Chapter 3:
Sensation and Perception
Sensation

Sensation - the activation of special receptors in the various sense organs allowing outside stimuli to become neural signals to the brain:

Eyes, Nose, Ears, Skin, Tongue/Taste Buds, each gather information about your environment

A **stimulus** is an energy pattern (*such as light, sound, pressure, temperature*) which is registered by the sense organs
Sensation and Perception are linked to form the entire process through which we gain sensory input, convert it to electrochemical energy, and interpret the info so it makes sense...organization, form, and meaning.
**Sensation**

Gathering info about the world takes 2 steps

1. Electrical signals reach the brain where they are turned into **Sensations**

*Sensations* are relatively meaningless bits of information (left figure) that result when the brain processes electrical signals that come from the sense organs.
An overview of the Nervous System

**Nervous system**

- **Central nervous system**
  - The brain and spinal cord

- **Peripheral nervous system**
  - Transmits information to and from the central nervous system

- **Brain**
  - Interprets and stores information and sends orders to muscles, glands, and organs

- **Spinal Cord**
  - Pathway connecting the brain and the peripheral nervous system

- **Autonomic nervous system**
  - Automatically regulates glands, internal organs and blood vessels, pupil dilation, digestion, and blood pressure

- **Somatic nervous system**
  - Carries sensory information and controls movement of the skeletal muscles

- **Parasympathetic division**
  - Maintains body functions under ordinary conditions; saves energy

- **Sympathetic division**
  - Prepares the body to react and expend energy in times of stress
Neurons and Nerves

**Neurons** - the basic cell that makes up the nervous system and which receives and sends messages within that system.

**Nerves** – bundles of axons in the body that travel together through the body.
The Structure of a Neuron

Axon terminals - branches at the end of the axon

Soma - the cell body of the neuron, responsible for maintaining the life of the cell.

Axon - long-tube-like structure that carries the neural message to other cells.

Dendrites - branch-like structures that receive messages from other neurons.

Neurons - the basic cell that makes up the nervous system and which receives and sends messages within that system.

Synaptic knob – rounded areas on the end of axon terminals
The Structure of a Neuron

- Axon terminal (synaptic knobs)
- Nucleus
- Soma
- Axon
- Myelin sheath
- Dendrites
- Axon terminal (synaptic knobs)
The Synapse

**Synaptic knob** – rounded areas on the end of axon terminals.

**Synaptic vesicles** – sack-like structures found inside the synaptic knob containing chemicals.

**Neurotransmitters** – chemical found in the synaptic vesicles which, when released, has an effect on the next cell.

**Synapse/synaptic gap** – microscopic fluid-filled space between the axon terminals of one cell and the dendrites or surface of the next cell.

**Receptor sites** – proteins on the surface of the dendrites, or on muscles and glands, shaped to allow only certain neurotransmitters to bind there.
The Synapse

- Nerve impulse
- Synaptic knob of pre-synaptic neuron
- Synaptic vesicles
- Surface of post-synaptic neuron
- Neurotransmitter
- Sodium ions
- Receptor site
Sensory Receptors

Sensory Receptors - specialized forms of neurons- cells that make up the nervous system; instead of receiving Neurotransmitters from other cells, they are stimulated by different kinds of energy (stimuli/stimulus):

The receptors in your eyes (Sight) are triggered by light

The receptors in your ears (Sound) are triggered by vibrations.

The receptors in your skin (Touch) are triggered by pressure or temperature

The receptors in your Nose and Mouth (Smell + Taste) are triggered by chemical substances
Sensory Thresholds

Weber’s Law of **Just Noticeable Difference** (jnd) a.k.a. **Difference Threshold**:

Minimum amount of stimulation required to tell the **difference** between two **stimuli**.

Weber’s Law of **jnd** can be applied to different senses: the **brightness** of light, the **weight** of objects, the **length** of lines.

