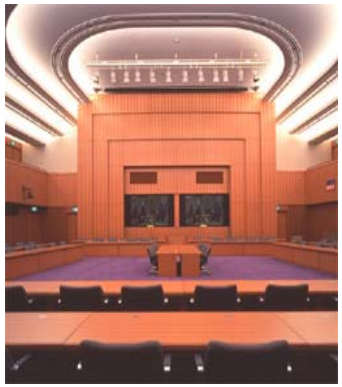
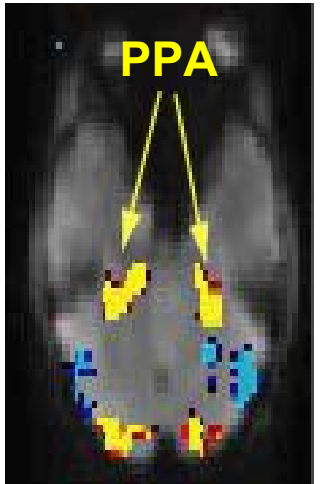
Visual Scene Understanding

Aude Oliva

Department of Brain and Cognitive Sciences
Massachusetts Institute of Technology
Website: http://cvcl.mit.edu

brain+cognitive sciences





High-level Scene Representation

I. Long-term Memory Representation

What is the fidelity of stored scene representations and the infrastructure that supports them?

Talia Konkle

Timothy Brady

George Alvarez

II. High-level Neural Representation of Visual Scenes

How is the *shape* of visual scene represented?

Soojin Park

Michelle Greene

Timothy Brady

Memory Representation

What we know…

Standing (1973)

10,000 images

83% Recognition

… people can remember thousands of images

What we don't know…

… what people are remembering for each image?

According to Standing

"Basically, my recollection is that we just separated the pictures into distinct thematic categories: e.g. cars, animals, single-person, 2-people, plants, etc.) Only a few slides were selected which fell into each category, and they were visually distinct."

Dogs
Playing Cards

Welcome to

Massive Memory Experiment

A stream of scenes will be presented on the screen for 3 seconds each.

Your primary task:

Remember them ALL!

afterwards you will be tested with…

Completely different kinds of places…

Different instances of the same kind of place…

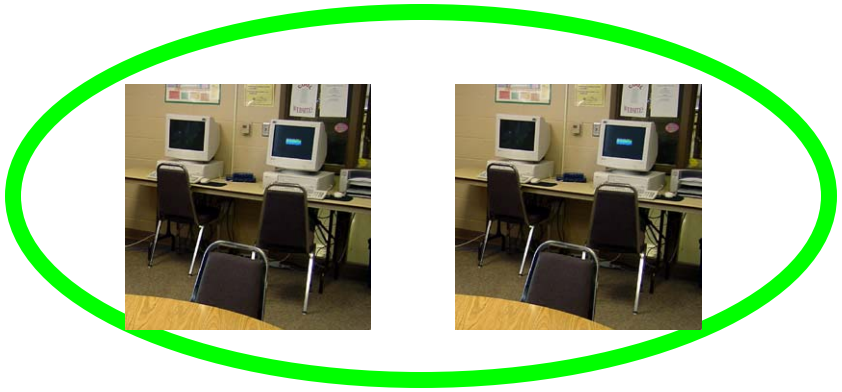
Welcome to

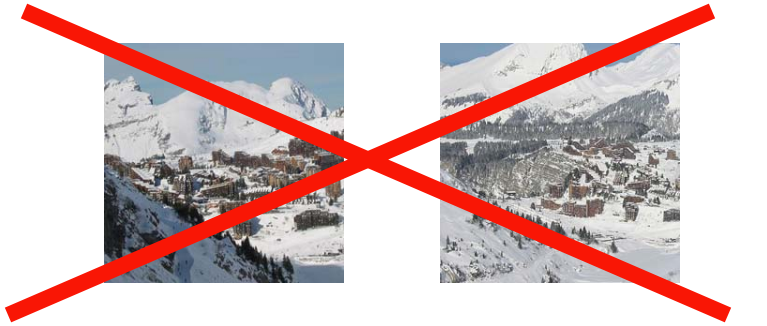
Massive Memory Experiment

A stream of scenes will be presented on the screen for 3 seconds each.

Your other task:

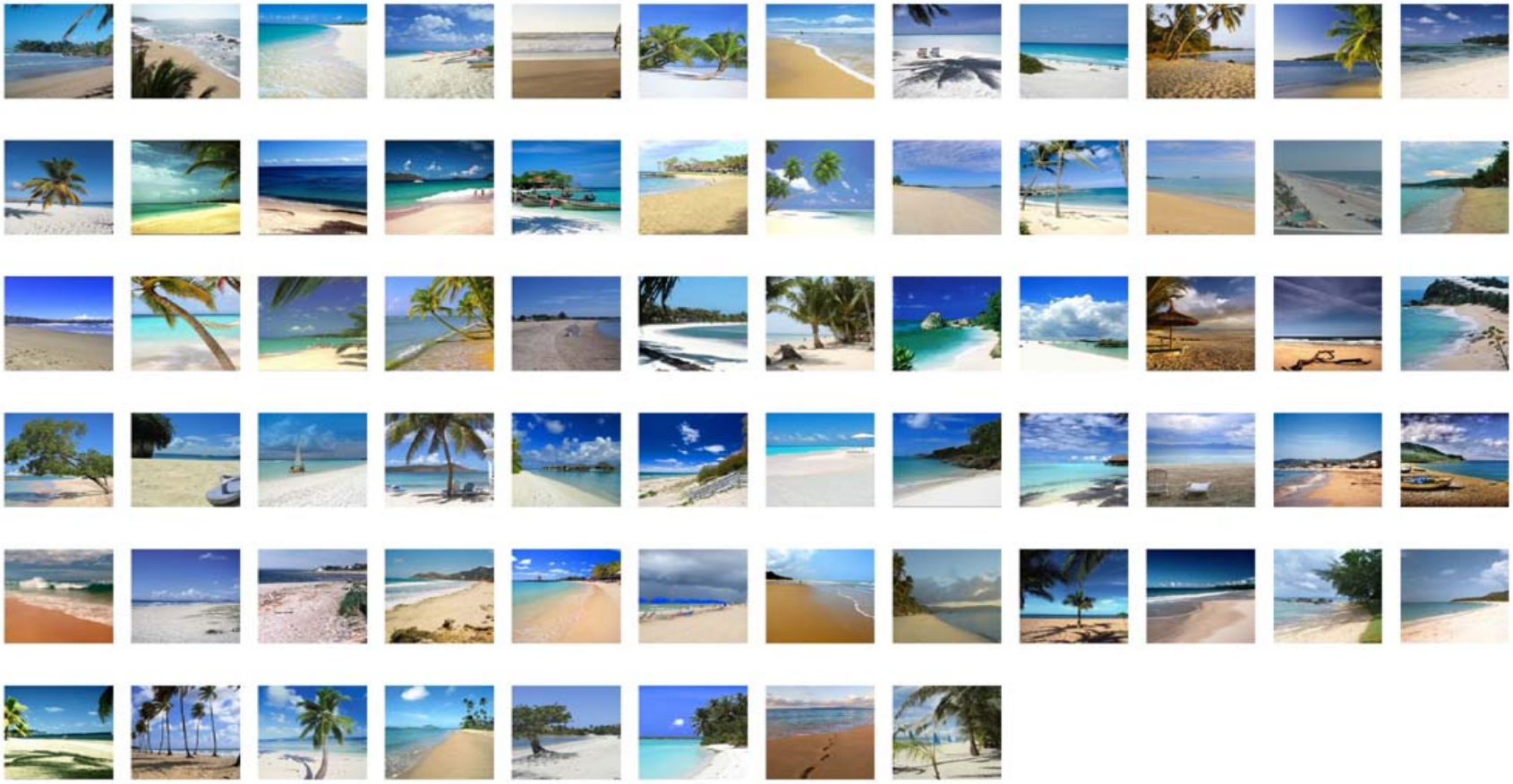
Detect exact repeats anywhere in the stream



