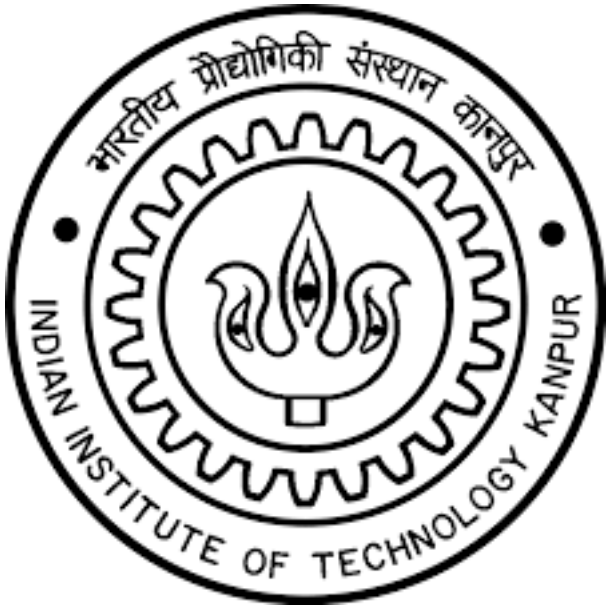

Indian Institute of Technology
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In Collaboration
with

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Presents

Course Title:

Basic Cognitive Processes

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Lecture 22: Perception & Action

Linking Perception to Action

- In the course of the last few lectures we have often wondered the utility of perception.
- Certainly, humans are not perceiving the environment only passively.
- We interact with the environment & the link between perception and action is established thereof.

Theoretical Background

- J. J. Gibson's Ecological Approach to Perception
  - the idea that perception should be studied as people move through the environment and interact with it.
  - the ecological approach to perception then focused itself on studying moving observers and determining how this movement creates a perceptual input leading to better navigation in the environment.

- As, we have already studied in detail, the concept of ***optic flow*** is informative about our movements in the environment for e.g. direction, speed, relative distance etc.

  - Optic is flow is rather fast near the observer & slower farther away from the observer, this is referred to as ***gradient of flow***.

  - There is now flow at the point which the observer is approaching, which is called the ***focus of expansion*** **(FOE).**

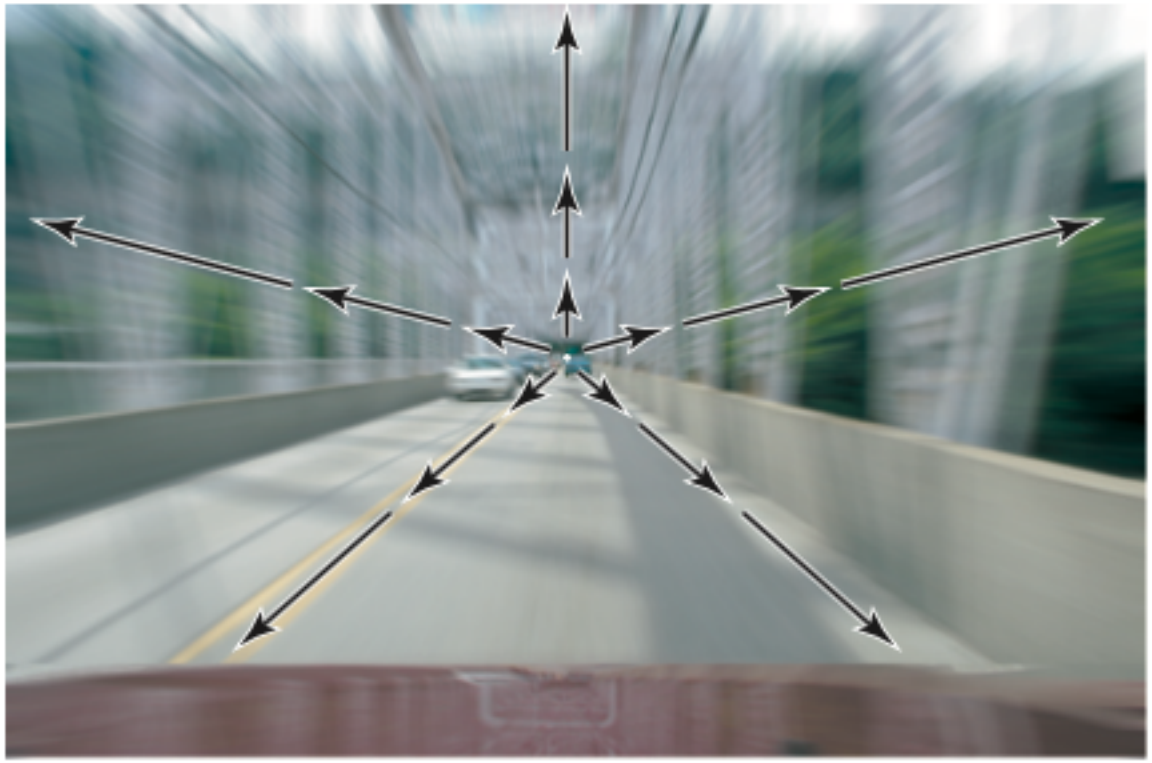


Figure 7.1 The side and top of the bridge and the road below appear to move toward a car that is moving forward. This movement is called optic flow.

Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 154)

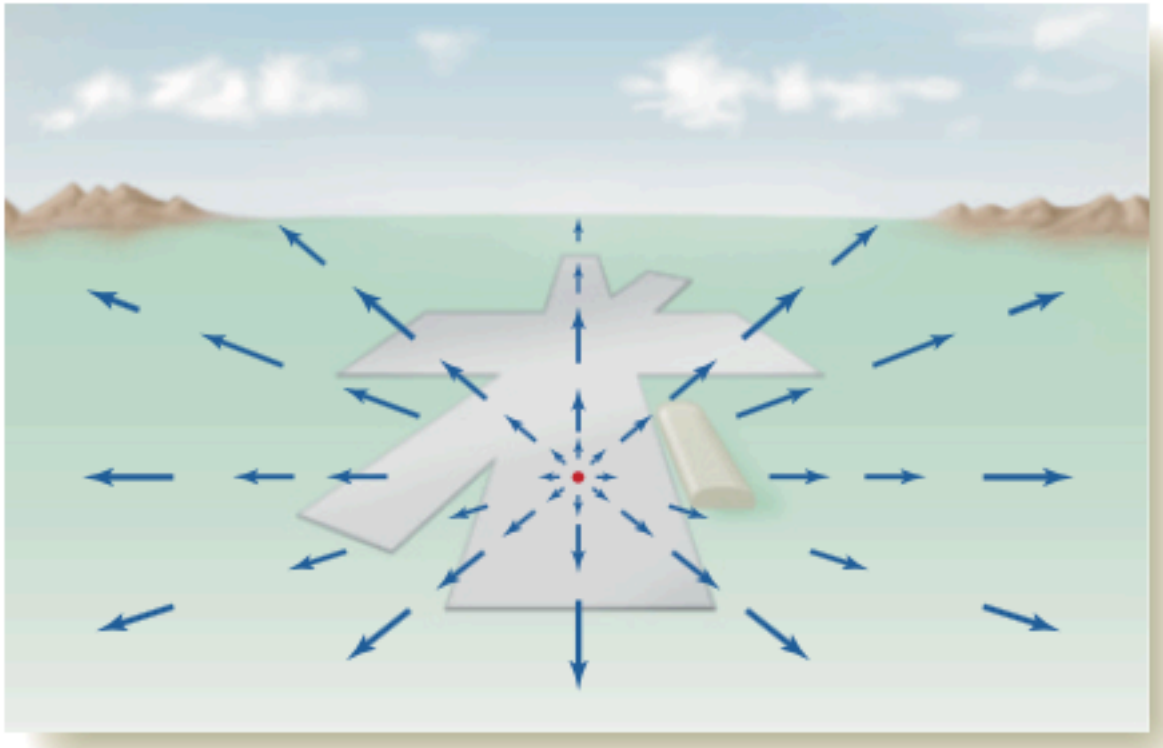


Figure 7.2 Optic flow created by an airplane coming in for a landing. The focus of expansion (FOE), indicated by the red dot, is the place where the plane will touch down on the runway. From Gibson, J. J. *The perception of the visual world.* Boston: Houghton Mifflin. 1950. Figure 58, page 128.

Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 154)

- Another important aspect of the ecological approach is the - ***invariant information*** – information that does not change with respect to the moving observer.
    - as soon as the observer stops moving around the environment the flow information is not there anymore.
    - the FOE shifts as soon as the observer changes it's direction of movement.

How does this work?

- ***Self – produced information*** : information that is produced when the person makes some movement; which is in turn used to guide further movement.

- for e.g. when a person is moving along a street in the car, the movement of the car provides flow information which can be used to help guide the car in the correct direction.

