# 8

# *Visual Motion Perception*

# Chapter 8 Visual Motion Perception

- Computation of Visual Motion
- Using Motion Information
- Eye Movements
- Development of Motion Perception

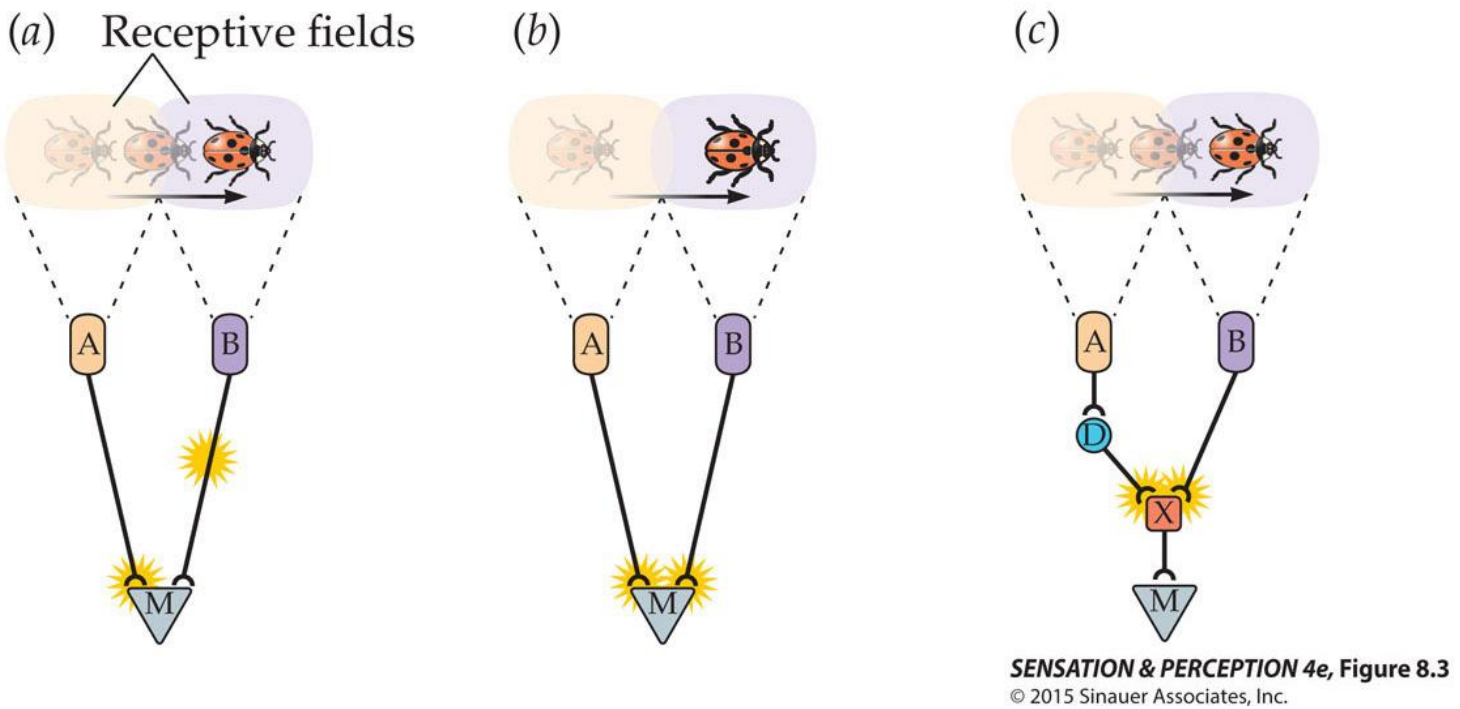
- Waterfall Illusion
  https://www.youtube.com/watch?v=2CPWdJ9EGX0

# Computation of Visual Motion

How would you build a motion detector?

- Motion is just a change in position over time.
- Start with two adjacent receptors.
  - Registers change in position
- Incorporate a delay.
  - Accounts for change in time

# Figure 8.3 Constructing a neural circuit for the detection of rightward motion



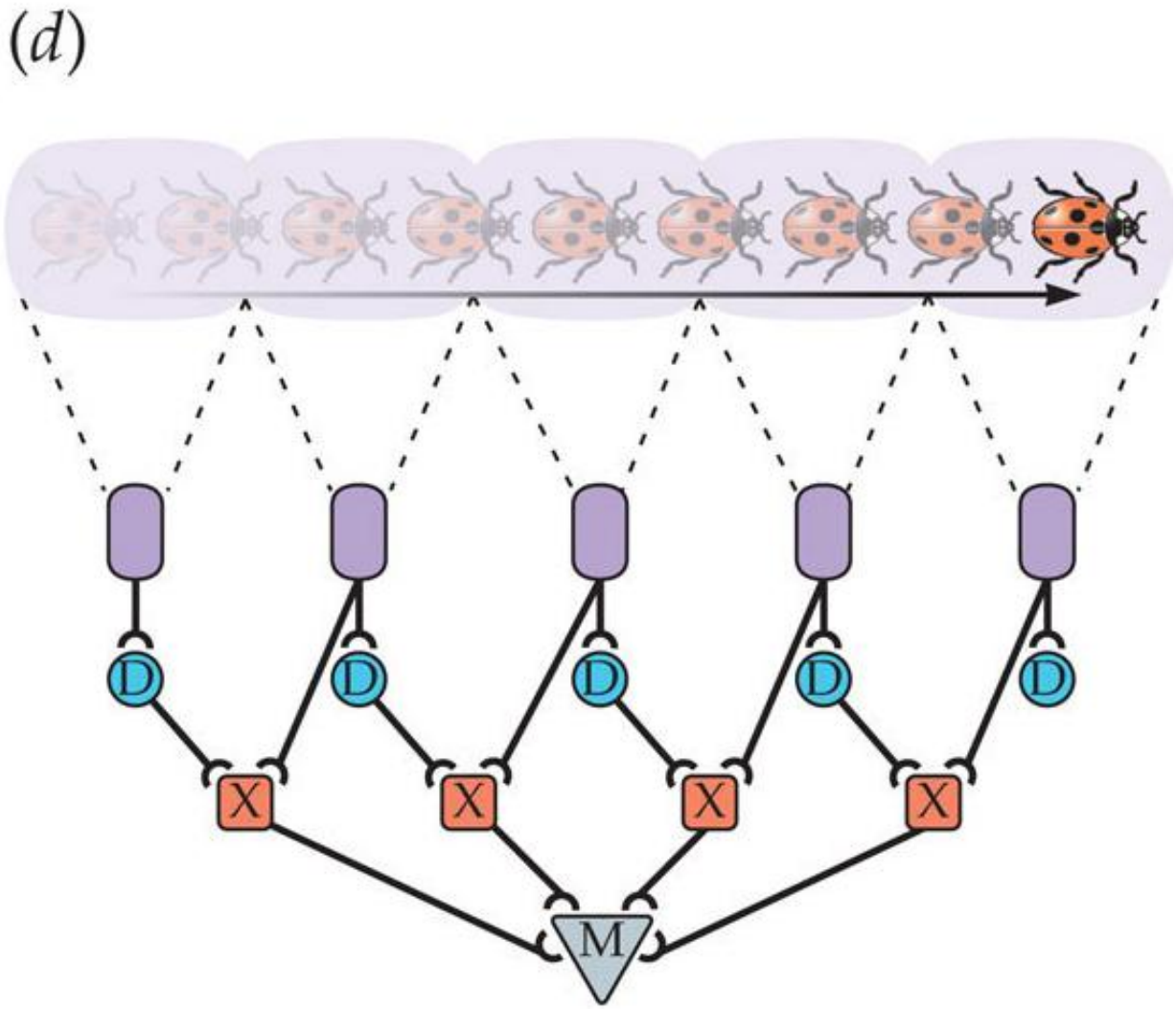

***SENSATION & PERCEPTION 4e*, Figure 8.3**

# Computation of Visual Motion

The motion detector circuit in the previous slide works, but it doesn’t cover a very big area.

Is there a way to string several motion detector circuits together and cover a larger area?