Our sensory systems are good at detecting changes in our surroundings, but we do better when the initial value of the **stimulus** is **weak** rather than **strong**.
Sensory Thresholds

Links to test Weber’s Law of *just noticeable difference* (jnd):


Weber’s Just Noticible Difference


**Outcome:**

Our sensory systems are good at detecting changes in our surroundings, but we do better *in detecting differences* when the initial value of the *stimulus* is *weak* rather than *strong*: (*soft tones vs. loud tones, weak [less concentrated] smells vs. strong [greater concentration] smells*), etc.
Absolute Thresholds

Absolute threshold - the smallest amount or lowest level of energy needed for a person to consciously detect a stimulus 50 percent of the time it is present. (Remember that jnd is detecting a difference between two stimuli)

<table>
<thead>
<tr>
<th>Table 3.1</th>
<th>Examples of Absolute Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SENSE</strong></td>
<td><strong>THRESHOLD</strong></td>
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<tr>
<td>Sight</td>
<td>A candle flame at 30 miles on a clear, dark night</td>
</tr>
<tr>
<td>Hearing</td>
<td>The tick of a watch 20 feet away in a quiet room</td>
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<tr>
<td>Smell</td>
<td>One drop of perfume diffused throughout a three-room apartment</td>
</tr>
<tr>
<td>Taste</td>
<td>1 teaspoon of sugar in 2 gallons of water</td>
</tr>
<tr>
<td>Touch</td>
<td>A bee’s wing falling on the cheek from 1 centimeter above</td>
</tr>
</tbody>
</table>
Absolute Thresholds

Another example:
How much salt must be added to a glass of water before a change in taste can be detected in at least half of the taste tests?
Subliminal Sensation

**Subliminal Stimuli** - stimuli that are below the level of conscious awareness.

– Just strong enough to activate the sensory receptors but not strong enough for people to be consciously aware of them.  **Limin** - “threshold” **Sublimin** - “below the threshold.”

**Subliminal Perception** – process by which subliminal stimuli act upon the unconscious mind, influencing behavior.

There is no evidence that subliminal stimuli in advertisements influence people’s behavior.
Habituation & Sensory Adaptation

- Habituation – brain stops attending to constant, unchanging stimuli (cognitive)
- Sensory adaptation – sensory receptors less responsive to constant

Does sensory adaptation mean that if I stare at something long enough, it will disappear?
Habituation and Sensory Adaptation

**Habituation** - Tendency of the brain to stop attending to constant, unchanging information.

Our brains are only really interested in changes in information and our brains “ignore” conscious attention to stimuli that does not change.

**Example:** Not “hearing” the air conditioner until the sound changes (stops, increases, decreases)

This is how our brains deal with unchanging information in our environments
Habituation and Sensory Adaptation

**Sensory Adaptation** - Tendency of *sensory receptor cells* to become less responsive to a stimulus that is unchanging.

**Example:** Walking into someone’s house you get a certain smell, but after awhile, the smell “goes away”

The difference between **Habituation** and **Sensory Adaptation**:

**Habituation:** Your sensory receptors are still responding to the stimulation but the lower centers of your brain are not sending signals from those sensory receptors to the brain’s cortex for interpretation.

**Sensory Adaptation:** *The receptor cells themselves* become less responsive to an unchanging stimulus and no longer send signals to the brain for interpretation.
Habituation and Sensory Adaptation

So if **Sensory Adaptation**, The tendency of **sensory receptor cells** to become less responsive to a stimulus that is unchanging, is “true” then explain why unchanging things we stare at for long periods of time do not disappear?

If I put tape on your arm after awhile you would not feel it; you don’t constantly feel your clothes because your skin (touch) adapts. So do your ears (sound), nose (smell), and mouth (taste)- so why not your eyes(vision)?
Habituation and Sensory Adaptation

Unchanging things we stare at for long periods of time do not disappear because of *Microsaccades* - constant tiny movement of the eyes that prevents sensory adaptation to visual stimuli (we do not consciously notice this)
Activity: Temperature Adaptation

Place one hand in a bowl of ice water and the other hand in a bowl of hot water for about 30 seconds-1 minute. Then take both hands and place them in lukewarm water.

When placed in the lukewarm water, the hand that was in the ice water will feel warm and the hand that was in the hot water will feel cold.

Why does it happen?

It's because all of our senses are relative. They don't measure an absolute temperature or an absolute brightness of light; they make their measurements relative to the things around it.

In the case of this experiment, the temperature sensors on your hands measure the temperature of the water relative to the temperature of your hand. If the water is warmer than your hand, it feels warm, and if it is colder than your hand, it feels cold: the receptors that got used to the hot water, send signals to the brain that sense the lukewarm water as cold; and the receptors that got used to the cold water sense the lukewarm water as hot and send that signal to the brain.
Sensory Adaptation

Some sense organs adapt quickly...some more slowly...depends on the intensity of the stimulation...

