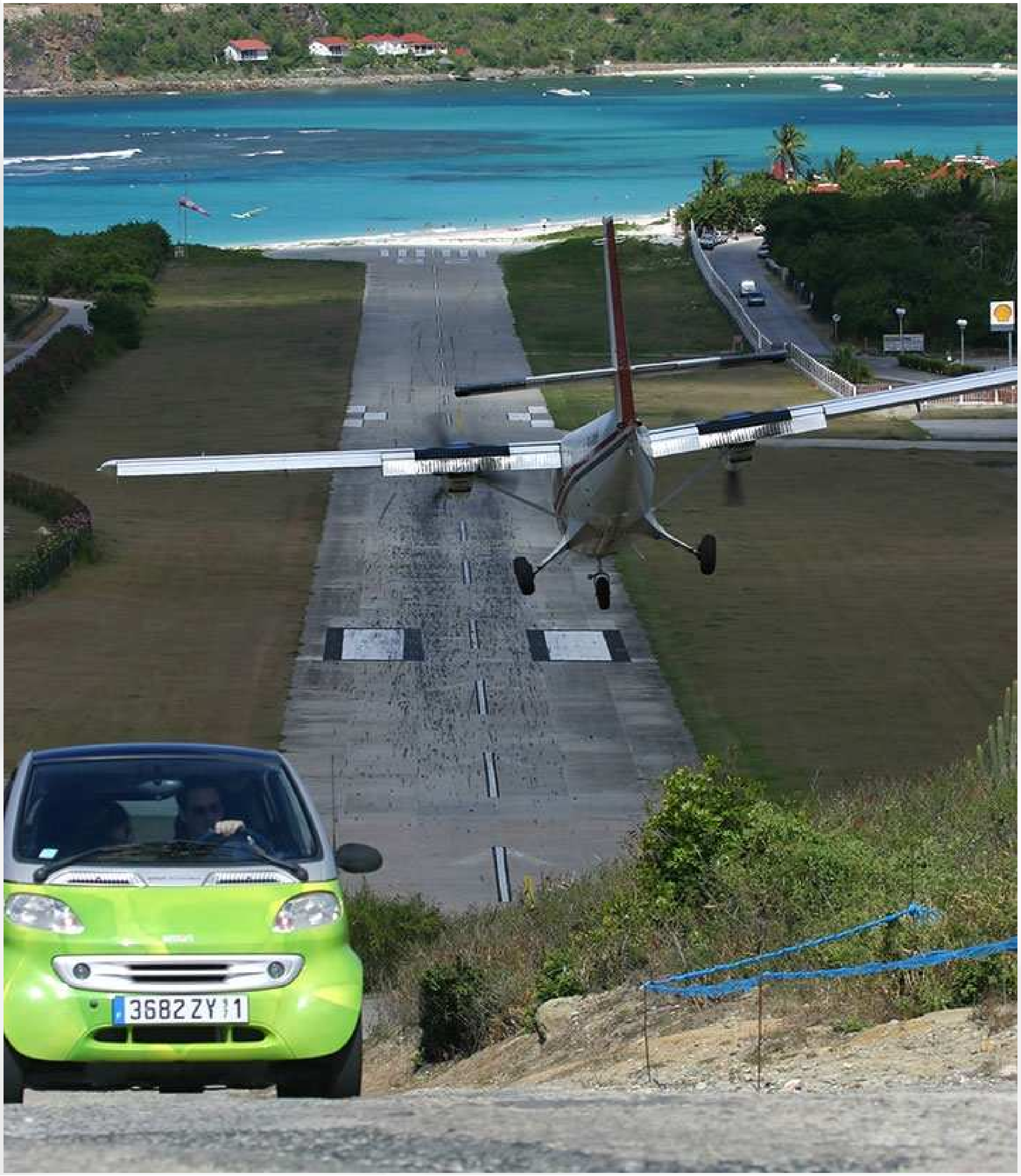
Chapter 10: Perception and Action



Until now, we've thought of vision as the process of using retinal information to determine the properties of things out there in the world.

This is different than touch, where we actively explore the world.

However, various aspects of vision require action. Like touch, we can learn a lot about the environment when we move around in it and see how the percept of the world changes.

Examples of ‘active vision’ that we’ve seen so far are:

1) Eye-movements, where we choose to saccade to locations in a scene to obtain more information about that location.

2) Motion parallax, where we can move our position to better judge distances.

The Ecological Approach to Perception

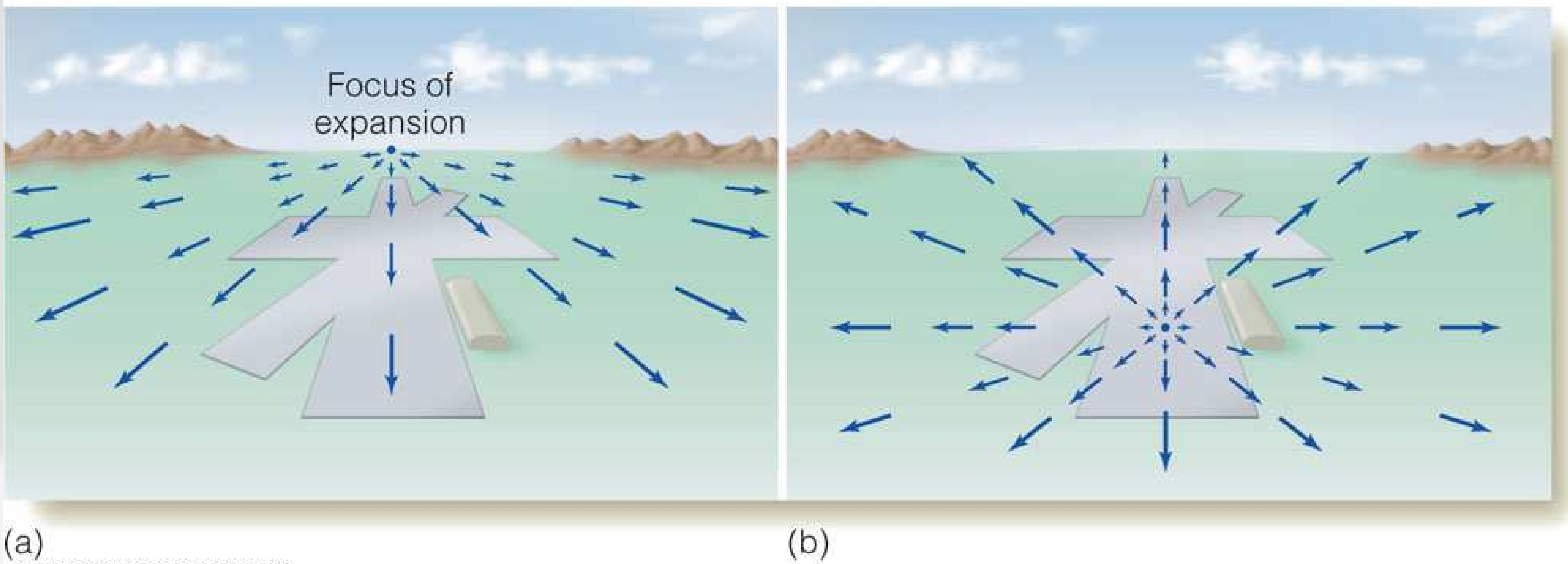
"It's not what is inside the head that is important, it's what the head is inside of"

