Selective Neural Representation of Objects Relevant for Navigation

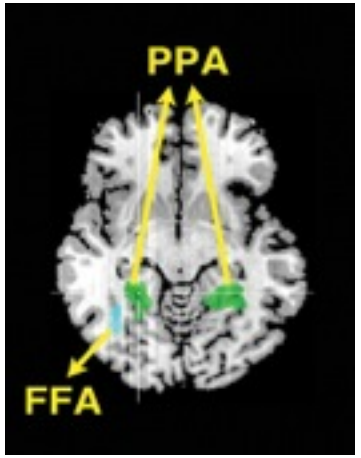
Gabriele Janzen and Miranda van Turennout

Presentation by Anirudh Viswanathan

The Discussion So Far…

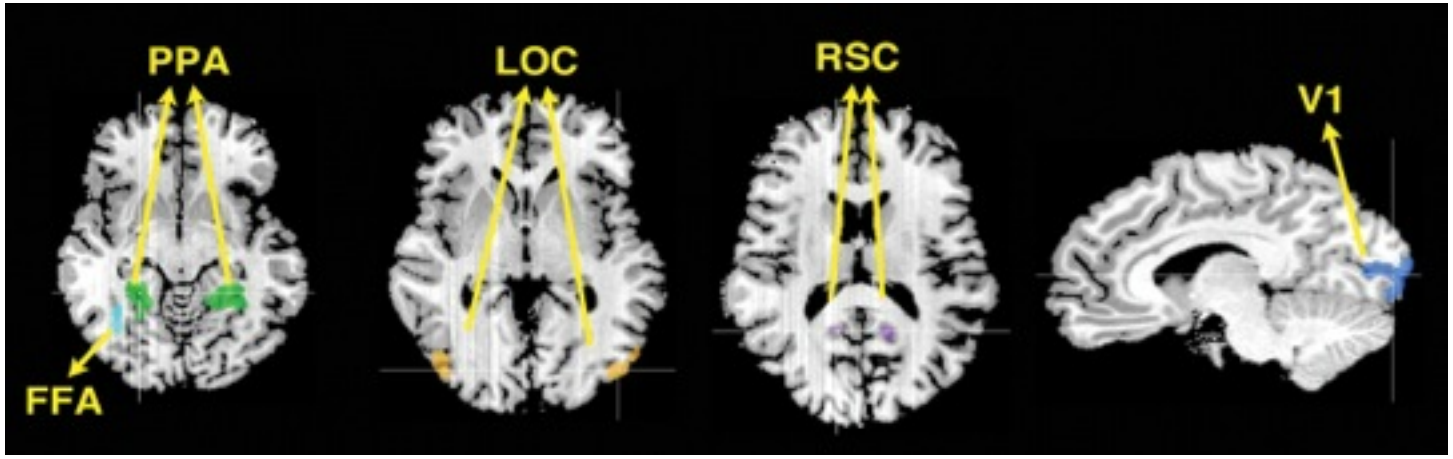
- Functional relevance to objects
- Especially, the cluster of objects were related to each other, and the spatial layout was a concern
- Objects used in the last study were large, non-manipulable

Parahippocampal Gyrus(PPG)



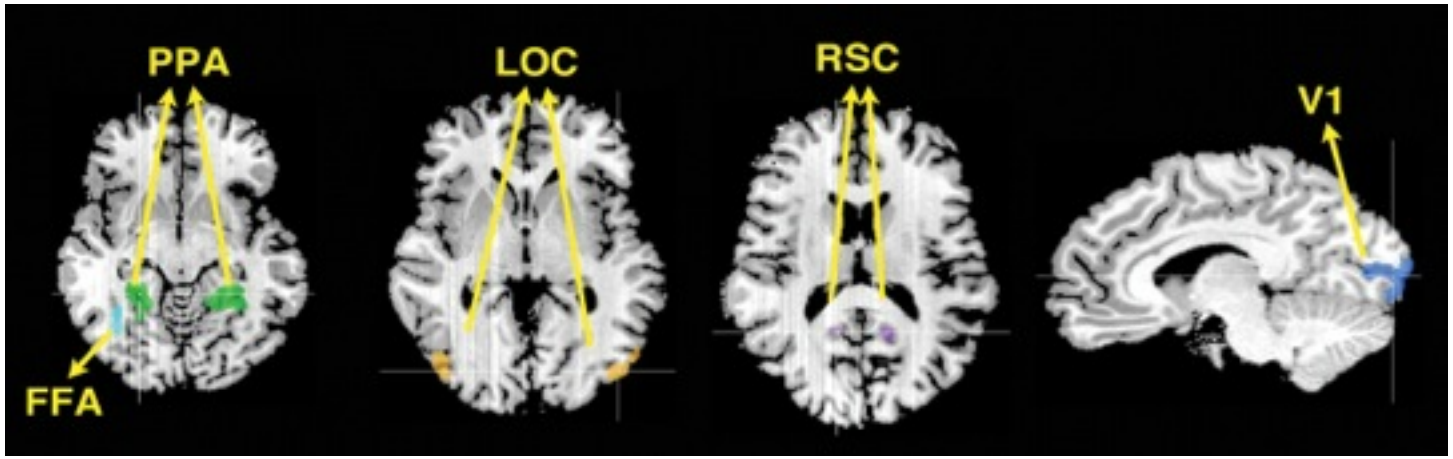
The **parahippocampal place area** (PPA) is a sub-region of the parahippocampal cortex

PPA Activation for Scenes



Park and Oliva, Disentangling scene content from its spatial boundary: Complementary roles for the PPA and LOC in representing real-world scenes

PPA Activation
Scenes at a Functional Level



- PPA is know for activating during scenes, landmarks, navigation

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PPA Activation
Scenes at a Functional Level

