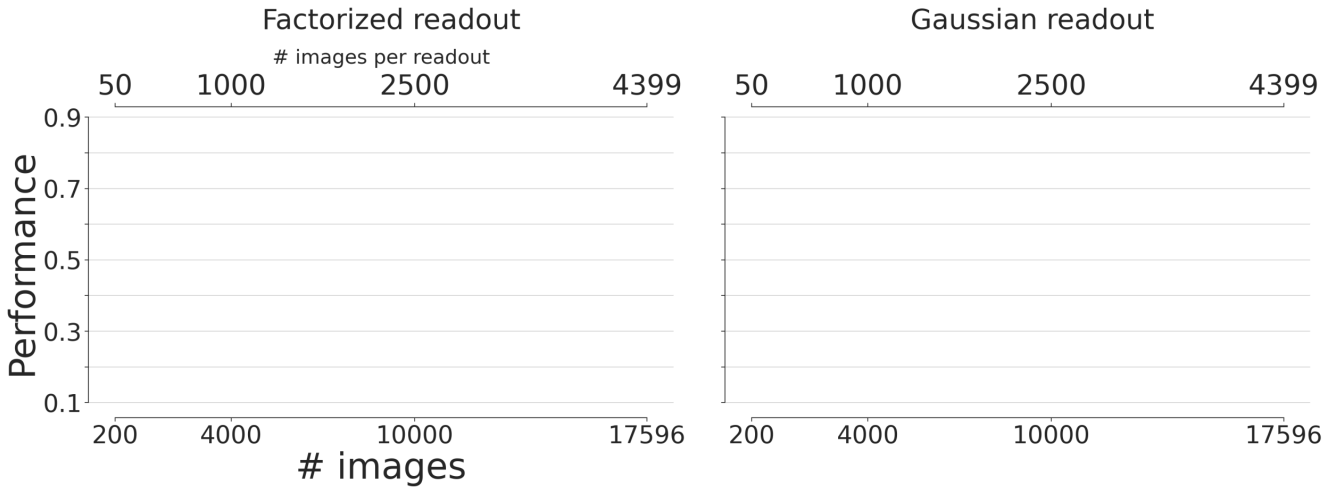
  Yes: 7% improvement to SOTA.

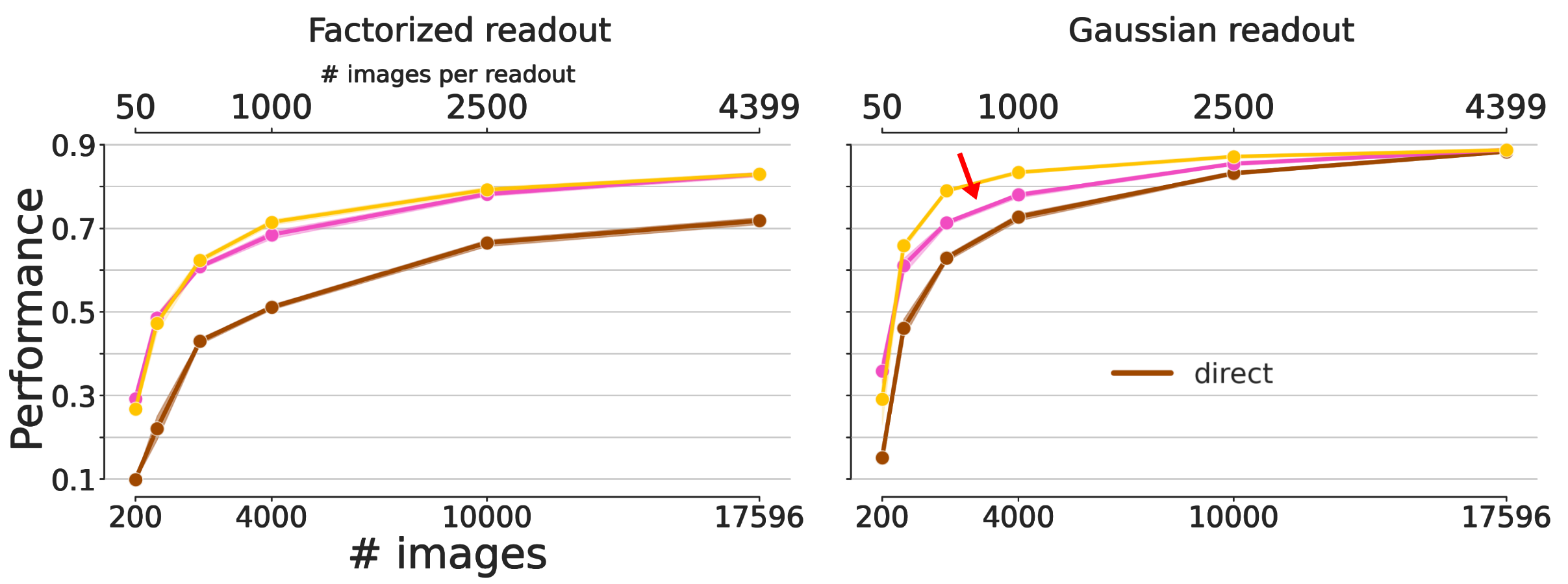
- Does it yield more generalizing features? (transfer)