- Approach developed by J. J. Gibson (began in late 1950s)
  - Gibson felt that traditional laboratory research on perception was
    - Too artificial - observers were not allowed to move their heads
    - Unable to provide an explanation for how pilots used environmental information to land airplanes

- Types of information used by perceivers as they move through an environment
  - Optic flow - appearance of objects as the observer moves past them
    - Gradient of flow - difference in flow as a function of distance from the observer
    - Focus of expansion - point in distance where there is no flow

Optic Flow

– Self-produced information - flow is created by the movement of the observer



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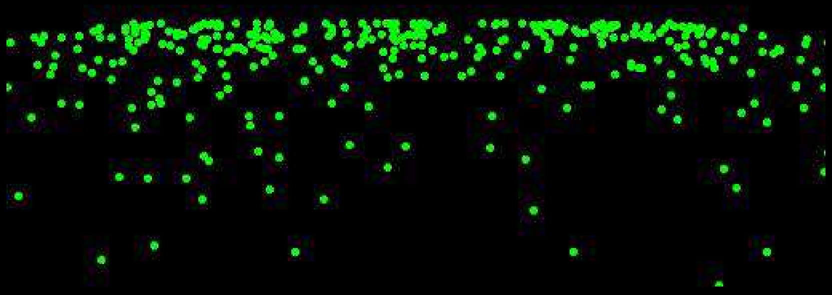
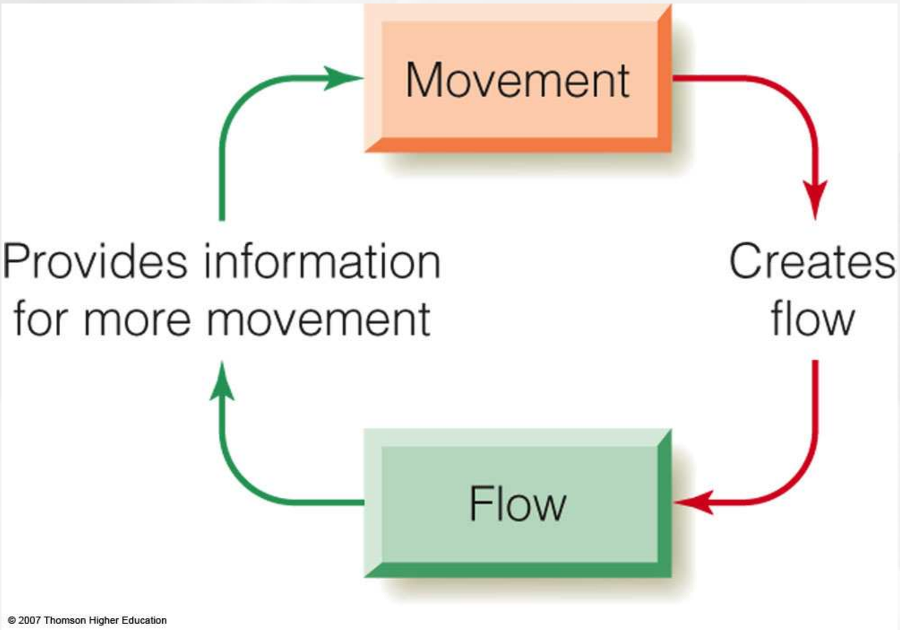
Optic Flow

Moving straight toward fixation on horizon



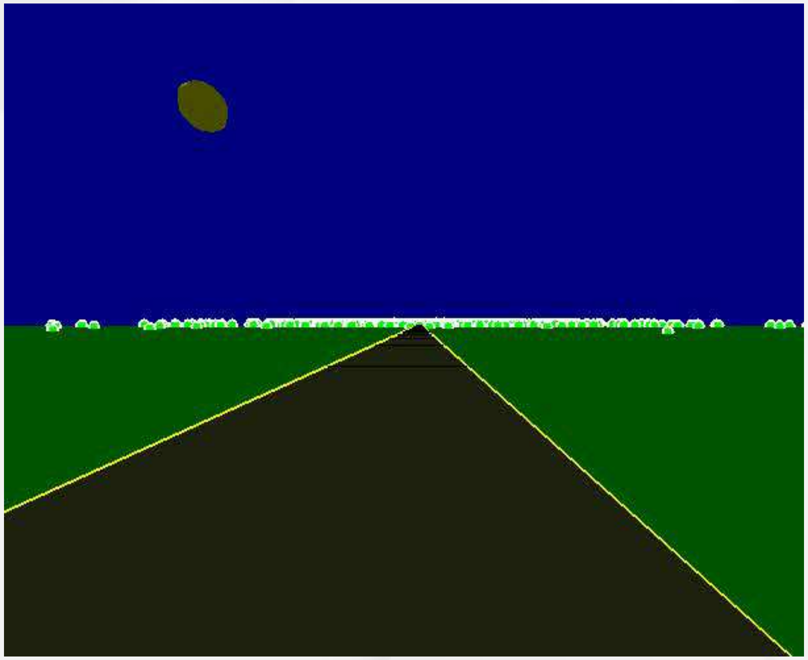
Optic flow is a good cue to determine where we are in the environment.

It differs from other cues because it is determined by our own actions.



Do People use Flow Information?

- Experiment by Land and Lee
  - Car fitted with instruments to measure
    - Angle of steering wheel
    - Speed of vehicle
    - Direction of gaze of driver

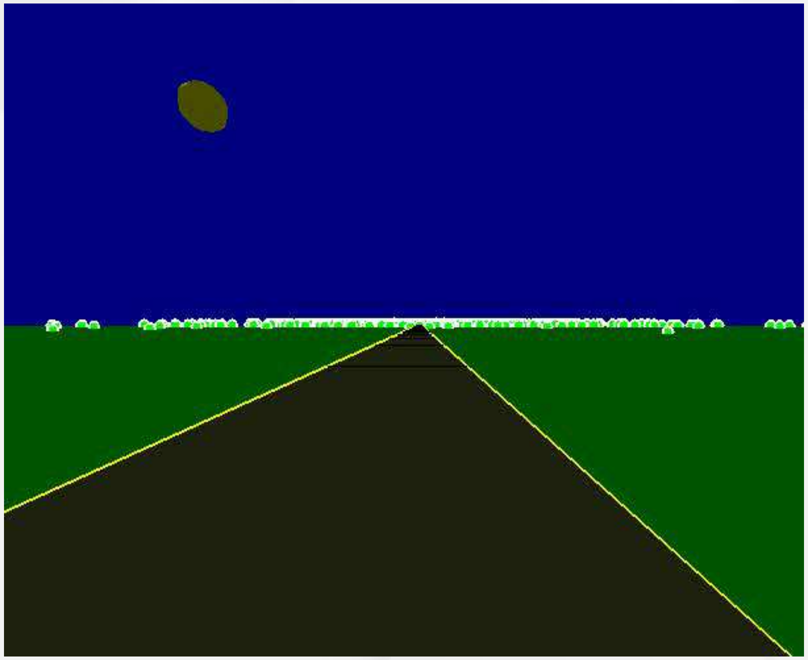


Experiment by Land and Lee

When driving straight, driver looks straight ahead but not at focus of expansion

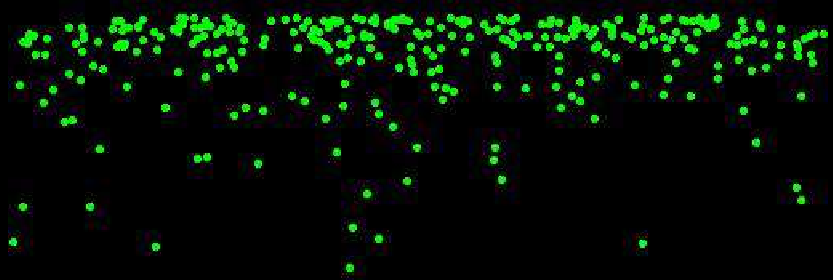
When driving around a curve, driver looks at tangent point at side of the road.