- PPA is know for activating during scenes, landmarks, navigation

Objects are Relevant to Navigation Decisions Too

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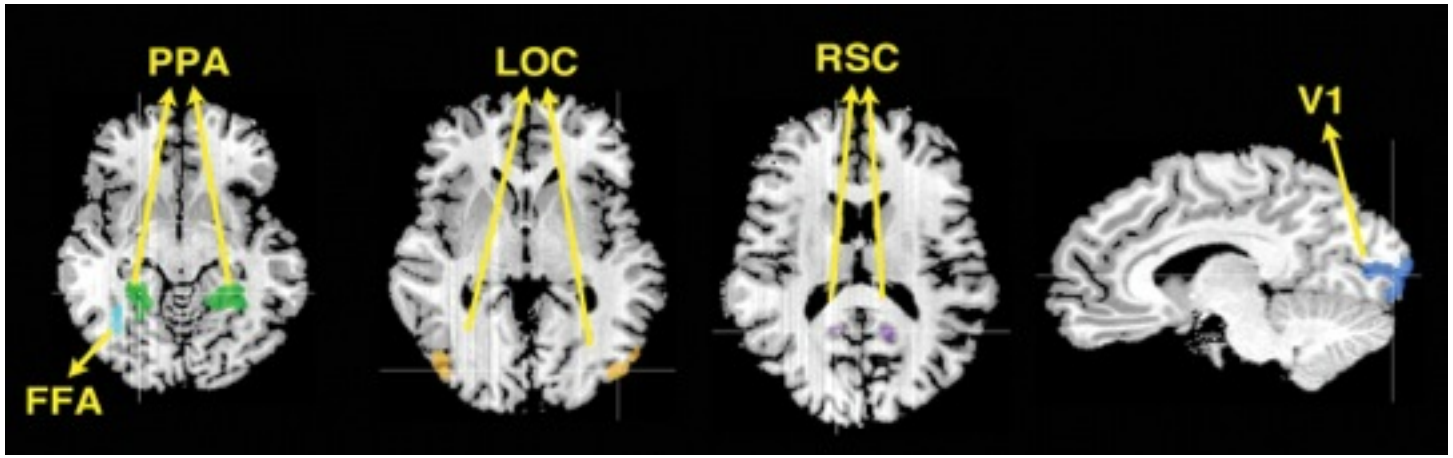
Differential Representation of Objects Relevant for Navigation ?

- Do navigationally relevant objects activate the PPA?

Differential Representation of Objects Relevant for Navigation ?

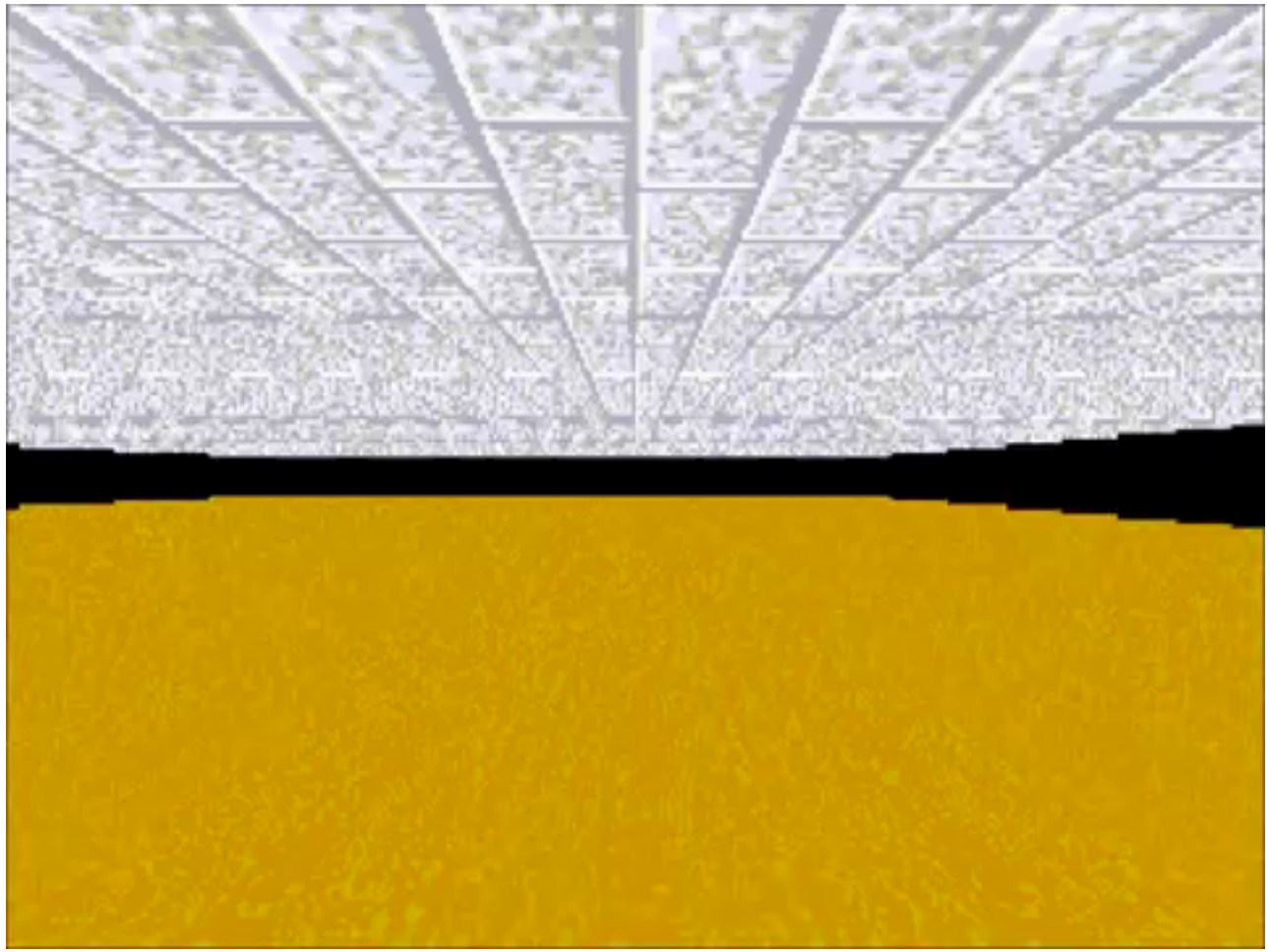
- How does the PPA respond to navigationally relevant objects?