Figure 8.3 Constructing a neural circuit for the detection of rightward motion

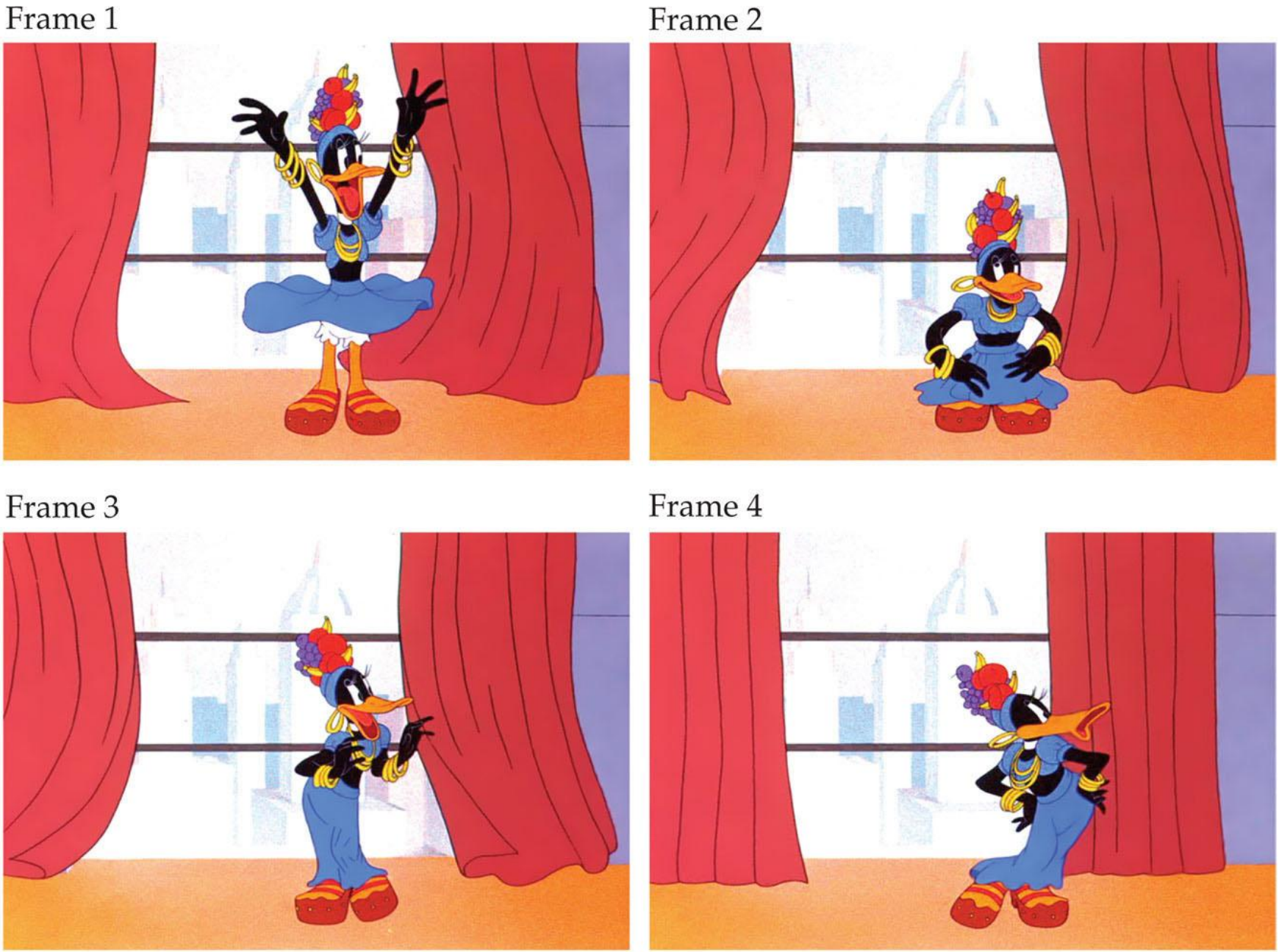


# Computation of Visual Motion

**Apparent motion:** The illusory impression of smooth motion resulting from the rapid alternation of objects that appear in different locations in rapid succession.

- First demonstrated by Sigmund Exner in 1875
- Motion detector circuit does not need real motion in order to fire.

# Figure 8.4 Apparent motion on the screen




***SENSATION & PERCEPTION 4e*, Figure 8.4**

# Computation of Visual Motion

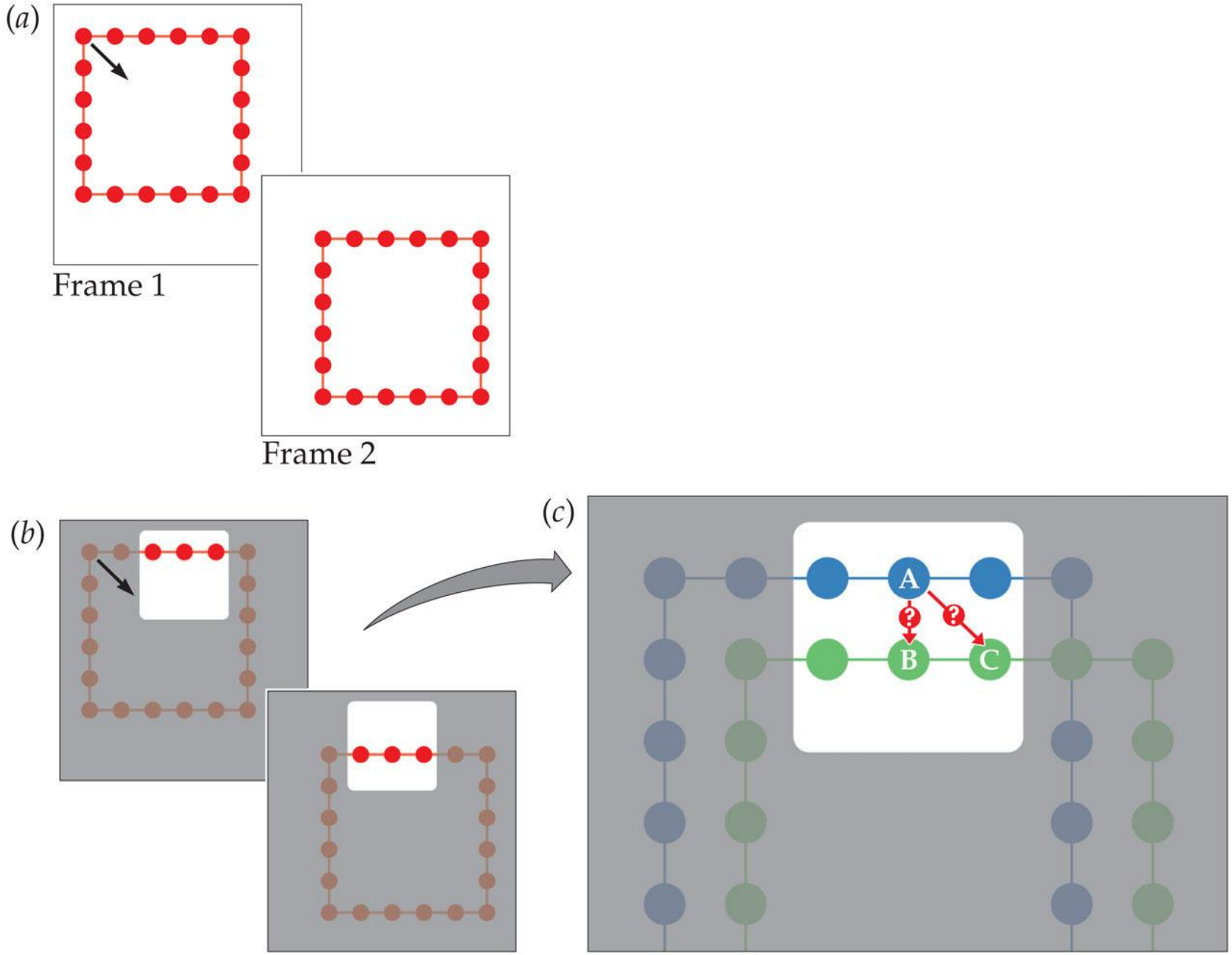
Correspondence problem (motion): The problem faced by the motion detection system of knowing which feature in frame 2 corresponds to which feature in frame 1.