Results suggest that drivers use other information in addition to optic flow to determine their heading.



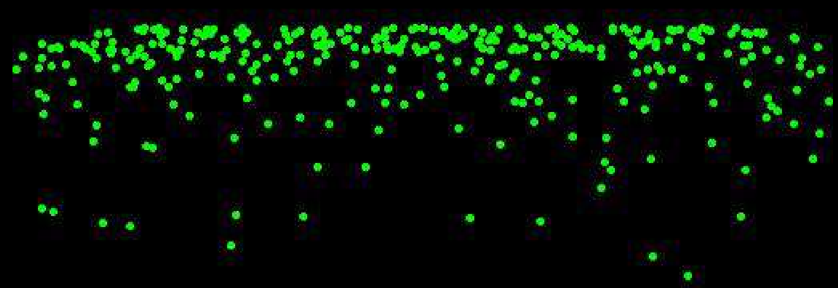
Optic Flow

Slight horizontal translation while moving forward



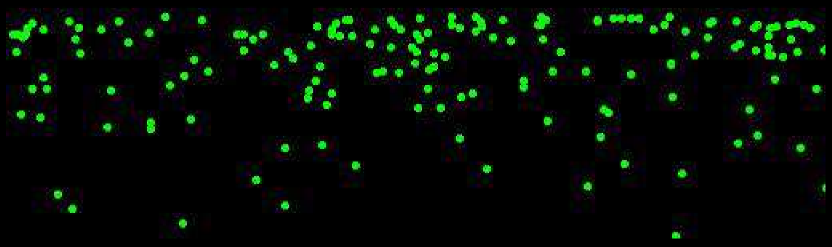
Optic Flow

Strong horizontal translation while moving forward



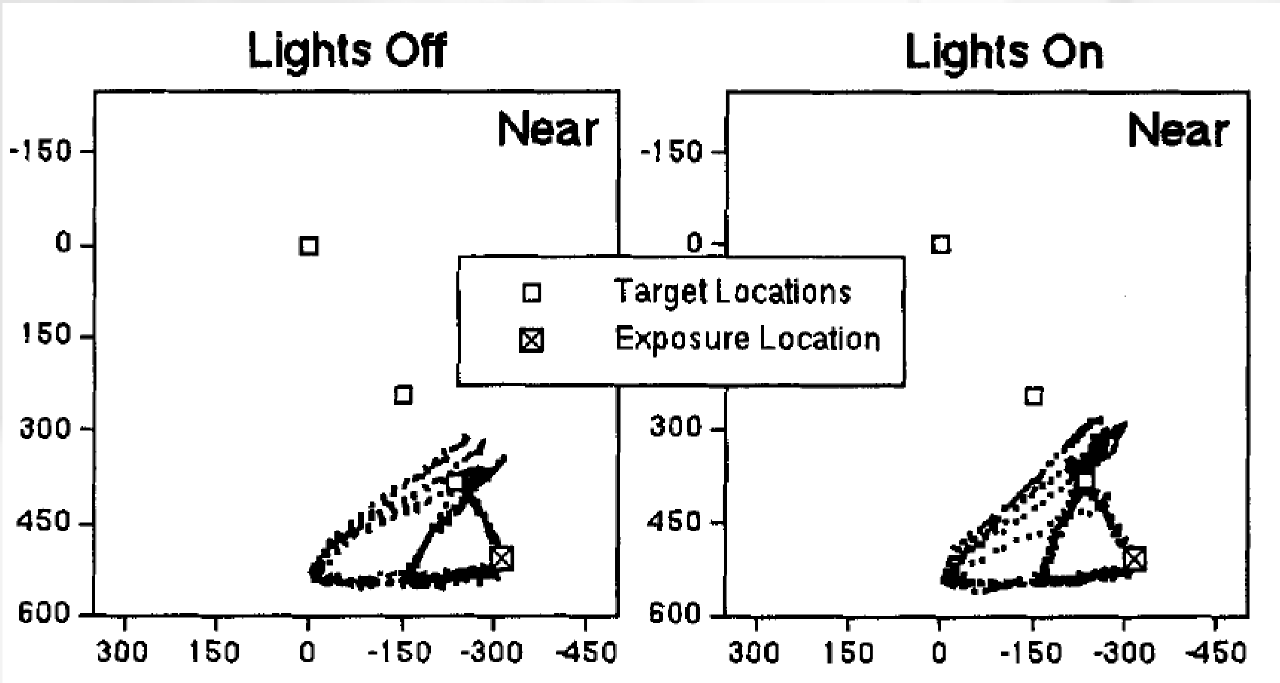
Optic Flow

Oscillating horizontal translation while moving forward



Optic flow (or even vision) is not necessary for navigation.

Blindfolded walking experiments show that people can navigate without any visual stimulation from the environment (Loomis et al., 1997).