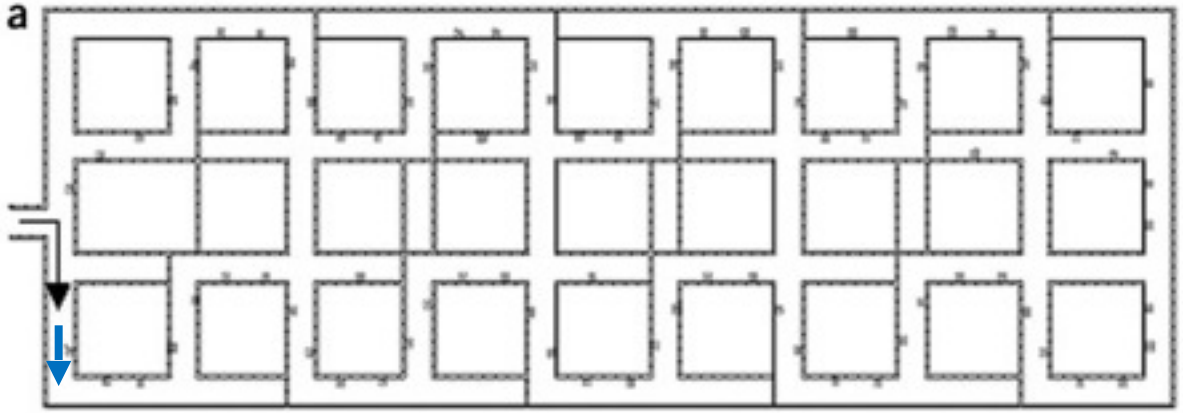
The Hypothesis

Navigationally relevant objects differentially modulate the PPA

Objects and Mazes – The Method



The Maze



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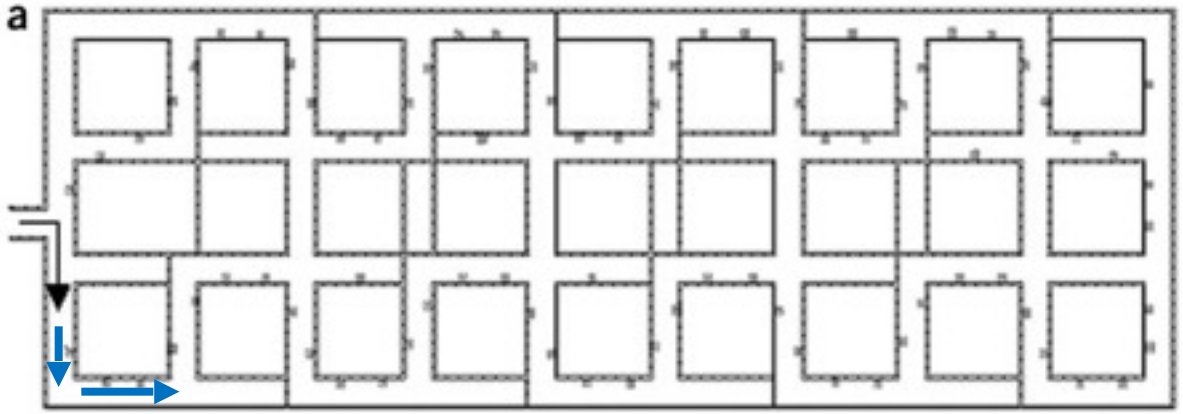

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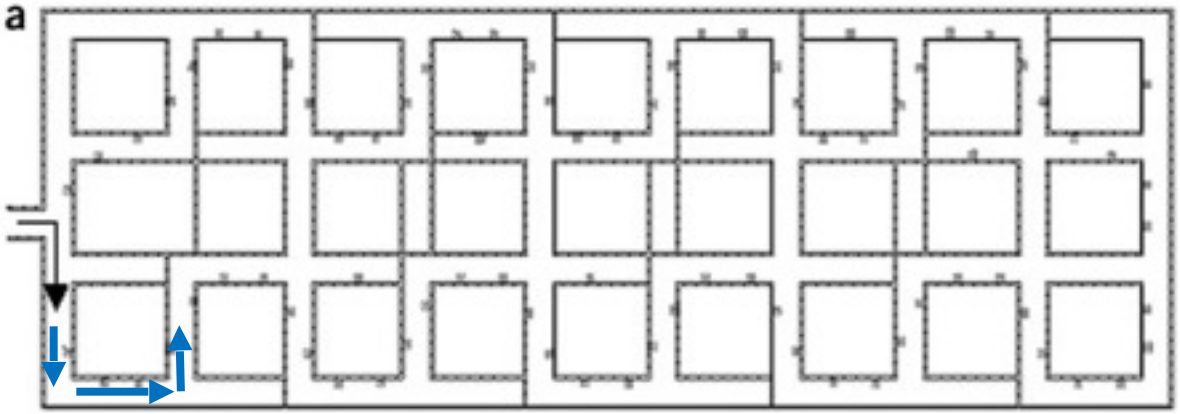
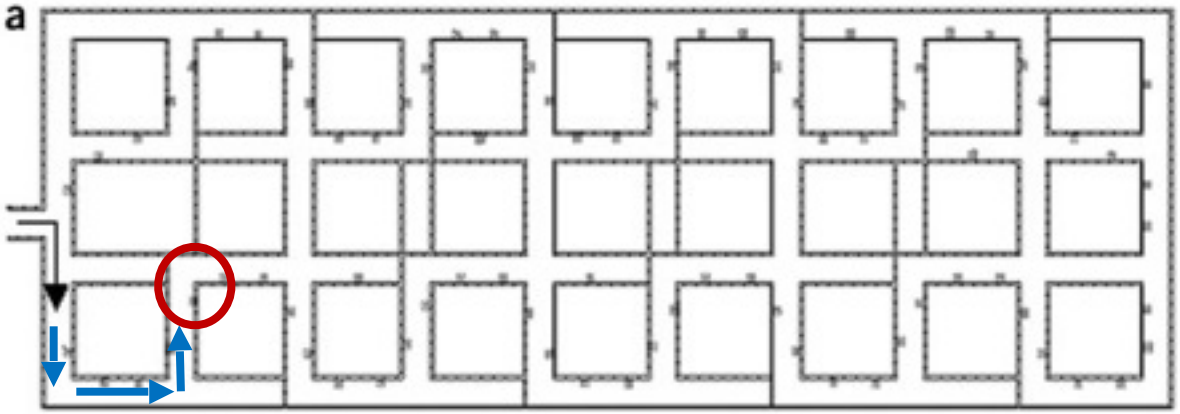
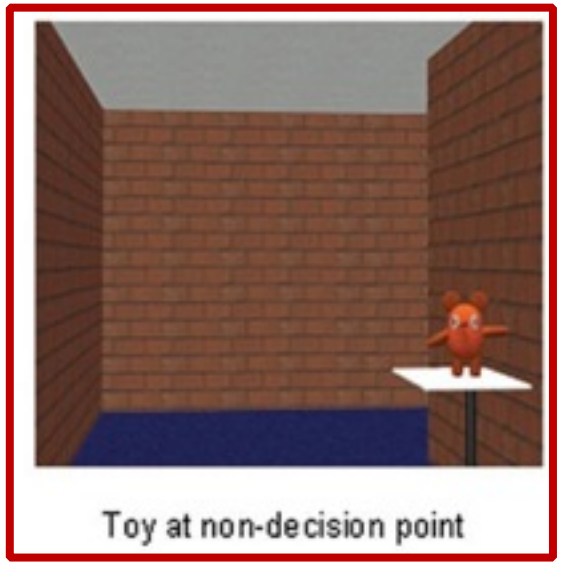