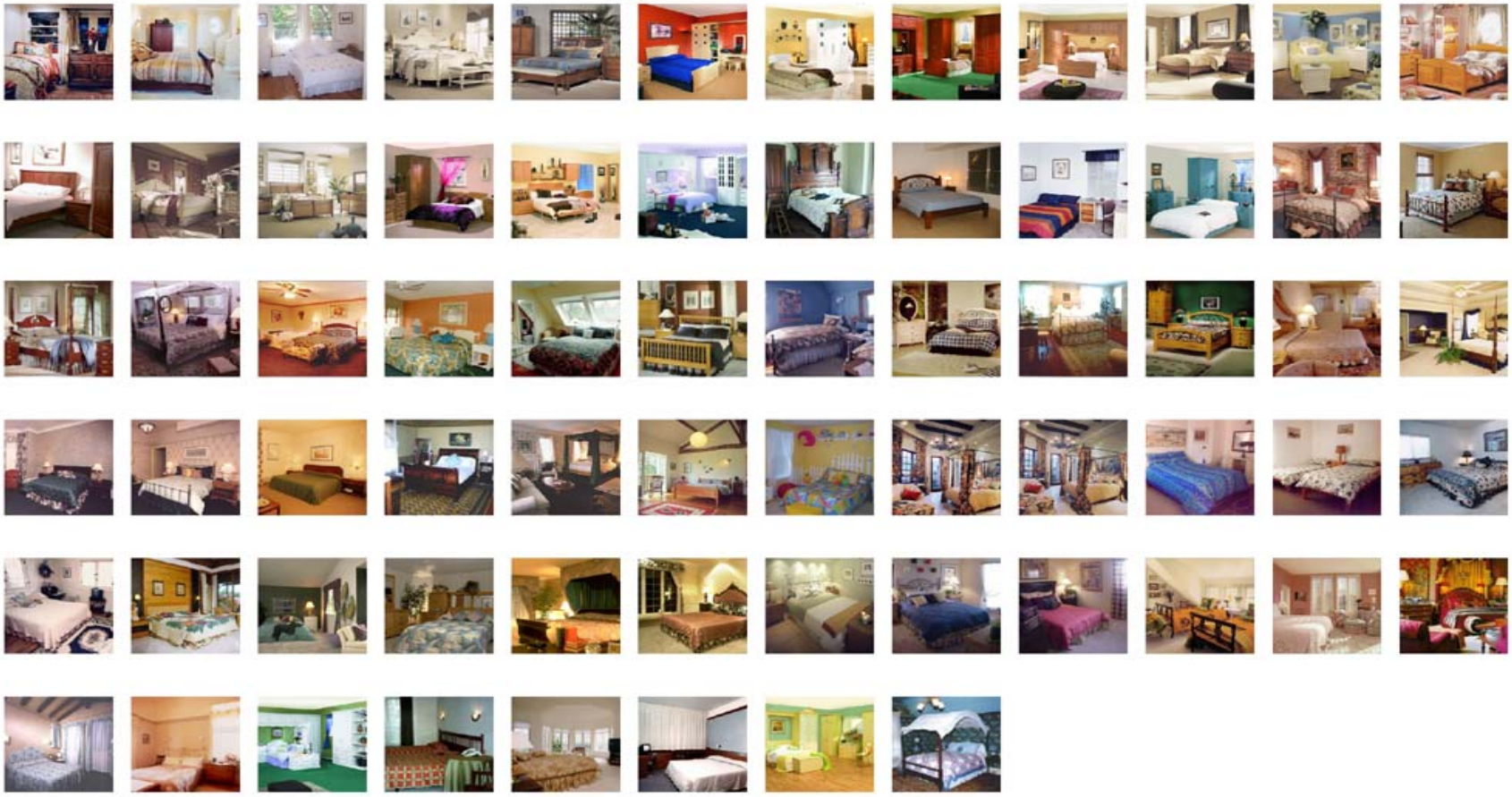


Barn

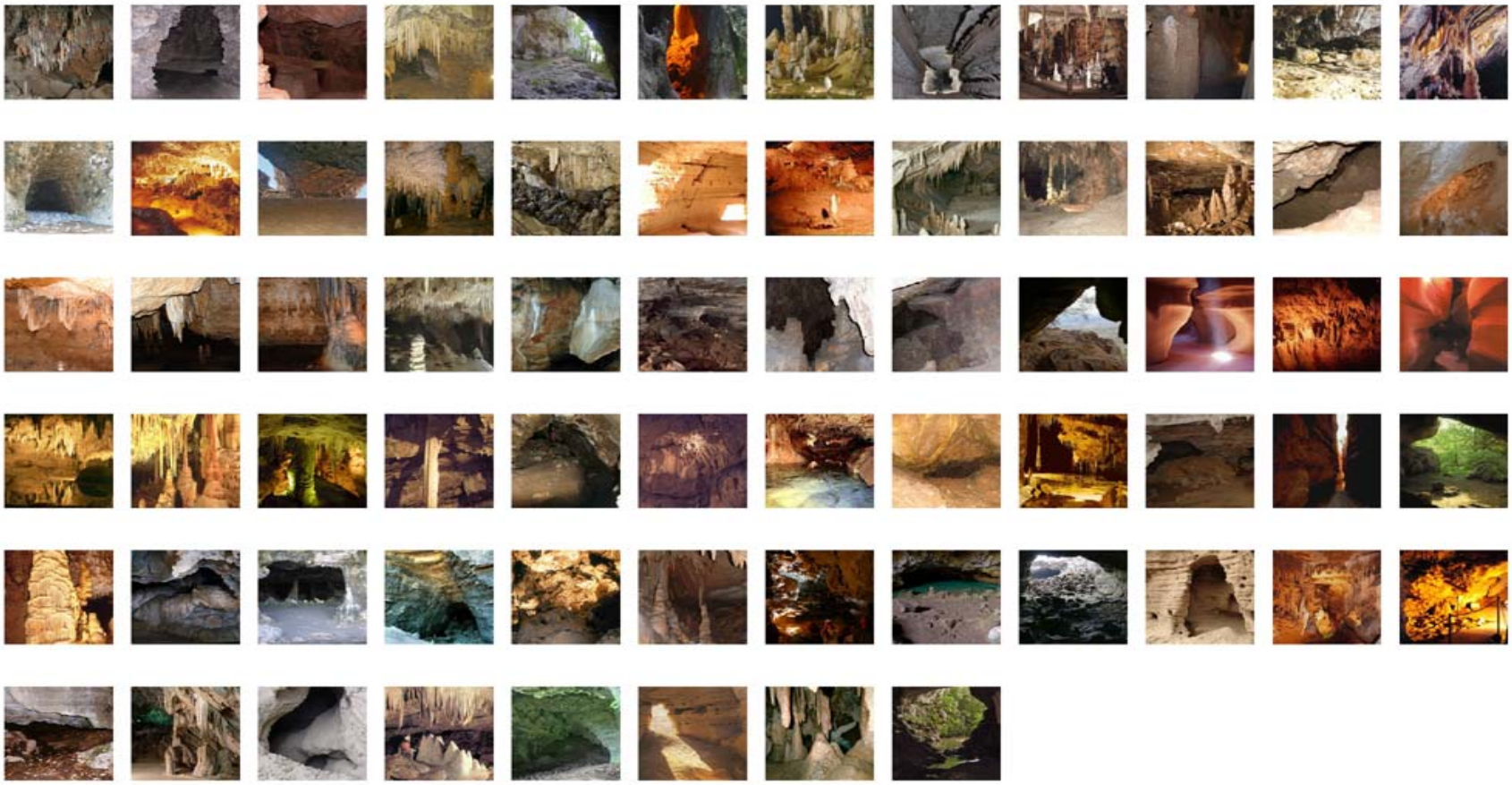
Beach



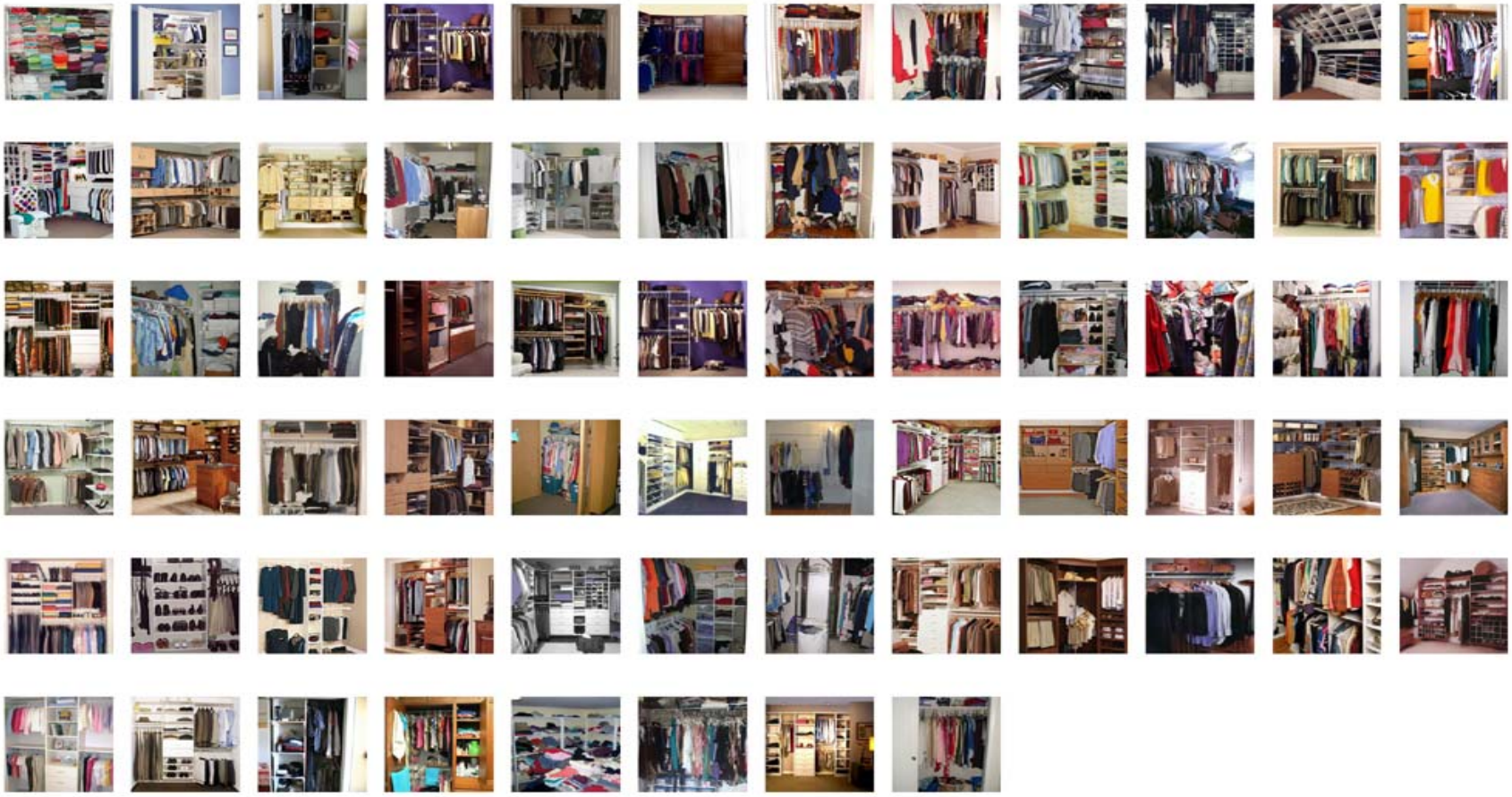
Bedroom



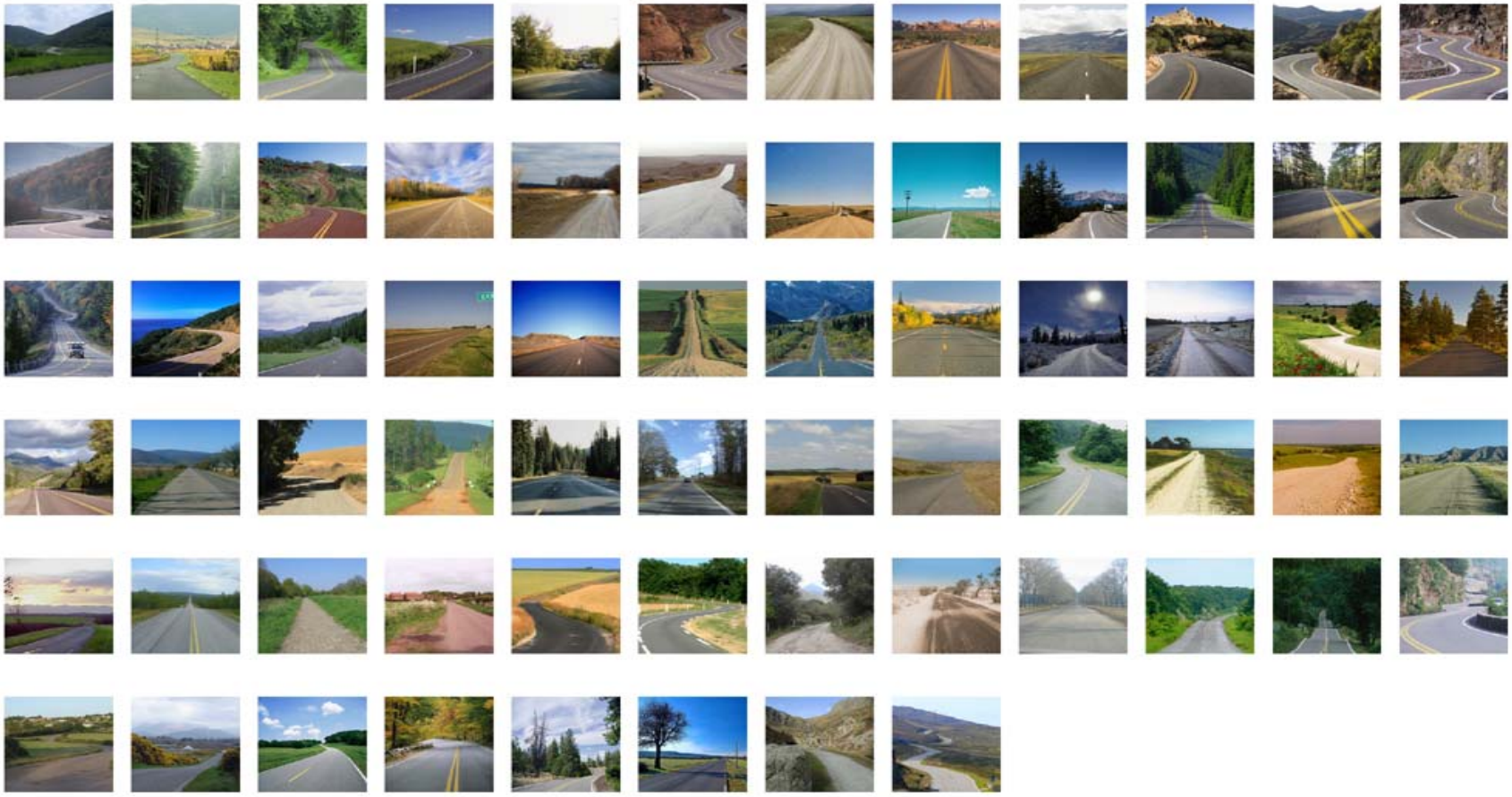
Cavern



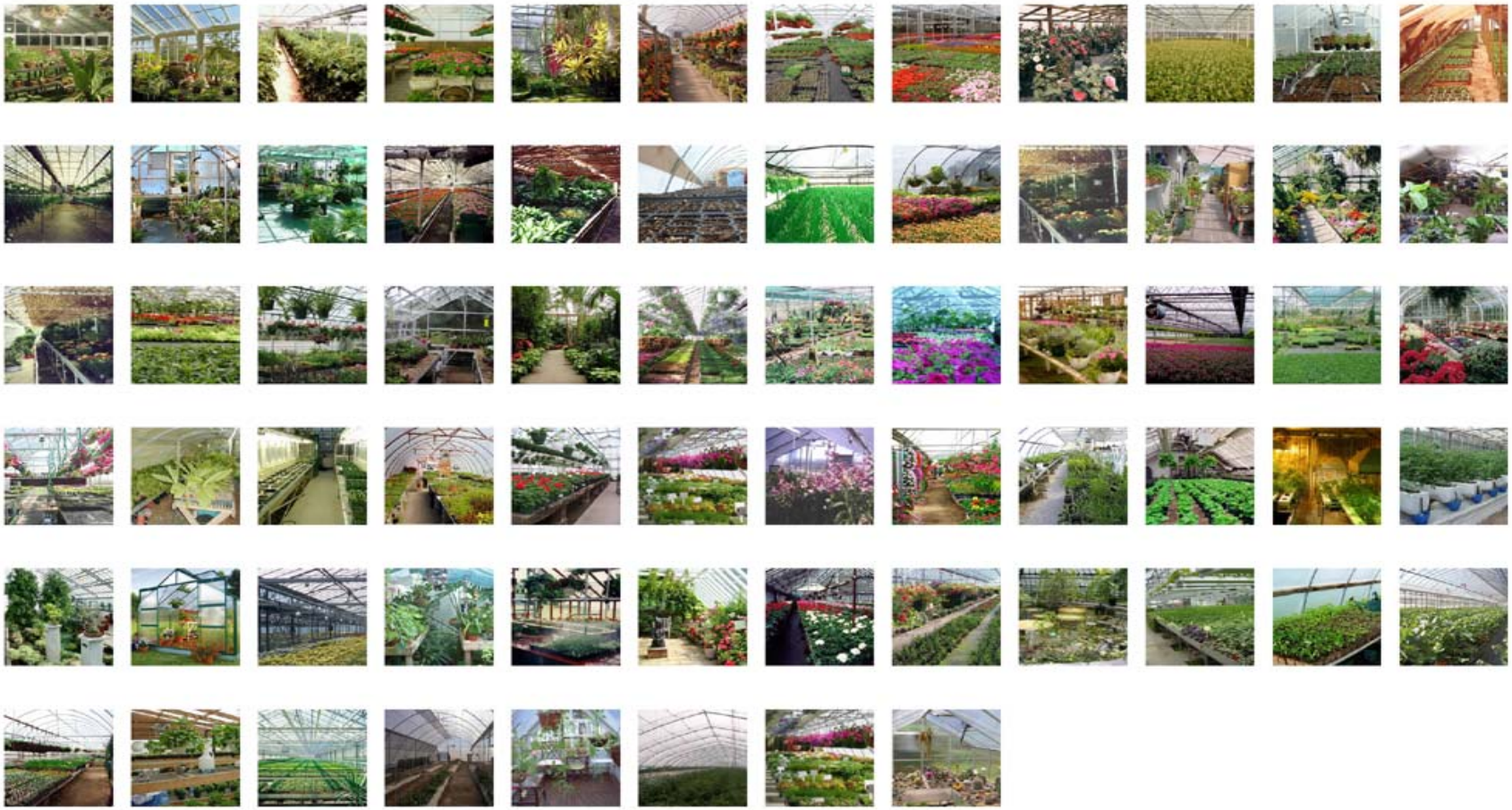
Closet



Countryroad



Greenhouse



Waves

Methods – The Study Stream

128 unique semantic categories of natural images

2912 natural images shown in the stream (3 seconds each, 800 msec ISI)

Number of exemplars per category: 4, 16, or **64 !**

N= 24 observers

Methods – The Study Stream

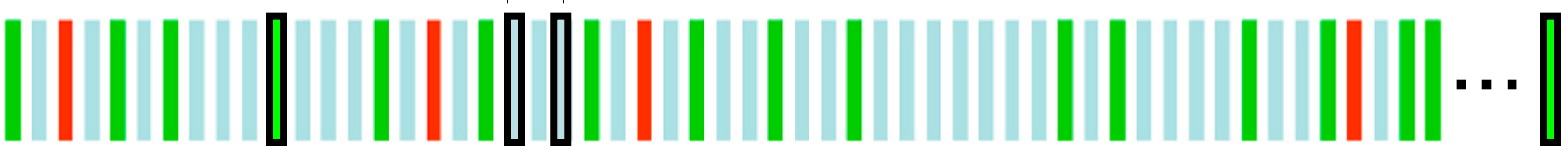
Online Task: **Detect Exact Repeats**

Repeats could be 2 to 1024 back in the stream

Repeats could be from categories with 4, 16, or 64 exemplars

7% of images in the stream were repeats (192 / 2912)



