**Chapter 5**

**OBJECT PERCEPTION**

One of the main functions of the visual system is object perception. Our ability to detect objects relies on overcoming three aspects of the environment: image clutter, object variety, and variable views. Moreover, previous knowledge affects object perception: recognition and representation are integral to understanding object perception. Similarly, perceptual organization allows us to group and segregate objects. Gestalt psychologists, such as Max Wertheimer, argued that what we see is greater than the individual parts; the process of perception is designed to see the scene rather than each individual piece. Specifically, gestalt psychologists studied figure-ground relations, laws of good fit, and laws of grouping. Overall, according to gestalt psychologists, our visual systems attempt to complete the scene, accounting for several illusions with illusory contours. The gestalt view is a top-down approach, meaning that our existing knowledge influences how we perceive them. Conversely, Irving Beiderman developed the recognition-by-components theory, a bottom-up approach in which the visual system breaks down objects in the environment into geons. A limitation of Biederman’s theory, however, is that it fails to account for some phenomena such as letter and face recognition.

A main function of the ventral pathway is object recognition. Area V4 is linked to shape perception, particularly contours. Several areas in the inferotemporal lobe (IT) are dedicated to perceiving specific features and even specific objects. The fusiform face area (FFA) is dedicated to recognition of specific faces, whereas the occipital face area makes the initial identification of a face as a face. Prosopagnosia, or face agnosia, results from damage to the FFA. The extrastriate body area is activated when bodies or body parts are viewed and the parahippocampal place area seems to be dedicated to recognizing spatial landscapes. Moreover, cells in the medial temporal lobe may be activated in response to specific people in specific situations.

Introduction

* Agnosias are acquired sensory deficits that occur without any loss of sensation.
* For example, Dr. P had a form of **object agnosia**, meaning that he could not recognize certain objects, despite the fact that he could see them.
* What object agnosias demonstrate is that we have specialized areas in the brain to identify specific objects.
* How the visual system recognizes objects is the focus of this chapter.

Introduction to Object Perception

* We recognize individual unfamiliar examples of familiar categories all the time, meaning that knowledge influences perception.
* Our ability to detect objects must overcome three aspects of the environment:
  + Image clutter—we must recognize an object despite the overlapping presence of nearby objects.
  + Object variety—we must recognize a particular object as a member of a particular category.
  + Variable views—we must recognize an object despite it being placed in different orientations.

Top-Down Processing and Bottom-Up Processing

* The physiology and anatomy of sensation can be distinguished from the psychological issues of perception.
* One way to look at this distinction is in the cognitive psychology arguments of top-down and bottom-up processing.
* **Bottom-up processing** means that physical stimuli influence how we perceive them.
* **Top-down** processing means that our existing knowledge of objects influences how we perceive them.

Recognition and Representation

* Memory and representation are integral to understanding object perception.
* **Recognition** refers to the ability to match a presented item with an item in memory.
  + We recognize two classes of objects.
    - Specific objects as members of larger classes (e.g., the object on the floor as a shoe).
    - Objects as specific instances of that category (e.g., that sock on the floor is one of my favorite leather shoes).
      * Being able to recognize specific instances of a particular category is vital in face recognition.
* **Representation** refers to the storage and/or reconstruction of information in memory when that information is not in use.
  + In cognitive psychology, a representation is the form in which information itself is stored.
  + If we consider a class of familiar faces, we need to be able to represent information about them.

Perceptual Organization

* **Perceptual organization** is the process by which multiple objects in the environment are grouped, allowing us to identify those objects in complex scenes.
  + This allows us to group what we see into coherent perceptions.
* Two important processes in perceptual organization are grouping and segregation.
  + **Grouping** is the process by which elements in a figure are brought together into a common unit or object.
  + **Segregation** is the process of distinguishing two objects as being distinct.

Gestalt Psychology and Perceptual Organization

* In the early 20th century, gestalt psychology was developed in Western Europe.
* Gestalt theorists claimed that the brain is holistic, with self-organizing tendencies.
  + That is, higher levels of organization take precedence over lower levels.
* For vision, gestalt psychologists argued that what we see is greater than individual parts; the process of perception is designed to see the scene rather than each individual piece.
* Gestalt psychologists were structuralists who thought that conscious perception was scaffolded on top of the building blocks of sensation.
  + Perception of a physical scene may not be directly predicted by the sensory components that it is composed of, but emerges when we integrate the components into a whole.
* Gestalt psychologists studied three principles about how our perceptual systems pick out the whole from its parts: figure-ground relations, laws of good fit, and laws of grouping.

Figure-Ground Organization

* **Figure-ground organization** refers to the experience viewers have as to which part of an image is in the foreground and which part is in the background.
* We more or less divide the world into two components:
  + The figure that is the object of concern.
  + The ground, which is the rest.
* Usually, the figure can easily be distinguished from the ground with the figure tending to be in the front and bottom of the field of vision and the ground in the back and top.
* However, figure-ground can be ambiguous in several situation.
* Many classic illusions, such as the face-vase, are examples of ambiguous figure-ground.

A Few Rules That Govern What We See as Figure and What We See as Ground

* The following rules allow us to make sense of complex scenes because we use our existing knowledge of the world to help us interpret what is visually in front of us.
  + The feature that appears in the foreground is often below the figure that appears in the background.
  + A figure with symmetrical borders is more likely to be judged as being in the foreground than in the background.
  + A figure is more likely to be perceived as being in the foreground if it is perceived to be on the convex (outward bulging) side of a border.

