Neural Correlates of Scene Perception
What’s a scene?

- anything that’s not an object?
- anything that extends beyond the scope of your view
- anything with a spatial layout
- Oliva: space is a 3d object with size and contents
What’s a place?

- a semantically coherent (and often nameable) view
- of a real world environment
- with background elements and discrete objects

“act on objects”

“act in scenes”

(Henderson & Hollingworth 1999)
(Epstein 2005)
We’re very good at recognizing scenes

This is termed the “gist” of the scene.
What processes and representations mediates this rapid scene recognition?
Do you know what this is?
Do you know what this is?

You do now!
What processes and representations mediates this rapid scene recognition?

Possibility 1

So... knowing the scene helped you recognize the object!
Another Example – What do you think are the hidden objects?

1

2

Courtesy of Wonderlane.
Another Example – What do you think are the hidden objects?

Answering this question does not require knowing what the objects look like. It is all about context.
What processes and representations mediate this rapid scene recognition?

Possibility 1

- World/Visual field
- Eye/Retinal image
- Object Recognition
- Matching
- Scene

Photo courtesy of Nick Devenish.

Possibility 2

Scene-centered representation
Global Properties

- Contours
- Early visual areas
- man-made small volume enclosed low clutter
- Semantic category
- Waiting area
- chair lamps plant desk

Object-centered representation

Courtesy of Aude Oliva. Used with permission. (Oliva and Torralba, 2006)
Questions

1) Are scenes processed differently from objects in the brain?

2) Is there evidence that scenes and objects are processed in different parallel pathways in the brain?
Are there brain regions that respond selectively to scenes?

Scan subjects while they look at these three kinds of stimuli

Courtesy of Jason Gulledge.

Courtesy of wrestlingentropy.

Face photos modified by OCW for privacy considerations.
Scenes > Faces & Objects
in 1 subject

“Parahippocampal Place Area” (PPA)
PPA in all 9 subjects

Image removed due to copyright restrictions.

[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf](http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf)
PPA
(scenes>objects at t>4)
1 subject
Region of Interest Analysis

- Using a separate set of localizer scans, define PPA.
- Then look at response to stimuli of interest within PPA during test scans:

Images removed due to copyright restrictions.
Fig. 1b and part of Fig. 2b (left) in Epstein, Russell and Kanwisher, Nancy. "A cortical representation of the local visual environment." Nature 392 (1998): 598 - 601.

[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf](http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf)
Image removed due to copyright restrictions.
Fig. 1a in Epstein, Russell and Kanwisher, Nancy.
[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf]
Each Scan:

Each Epoch:
(20 pictures in an epoch)

Tasks: Passive Viewing or 1-Back Repetition Detection

Procedure

IntactHouses
Scram.Houses
IntactScenes
Scram.Scenes
IntactFaces
Scram.Faces
IntactObjects
Scram.Objects

5:36:16s :32s :48s
300 msec
500 msec
300 msec
300 msec
500 msec
Results
average % signal change for each condition (N=9)

Image removed due to copyright restrictions. Fig. 1a in Epstein, Russell and Kanwisher, Nancy. "A cortical representation of the local visual environment." Nature 392 (1998): 598 - 601.

[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf]
Why does the PPA respond to scenes?

- high-level visual/semantic complexity
- multiplicity/relative position of objects
- spatial layout
Predictions:

• visual/semantic complexity
• multiplicity of objects
• spatial layout

Furniture ?<br>Empty Rooms

Scene
Furniture Arrays
Empty Rooms

Courtesy of Jason Gulledge.

Courtesy of greenbroke.

Courtesy of ZapTheDingbat.

Courtesy of Baltimike.
Predictions:

- visual/semantic complexity
- multiplicity of objects
- spatial layout

\[ \begin{align*}
1.3 & \quad 0.5 & \quad 1.2 \\
\text{Furniture} & > & \text{Empty Rooms} \\
\text{Furniture} & < & \text{Empty Rooms} \\
\text{PSC} & (N=6) & [p<0.01]
\end{align*} \]
Experiment 3

If the PPA responds to spatial layout, then its response to surfaces that do not define a space should be low.

Image removed due to copyright restrictions.