The Maze – Toy at Non-Decision Point





Toy at non-decision point

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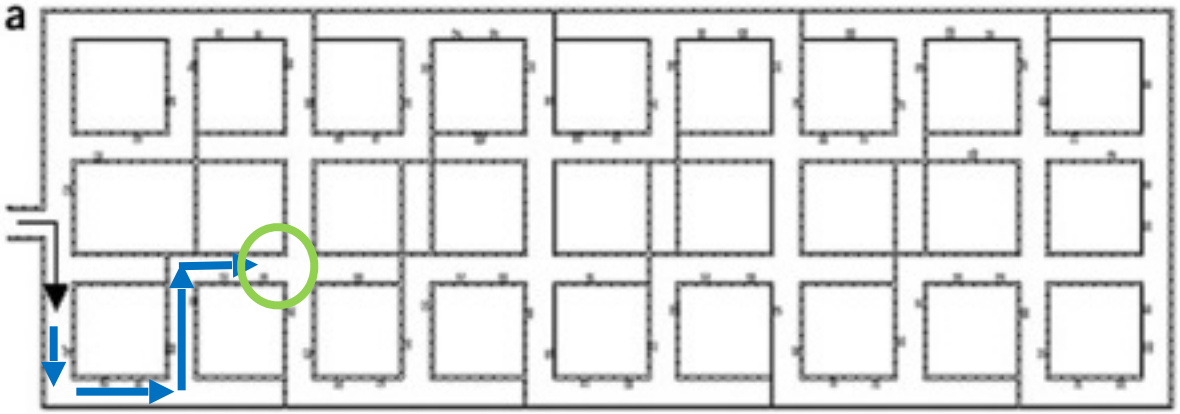
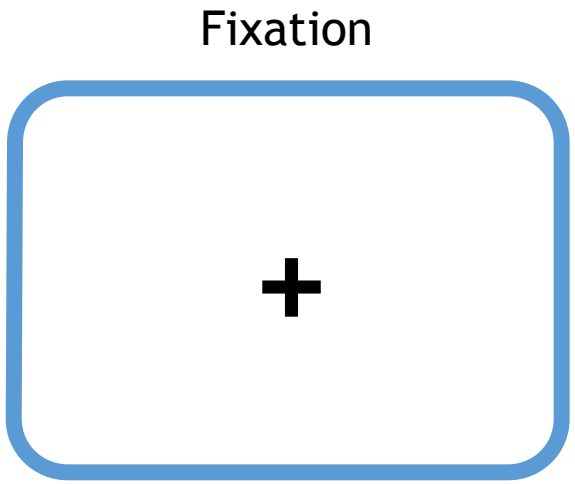


Toy at decision point

fMRI Study Tests Object Recall
Toys at Decision Points are Frequently Recalled



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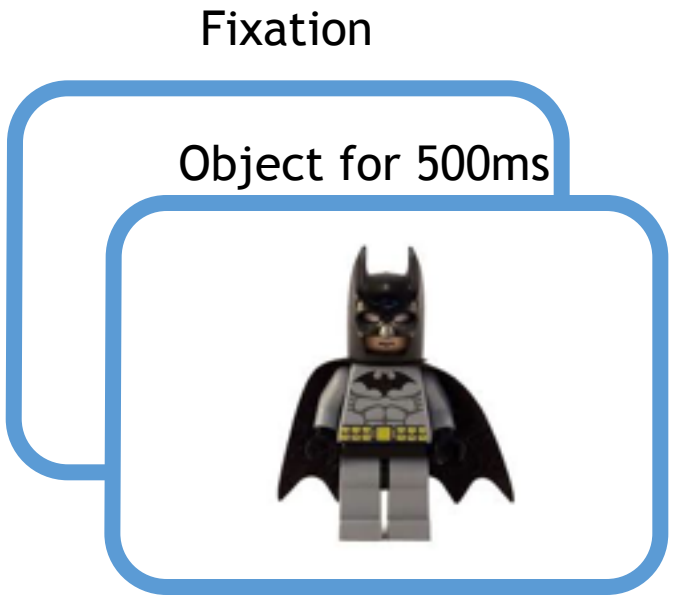