Experimental Evidence



Questions

Experimental Evidence



Questions

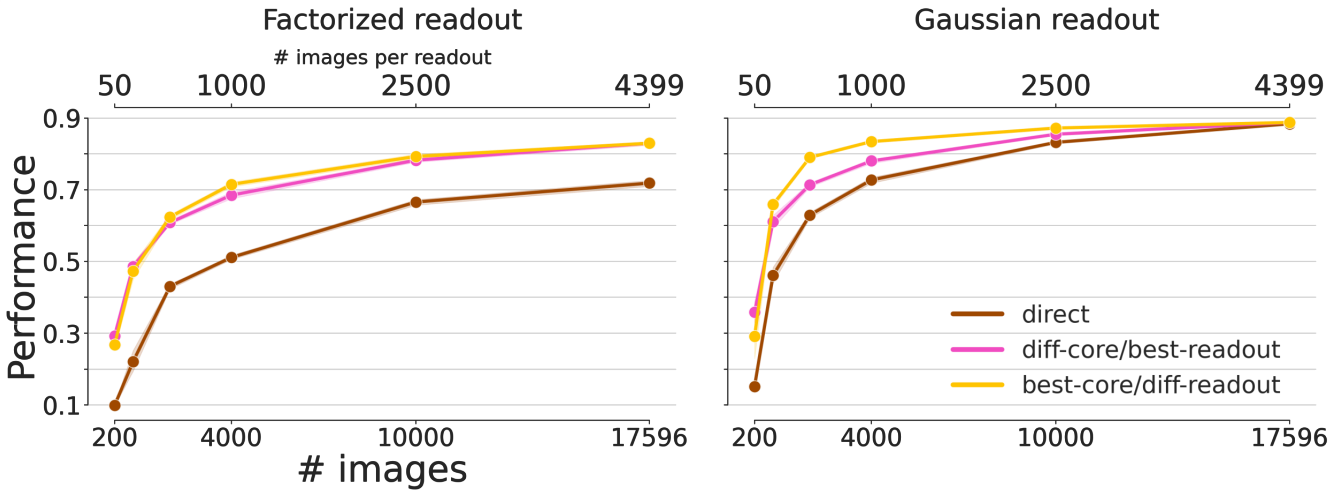
- Does the new readout generally perform well? (direct)

  Yes: 7% improvement to SOTA.

- Does it yield more generalizing features? (transfer)

  Yes: pink line does not overtake yellow line

Experimental Evidence



Questions

- Does the new readout generally perform well? (direct)

