The Ecological View of Perception

Lecture 14
Ecological View of Perception
James J. Gibson (1950, 1966, 1979)
Eleanor J. Gibson (1967)

• Stimulus provides information
• Perception involves extracting this information
• Direct Perception (Direct Realism)
  – All information needed for perception is supplied by the stimulus
  – No need for “higher” cognitive activity
  – Learn to extract relevant information
    • Exploration of object
    • All information is available “in the light”
Applications of Ecological View

• Motion Perception
  – Is the Object Stable or Moving?

• Depth Perception
  – Is the Object Near or Far?

• Perception of Plasticity
  – Is the Object Rigid or Flexible?
The “Stimulus” in Ecological Perception

• Distal Stimulus
  – Object of Regard

• Surrounding Stimulus Field
  – Environmental Context
    • Exteroceptive Stimuli
  – Information from Perceiver’s Body
    • Proprioceptive Stimuli
Cues for the Perception of Motion

• Successive Covering, Uncovering
Covering and Uncovering: Watch the Red Square
Cues for the Perception of Motion

• Successive Covering, Uncovering
• Movement of Image Across Retina  
  – Holding Head and Eyes Steady
Movement of the Retinal Image:
Focus on the Cross
And Hold Your Head and Eyes Steady
Cues for the Perception of Motion

• Successive Covering, Uncovering
• Movement of Image Across Retina
  – Holding Head and Eyes Steady
• Egomotion
  – Head/Eye Movements
    • Alter placement of retinal image
Egomotion:
Focus on the Cross, then
Track the Circle with your Eyes
Don’t Move Your Head!
Egomotion:
Focus on the Cross, then
Track the Circle by Moving Your Head
Don’t Move Your Eyes!
An Exercise in Carwatching

• Fixate on target across the street
• Wait for Car to Pass
  – Covering and Uncovering
  – Movement of Retinal Image
• Follow Passing Car
  – With Eyes, Holding Head Steady
  – With Head, Holding Eyes Steady
Two Systems for Perceiving Motion

Gregory (1966)

6.1 Two movement systems. (a) The image–retina system: the image of a moving object runs along the retina when the eyes are held still, giving information on movement through sequential firing of the receptors in its path. (b) The eye/head system: when the eye follows a moving object, the image remains stationary upon the retina, but we still see the movement. It is signalled from the commands to move the eyes. The two systems can sometimes disagree, to give paradoxical illusions of movement.
Conflicting Signals: The World Moves

Cover one eye with your hand.
Focus other eye on the cross.
Then *gently* push on your open eye with your finger.
The Information for Motion: 
*Discrepancy*

- Information provided by image-retina system
  - Movement of image across retina
- Information provided by the eye/head system
  - Movement of eyes, head, body
# Image-Retina and Eye-Head Systems

After Coren, Porac, & Ward (1976)

<table>
<thead>
<tr>
<th>Target</th>
<th>Action of Eye</th>
<th>Retinal Image</th>
<th>Command to Eye (Head)</th>
<th>Perception of Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image-Retina System</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving</td>
<td>Stationary</td>
<td>Moves</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Eye-Head System</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving</td>
<td>Tracks</td>
<td>Stationary</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stationary</td>
<td>Moves</td>
<td>Moves</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stationary</td>
<td>Pushed</td>
<td>Moves</td>
<td>None</td>
<td>Opposite Direction</td>
</tr>
<tr>
<td>Stabilized</td>
<td>Moves</td>
<td>Stationary</td>
<td>Yes</td>
<td>Same Direction</td>
</tr>
</tbody>
</table>

*Note: The table lists the relationship between target movement and image stability for the Image-Retina and Eye-Head systems.*
Binocular Cues for the Perception of Distance