# Computation of Visual Motion

Aperture: An opening that allows only a partial view of an object.

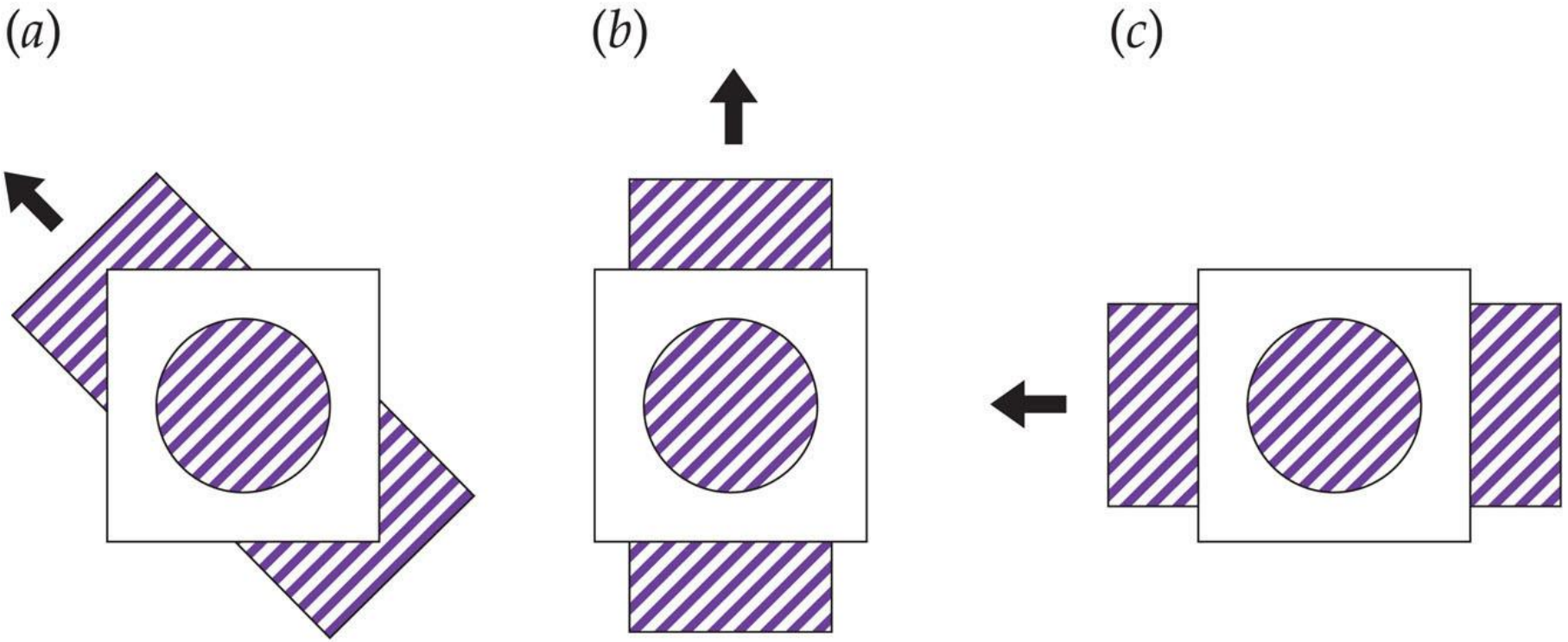
- Aperture problem: The fact that when a moving object is viewed through an aperture (or a receptive field), the direction of motion of a local feature or part of an object may be ambiguous.
- https://www.youtube.com/watch?v=lvvcRdwNhGM

# Figure 8.5 The correspondence problem




**SENSATION & PERCEPTION 4e, Figure 8.5**

# Figure 8.6 The aperture problem




***SENSATION & PERCEPTION 4e*, Figure 8.6**

# Computation of Visual Motion

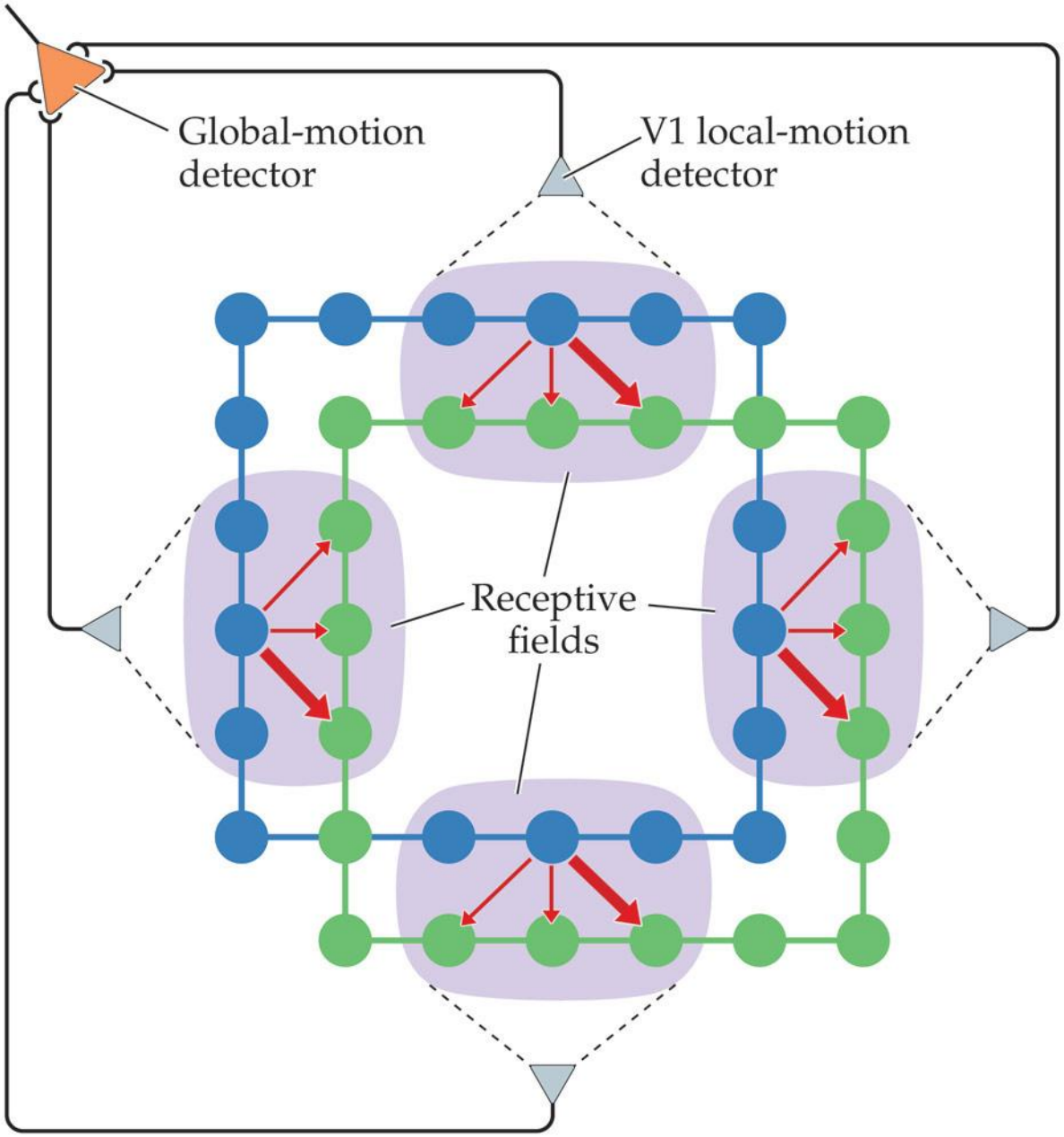
Given that motion within any single aperture (or receptive field) is ambiguous, how might the visual system correctly perceive the overall motion of objects?

# Computation of Visual Motion

Motion information from several local apertures (or receptive fields) can be combined to determine the global motion of the object.

- There are several directions of motion within each aperture that are compatible with the stimulation the receptor is receiving.
- Whichever possible motion direction is the same in all apertures is the true global motion direction of the object.