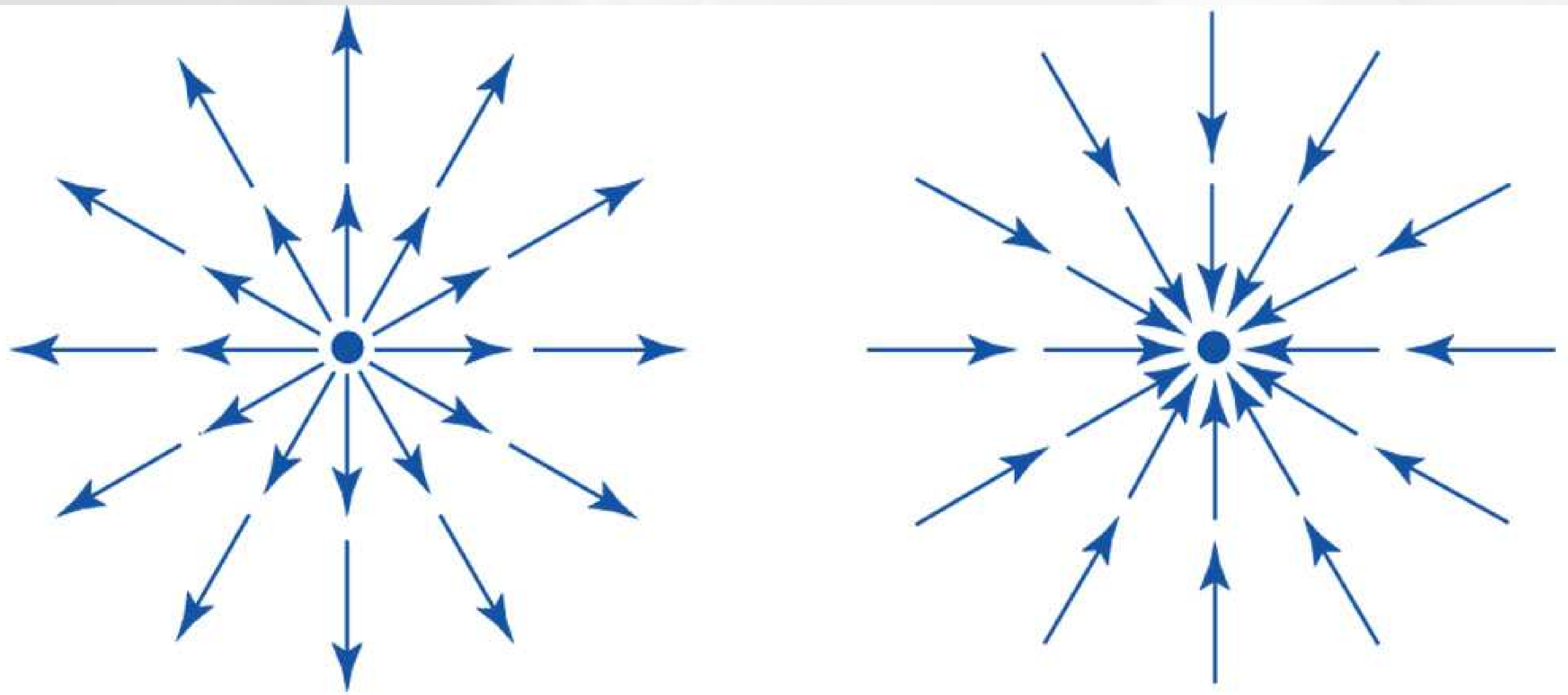


Flow, Posture, and Balance

- Experiment by Lee and Aronson
  - 13- to 16-month-old children placed in “swinging room”
    - In the room, the floor was stationary but the walls and ceiling swung backward and forward
    - The movement creates optic flow patterns
  - Children swayed back and forth in response the flow patterns created in the room
  - Adults show the same response as children when placed in the swinging room
- Results show that vision has a powerful effect on balance and even overrides other senses that provide feedback about body placement and posture

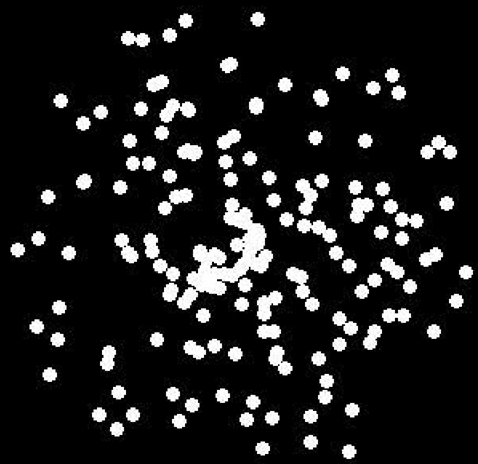
The Physiology of Navigation

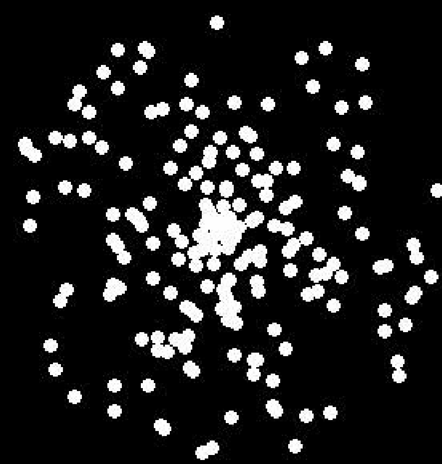
- Optic flow neurons - neurons in the medial superior temporal area (MST) of monkeys respond to flow patterns