Gestalt Laws of Perceptual Grouping

* Perceptual grouping is the process by which visual systems combine figures within an image into wholes.
* Gestalt psychologists, primarily Max Wertheimer, developed several “laws” that predict how perceptual grouping occurs:
  + The **law of good continuation** states that edges that are smooth are more likely to be seen as continuous than edges that have abrupt or sharp angles.
  + The **law of proximity** states that elements that are close together tend to be perceived as a unified group.
  + The **law of similarity** states that elements that are similar (e.g., color, orientation, size, motion) to one another tend to be perceived as a unified group.
  + The **law of symmetry** states that elements that are symmetrical to one another tend to be perceived as a unified group.
  + The **law of common fate** states that elements that are moving together tend to be perceived as a unified group.

Perceptual Interpolation

* We infer the continuation of objects even when they are partially occluded by other objects.
* Filling in edges and completing surfaces are important functions of our object recognition system.
* **Edge completion** is the perception of a physically absent but inferred edge, letting us complete the perception of a partially hidden object.
  + The Kanizsa triangle and Necker cube are famous examples of edge completion. These figures have **illusory contours**, which are perceptual edges that exist because of edge completion but do not actually exist.
* Neuroscience data with monkeys suggest that edge detection cells in V1 and V2 respond to illusory edges as strongly as they do to real ones.
  + Thus, illusory contours seem to be a relatively low-level feature of object identification, supporting the gestalt view that we pick up features in the stimulus rather than as a function of nonconscious processing.

Recognition by Components

* Whereas gestalt psychologists emphasized a top-down approach, other research has emphasized a bottom-up approach—we use the information in the world to construct a perception of what we see.
* In the 1980s, Irving Biederman developed one of the most influential bottom-up theories of object recognition.
* In this view, the visual system breaks down objects in the environment into geometric ions, or **geons.**
* Geons represent the basic units of objects and consist of simple shapes such as pyramids and cylinders.
* This **recognition-by-components** theory states that object recognition occurs by representing each object as a combination of geons that make up that object.
* Biederman proposed that there were about 40 independent geons and that any object could be represented by a combination of them.
* However, this theory is limited in accounting for some phenomena, such as letter and face recognition.

The Neuroanatomy and Physiology of Object Perception

* One of the main functions of the ventral pathway is object recognition.

Representation of Shapes in Area V4

* After information leaves V1 and heads toward the extrastriate cortex along the ventral pathway, an important locus is area **V4** in the occipital cortex.
* V4 is linked to color vision.
* V4 is also linked to shape perception, particularly through response to contours.

Object Recognition in the Inferotemporal Area

* After leaving the occipital cortex, information goes to the **inferotemporal (IT) area** of the temporal lobe.
* Neurons in the IT have much larger receptive fields than those in V1 and V4.
* Neurons in the IT seem to be devoted to detecting specific kinds of objects in the visual field rather than specific features.

The Fusiform Face Area and Face Recognition

* The **fusiform face area (FFA)** is a specific region in the brain designed for recognition of faces. For example, the FFA distinguishes the face of Michael Jordan from the face of Kobe Bryant.
* The **occipital face area (OFA)** appears to make the initial identification of a face as a face, regardless of whether it is familiar.

Prosopagnosia

* Damage to the FFA results in **prosopagnosia** (face agnosia), in which there is a selective deficit in perceiving faces but other forms of object recognition are intact.
* The usual cause is stroke but it is sometimes congenital.
* Prosopagnosic patients can recognize people by other cues, however, such as voices, gait, or distinctive features like a birthmark.

Other IT Cortex Areas with Specific Object Recognition Functions

* The **parahippocampal place area (PPA),** located in the IT cortex, appears to specifically recognize spatial landscapes, both indoors and outdoors.
  + **Topographic agnosia** is a deficit in recognizing spatial landscapes and is related to damage of the PPA.
* The **extrastriate body area**, also in the IT cortex, is activated when bodies or body parts are viewed, but not faces.

Grandmother Cells and Specific Coding in the IT Cortex

* Is there an area in the brain in the IT cortex that codes for your grandmother, but no other person?
* In memory research, the pursuit to the answer of this question has been labeled the search for the engram. The engram is the specific location of a specific memory, such as the visual identity of your grandmother.
* Quiroga et al. (2005) conducted a unique study with patients undergoing brain surgery for epilepsy.
  + They asked the patients to look at a series of pictures presented on a computer screen while individual neurons were monitored.
  + In the medial temporal lobe, they found cells that appeared to be specific to individual people in specific circumstances.
  + For example, one cell was selectively responsive to a photograph of Kobe Bryant but not Mark Hamill whereas another cell had the opposite response. Moreover, the cells responded differently if the celebrities had different hairstyles or were wearing different clothes.
  + This study, however, has proved to be difficult to replicate.

***In Depth: Vision and Animacy: How Do We Tell a Who From a What?***

* Most of the research discussed thus far examines how we detect faces, Wheatley and colleagues investigated how we detect faces that have minds attached. That is, how do we discriminate the face of a doll from a real human face?
* When we see a face, it instantly activates face-sensitive areas of the brain, like the FFA.
* Wheatley and colleagues found that animate face recognition requires an additional step to go from face to mind. We must associate the face with a moving, living, animate being.
* Human visual systems are extremely sensitive to stimuli that look like human faces, but we often get “false alarms,” such as a well-made doll.