Methods – The Memory Test

Followed by 224 **2-alternative forced choice tests**

Novel

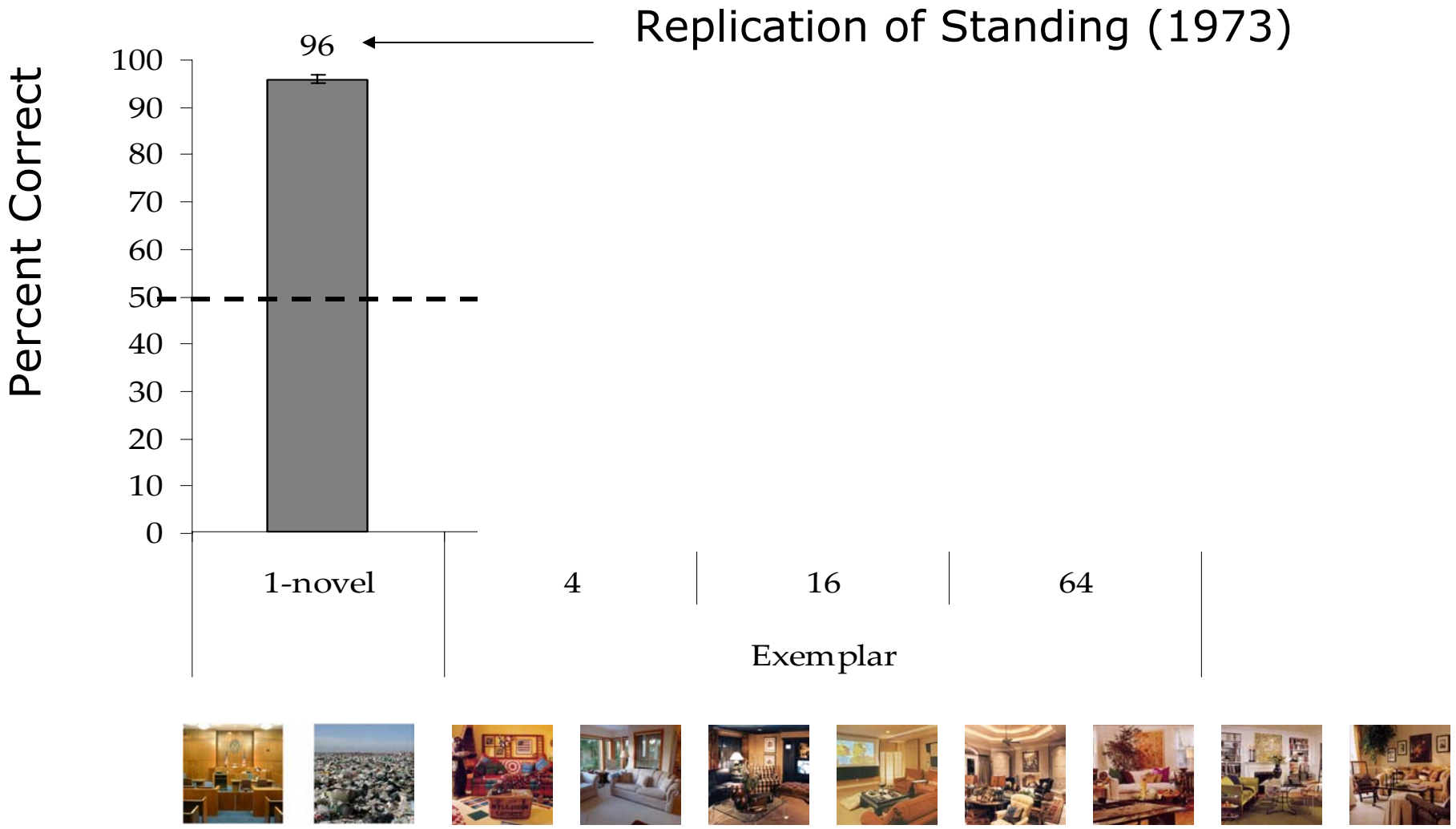
Exemplar

None of the tested categories were n-backed

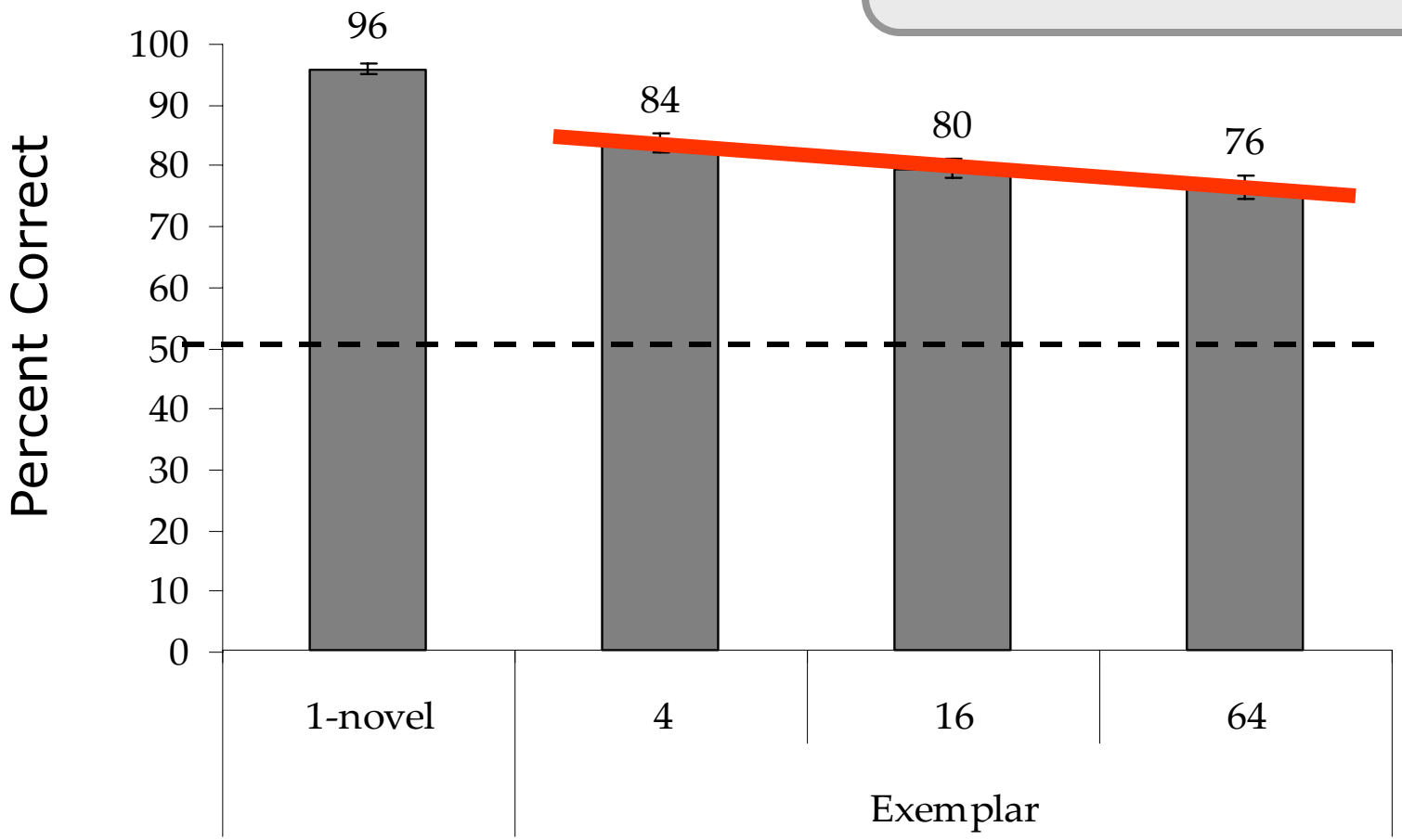
Test Pairs were always the same for all subjects