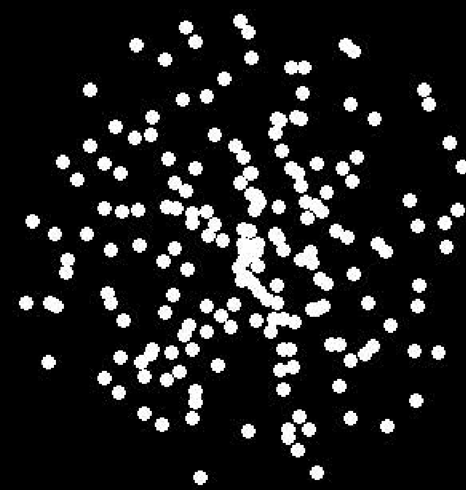


(a) Forward movement (b) Backward movement

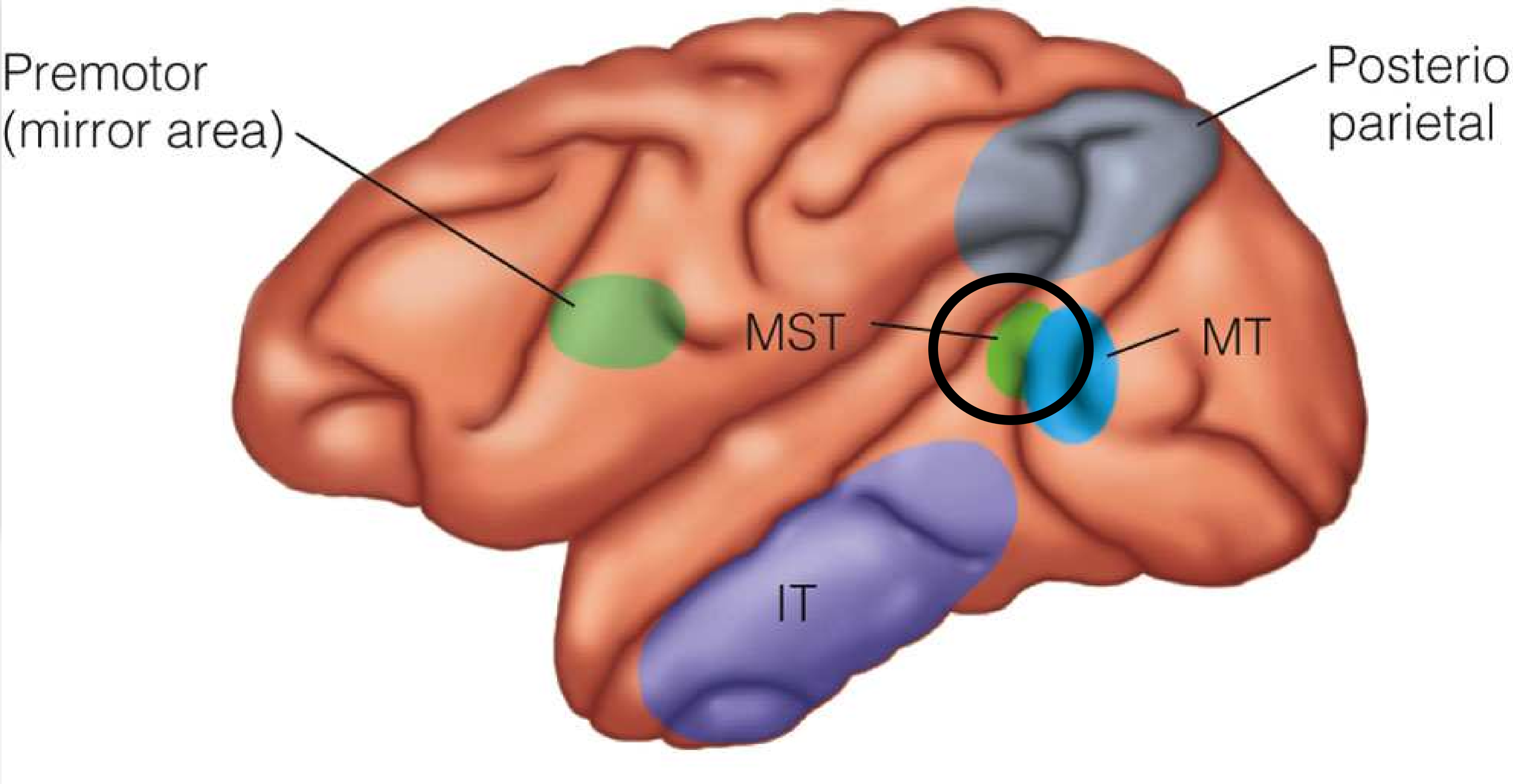
Optic flow stimuli


Expansion


Contraction


Rotation

- Optic flow neurons - neurons in the medial superior temporal area (MST) of monkeys respond to flow patterns



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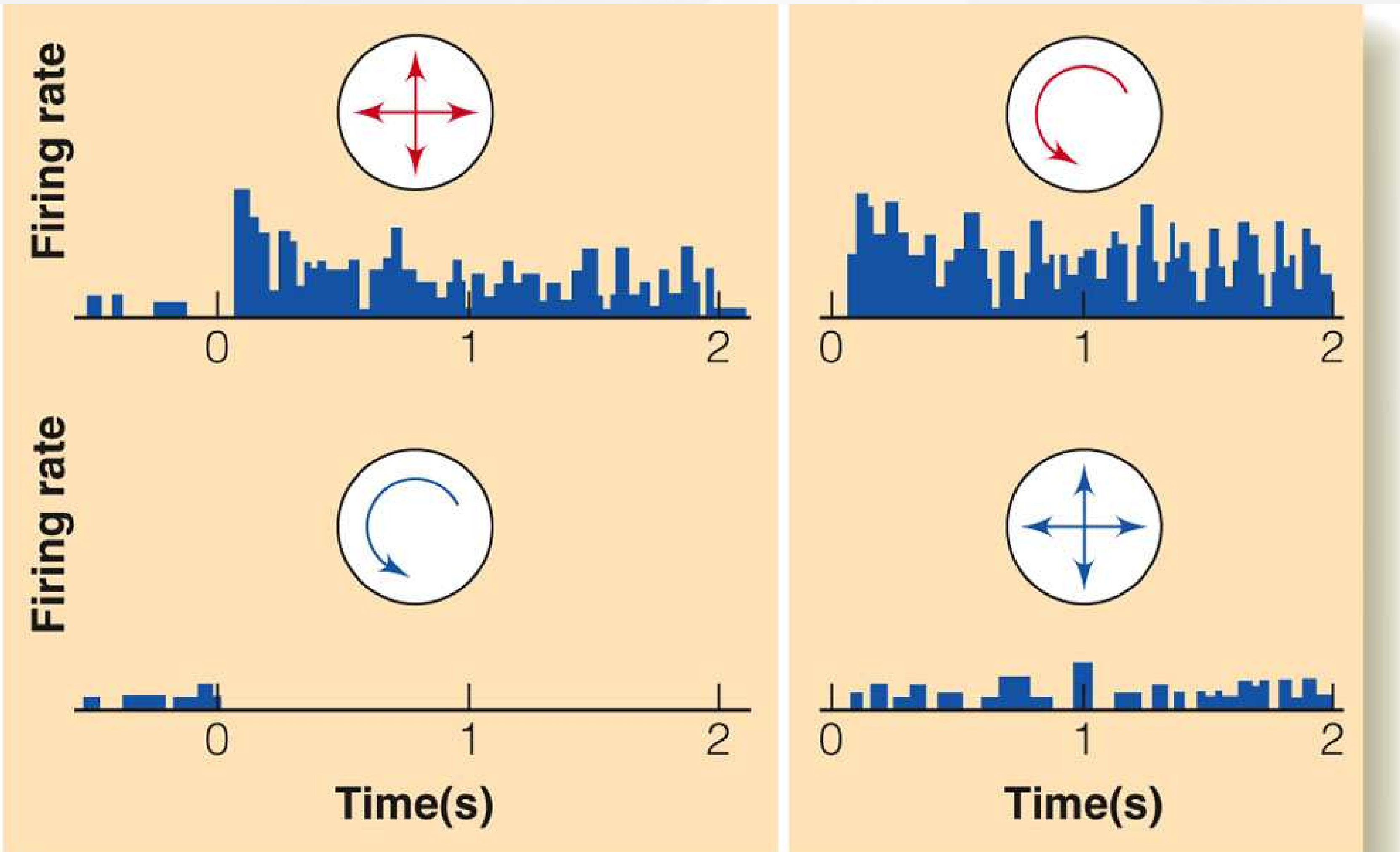
MST neuron sensitive to expansion rotation



(a) Neuron 1 (b) Neuron 2

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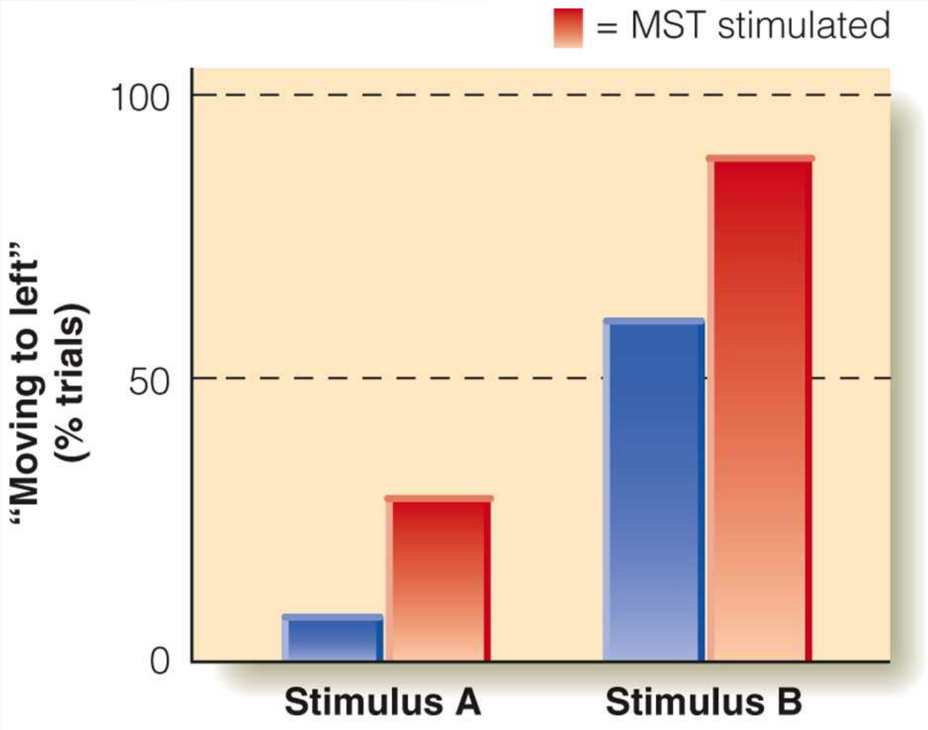
Associating area MST with Perception

