Image Memorability is Predicted by Activity Across Stages of Convolutional Neural Networks and the Human Ventral Stream

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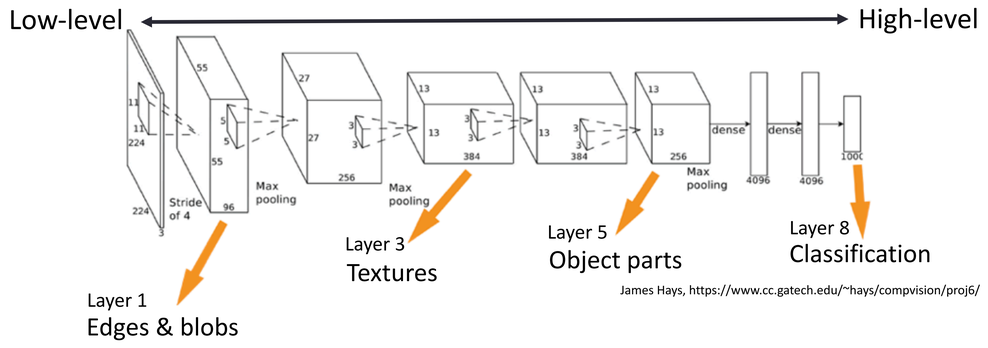
INTRODUCTION

- Why are certain images more memorable than others and what features are predictive of this memorability?
- Image memorability is consistent across individuals (Bainbridge, Isola, & Oliva, 2013; Bylinskii, Isola, Bainbridge, Torralba, & Oliva, 2015; Isola et al., 2014)
- Aided by visual distinctiveness & sparseness (Bartlett, Hurry, & Thorley, 1984; Busey, 2001; Huebner & Gegenfurtner, 2012; Lukavský & Děchtěrenko, 2017)
- Yet, also aided by similarity (Bainbridge, Dilks, & Oliva, 2017)
- Do visual features at low and high levels impact memorability in the same way? If so, how might this be reflected in the brain?

Convolutional neural network (CNN) representing visual levels



METHODS

Experiments 1 & 2 (Prospective assignment)

Participants
Exp. 1: 100 adults (*M* age = 19.6 years; 49 females, 51 males); 25/condition
Exp. 2: 50 adults (*M* age = 19.7 years; 25 females, 25 males); 25/condition
Stimuli
Scene images from BOLD5000 dataset (Chang et al., 2019)
Exp. 1: 4 conditions; 1 condition for each level (CNN layer 1, 3 , 5, and 8)
Exp. 2: 2 conditions; 1 condition for each level (CNN layer 1 and 8)
Each condition: 50 most **similar** & 50 most **discriminable** images based on level
Tasks
Incidental Encoding: Indoor/Outdoor judgment of scene image
Recognition Memory: *Did you see this image previously? Yes or No*
Statistical Analyses
Separate logistic regression models for each condition; Signal detection theory

	Correlation *r*
Layer 1	0.4
Layer 3	0.1
Layer 5	0.0
Layer 8	0.2

Experiment 3

Participants
32 adults (*M* age = 19.7 years; 15 females, 17 males); 25/condition
Stimuli
House images; Similarity value for each level (4 CNN layers) for each house image
Tasks
Incidental Encoding: Price estimate for house
Recognition Memory: *Did you see this image previously? Yes or No*
Statistical Analyses
Separate logistic regression models for each feature; Signal detection theory

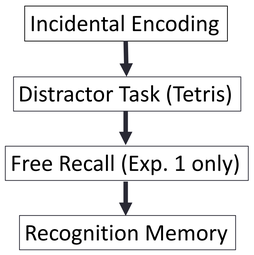
	Correlation *r*
Layer 1	0.3
Layer 3	0.2
Layer 5	0.1
Layer 8	0.0

Experiment 4 (Neuroimaging case study)

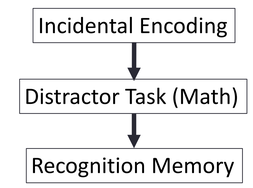
Dataset
fMRI data from BOLD5000 dataset (Chang et al., 2019)
Procedure
Compare neural data with behavioral measures of memory from Exp. 1 using a multivariate (MVPA) searchlight approach (Kriegeskorte et al., 2006)