Any effect of interference is due to the additional exemplars

Results – Recognition Memory

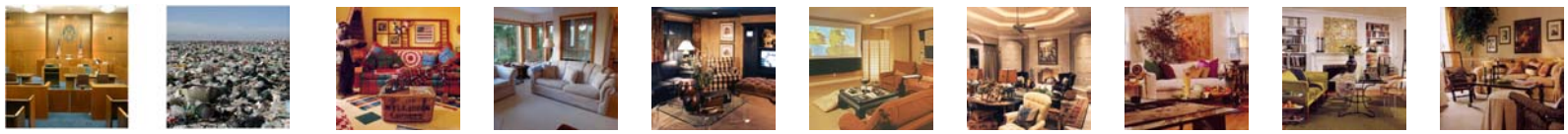


Detailed Representation
Minor Interference



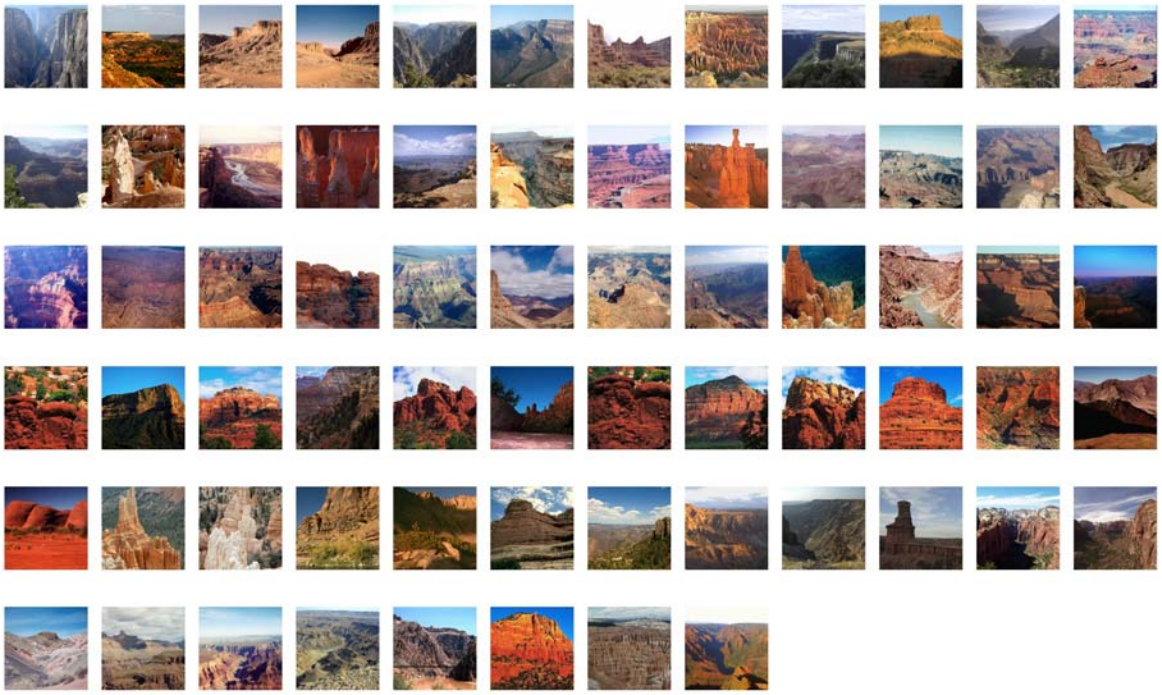
2%

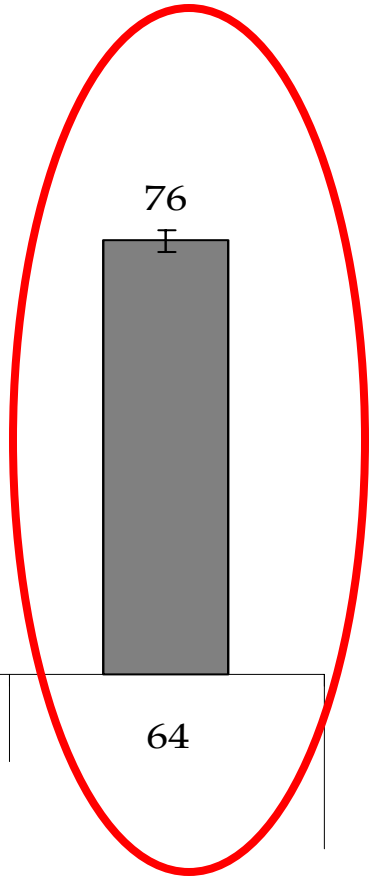
drop with doubling the number of exemplars in memory



Konkle, Brady, Alvarez & Oliva (submitted)

Highly Detailed
Minor Interference





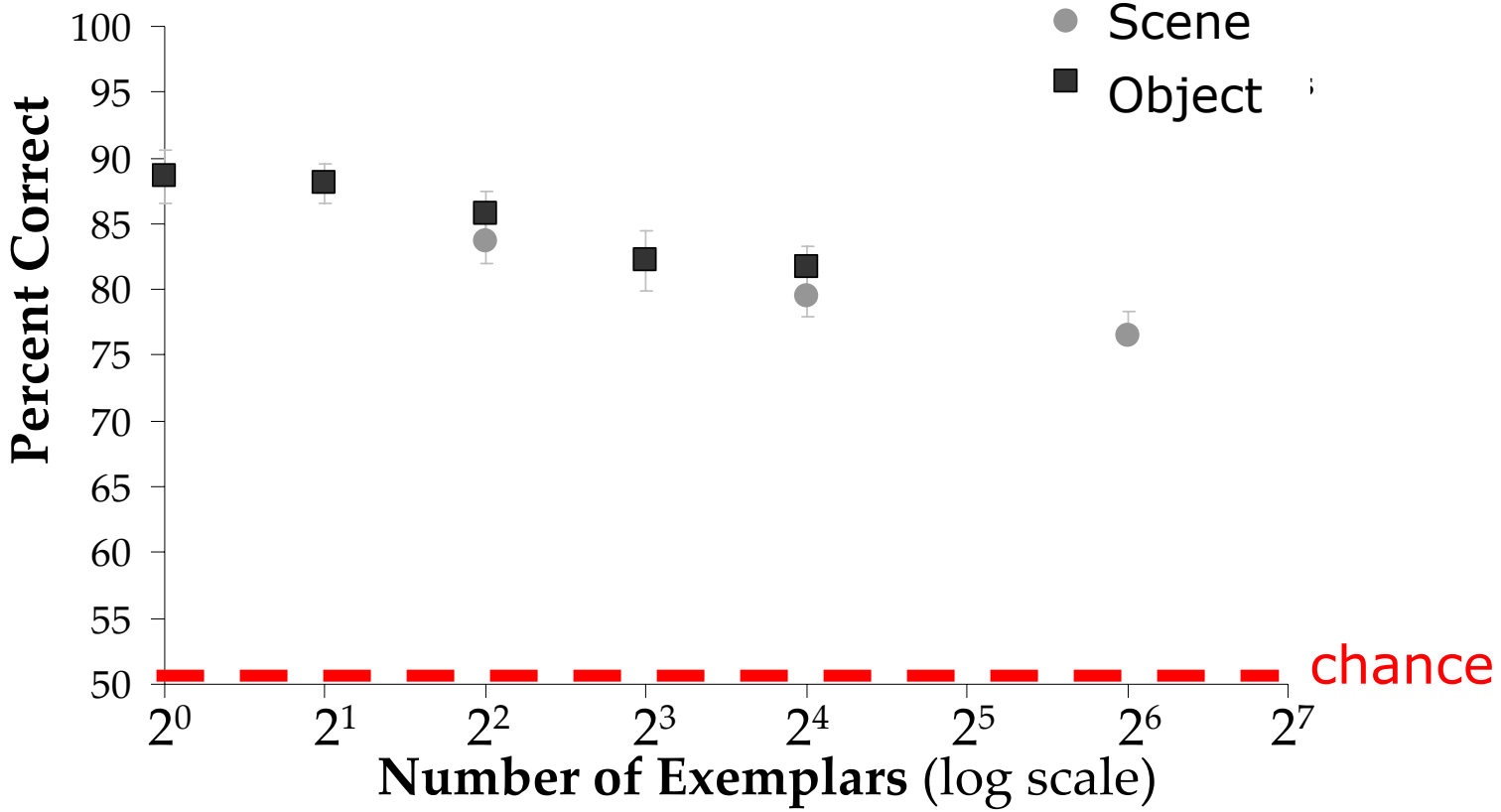

KEEP THIS COUPON
NO STANDING
Daim
Excedrin MIGRAINE
COLD PACK

Objects & Scenes
Is it fair to compare?

You can make each test item and foil **arbitrarily hard**

We tried to **span the category** with our exemplars and sampled the test item and foil uniformly

Memory for Scenes and Objects

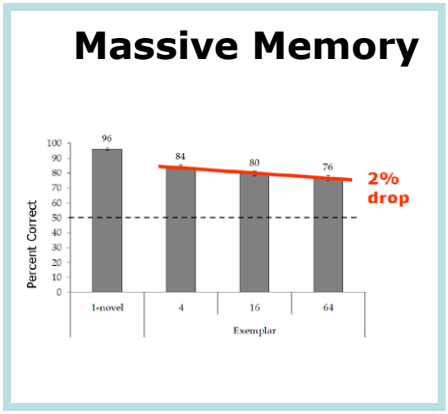


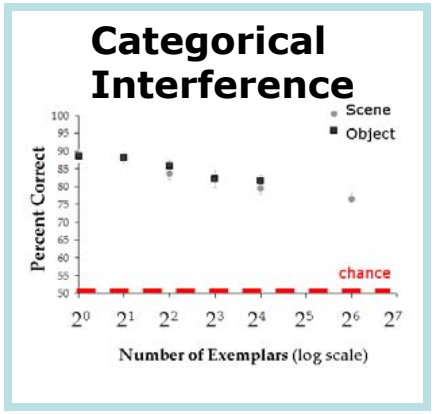
Similar categorical interference effects for objects and scenes

Konkle, Brady, Alvarez & Oliva (submitted)

I. Conclusion

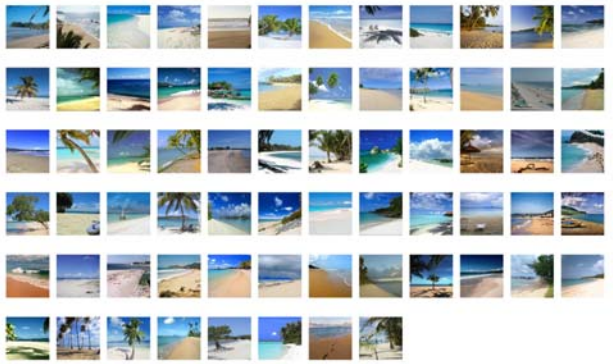
- High fidelity representation in long term visual memory
- Similar categorical interference effects for scenes and objects
- Objects and scenes are entities represented at a similar level of abstraction in long term storage
- The results suggest that the structure of visual categories is information-theoretic optimal: It maximizes within category similarity & minimize between category similarities