- Experiment by Britten and van Wezel
  - Monkeys were trained to respond to the flow of dots on a computer screen
    - They indicated whether the dots flowed to the right, left, or straight ahead
  - As the monkeys did the task, **microstimulation** was used to stimulate MST neurons that respond to specify directions of flow patterns
  - Judgments were shifted in the direction of the stimulated neuron



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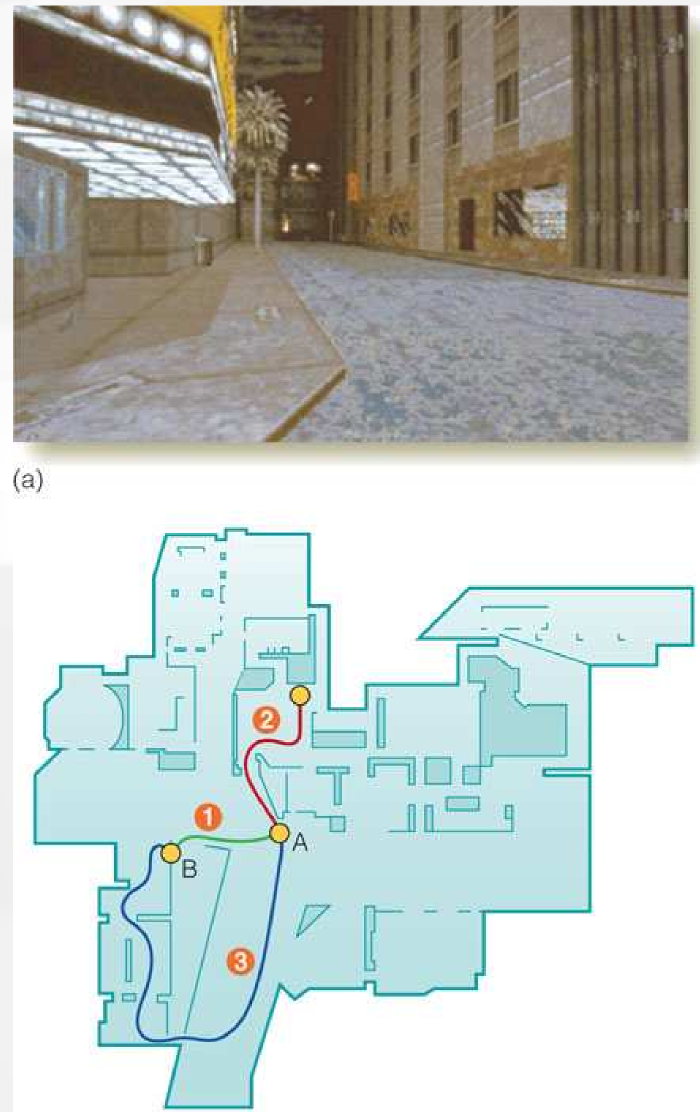
The hippocampus is involved in navigation

- Experiment by Maguire et al.
  - Observers learned the layout of a “virtual town”
  - In a PET scanner, they were told to navigate to locations in the town
  - Navigating activated the right hippocampus and part of the parietal cortex
    - Activation was greater when the navigation between points was accurate than when it was inaccurate



(a) (b)

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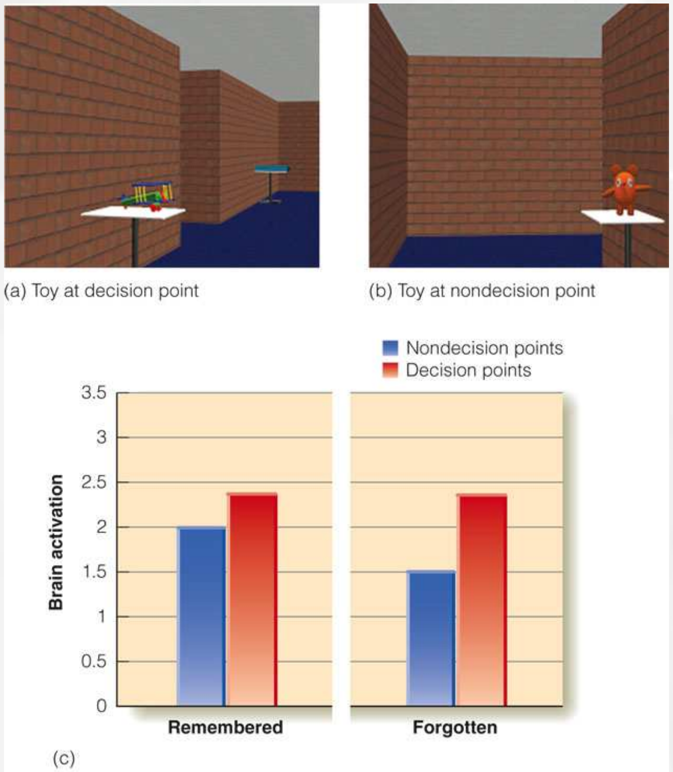
Experiment by Janzen and van Turennout

- Observers studied a film that moved through a “virtual museum”
- Exhibits appeared at decision points where turns were necessary and non-decision points.
- Observers were given a recognition task while in an MRI scanner
  - They were presented objects they had seen as exhibits and ones they had not seen



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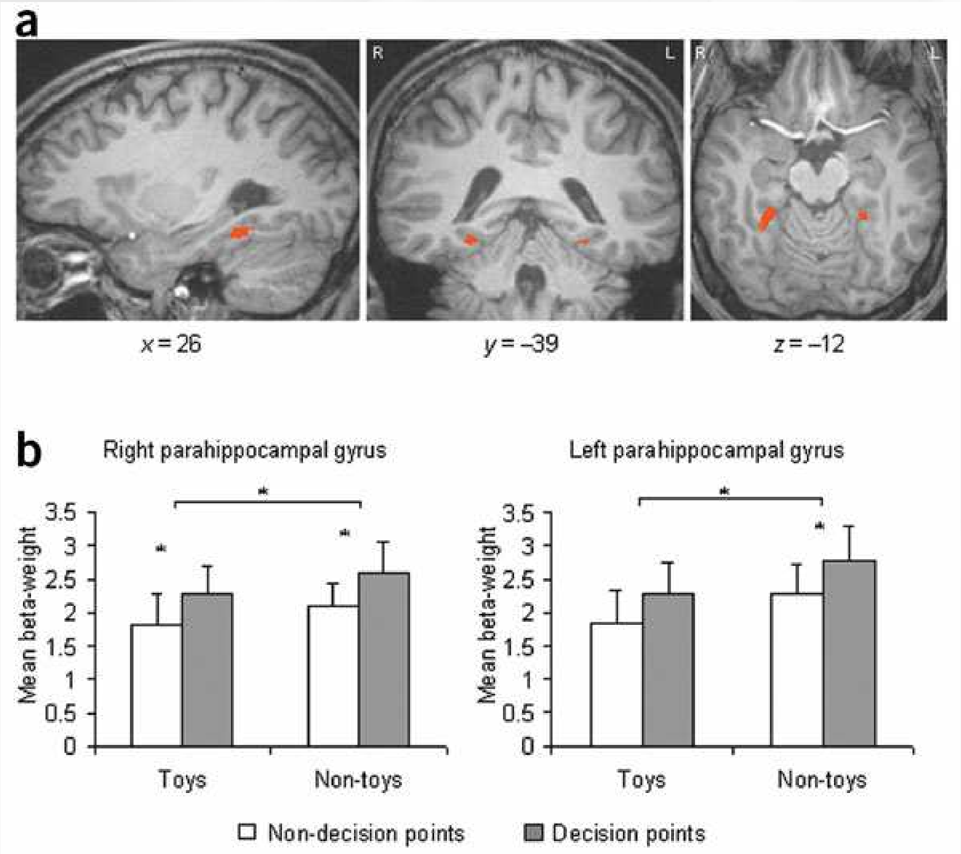
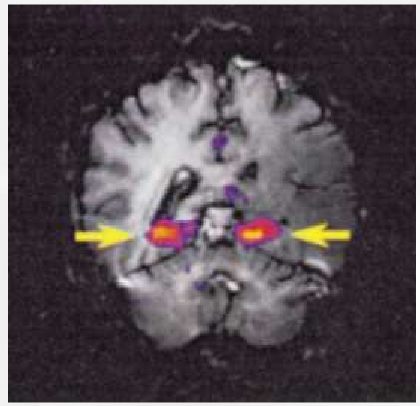
Results showed the greatest activation for objects at decision points (landmarks) in the parahippocampal gyrus, especially when these points were correctly remembered.