Procedure

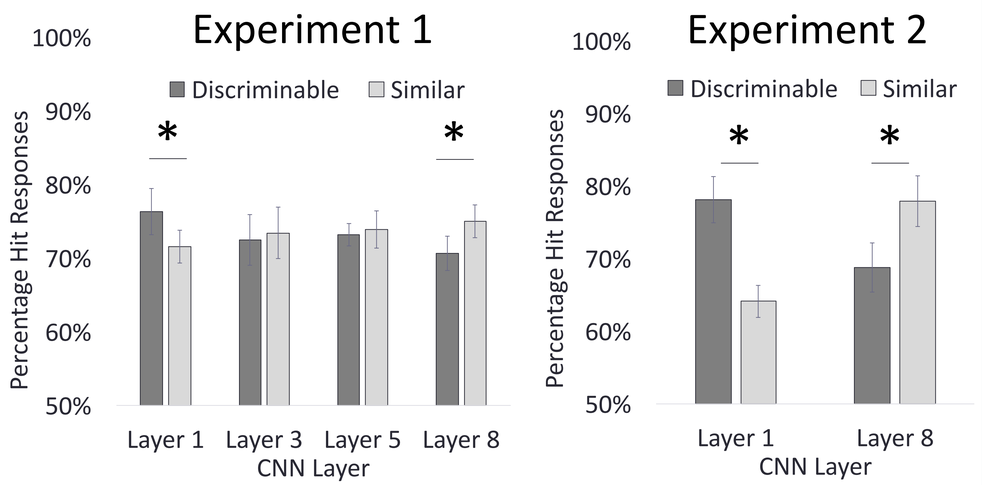
Experiments 1 & 2



Experiment 3



RESULTS



* Indicates $p < .05$; error bars reflect SEM

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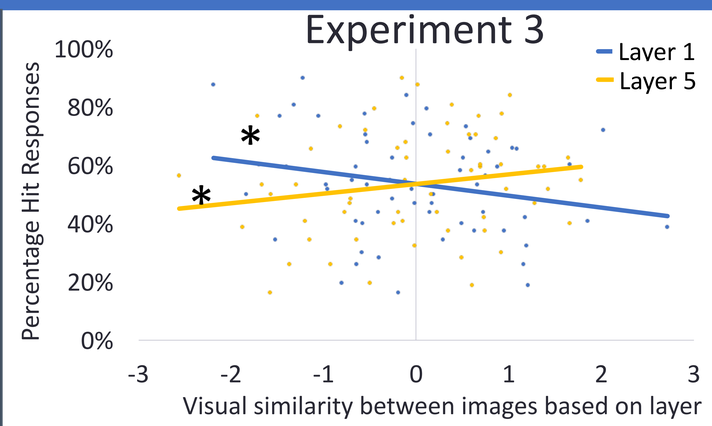
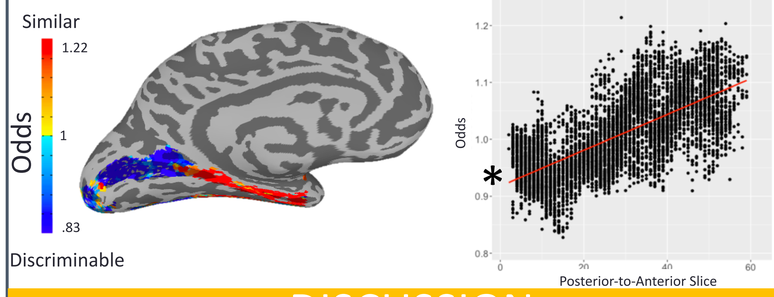
Experiment 3



Experiment 4



DISCUSSION

- Utilizing a CNN to predict human memory performance
- Characteristics of levels are associated with superior subsequent recognition memory
  - Discriminability for low-level
  - Similarity for high-level
- Context is important
  - Within vs. across categories affects which levels are predictive of recognition memory
- Corresponds to organization in human ventral stream

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