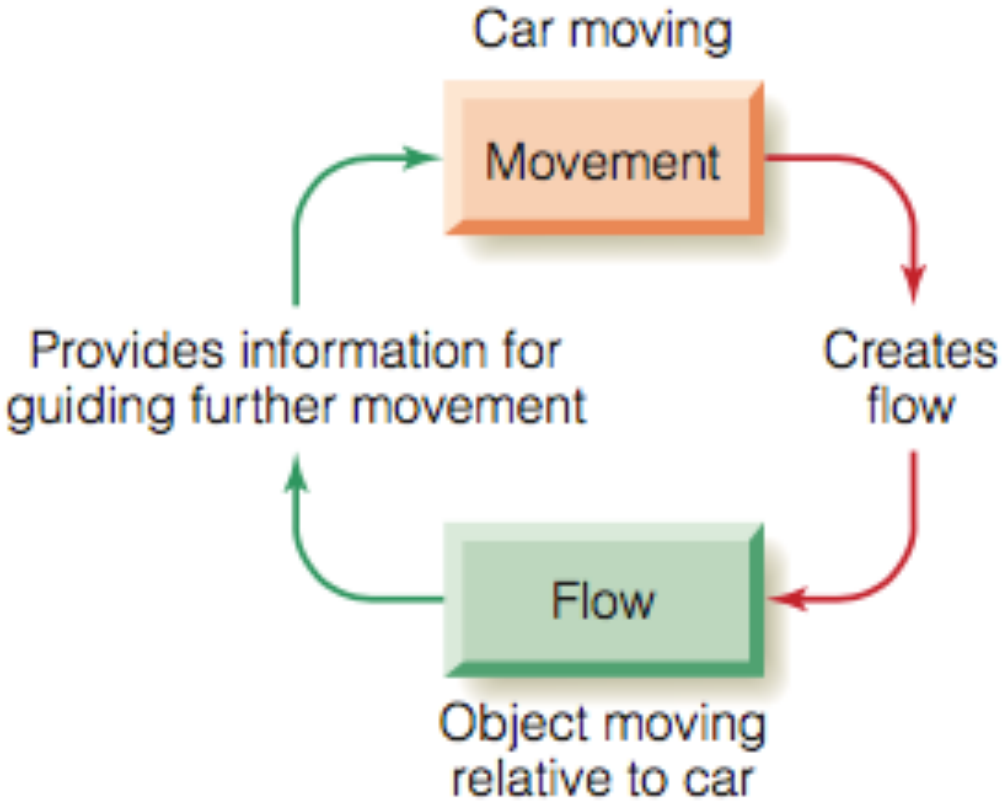


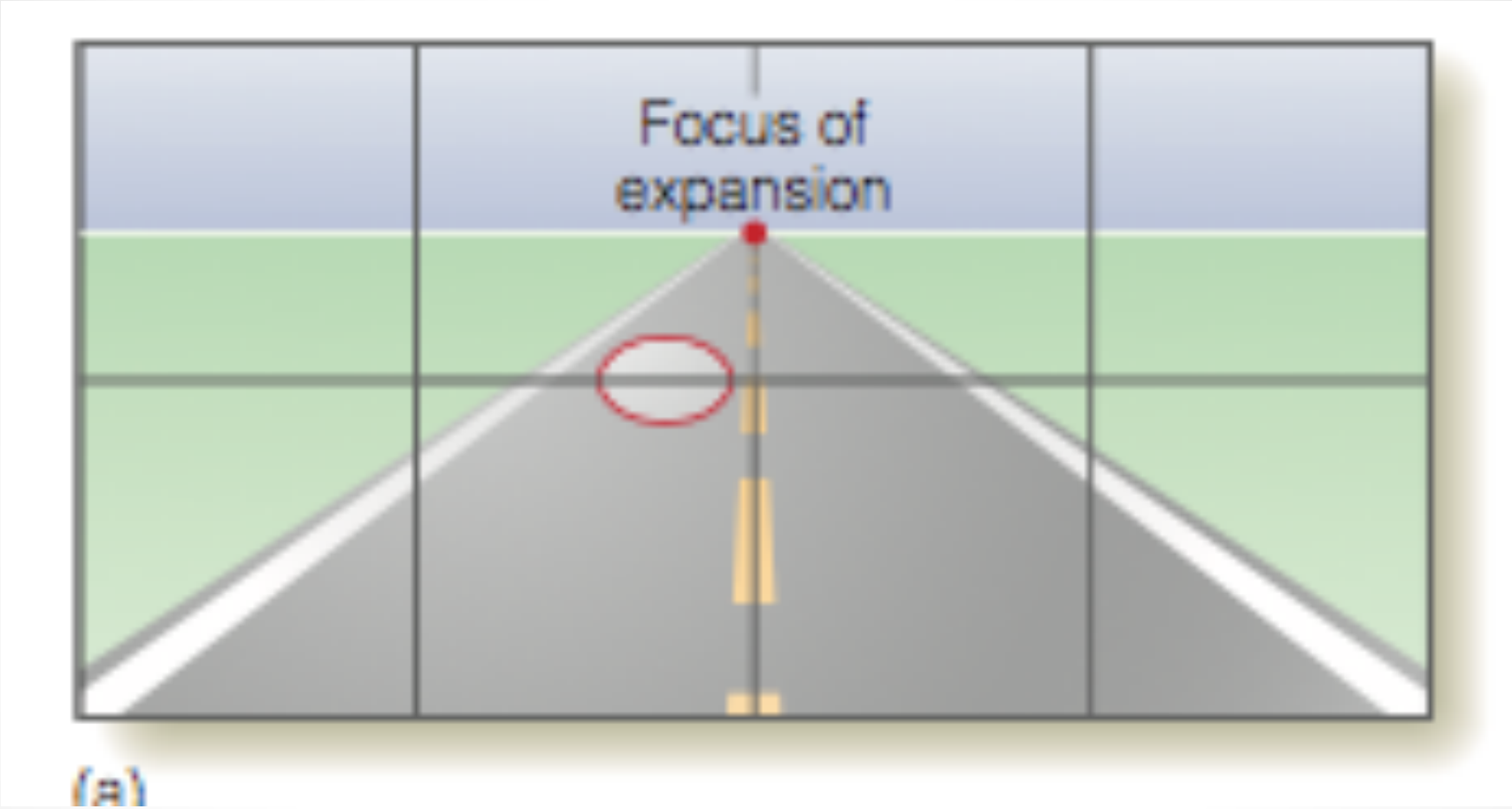
Figure 7.3 The relationship between movement and flow is reciprocal, with movement causing flow and flow guiding movement. This is the basic principle behind much of our interaction with the environment.

Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 155)

- the Senses :
  - Gibson proposed that the five senses i.e. vision, hearing, touch, smell & taste work together to produce information to facilitate moving around & interacting with the environment.
  - For e.g. our ability to stand upright & maintain balance while still standing or even walking or running depends upon systems like the vestibular canals (in the inner ear) and receptors in joints & muscles to work together.
  - Lee and Aronson (1974) through their *"**swinging room**"* experiments demonstrated that vision is a powerful determinant of balance and can override the traditional sources of balance information provided by the inner ear & receptors from muscles and joints.