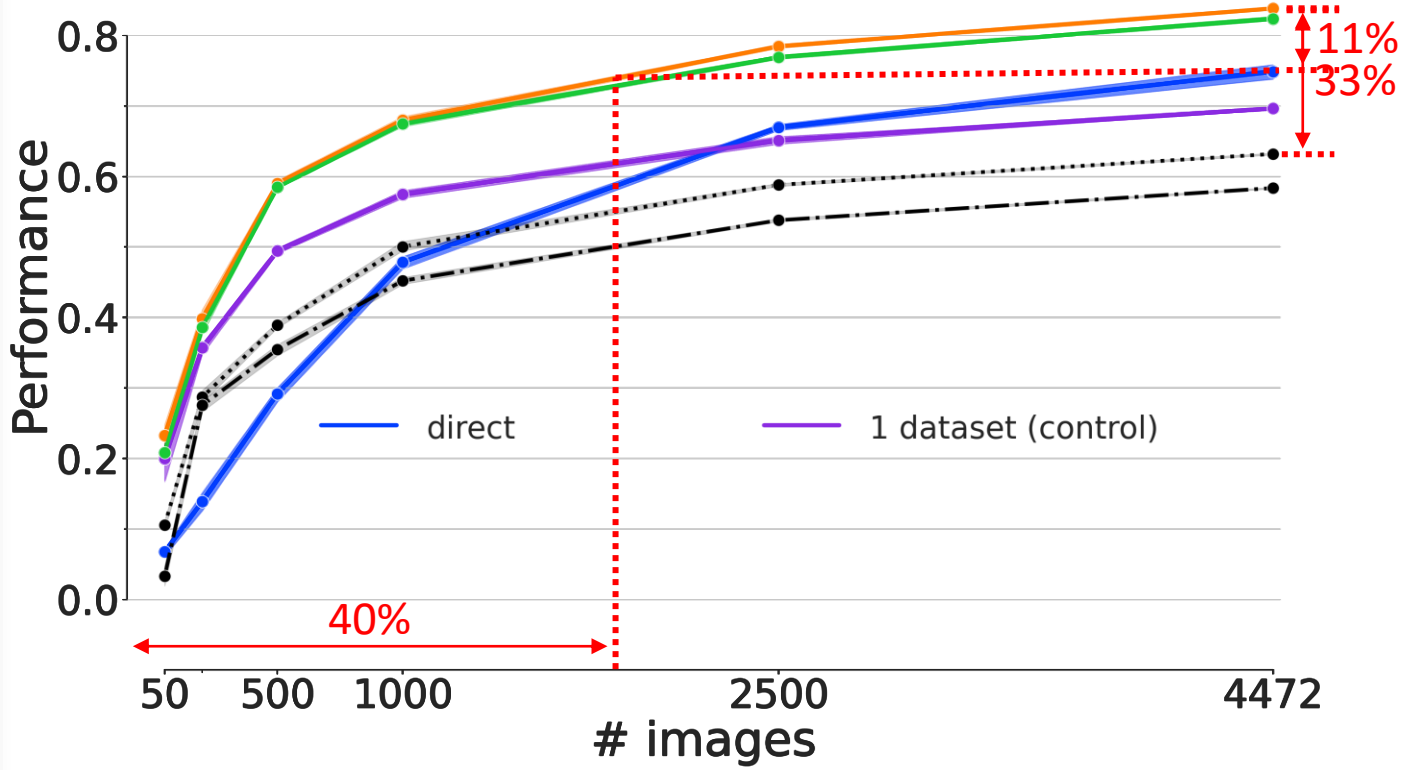
  Yes: 7% improvement to SOTA.

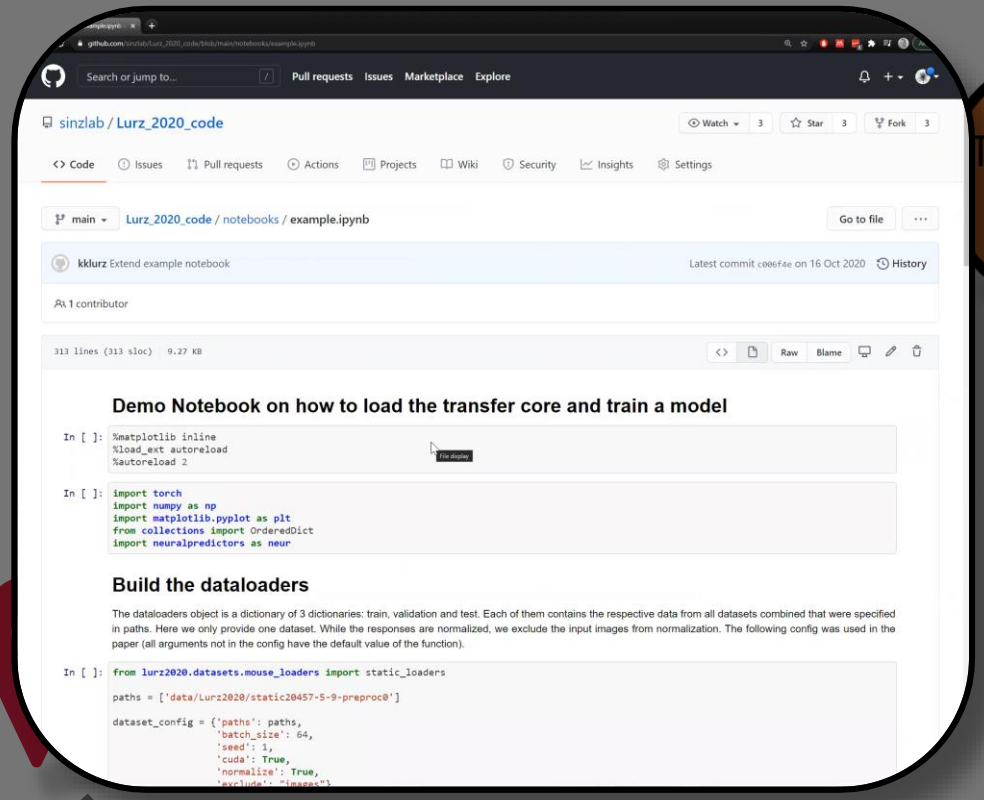
- Does it yield more generalizing features? (transfer)