The parahippocampus shows greater responses to ‘places’ than other things.

Kanwisher and colleagues (who named the FFA) call this the ‘parahippocampal place area, or **PPA**.



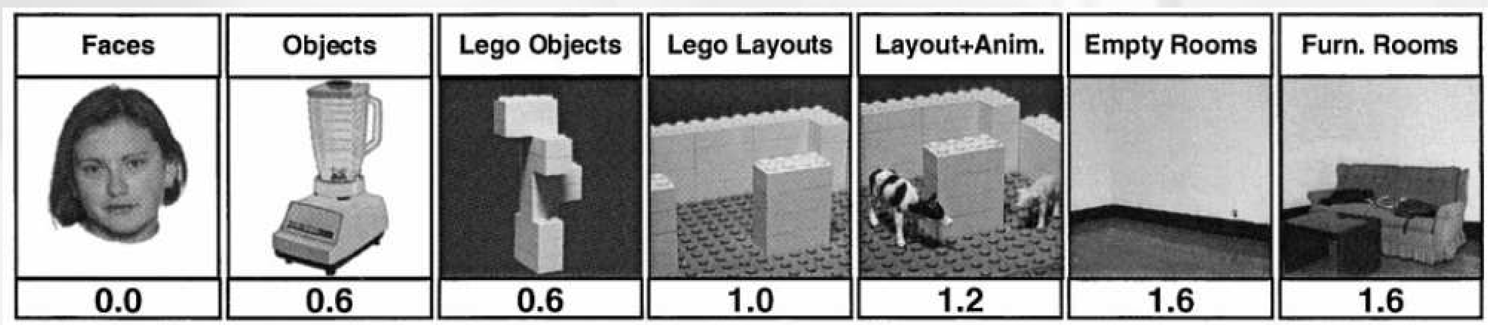


Figure 3. Example Stimuli and Results for Experiment 2, Showing the Average Percent Signal Change within the PPA for Each Stimulus Condition

MRIs of London taxi drivers have shown that they have more gray matter in their hippocampus than control subjects!

PNAS
Proceedings of the National Academy of Sciences of the United States of America www.pnas.org

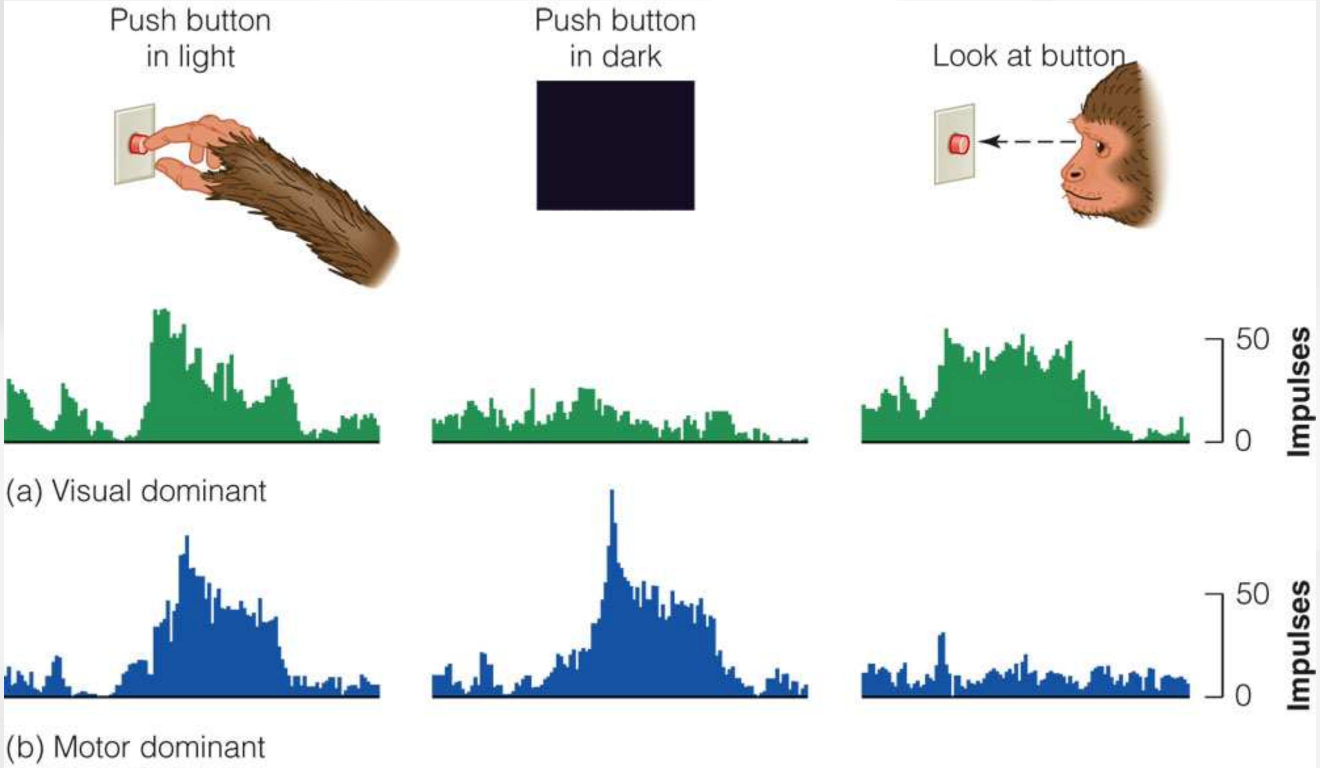
Navigation-related structural change in the hippocampi of taxi drivers

Eleanor A. Maguire, David G. Gadian, Ingrid S. Johnsrude, Catriona D. Good, John Ashburner, Richard S. J. Frackowiak, and Christopher D. Frith

PNAS 2000;97;4398-4403; originally published online Mar 14, 2000;
doi:10.1073/pnas.070039597