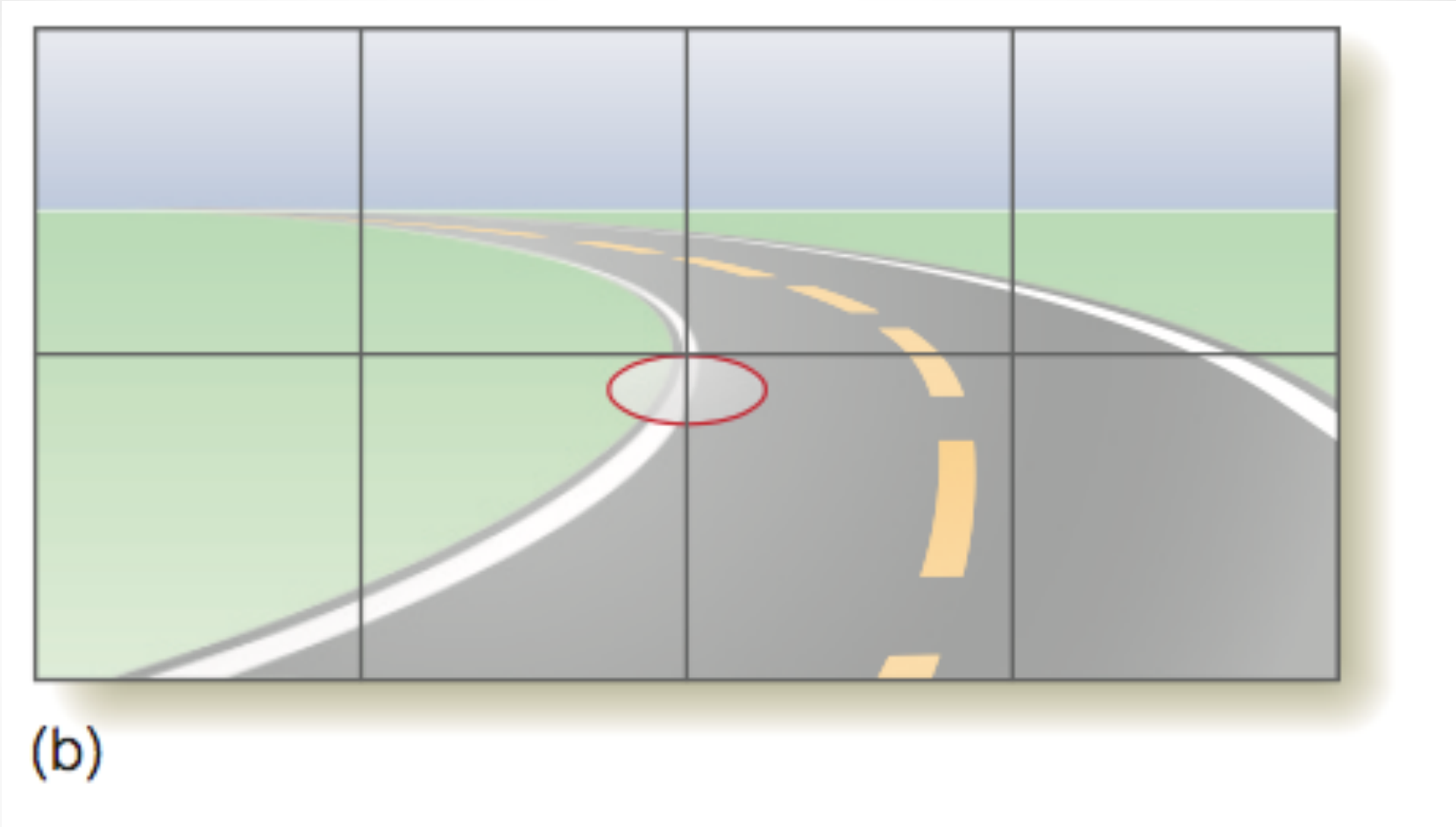
Navigating Through The Environment

- *Driving a Car*
  - Land & Lee (1994) wanted to study the information generally used by the people while driving a car.
  - So, they fitted a car with devices o record the angle of the steering wheel and the speed, & measured where the driver was looking with a video eye – tracker.
  - They found that although drivers look straight ahead while driving, they also look at a spot in front of the car rather than looking directly at the FOE.



Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 159)

- Land & Lee also studied where drivers look while navigating a curve.
    - This is important as the FOE will keep changing as the driver's destination keeps changing as the car is moving around the curve.
    - Land & lee found that when going around a curve, the drivers don't look directly at the road, but at the tangent point of the curve on the side of the road.
    - As, the drivers are not looking directly at the FOE, Land & Lee suggested that drivers use information in addition to the optic flow to determine the direction of movement. For e.g. position of the car with respect to the lines at the center of the road.



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- ***Walking***

  - It has been argued that while walking people may not be using optic flow information.

    - For e.g. they might be following a ***visual direction strategy*** i.e. keeping their bodies pointed towards a target. If they go off – direction, the target shifts to the left or right and so, the walkers can use this information for course - correction.

    - Loomis & colleagues (Loomis et al., 1992; Philbeck, Loomis & Beall, 1997) demonstrated by making participants blind – walk towards a target, that people are able to walk directly towards a target & stop very close to it

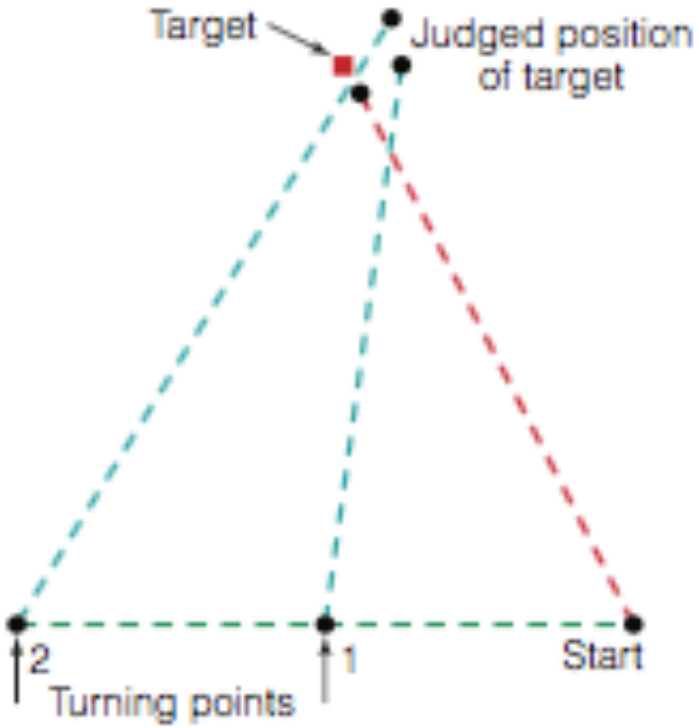


Figure 7.12 The results of a "blind walking" experiment (Philbeck et al., 1997). Participants looked at the target, which was 6 meters from the starting point, then closed their eyes and begin walking to the left. They turned either at point 1 or 2, keeping their eyes closed the whole time, and continued walking until they thought they had reached the target.

Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 160)

- *Wayfinding*
  - refers to navigating for long distances towards object not in sight.
  - is a complex process that involves perception of objects in the environment, remembering objects and their place in the overall scene & also judging when & what direction to turn.
  - an important aspect of such navigation is ***landmarks*** – those objects on the route that serve as cues to indicate where to turn.

- Sahar Hamid & colleagues (2010) studied the use of landmarks by participants as they were negotiating a mazelike environment presented on a computer screen and while pictures of common objects were supposed serve as landmarks.

- Participants were first trained to go through the maze & then were told to travel from one point in the maze to another.

- Eye – movements were measured using a head-mounted eye – tracker.

- Eye – tracking measures indicate that participants spent more – time looking at more informative landmarks than uninformative landmarks.

- In a similar study (Schinazi & Epstein, 2010) it was shown that after the subjects had learned a particular route, they were more likely to recognize pictures of buildings at decision points that those located in the middle of the block.

- Also, it was shown that when in an fMRI scaner, the brain response in navigational areas of the brain (like parahippocampal gyrus, hippocampus, & retrosplenial cortex) was larger than the response to non – decision point buildings.

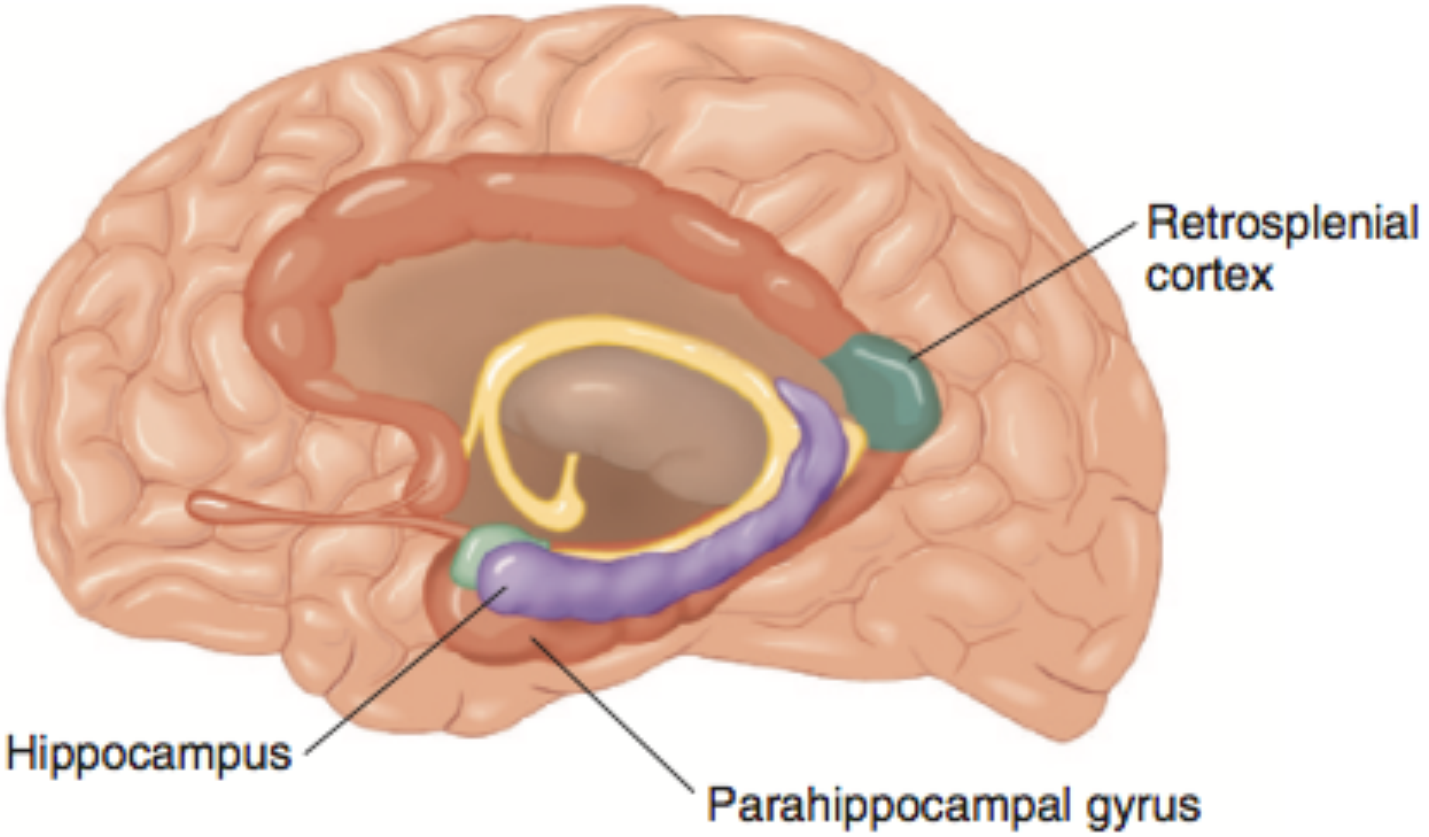


Figure 7.14 The human brain, showing three structures important to navigation: the parahippocampal gyrus, the hippocampus, and the retrosplenial cortex.