# Figure 8.7 Building a global-motion detector



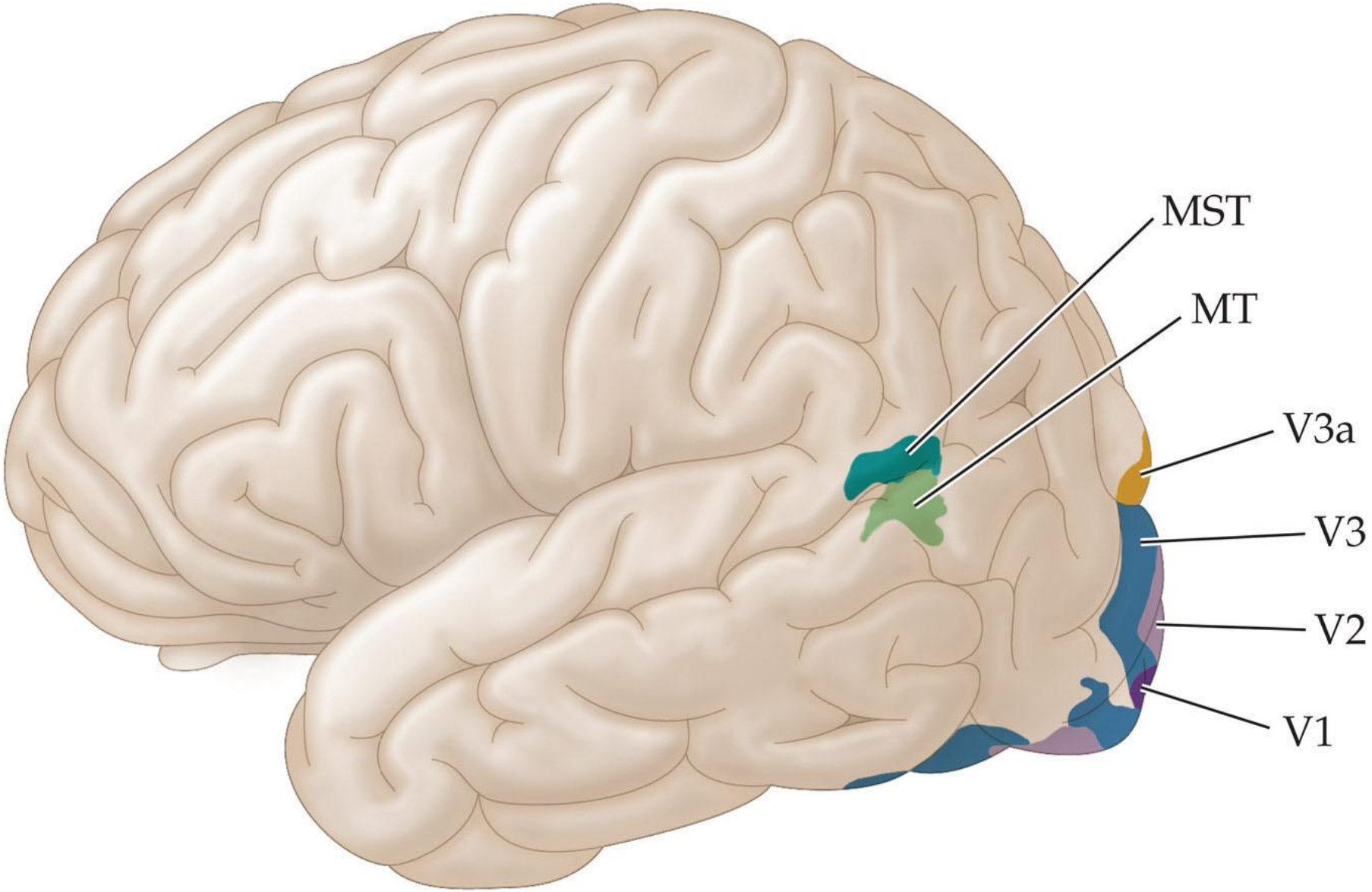

***SENSATION & PERCEPTION 4e*, Figure 8.7**

# Computation of Visual Motion

We can say something about where global-motion detectors are.

- Lesions in magnocellular layers of LGN impair perception of large, rapidly moving objects.
- Middle temporal area (MT) also plays an important role in motion perception.
  - The vast majority of neurons in MT are selective for motion in a particular direction.

# Figure 8.8 Motion-sensitive areas in the human brain



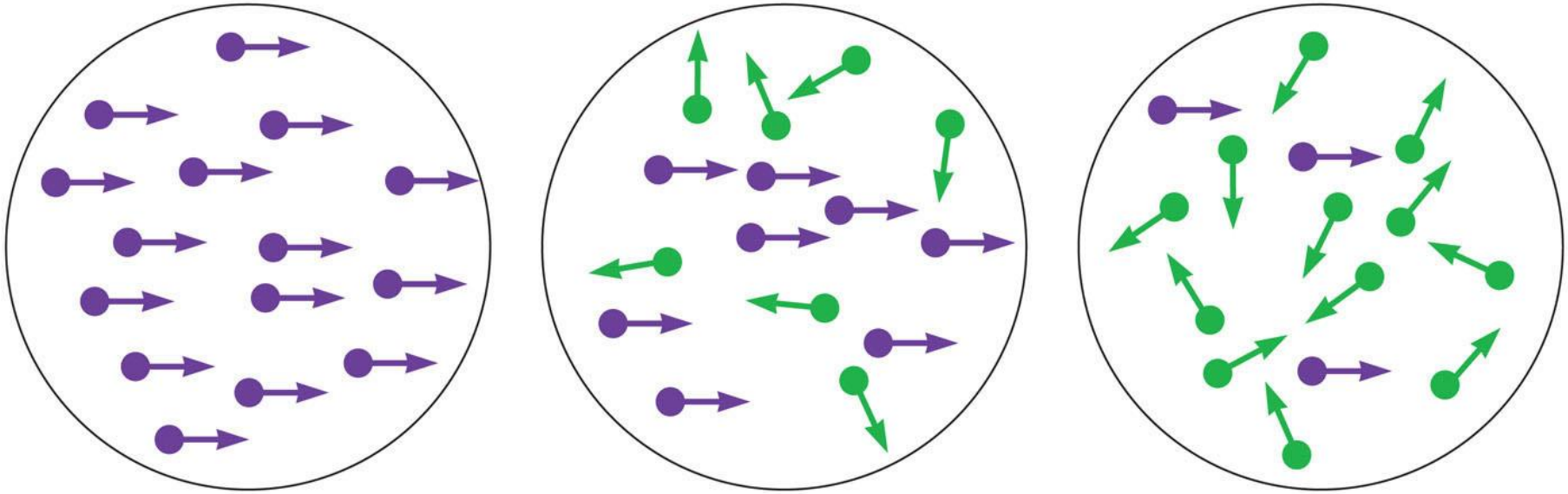

***SENSATION & PERCEPTION 4e*, Figure 8.8**

# Computation of Visual Motion

Newsome and Pare (1988) conducted a study on motion perception in monkeys.

- They trained monkeys to respond to correlated dot motion displays.
- The MT area of the monkeys was lesioned.
- Result: Monkeys needed about ten times as many dots to correctly identify direction of motion.

# Figure 8.9 The Newsome and Pare paradigm




***SENSATION & PERCEPTION 4e*, Figure 8.9**

# Computation of Visual Motion

Disadvantages of using lesion studies to study motion

- Invasive
- Lesions may be incomplete or may influence other structures.

Electrical stimulation of MT neurons

- Avoids problems of lesion studies
- Biases motion detection in the direction the MT neuron normally responds to

# Computation of Visual Motion

Motion aftereffect (MAE): The illusion of motion of a stationary object that occurs after prolonged exposure to a moving object.

- Existence of MAE implies an opponent process system, like that of color vision.

**Interocular transfer:** The transfer of an effect (such as adaptation) from one eye to another.

- MAE exhibits interocular transfer.
- Therefore, MAE must occur in neurons that respond to both eyes.
  - Input from both eyes is combined in area V1, so MAE must be in V1 or later.
  - Recent studies with fMRI confirm that adaptation in MT is responsible for MAE.