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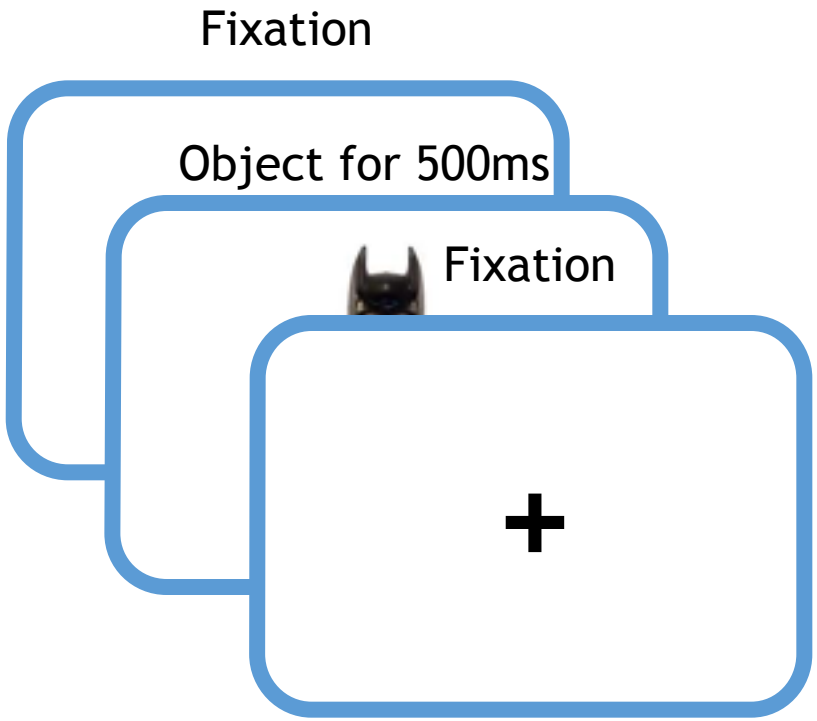


Questions – on the Experimental Setup

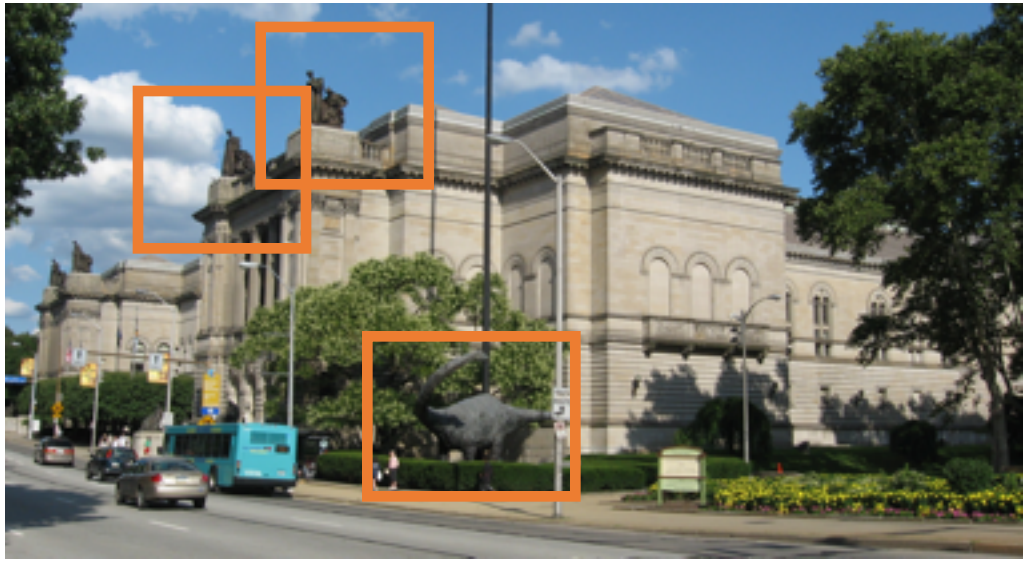
- Time spent looking the objects?
  - At decision points – more time spent looking at objects?
  - Seems like the natural thing that people do

Questions – on the Experimental Setup

- Time spent looking the objects?
- Controlled for time spent
- Panned the camera to view the object, independent of location

Questions – on the Experimental Setup

- What about object heights?
- Things that appear at street level, are more likely to be remembered



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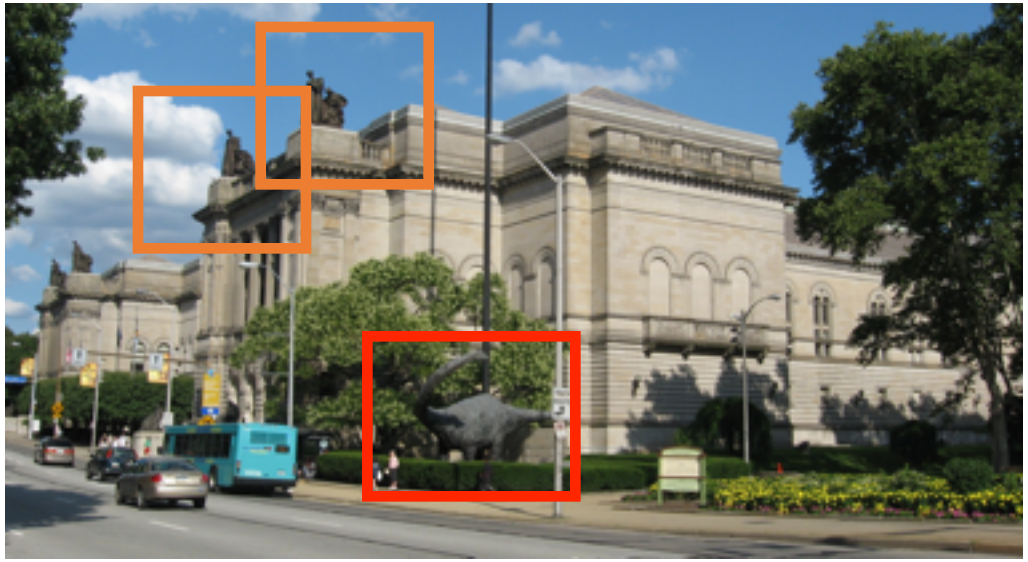