Responses of Neurons in the Parietal Lobe

- Visual-dominant neuron - responds best when a monkey looks at a button or pushes it in the light
- Motor-dominant neuron - responds best when pushing button both in light and dark
  - Does not respond to looking at a button



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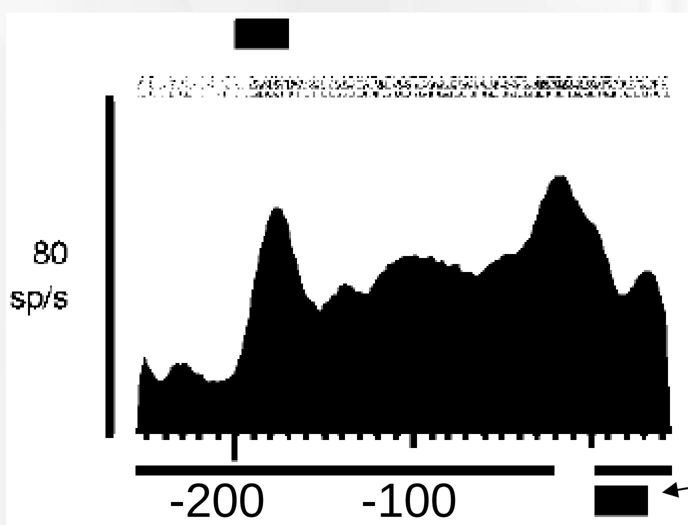
Parietal Reach Region

- Neurons in the posterior parietal cortex show
  - Response *before* monkeys grasp an object
    - These neurons signal the *intention* to grasp
- Neurons from this region send signals to the premotor area
  - These neurons respond to carrying out actions and to observing others carrying out the same actions

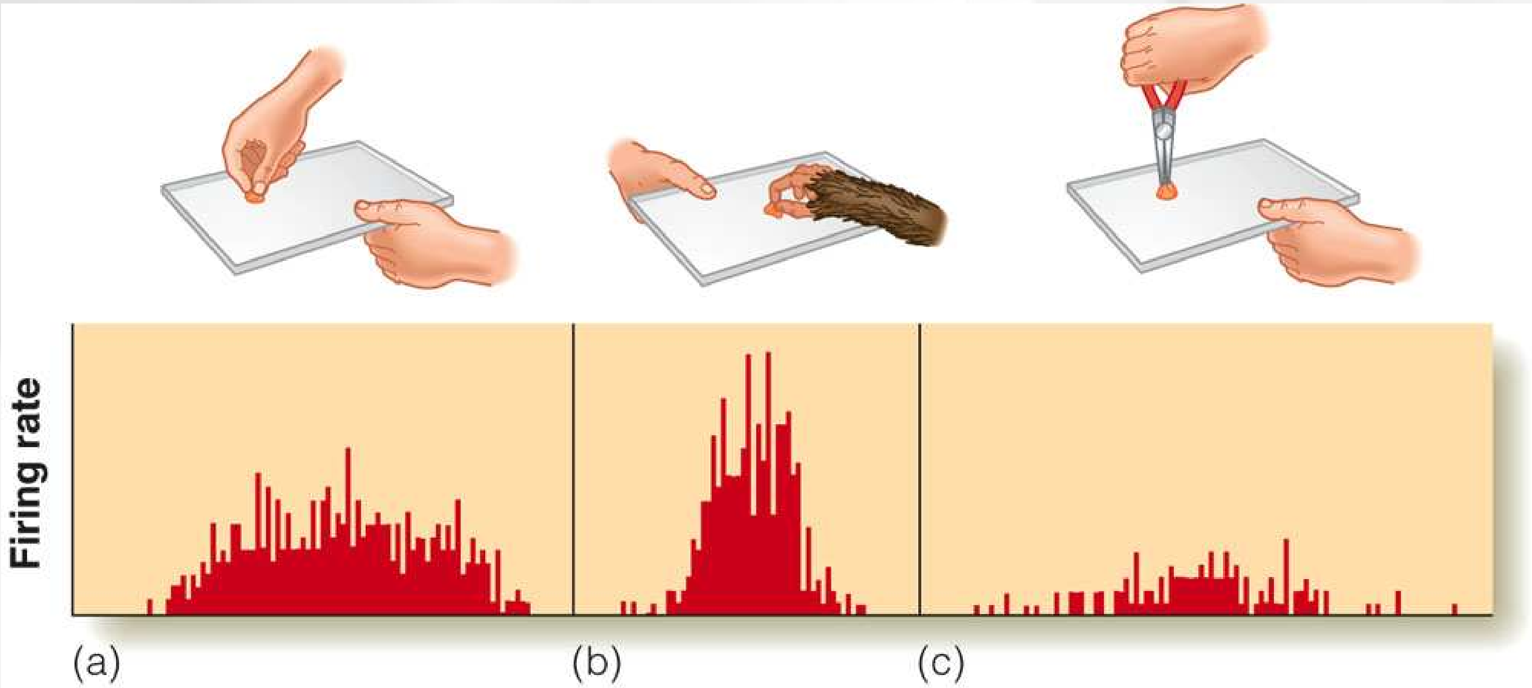


Monkey reaches at this time

Time (ms)

Mirror Neurons in Premotor Cortex

- Neurons in the premotor cortex of monkeys that
  - Respond when a monkey grasps an object **and** when an experimenter grasps an object
  - Response to the observed action “mirrors” the response of actually grasping
  - There is a diminished response if an object is grasped by a tool (such as pliers)



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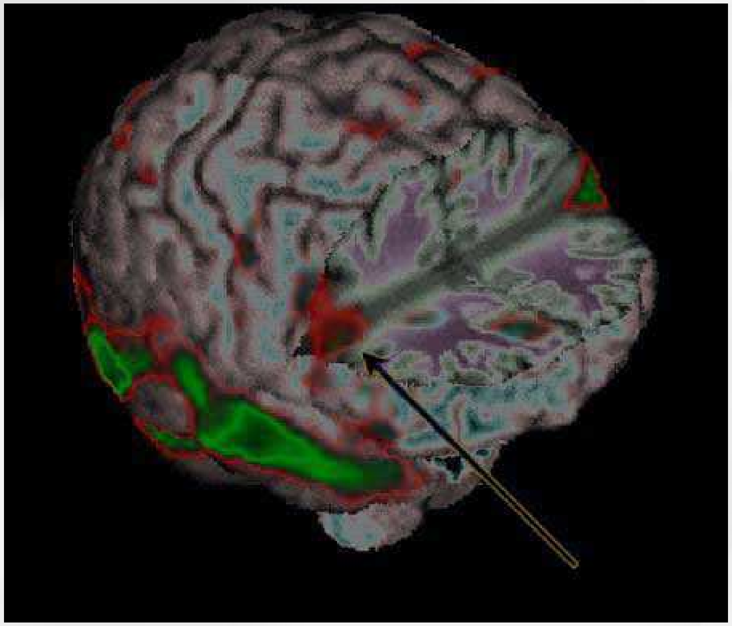
Mirror Neurons in Premotor Cortex - continued

- Possible functions of mirror neurons
  - To help understand another animal's actions and react to them appropriately
  - To help imitate the observed action
- Mirror neurons may help link sensory perceptions and motor actions

May be associated with empathy? Autism??



"I predict that mirror neurons will do for psychology what DNA did for biology: they will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments." – V.S. Ramachandran