# Computation of Visual Motion

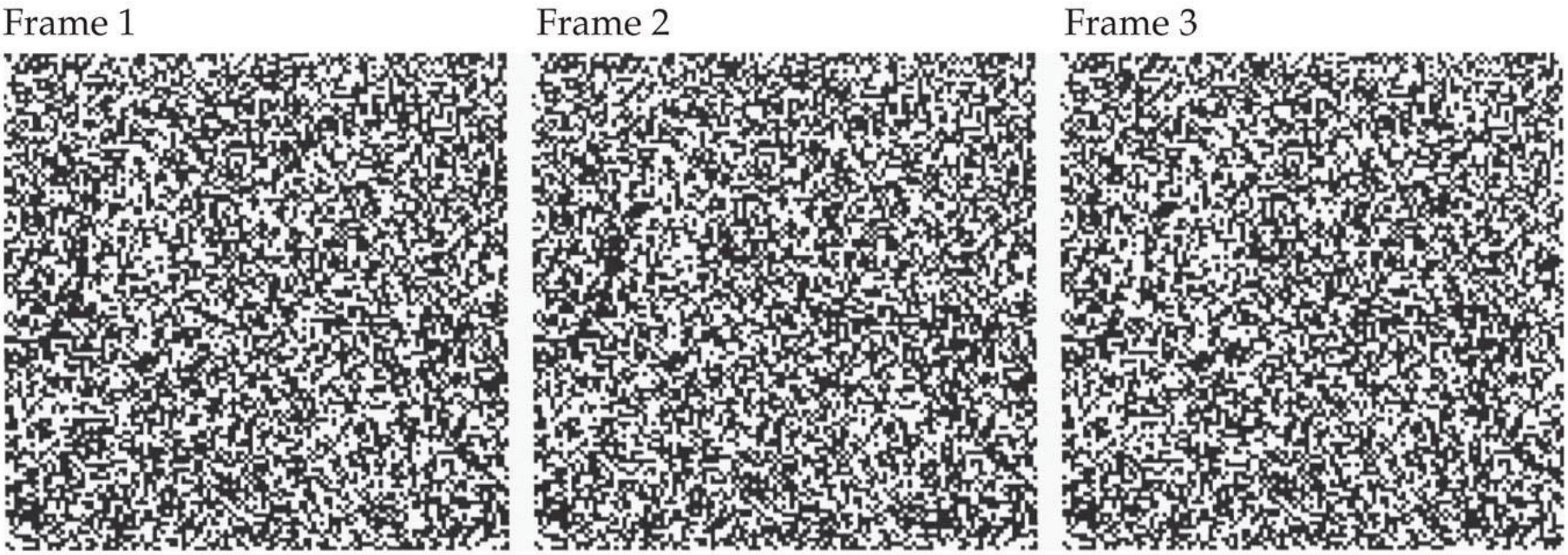
First-order motion: The motion of an object that is defined by changes in luminance.

- Luminance-defined object: An object that is delineated by differences in reflected light.

Second-order motion: The motion of an object that is defined by changes in contrast or texture, but not by luminance.

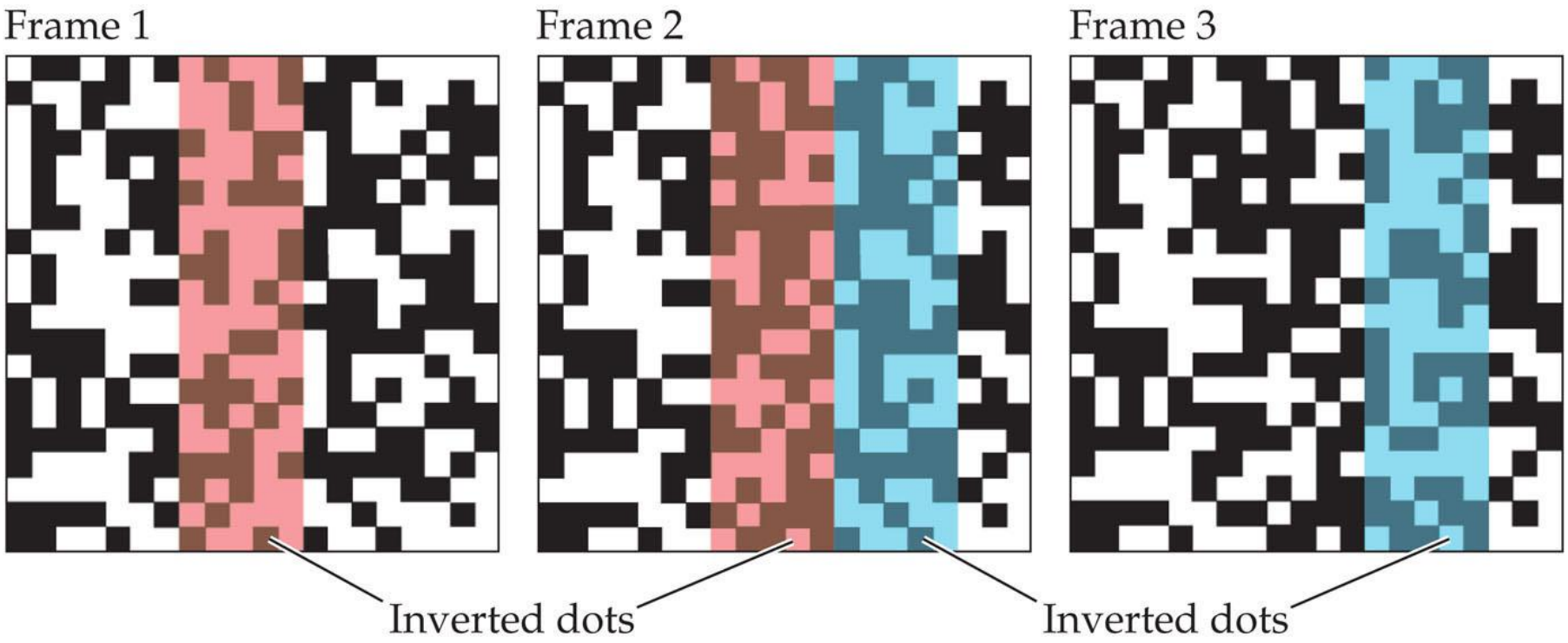
- Texture-defined (contrast-defined) object: An object that is defined by changes in contrast or texture, but not by luminance.

# Figure 8.10 Second-order motion




***SENSATION & PERCEPTION 4e*, Figure 8.10**

Figure 8.11 Close-ups of one section of the frames in Figure 8.10, illustrating the changes from frame to frame