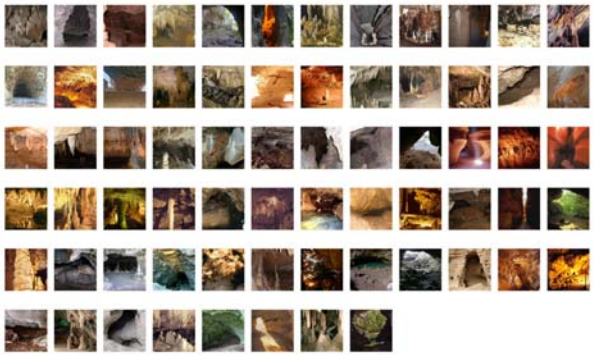




See website with papers and stimuli: http://cvcl.mit.edu/MM

Visual Categories are represented by their shape



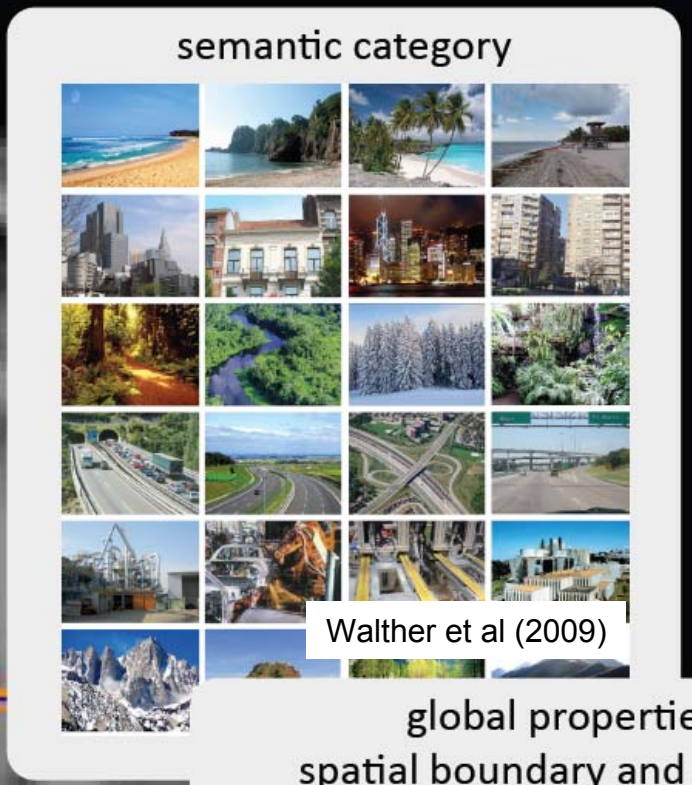


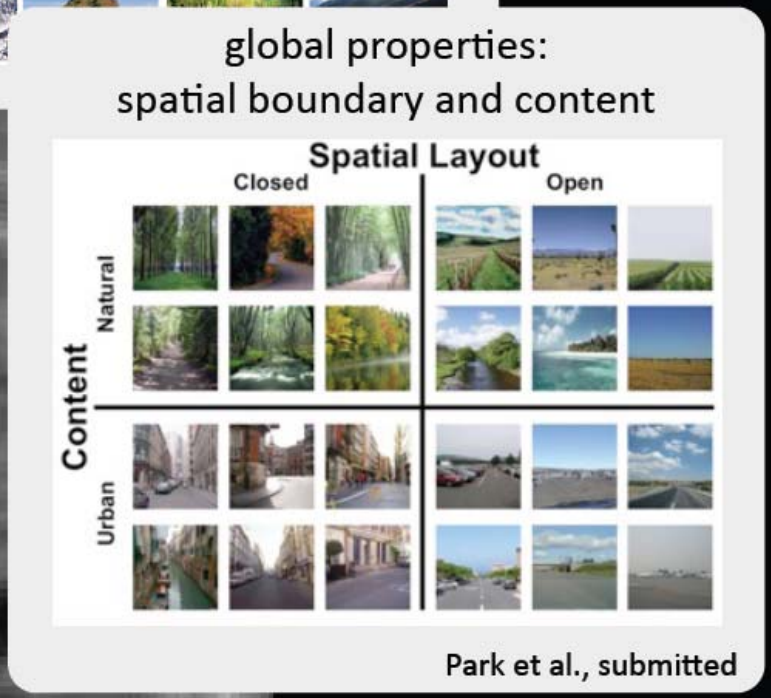
How to represent the *shape* of scenes ?

II – Neural Representation of Visual Scenes



Soojin Park Michelle Greene Timothy Brady





Scenes are spatial entities

A scene is a 3 dimensional entity we act within:

it extends in space, it has a size, boundary, content, layout.

Shape of a scene: Spatial Boundary and Content

Spatial Envelope Representation

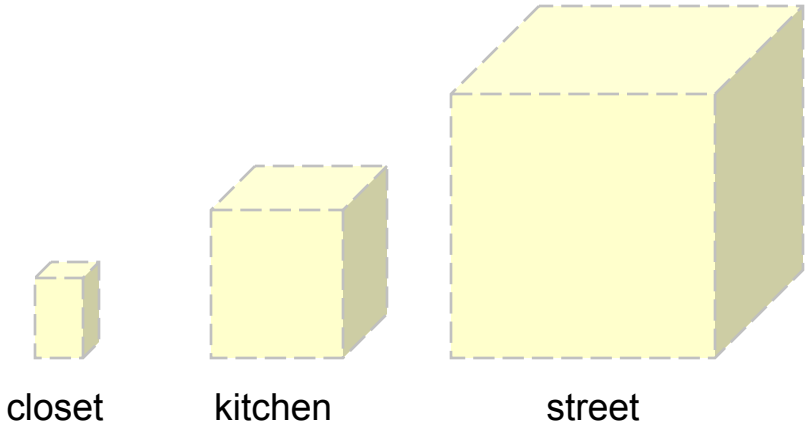
A scene is inherently a 3D entity that may be described by properties related to its size (volume) and its content

(1) <u>Boundary of the space</u>

Mean depth/Size

Openness

Perspective …

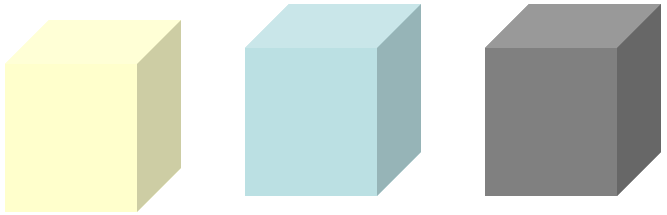


(2) <u>Content of the space</u>

Naturalness

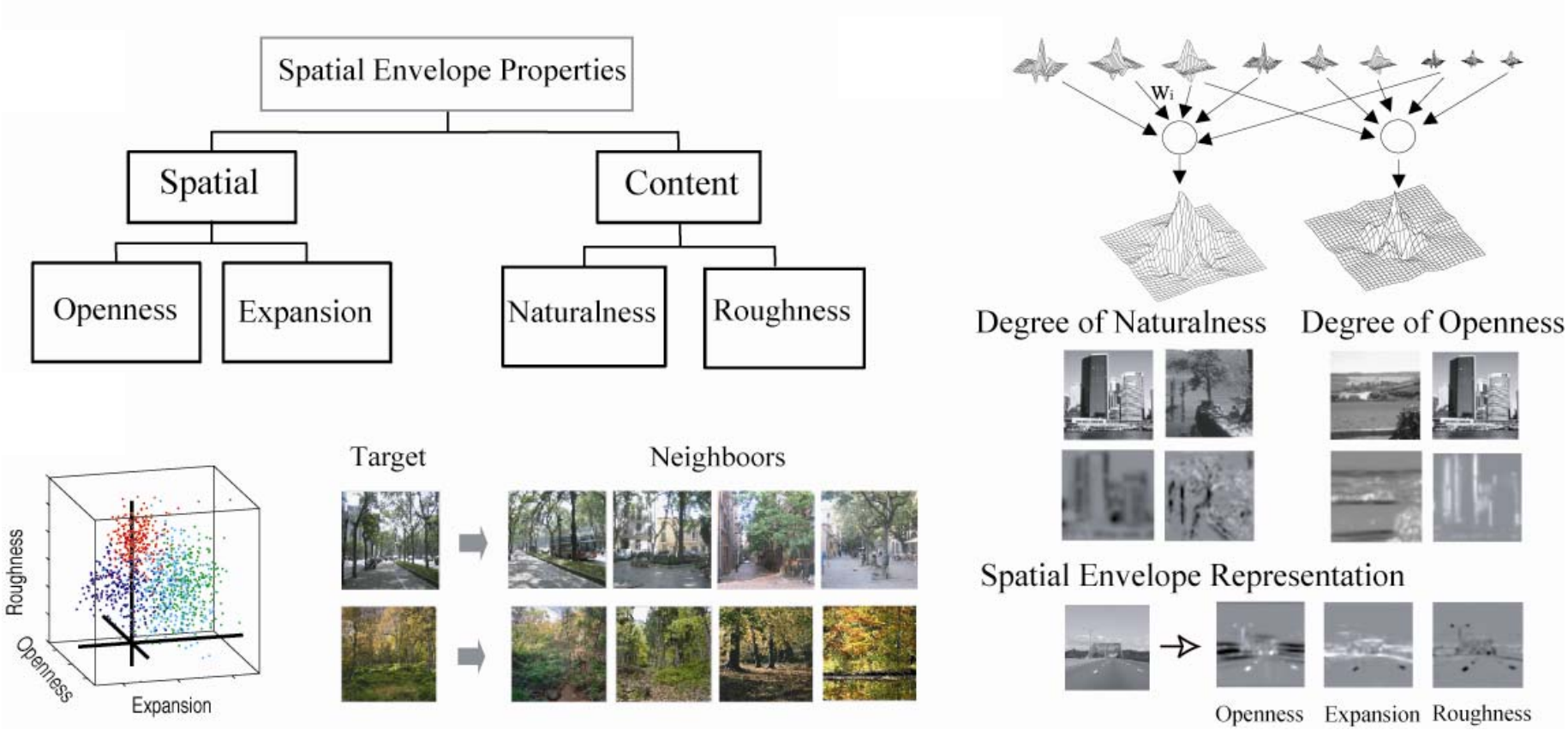
Roughness

Clutter …



Oliva & Torralba (2001, 2002, 2006); Torralba & Oliva (2002, 2003); Greene & Oliva (2010, in press); Ross & Oliva (2010)