[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf](http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf)
Experiment 3 Results

average % signal change in PPA for each condition (N=5)

Image removed due to copyright restrictions.

[http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf](http://web.mit.edu/bcs/nklab/media/pdfs/EpsteinKanwisher98.pdf)
Experiment 4

**Issue:** Is it the *layout* (physical structure) or the *placeness* (meaning) of the scene that drives the PPA response?

**To Test:** Examine PPA response to layouts that are not real places in the world.

Layout, Real Place in World vs. Layout, Not Real Place

Courtesy of greenbroke.
**Question:** Does the PPA respond strongly to spatial layouts that are not real places?

![Images of various objects and layouts]( Courtesy of wrestlingentropy, Baltimike, greenbroke )
Experiment 4 Results

Avg. % signal change in PPA (N=6):

<table>
<thead>
<tr>
<th>Objects</th>
<th>Lego Objects</th>
<th>Lego Layouts</th>
<th>Layout+Anim.</th>
<th>Empty Rooms</th>
<th>Furn. Rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.6</td>
<td>1.0</td>
<td>1.2</td>
<td>1.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

p<0.01

Yes: The PPA is strongly activated by spatial layouts that do not represent real places in the world.
Experiment 4 Results

Avg. % signal change in PPA (N=6):

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* p<0.01

Yes: The PPA is strongly activated by spatial layouts that do not represent real places in the world.

However, PPA response is even greater to real scenes.
Experiment 5

**Question:** Is the PPA involved in the recognition of a scene, or in processes specific to familiar scenes?

**To Test:** Examine PPA response to MIT versus Tufts scenes in MIT versus Tufts students - can thus counterbalance for specific stimuli.

**Result:**
1.9 PSC familiar vs. 1.8 PSC unfamiliar, n.s.

**Conclusion:** The PPA does not conduct semantic or other postrecognition processing on scenes.
Experiment 6

**Question:** Is the PPA involved in planning navigation?

**To Test:** Examine the PPA response to places you can't navigate in: “desktop scenes”.
Experiment 6: The PPA responds as strongly to table tops as to “full” scenes.

![Graph showing PPA responses to different types of scenes.](image-url)

- **real scenes**: 1.20%
- **desktops**: 1.40%
- **full-view objects**: 0.40%

Courtesy of Per Ola Wieberg, Living Juicy, independentman.
Experiment 6

**Question:** Is the PPA involved in planning navigation?

**To Test:** Examine the PPA response to places you can’t navigate in: “desktop scenes”.

**Result:**
Response is just as high for tabletop as “real” scenes.

**Conclusions:**
The PPA is not specific to navigational planning.
Summary of Exps. 1-6

**Exp. 1**  There is region of parahippocampal cortex that responds selectively and automatically to scenes.

**Exp. 2**  When all the objects are removed from the scenes, the response is unchanged.

**Exp. 3**  When the surfaces of the scenes are rearranged so that they no longer define a coherent space, the response is significantly reduced.

**Exp. 4**  Response to layouts is strong even if they do not represent real places in the world.

**Exp. 5&6**  The PPA does not respond differentially to familiar & unfamiliar scenes, or to navigable versus non-navigable scenes.

The PPA analyzes the **shape** of the local environment.
Unanswered Questions

What exactly does the PPA *do* with scene information? what information does it represent? what tasks is it engaged in?
  just seeing spatial layout? scene *recognition* (specific versus general?)? navigation? (construed broadly? web “navigation”?) other?
what functions would you lose if you did not have a PPA?

What about those other scene-selective regions? are they functionally different from the PPA? How?

[How] do these regions interact with each other and the rest of the brain?
Beyond the PPA

- There are **three** contiguous brain regions that you find which have greater activity for scenes than objects:

  Parahippocampal Place Area
  
  Transverse Occipital Sulcus
  
  Retrosplenial Cortex

Courtesy of Russell Epstein. Used with permission.
Presentations

1) Are scenes processed differently from objects in the brain?
   Yes! There is an area called the PPA that selectively responds to scenes and not objects.

   What about the other scene selective areas you mentioned?

2) Is there evidence that scenes and objects are processed in different parallel pathways in the brain?

3) What is the role of the PPA in during navigation?