- **Convergence**
  - Eyes turn inward when focusing on object
  - Angle of vectors indicates distance
    - up to 30-40 feet
Figure 5.2.2 Depth information from eye convergence. The angle of convergence between the two eyes ($a$) varies with the distance to the object they fixate: smaller angles for objects far away ($a_2$) and larger angles for objects nearby ($a_1$).
Binocular Cues for the Perception of Distance

- Convergence

- **Retinal (Binocular) Disparity**
  - Eyes Separated by 2-3 Inches
    - Each receives somewhat different image of object
  - Stereoscopical Vision
    - 2-Dimensional images on retina
    - Fused into 3-dimensional image in brain
Figure 5.3.2 Crossed versus uncrossed binocular disparity. When a point P is fixated, closer points (such as C) are displaced outwardly in crossed disparity, whereas farther points (such as F) are displaced inwardly in uncrossed disparity.
Different Images: The World Moves

Hold your left index finger at full arm’s length.
Hold your right index finger at half arm’s length.
Close your right eye.

+ 

Align your two fingers using your left eye.
Both should coincide with cross above.
Then close your left eye and open your right eye.
The Stereoscope
Monocular Cues for the Perception of Distance

• Accommodation
  – Lens bulges to focus on near objects
  – Lens flattens to focus on distant objects
Figure 5.2.1 Depth information from lens accommodation. The lens of a human eye changes shape to focus the light from objects at different distances: thin for objects far away and thick for ones nearby.
Monocular Cues for the Perception of Distance

• Accommodation

• Relative Size (the size-distance rule)
  – Distance constant, object size = \( f(\text{image size}) \)
  – Size constant, object distance = \( f(1/\text{image size}) \)
Figure 5.5.8  Relative size. If two otherwise identical objects are viewed at different distances, the farther object projects a smaller image onto the retina. The relative size of such objects can therefore provide information about relative depth.

Figure 5.5.9  The size-distance relation. The viewing geometry of perspective projection shows that the distance to an object can be determined from its size ($h$) and the tangent of its visual angle ($a$).
Monocular Cues for the Perception of Distance

- Accommodation
- Relative Size
- **Superposition (Interposition)**
  - Nearby object cuts off view of more distant object
Magritte
*Carte Blanche*
(1965)

National Gallery of Art
Monocular Cues for the Perception of Distance

- Accommodation
- Relative Size
- Superposition
- Linear Perspective
  - Vanishing Point

*Madonna with Child* (13th c.)
Wikipedia
Raphael, “The School of Athens” (1510)
“Raphael Rooms”, Vatican City
Figure 1. The School of Athens, Raphael’s Renaissance masterpiece, demonstrates the artist’s awareness of many of the visual cues used by the brain to determine the shape and depth of objects. Raphael creates the vivid perception of a three-dimensional scene through shading, texture and contour information, together with linear perspective. The painting depicts the major figures of Greek science, with Plato and Aristotle at the center, Euclid holding the compass, Ptolemy with the globe, and Pythagoras shown writing. Historically, the argument whether perception is driven by “top-down” or “bottom-up” processes originated with Plato and Aristotle, who convey their views by the directions of their pointing fingers. The argument extended to 19th-century psychology, in the debate between Helmholtz and the Gestalt school, and continues into current computational approaches to vision. (Reprinted with permission from the Vatican museums.)
Masaccio,
“The Trinity”
(1427)

Basilica of Santa Maria Novella, Florence
Orvieto Cathedral
(14th c.)
Basilica of Santa Maria Novella, Florence
(Alberti, 1458)
Magritte
*The Human Condition*
(1933)

National Gallery of Art
Magritte, *The Fair Captive* (1931)

Hogarth Galleries, Sydney
Magritte
*The Promenades of Euclid*
(1935)

Minneapolis Institute of Arts
Monocular Cues for the Perception of Distance

• Accommodation
• Relative Size
• Superposition
• Linear Perspective
• Elevation
  – distance from horizon
Figure 5.5.6  Position relative to the horizon. In perspective projection of a 3-D scene, objects on a level plane that are closer to the horizon are perceived as being farther from the observer.
Monocular Cues for the Perception of Distance