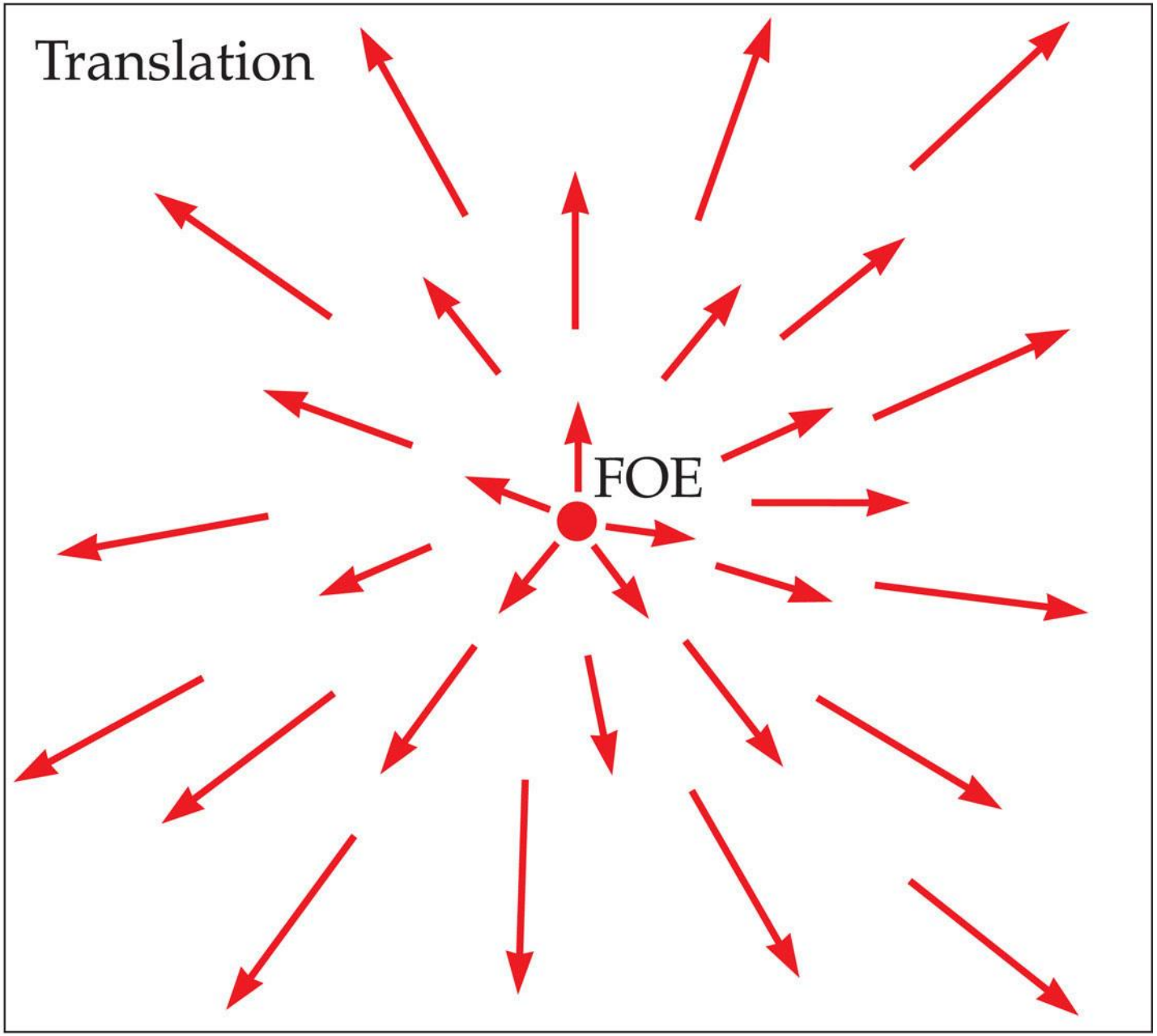

***SENSATION & PERCEPTION 4e*, Figure 8.11**

# Using Motion Information

How do we use motion information to navigate?

- Optic array: The collection of light rays that interact with objects in the world in front of a viewer. Term coined by J. J. Gibson.
- Optic flow: The changing angular position of points in a perspective image that we experience as we move through the world.

Figure 8.12 The optic flow field produced by movement forward in space




***SENSATION & PERCEPTION 4e*, Figure 8.12**

# Using Motion Information

Focus of expansion (FOE): The point in the center of the horizon from which, when we are in motion, all points in the perspective image seem to emanate.

- This is one aspect of optic flow.
- The focus of expansion tells the observer which way they are heading.

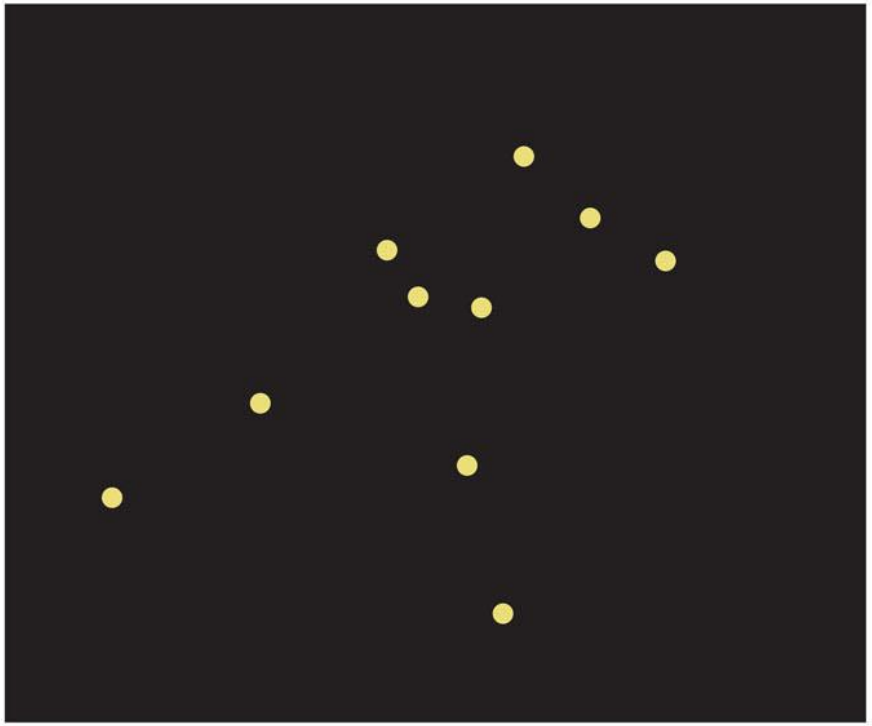
# Using Motion Information

Biological motion: The pattern of movement of all animals.

# Figure 8.13 Biological motion can be seen compellingly when lights attached to a moving human are viewed in total darkness

(a)


(b)



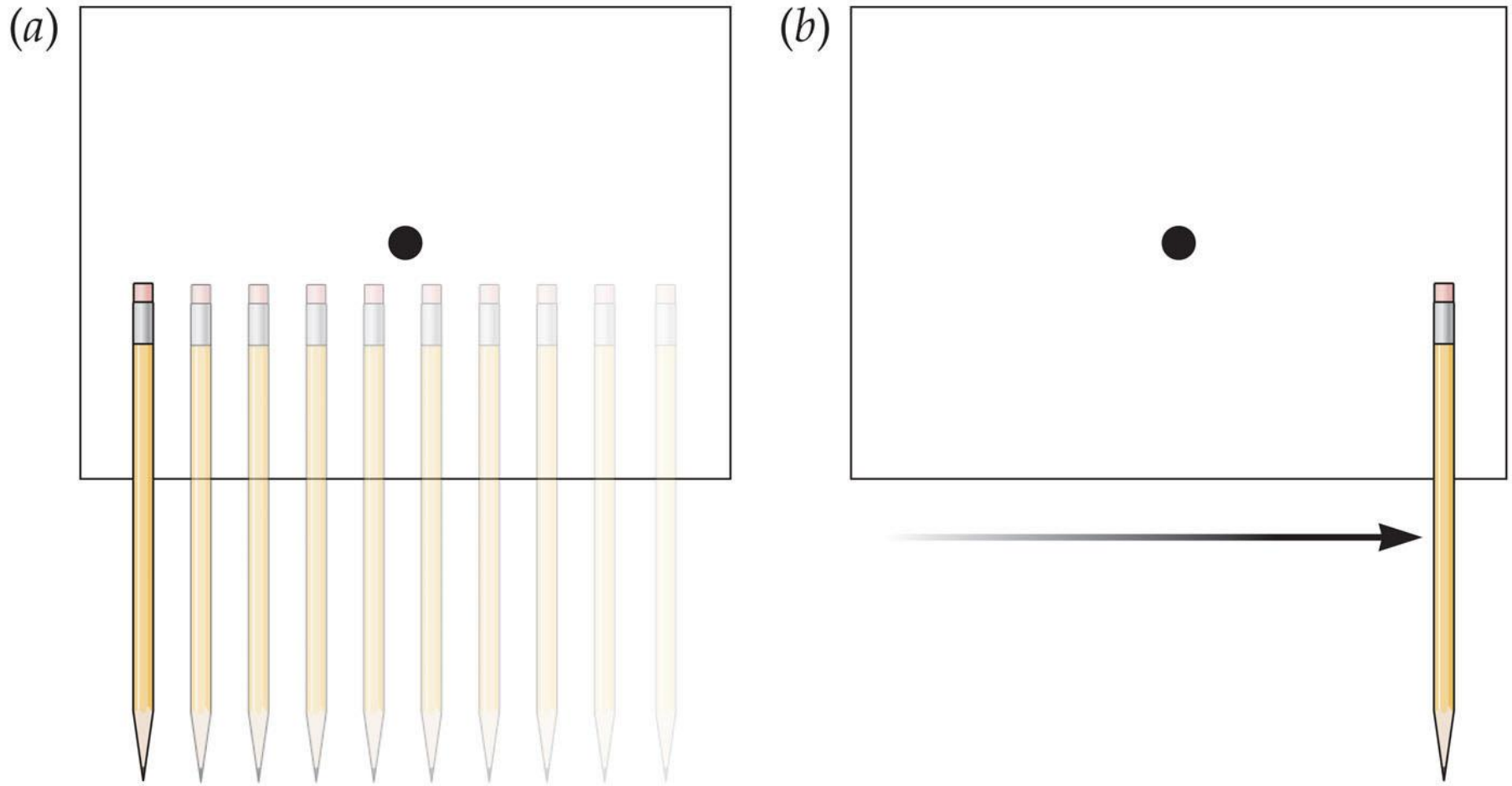
***SENSATION & PERCEPTION 4e*, Figure 8.13**

# Using Motion Information

Avoiding imminent collision: How do we estimate the time to collision (TTC) of an approaching object?