Discussion of the Method

- Maze based method is described earlier. Specifically, the authors control for:
- Toy-vs-non-toys - equally distributed in the environment. (object based)




Discussion of the Method

- Intersection/non-intersection - equally distributed (decision based)

Discussion of the Method

- Navigation-vs-motion - the scene fixates on the object irrespective of whether it is at a decision location

Discussion of the Method

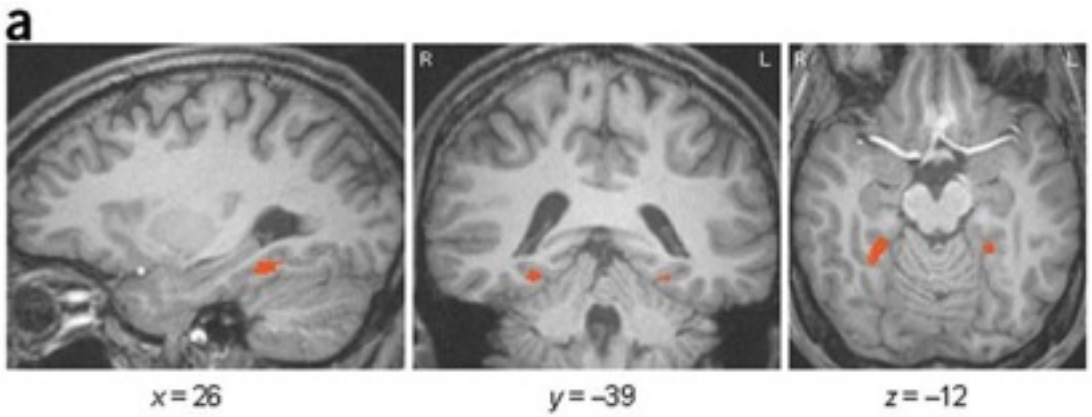
- Control for navigation relevance -
  show normalized object size during fMRI study



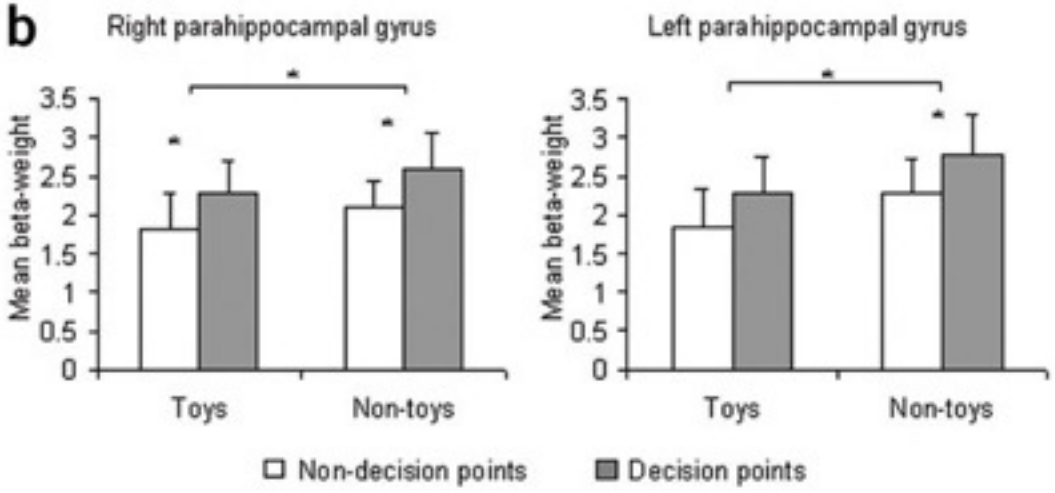

Results

- The subjects successfully recalled objects at locations relevant to navigation.
- The effect of attention - quicker to recognize toys

Results



- (a) PPA activates for objects
- **PPA** shows increased activity for decision- as compared to non-decision-point objects



- (b) Regional responses show increased activity for decision as compared to non-decision point objects

Takeaway

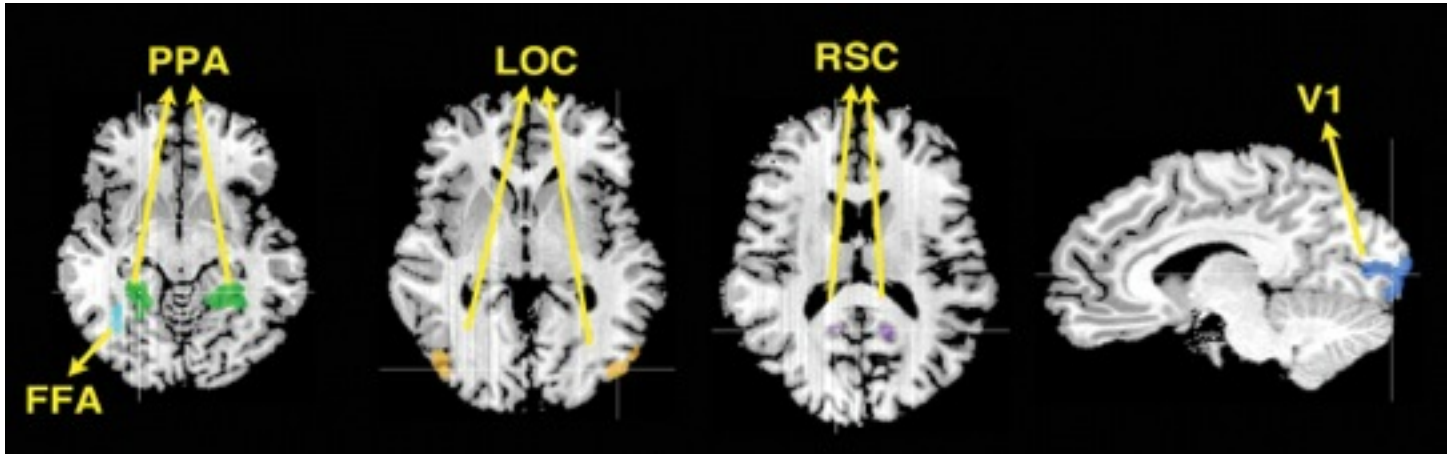
- So far the PPA is a scene selective regions
- Is it because it is a specific stimuli class? Or is the task related to scenes, such as the navigation category?
- What's special about it is the stimuli class that activates the PPA?
- This paper says that activation on an area so selective to scenes, can also be done with a single object
- Objects alone could differentially modulate the PPA activity, based on their navigation relevance