Spatial Envelope Representation of Visual Scenes



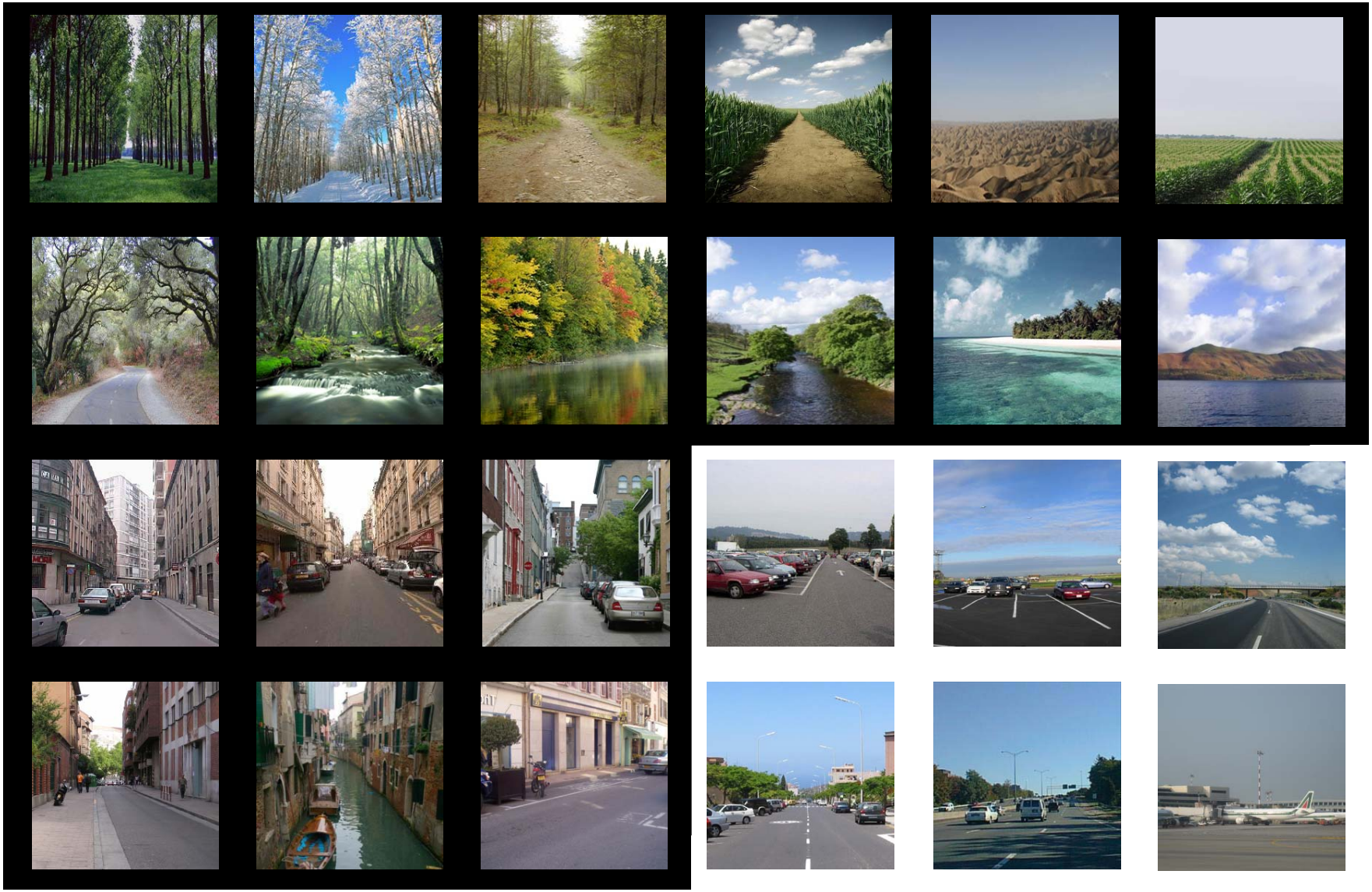
Oliva & Torralba (2001, 2002, 2006); Torralba & Oliva (2002, 2003); Greene & Oliva (2009, in press); Ross & Oliva (2010)

Spatial Boundary & Content

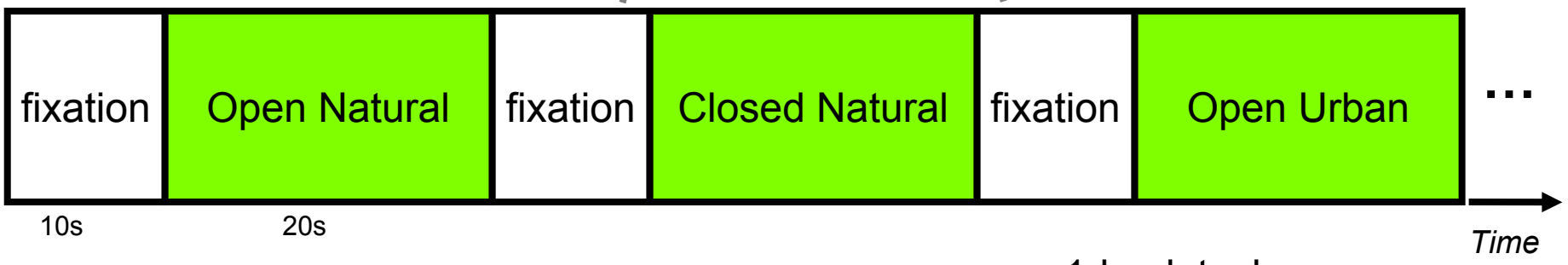
Orthogonal Properties

Park, Brady, Greene & Oliva (submitted)

Experimental Conditions

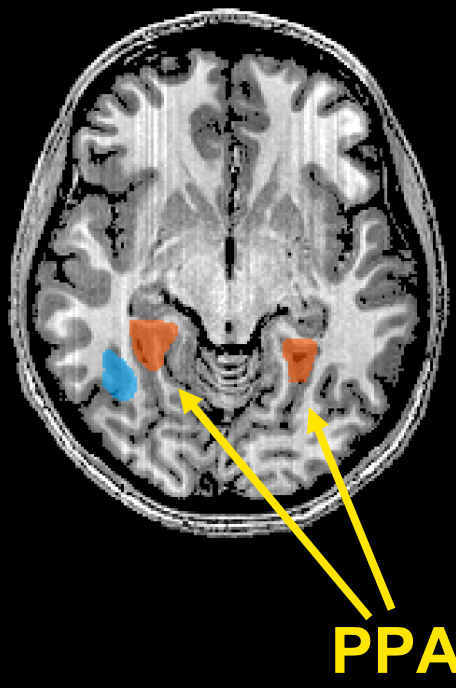


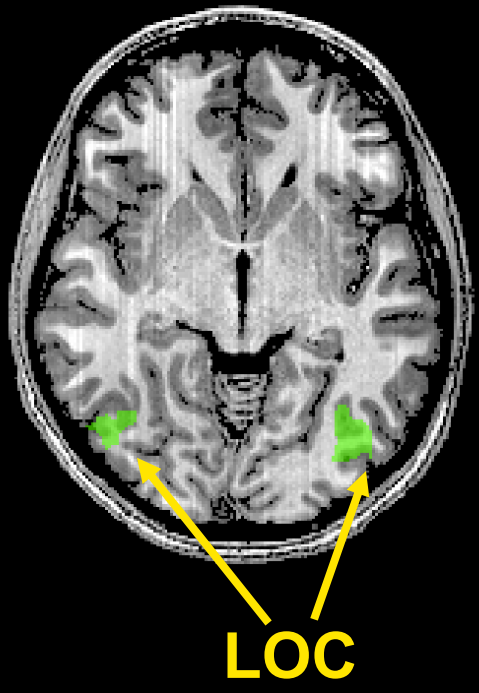
Experimental Procedure



1-back task
20 blocks per condition

ROIs localized with Independent localizers



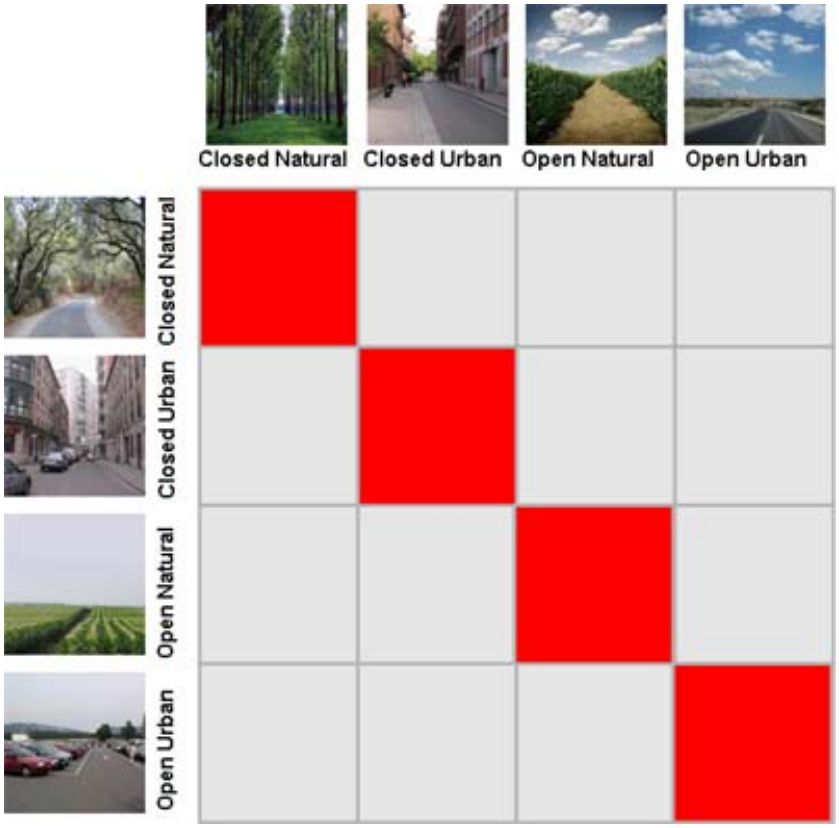


Epstein & Kanwisher (1998)