- Tau ($\tau$): Information in the optic flow that could signal TTC without the necessity of estimating either absolute distances or rates.
  - The ratio of the retinal image size at any moment to the rate at which the image is expanding is tau, and TTC is proportional to tau.

# Figure 8.15 Studying eye movements




***SENSATION & PERCEPTION 4e*, Figure 8.15**

# Eye Movements

Why do we perceive the pencil to be in motion in the first case, but perceive the dot to be stationary in the second case? After all, both items moved across our retinas to the left.

- Because in the second case there was an eye movement

# Eye Movements

Types of eye movements

- Smooth pursuit: Voluntary eye movement in which the eyes move smoothly to follow a moving object.
- Saccade: A type of eye movement, made both voluntarily and involuntarily, in which the eyes rapidly change fixation from one object or location to another.

# Eye Movements

Types of eye movements (*continued*)

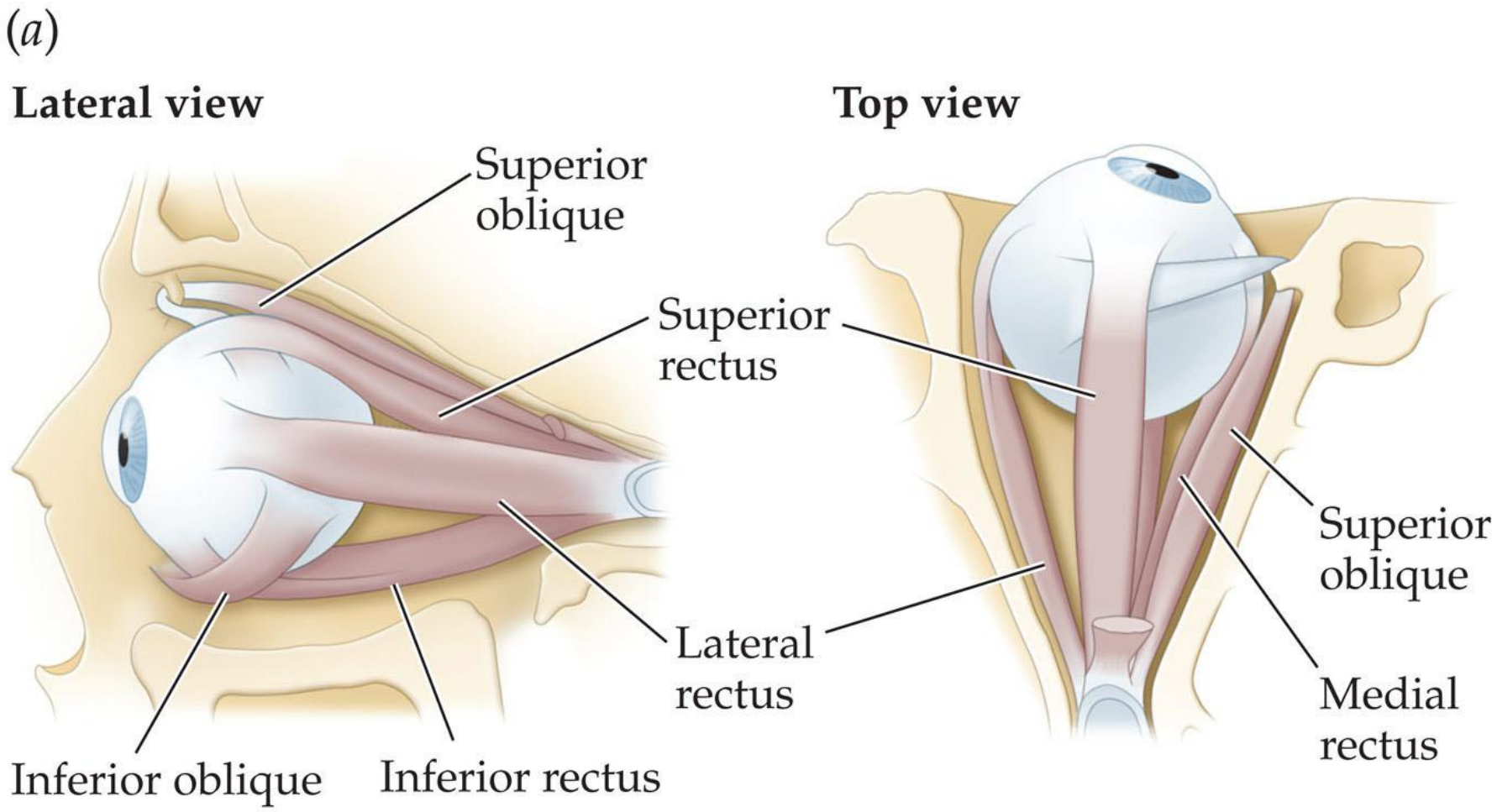
- Vergence: A type of eye movement, both voluntary and involuntary, in which the two eyes move in opposite directions.
  - Convergent eye movements turn the eyes inward
  - Divergent eye movements turn the eyes outward.
- Reflexive: Automatic and involuntary eye movements.

# Eye Movements

Six muscles are attached to each eye and are arranged in three pairs.