  Yes: pink line does not overtake yellow line

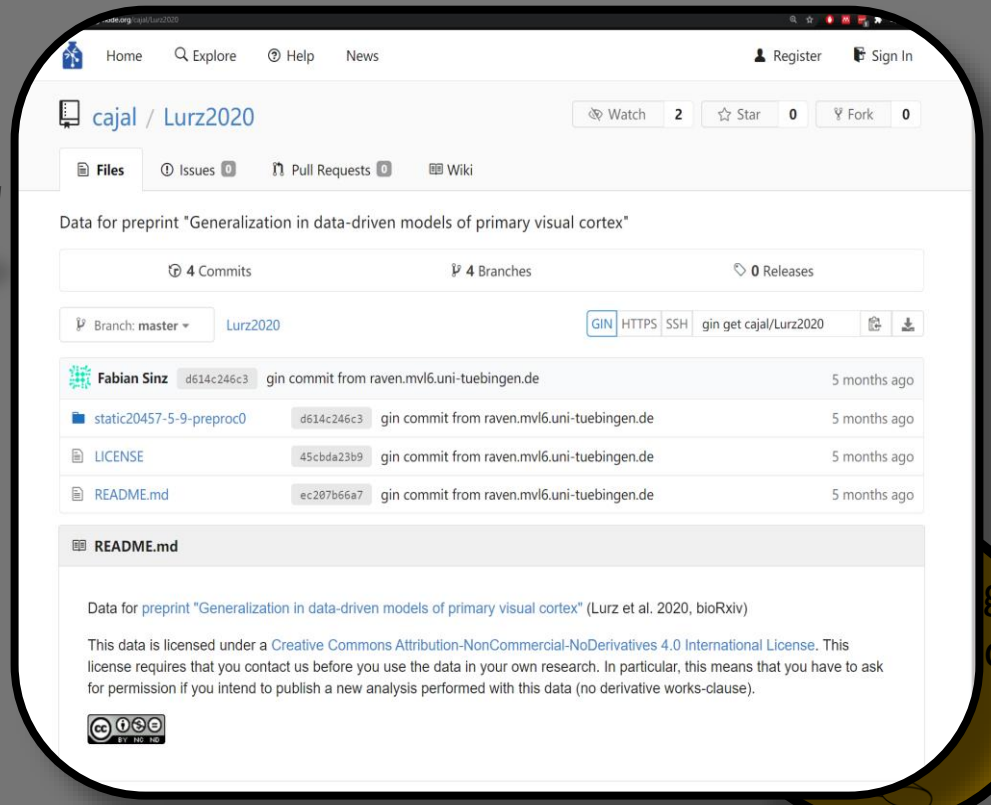
- How well does the learned representation generalize to a new animal? (transfer)
  - **Exceed direct training on transfer animal**
  - **Another 11% improvement to new SOTA**
  - **33% improvement to task-driven representation (VGG16)**
  - **40% data-efficiency**