Scenes Unseen: The Parahippocampal Cortex Intrinsically Subserves Contextual Associations, Not Scenes or Places Per Se

Moshe Bar, Elissa Aminoff, and Daniel L. Schacter

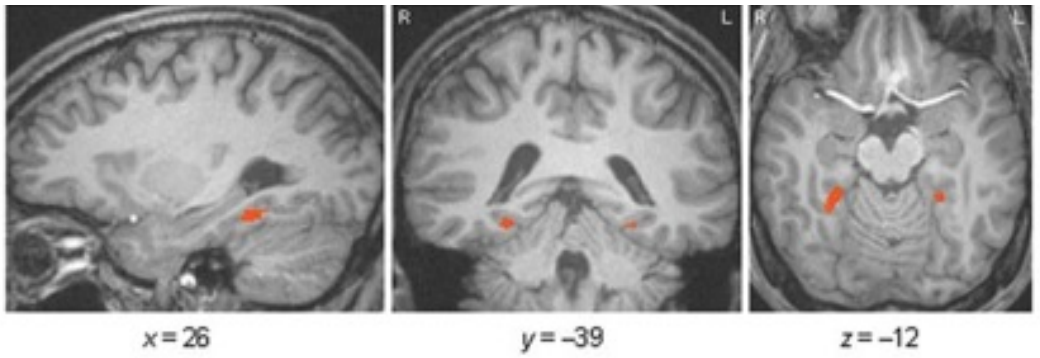
The PPA so far…

- PPA activation is specific to scenes - context is provided by the functional level of the scene



The PPA so far…

- Is it the visual class, or functional categories, that cause activation of the PPA?
- Paper 1, Janzen paper - shows that objects alone can activate the PPA



The PPA so far…

- Objects are navigationally relevant
- Navigationally relevant objects - link to the broader context of steering the environment

Contextual Association

Context adds on meaningful information

Contextual Association

Contextual Association - Strong

Contextual Association

Contextual Association - Strong

Contextual Association

Contextual Association - Weak

Contextual Association - Weak

Contextual Association - Weak

Contextual Association - Weak

Contextual Association - Weak

The PPA so far…

- Is navigation the only property involved with objects and scenes?

Another Perspective on the PPA

- Scenes as stimuli have strong contextual associations

- Navigational objects also have strong contextual associations with the decision point, and the goal

Roles of the PPA

Do strong *contextual associations* cause PPA activation?

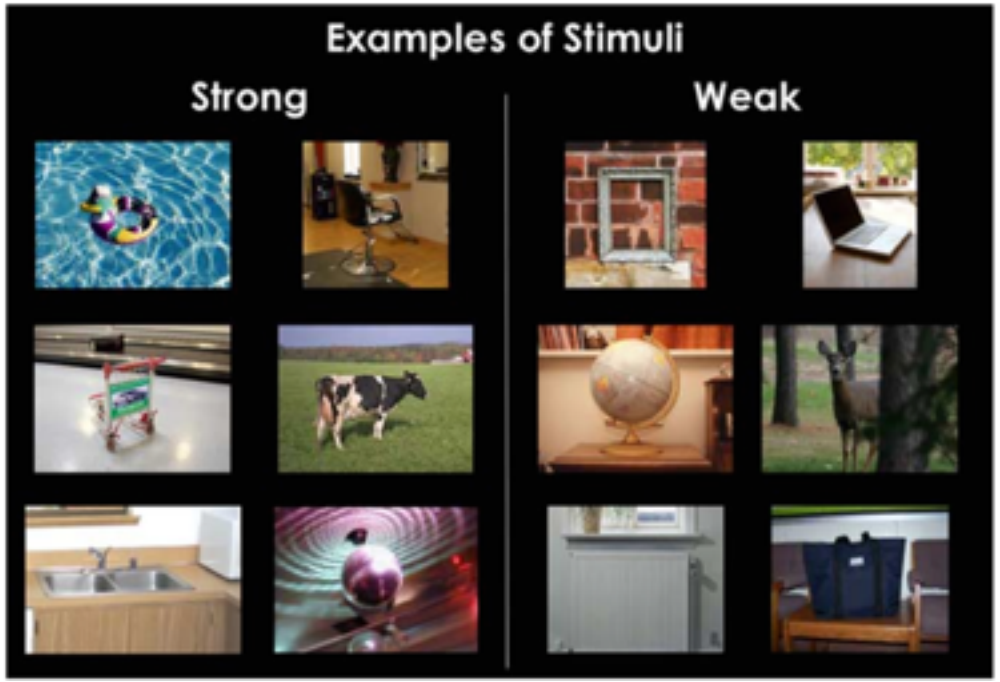
Overview of the Experiment

- Construct a database of images belonging to two categories: those with strong contextual association, and those with weak contextual association




Overview of the Experiment

- Strong context included things like traffic-signals, a kitchen sink etc.