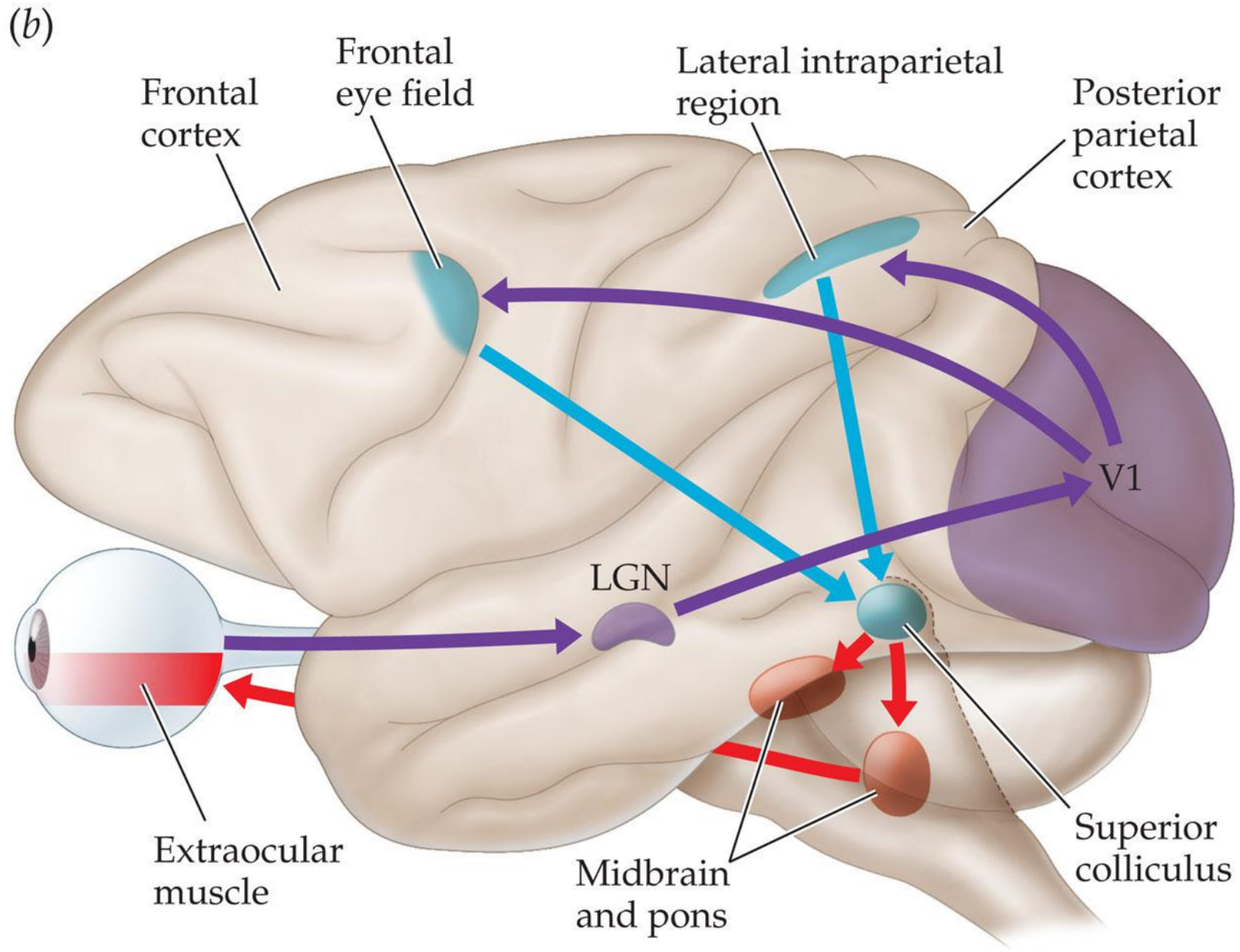
- Controlled by an extensive network of structures in the brain
- Superior colliculus: A structure in the midbrain that is important in initiating and guiding eye movements.
  - When this structure is electrically stimulated, eye movements result.

Figure 8.16 Muscles of the eye (Part 1)




***SENSATION & PERCEPTION 4e,* Figure 8.16 (Part 1)**

Figure 8.16 Muscles of the eye (Part 2)




***SENSATION & PERCEPTION 4e*, Figure 8.16 (Part 2)**

# Eye Movements

Saccadic suppression: The reduction of visual sensitivity that occurs when we make saccadic eye movements.

- Saccadic suppression eliminates the smear from retinal image motion during an eye movement.

# Eye Movements

How do we discriminate motion across the retina that is due to eye movements vs. object movements?

- Comparator: An area of the visual system that receives one copy of the order issued by the motor system when the eyes move (the other copy goes to the eye muscles).
  - The comparator can compensate for the image changes caused by the eye movement.

# Eye Movements

How else do we compensate for eye movements to preserve the stability of the visual world?

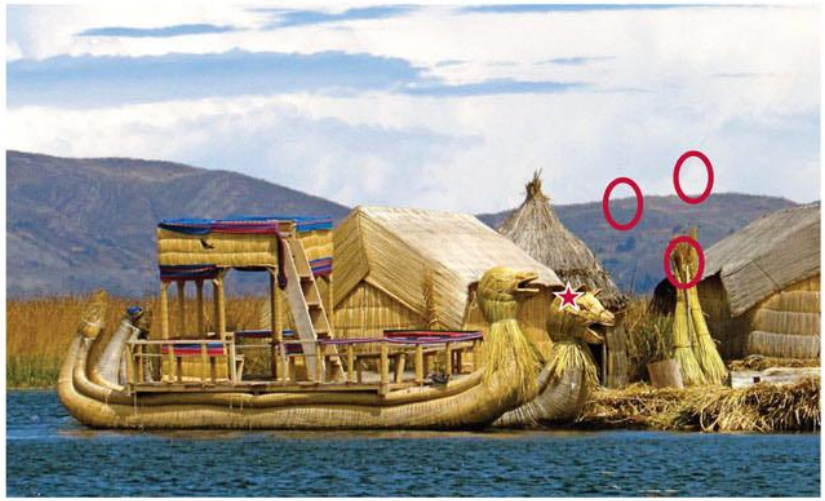
- Dynamic remapping of receptive fields
  - A saccade is planned but not yet executed.
  - Some neurons in parietal cortex remap their receptive fields relative to upcoming fixation location.

# Eye Movements

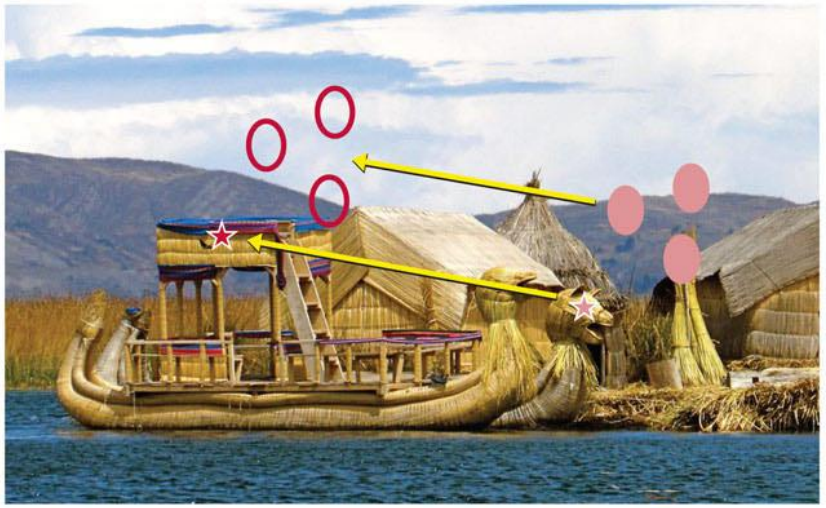
  - Saccade is executed.
  - Receptive fields are already processing information from new location before eye lands there.
- Receptive fields of neurons in the frontal eye fields also transiently shift inward towards the new point of fixation.

# Figure 8.19 Receptive field updating

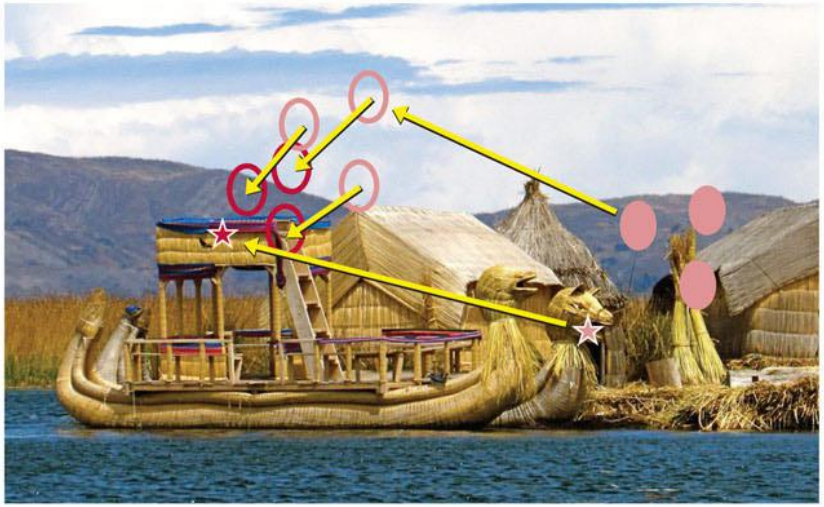
(*a*) RFs relative to a point of fixation



(*b*) RFs shift with the point of fixation



(*c*) RFs transiently remap toward the new point of fixation



***SENSATION & PERCEPTION 4e*, Figure 8.19**

# Development of Motion Perception

Sensitivity to visual motion develops over time.

Infants have some reflexive eye movements at birth.

However, adult-like sensitivity to motion does not reach maturity until about 3 to 4 years of age.

Sensitivity to motion-defined form and biological motion takes even longer to develop.

# Sensation and Perception in Everyday Life: The Man Who Couldn't See Motion

Akinetopsia: A rare neurophysiological disorder in which the affected individual has no perception of motion.

- Caused by disruptions to cortical area MT