Experimental Evidence





Task-driven transfer



Code: github.com/sinzlab/Lurz_2020_code

Data: gin.g-node.org/cajal/Lurz2020

Data-driven transfer

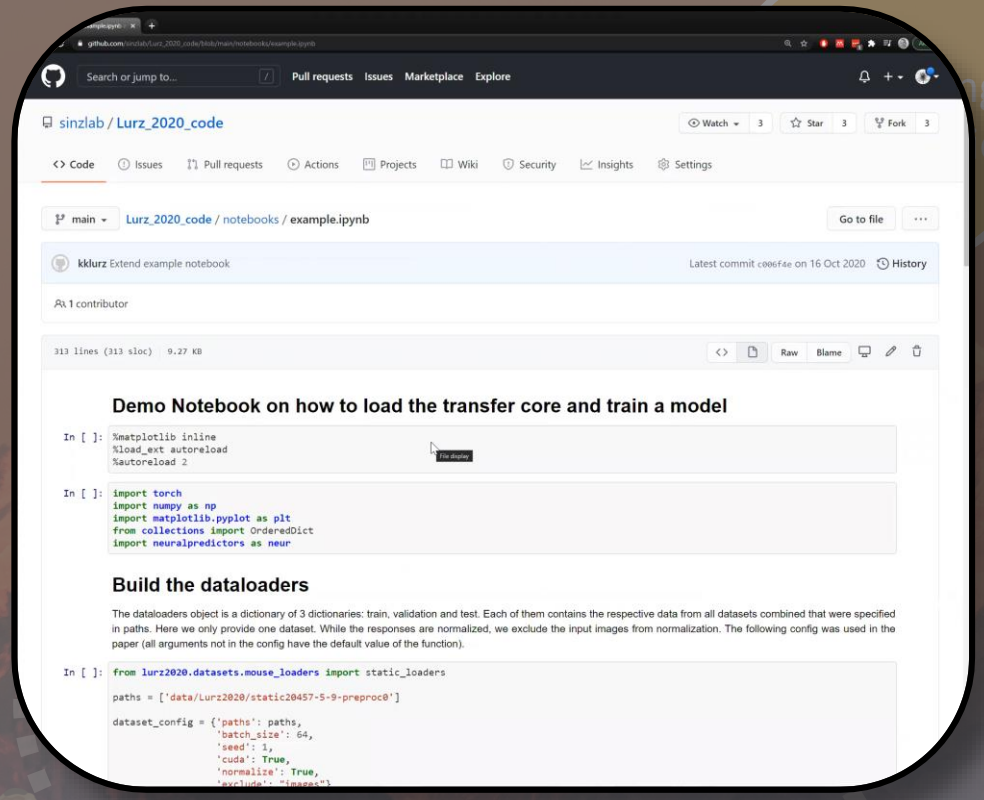
Experiment

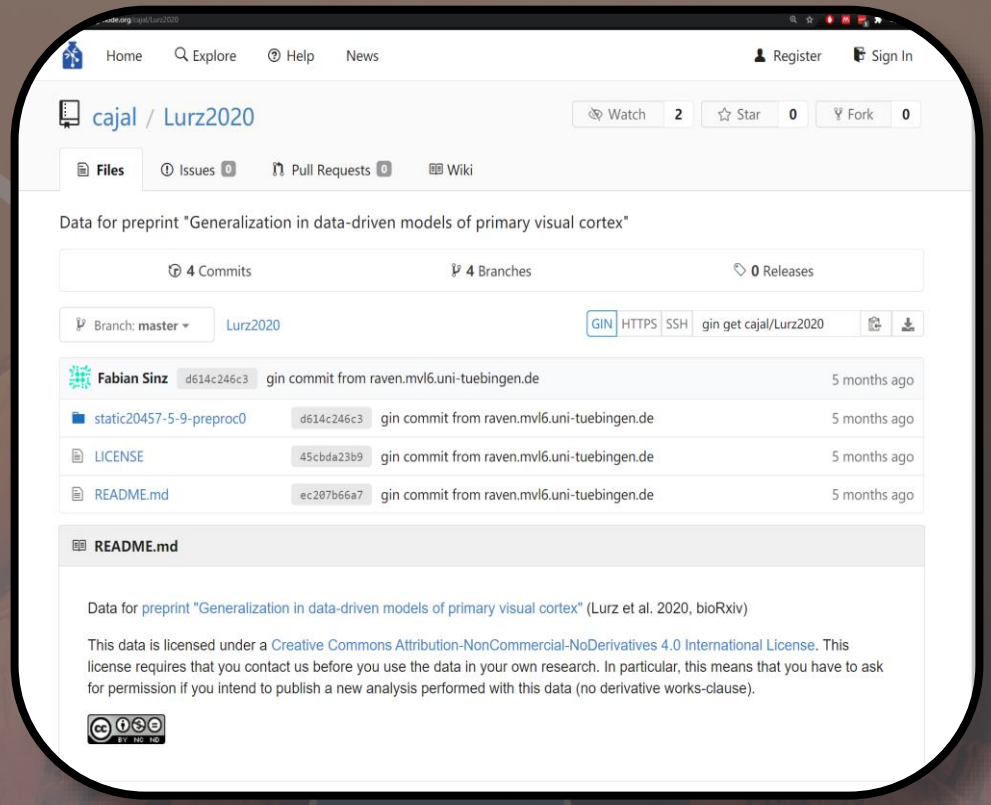
ICLR

Poster Session 4

May 4, 1 – 3 a.m. PDT

DFG imprs-is Bundesministerium für Bildung und Forschung Carl Zeiss Stiftung aws IARPA





Code: github.com/sinzlab/Lurz_2020_code

Data: gin.g-node.org/cajal/Lurz2020

Current status

Solutions

ICLR

Poster Session 4

May 4, 1 – 3 a.m. PDT

DFG

Bundesministerium für Bildung und Forschung

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