Goldstein (2013). Sensation and Perception. *Cengage Learning.* (p. 161)

Interacting with Objects

- We have now seen how movement within an environment can facilitate or influence it's perception.
- One of the most salient movements we perform within our environments is reaching out & grasping objects. For e.g. reaching out & holding a cup etc.
- An important concept related to *reaching* & *grasping* is that of ***affordances*.**

- Gibson, in his ecological approach to perception had specified the idea of affordances –
    - *"The **affordances** of the environment are what it **offers** the animal, what it **provides** for or **furnishes**."* (Gibson, 1979)
    - a chair, or anything that is sit-on-able, affords sitting; an object that is of the right size and shape to be grabbed by a person's hand affords grasping; and so on. (Goldstein, 2013).

- So, this could imply that perception of an object not only includes physical properties, such as shape, size, colour and orientation, that might enable the person to recognize an object but our perception also includes information about how the object is to be used.

- One of the ways, affordances have been studied, is by investigating patients with brain – damage.
  - Humphreys & Riddoch (2001) studied a patient M.P., with damage to his temporal lobe that impaired his ability to name objects.

- M.P., was given one of two cues,i.e. (a) name of an object like a “cup” or (b) an indication of how the object worked (“ an object that you could drink from”).

- He was then shown 10 different objects and was told to press a key as soon as he found the object.

- It was found that M.P. identified the object more accurately & rapidly when the given cue referred to the object’s function.

- Humphrey & Riddoch concluded that M.P was using information about the object’s affordances to find the object.

- ***The Physiology of Perception and Action***

  - The link between perception & action was formalized with the discovery of the ventral & dorsal pathways of the brain.

  - Ungerleider & Mishkin 91982) studied a monkey's ability to identify an object and to determine an object's location; using the technique of brain ablation.

  - Ungerleider and Mishkin presented a monkey with two tasks: (1) an object discrimination problem and (2) a landmark discrimination problem.

- In the object discrimination problem: the monkey was shown one object, such as a rectangular solid, 7 was then presented with a two – choice task like the, wherein one of the objects was the “target object” and another stimulus.

- If the monkey would push aside the target object, it received the food reward that was hidden under the object.

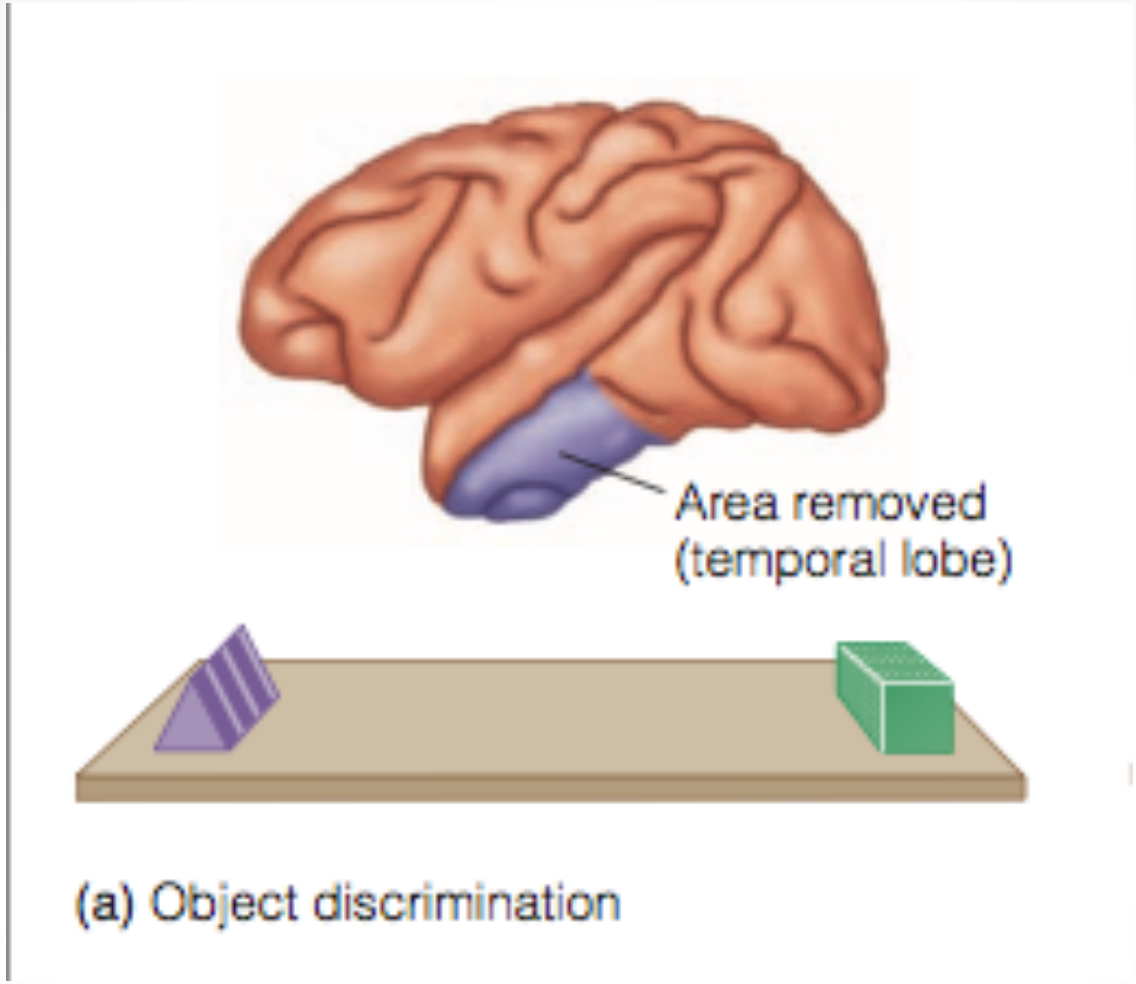
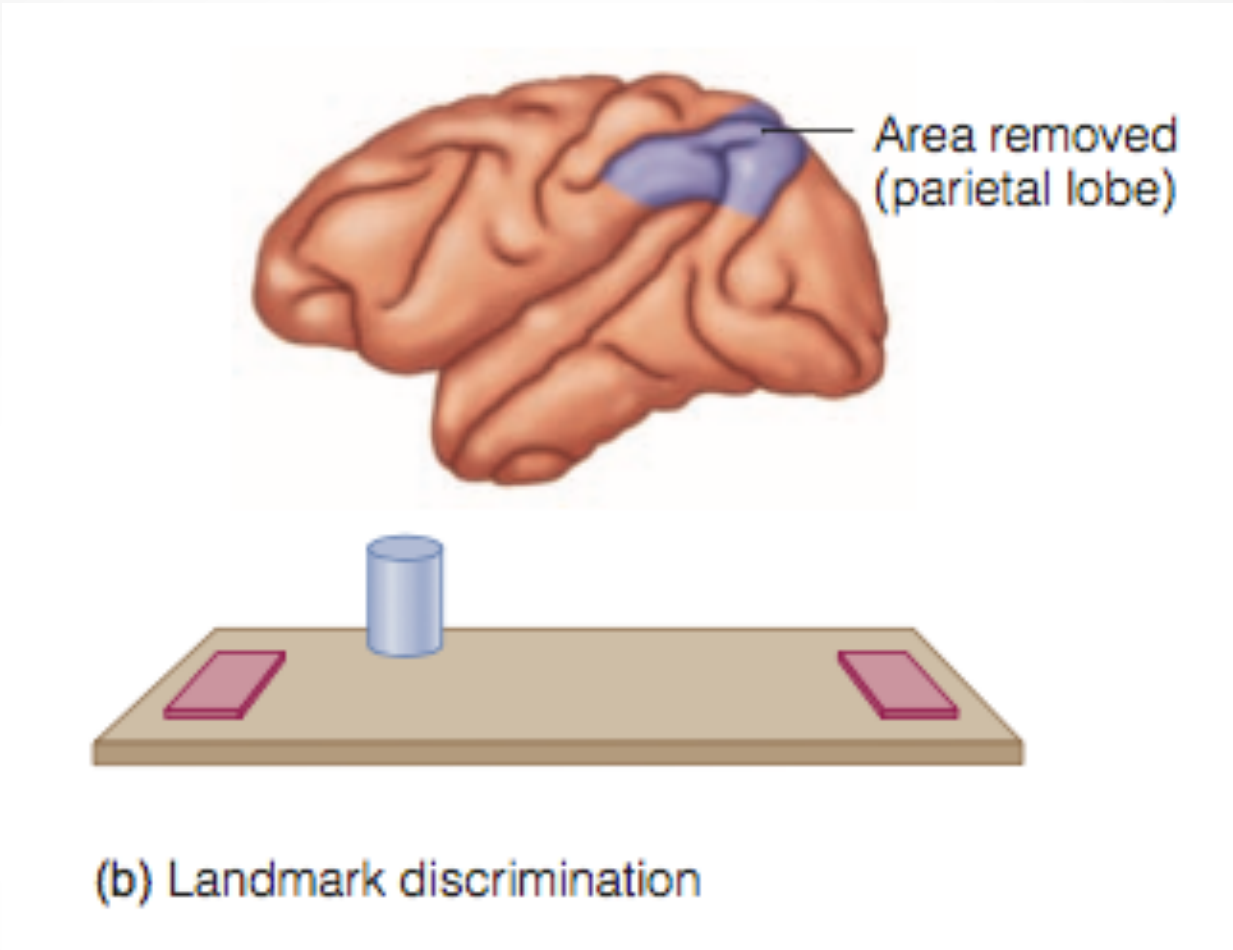