- Accommodation
- Relative Size
- Superposition
- Linear Perspective
- Elevation
- Aerial (Atmospheric) Perspective
  - Diffraction of Light by Dust, Moisture
  - “Bluing” of Distance
Blue Ridge Mountains
North Carolina Division of Tourism

Lake Atitlan, Guatemala
Photo by Thor Janson, courtesy of Susan McGovern
Atitlan: Chichicastenango
Magritte, *The Glass Key* (1959)

Menil Collection, Houston
Monocular Cues for the Perception of Distance

- Accommodation
- Relative Size
- Superposition
- Linear Perspective
- Elevation
- Aerial Perspective
- Texture Gradients
Examples of Texture Gradients  The elements that make up the textured surface (rocks on left, people on right) appear to be packed closer and closer together as the surface recedes.
O’Keeffe, “Sky Above Clouds I” (1963)
Georgia O’Keeffe Museum
O’Keeffe, “Sky Above Clouds I-IV” (1963-5)
O’Keeffe, “Sky Above Clouds II” (1963)
Private Collection
O’Keeffe, “Sky Above Clouds III” (1963)

Private Collection
O’Keeffe, “Sky Above Clouds IV” (1965)
Art Institute of Chicago
Town Houses, Dublin
Duomo, Arezzo, Italy
Monocular Cues for the Perception of Distance

• Accommodation
• Relative Size
• Superposition
• Linear Perspective
• Elevation
• Aerial Perspective
• Texture Gradients

• **Shadowing**
  – Relative positions of shadows
  – Distance with respect to light source
Figure 5.5.28  Direction of illumination and perceived convexity. The top row looks like convex bumps and the lower row like concave dents because the visual system assumes that illumination comes from above. If you turn the book upside down, the perceived convexity of these elements reverses.
perceived convexity of these elements reverse. If you turn the book upside down, the
illustration comes from above, and you see the visual system assumes that the
upper row looks like convex bumps and the lower row looks like concave
disks. The top row looks like convex bumps and the lower row looks like concave
disks.
However it may seem, this speed hump in Philadelphia is nothing more than flat pieces of plastic burned into the street. Municipal officials say the month-old program will soon be expanded.
Pictorial Cues to Depth and Distance

- Relative Size
- Linear Perspective
- Elevation
- Superposition
- Texture Gradients
- Aerial Perspective
- Shadowing
Motion Cues to Depth and Distance

- Motion Parallax
- Optic Flow
Motion Parallax
Motion Parallax:
The World Moves Again

Hold your left index finger at full arm’s length.
Hold your right index finger at half arm’s length.
Close your right eye.

+ 

Align your two fingers using your left eye.
Both should coincide with cross above.
Then move your head back and forth
to the left and right.
# Organization of Cues for Depth or Distance

<table>
<thead>
<tr>
<th></th>
<th>Binocular</th>
<th>Monocular</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ocular</strong></td>
<td>Convergence</td>
<td>Accommodation</td>
</tr>
<tr>
<td>From Eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Optical</strong></td>
<td>Retinal Disparity</td>
<td>Relative Size</td>
</tr>
<tr>
<td>(Stereopsis)</td>
<td>(Stereopsis)</td>
<td>Linear Perspective</td>
</tr>
<tr>
<td>From Light</td>
<td></td>
<td>Elevation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Texture Gradients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aerial Perspective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shadowing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optic Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallax</td>
</tr>
</tbody>
</table>
Direct Perception
(Gibson’s “Ecological View”)

- All the Information Needed for Perception is Supplied by the Stimulus
  - The Whole Pattern of Proximal Stimulus Information Available in the Environment
- Perceptual Systems Evolved to Extract the Information Relevant for Perception
  - Part of Innate Biological Endowment
  - Little or No Learning, Memory
  - Little or No Reasoning, Judgment, Inference