Classification Performances

in PPA and LOC

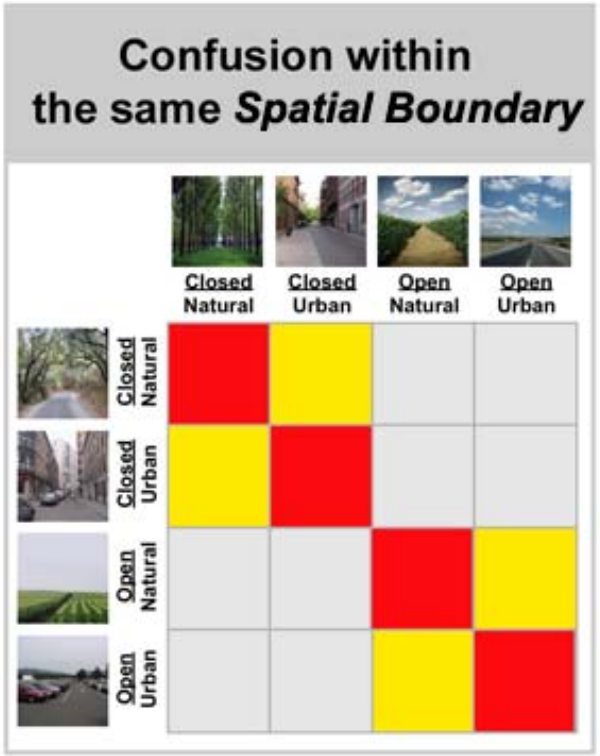
Both PPA and LOC regions classified the 4 groups with ~ **50%** accuracy

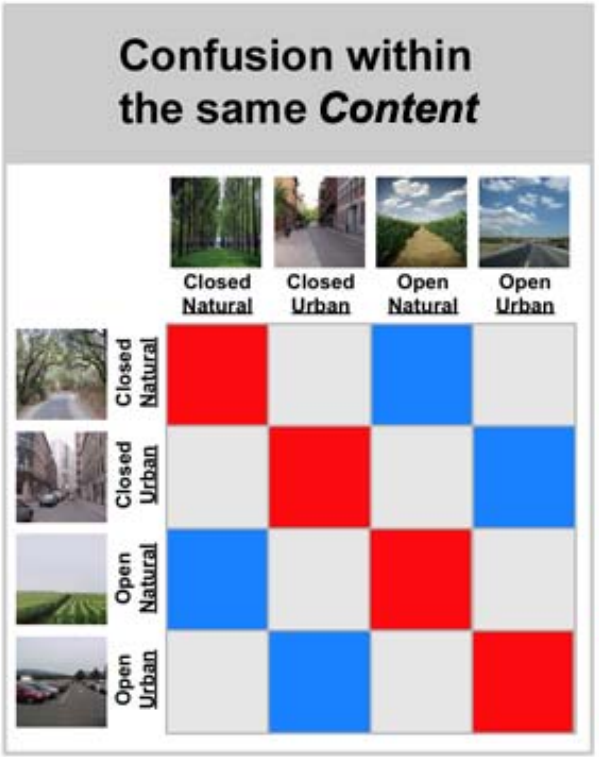


An SVM classifier was trained to classify the four conditions using all blocks but one, and then was tested on the remaining block.

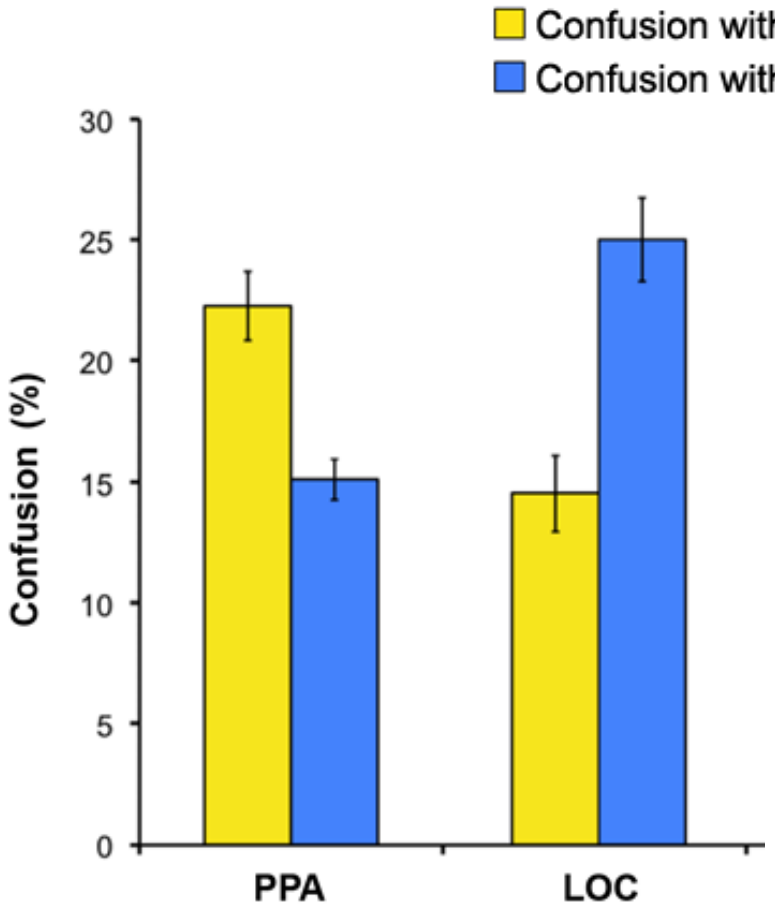
Patterns of Errors

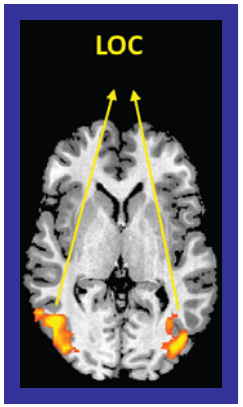
The patterns of errors allows to dissociate multiple levels of structure coexisting within intact images, and test the extent to which a specific property is coded in a certain brain area.





Patterns of Errors

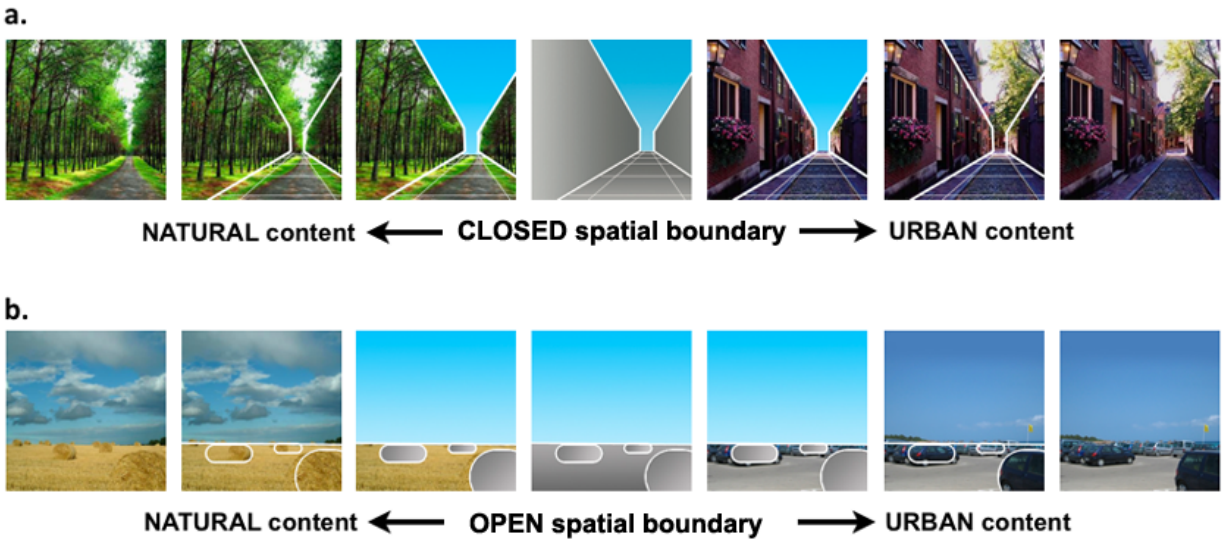




II. Conclusion

A dual neural pathway for representing the *shape* of a visual scene

Visual scenes are represented in a distributed and complementary manner by different brain regions sensitive to *spatial boundary* vs *content* of a scene



Park, Brady, Greene & Oliva (submitted)

Thank You

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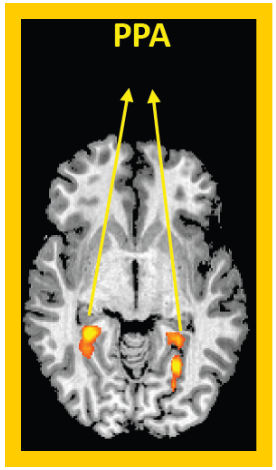

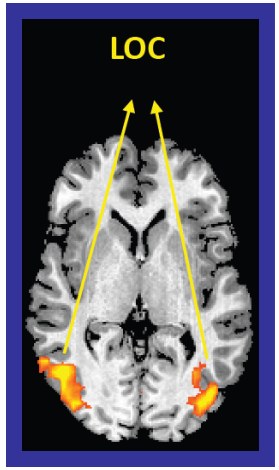

Funding: National Science Foundation Career Award IIS-0546262