Image: Goldstein(2010). Cognitive Psychology_Connecting Mind, research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed. Fig. 3.34 (p.72)

- In the landmark discrimination task, the monkey's task was to remove the food well cover that is closer to a tall cylinder.

- In the ablation phase, a part of the temporal lobe was removed in some monkeys while for the others the parietal lobe was removed.



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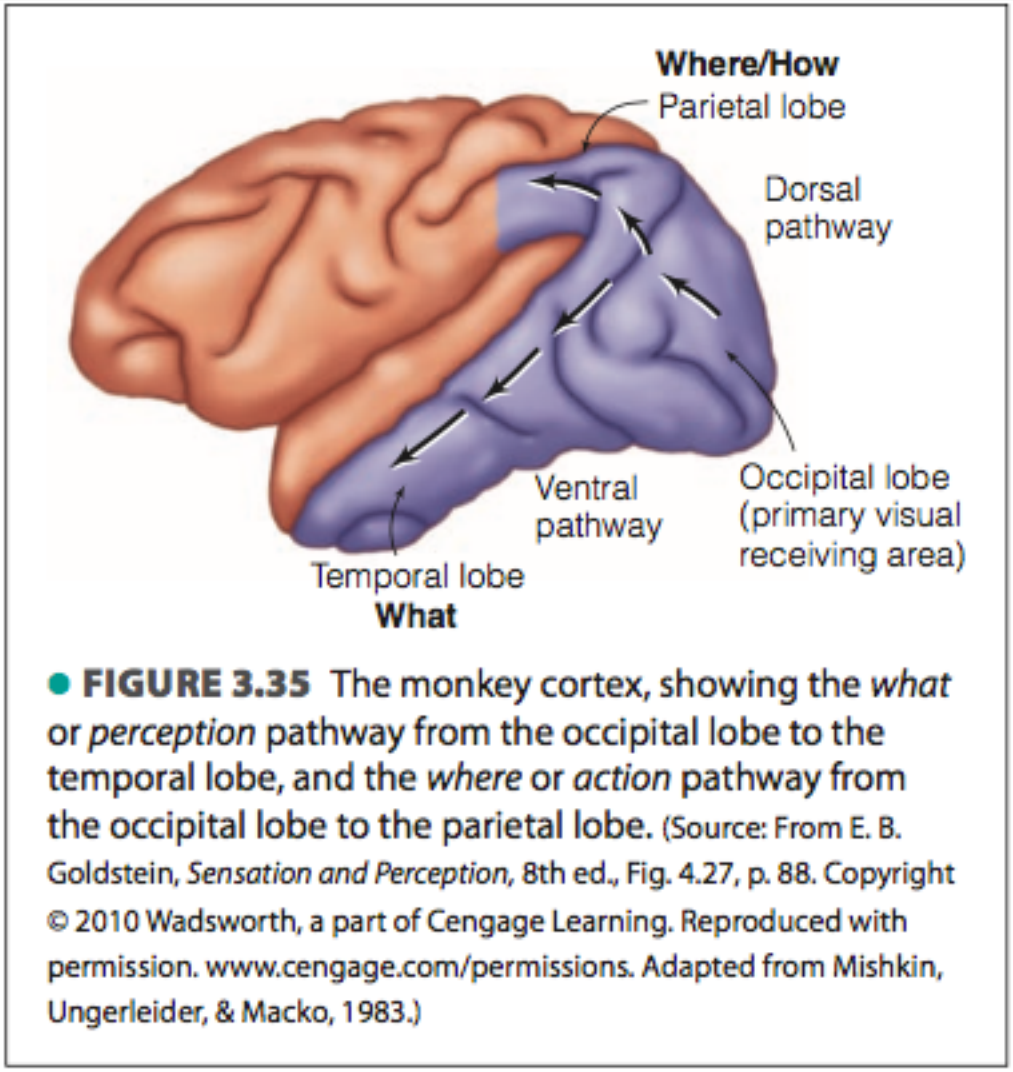
- Behavioral experiments showed that the object discrimination problem was very difficult for monkeys with the temporal lobes removed.
    - This was taken to imply that the pathways that reaches the temporal lobes is responsible for object identification.
- Ungerleider & Mishkin called this pathway as the ***what pathway***.

- Monkeys who had their parietal lobes removed, had difficulty solving the landmark discrimination problem.
    - This indicated that the pathway leading to the parietal lobe is responsible for determining an object's location.
    - Ungerleider & Mishkin called the pathway leading from the striate cortex to the parietal lobe the **where pathway.**



● **FIGURE 3.35** The monkey cortex, showing the *what* or *perception* pathway from the occipital lobe to the temporal lobe, and the *where* or *action* pathway from the occipital lobe to the parietal lobe. (Source: From E. B. Goldstein, *Sensation and Perception*, 8th ed., Fig. 4.27, p. 88. Copyright © 2010 Wadsworth, a part of Cengage Learning. Reproduced with permission. www.cengage.com/permissions. Adapted from Mishkin, Ungerleider, & Macko, 1983.)

Image: Goldstein(2010). Cognitive Psychology_Connecting Mind, research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed. Fig. 3.34 (p.72)

- So, in a simple task of reaching & grasping cup, one could assume that the “what pathway” would be involved in the initial perception of the cup & the “where pathway” would be involved in determining the correct location of the cup, so that it could be picked up.

Putting Things in Perspective

- We have seen that Gibson's approach was pushing for 'perception for action' while Marr's theory was more for 'perception for recognition'.
- It seems that in some way the idea of ventral & dorsal pathways echoes similar ideas.
- However, while these two streams may appear to be functioning independently, it is needless to say that we need both of them working fine in order to recognise objects and perform actions to interact with the environment.

- for e.g. Gibson's notion of affordance emphasises that we might need to detect what things are 'for' rather than what they actually 'are'.

- affordances are linked to actions & the dorsal stream appears to be ideally suited for providing the sort of information we need to act in the environment.

- Earlier, we saw that Gibson saw no role for memory in perception & as the dorsal stream seems to have very little storage also confirms that the dorsal stream works as Gibson proposed.

- In contrast, the ventral stream appears to be ideally suited to the role of recognizing objects. It is specialized in analyzing the sort of fine detail that Marr saw as essential to discriminating between objects.

- Also it seems to draw on our existing knowledge to assist in identifying objects.

- It is also slower than the dorsal stream; which is conducive to the fact that no immediate action is required.

- To somewhat address these & other concerns; Norman (2002) & Neisser (1994) suggested the dual processing approach:

- there appears to be evidence that the ventral stream is primarily concerned with recognition while the dorsal stream drives visual behaviour (pointing, grasping etc.)

- the ventral system is generally better at processing fine detail while the dorsal system is better at processing motion.

- the ventral system is knowledge based & uses stored representations to recognise objects; while the dorsal system appears to have only very short term storage.

- the dorsal system received information faster than the ventral system.

- we are much more conscious of the ventral than the dorsal stream.

- it has been suggested that the ventral system recognised objects & is object centred while as the dorsal stream is action oriented it uses a viewer centred frame of reference (more on this later).

- Norman (2002) defines the two as synergistic and interconnected rather than independent.

- Busted & Carlton (2002), provide an illustration of the interaction between the ventral & dorsal streams using the example of skill acquisition.

- previous work (Fitts, 1964) suggests that the early stages of learning a skill (e.g. driving) are characterised by cognitive processes of the kind associated with the ventral stream; whereas once, the skill is highly practiced it is characterised by learned motor actions of the sort associated with the dorsal stream.

References

- Goldstein E.B. (2010). Cognitive Psychology: Connecting Mind, Research and Everyday Experience. *Wadsworth Publishing*. 3rd Ed.

- Goldstein E.B. (2013). Sensation and Perception. *Cengage Learning*. 9th Ed.