Overview of the Experiment

- Ensure that the database is normalized for number of objects, scene complexity etc
- Compare the fMRI response of participants when shown images from each category, and measure activation in the PPA
- If the activation for the PPA is higher with strong context, it makes the case that the PPA is much broader than just scene processing

Details of the Method - Stimuli

- How do you measure context?
- Tell the subject the location/setting of the context
  eg. “kitchen”
- Ask them to name objects they associate with the word “kitchen” - eg. “oven”
- Taking the above list, show users objects, and ask them to name the context
- eg. shown an oven, they come up with the word “kitchen”

Control for Scene Complexity

- Number of objects in both categories is the same

Procedure and Design

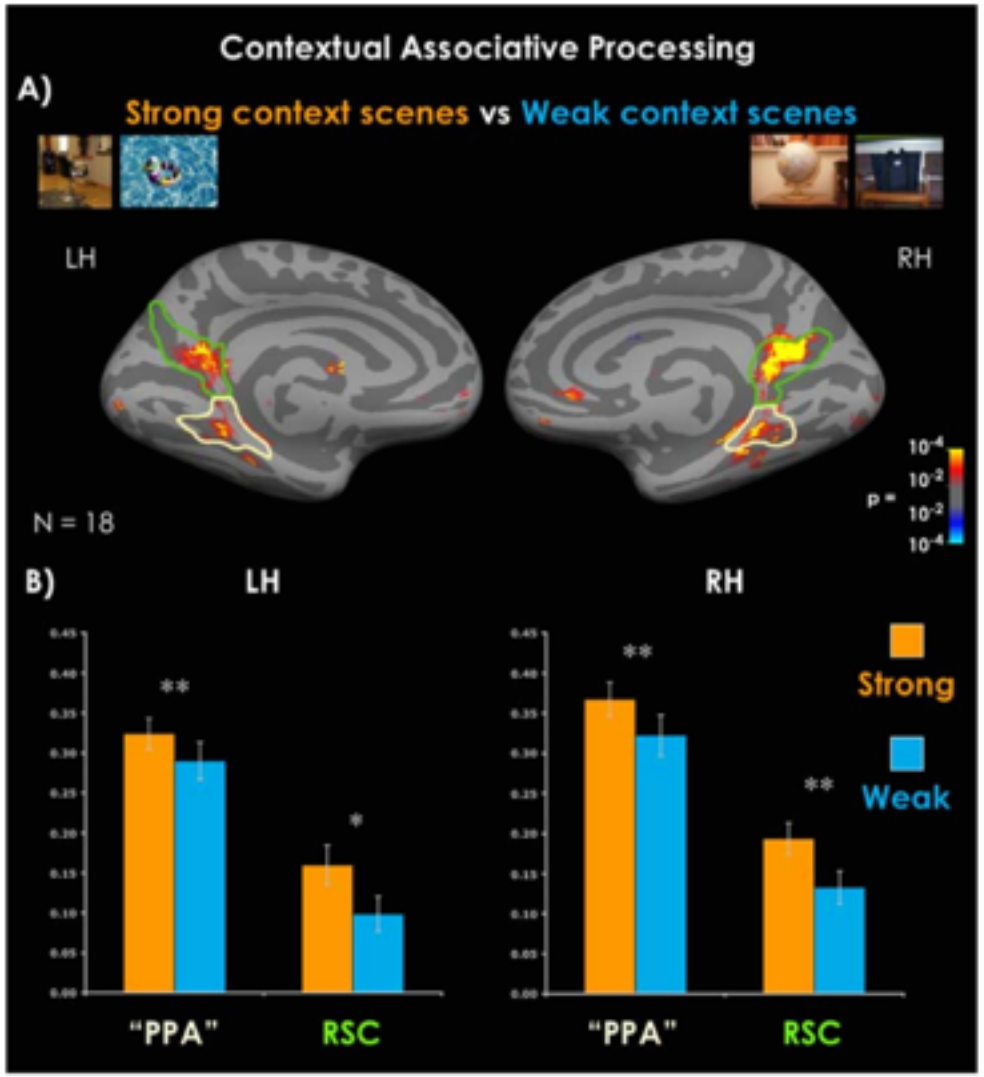
- Subjects shown a series of image from both categories with fixation. Asked to remember both foreground and background.

- Finally, the subjects were shown two blocks, and asked to hit a button if a picture repeated. This was repeated 6 times.

Results

- Is the PPA exclusively a scene specific process, or is it more generally related to contextual association?
- fMRI results comparing the activation of the PPA for strong against weak context, for scenes of similar visual quality will shed light on the question

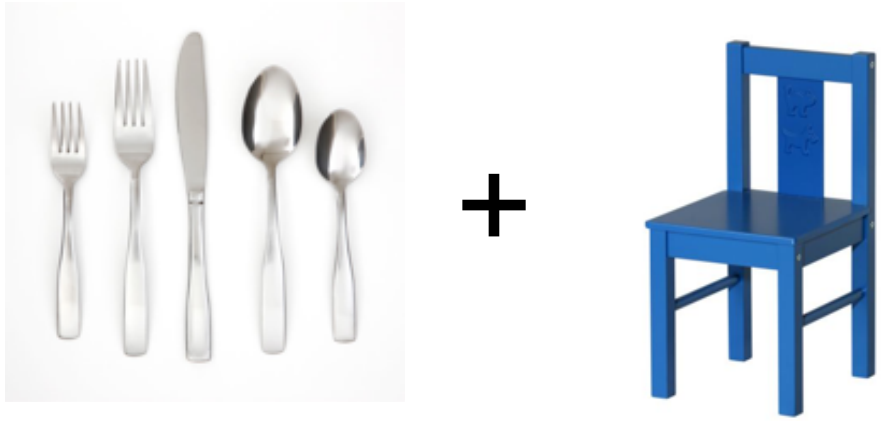
Results



- PPA response is stronger for images with strong context, independent of place information
- RSC region (scene processing) also shows a similar trend
- Medial PreFrontal Cortex (MPFC) - a region for context processing - also has increased activation

Additional Insights

- Additional results:
  - Indoor vs outdoor : indoor scenes had higher responses
  - Computer vision perspective?



Additional Insights

- Additional results:
  - Among indoor scenes - increased activity with more number of objects-per-scene
  - More objects, more associations

+

Takeaway

- PPA activation is specific to a visual class of stimuli
- The two papers (Janzen 2004, Bar 2008) show PPA activation for a functional level
- Objects, not just scenes, can differentially modulate the PPA
- Context plays the broad role at the functional level in PPA activation