**Will your senses eventually adapt to any stimulation despite intensity level?**

Yes or No and Why???
Adaptation

Your sense organs **WILL NOT** adapt to intense forms of stimulation if the stimulation will cause physical damage... extreme heat or cold on your skin for example... or...
Transduction
When a sense organ changes or transforms physical energy into electrical signals...example:

A skunk’s spray/molecules enters your nose, molecules get transformed into electrical signals/impulses. These signals get interpreted by your brain as unpleasant odor.
Transduction refers to the process in which a sense organ changes, or transforms, physical energy into electrical signals that become neural impulses, which may be sent to the brain for processing.

For example, trans-
Activity: TBS
Activity: Pressure Phosphene
Vision: Properties of Light

We experience light in 3 aspects:

1. **Brightness** (intensity of light) - determined by the **amplitude** (height) of the light wave
   The higher the wave = the brighter the light. Low waves are dimmer.

   All light travels in the form of waves at a speed of about **186,000 miles per second**; (almost eight times around the Earth in 1 second).

2. **Color/Hue** is determined by the **length** of the wave. Length determines the type of light.

   Long wavelengths are found at the red end of the **visible spectrum** (the portion of the whole spectrum of light that is visible to the human eye), whereas shorter wavelengths are found at the blue end. The entire range of different kinds of light including the ones the human eye cannot see is called the **electromagnetic spectrum**.

3. **Saturation** - refers to the purity of the color people see.

   Highly saturated Red would contain only **Red wavelengths** while a less saturated red would contain a mixture of wavelengths.
Vision: Properties of Light- **Amplitude**

Amplitude is a measurement of the top (or bottom) half of the wave. What is the Amplitude of this wave?
Vision: Properties of Light - Amplitude

The Amplitude of the wave = 2
Vision: Properties of Light - Color/Hue

Figure 3.1 The Visible Spectrum
Vision: Properties of Light

Invisible—too short. On this side of the electromagnetic energy spectrum are shorter wavelengths, including gamma rays, X rays, and ultraviolet rays. These waves are invisible to the human eye because their lengths are too short to stimulate our receptors. However, some birds (such as hummingbirds) and insects can see ultraviolet rays to help them find food.

Visible—just right. Near the middle of the electromagnetic spectrum is a small range of waves that make up the visible spectrum.

The visible spectrum is one particular segment of electromagnetic energy that we can see because these waves are the right length to stimulate receptors in the eye.

The reason you can see a giraffe is that its body reflects light waves from the visible spectrum back to your eyes. One function of the eyes is to absorb light waves that are reflected back from all the objects in your environment.

Invisible—too long. On this side of the electromagnetic spectrum are longer wavelengths, such as radio and television waves. These waves are invisible to the human eye because their lengths are too long to stimulate the receptors in the eye. Imagine the awful distraction of seeing radio and television waves all day long!

Stimulus. Thus, the most effective stimulus for vision is energy (light waves) from the visible spectrum. However, for you to see anything, reflected light waves must be gathered and changed into electrical signals, and for that process—transduction—we must look inside the eye itself.
Like energy passing through the ocean, light energy travels in waves, too. Some light travels in short, "choppy" waves. Other light travels in long, lazy waves. Blue light waves are shorter than red light waves.

All light travels in a straight line unless something gets in the way to: Reflect it (like a mirror), Bend it (like a prism), or Scatter it (like molecules of the gases in the atmosphere)

Sunlight reaches Earth's atmosphere and is scattered in all directions by all the gases and particles in the air. Blue light is scattered in all directions by the tiny molecules of air in Earth's atmosphere. Blue is scattered more than other colors because it travels as shorter, smaller waves. This is why we see a blue sky most of the time.
So what accounts for this sky line in LA? Why the orange and yellow tint? Is it Smog...? NO!
As the Sun sets the light travels through MORE of the atmosphere and along the way more and more of the shorter wavelengths are scattered. By the time the light reaches your eye, all the blue and violet has been scattered out, leaving only the longer wavelengths in the sky for you to see. That's why a setting sun turns the sky red, orange, yellow and all shades in between. All of that scattered blue and violet is busy creating a blue daytime sky somewhere else in a different time zone.

But smog from a smoke stack or car is composed of particles of so many different sizes, the scattering is nearly indiscriminant. The aerosols in smog are varied, and relatively large, to the point that they can scatter every wavelength of light. The result is a sunset with no colors at all. The sky is simply a hazy, grayish white, with all of the yellow, orange and red having been scattered out before they could reach the eye.

Chances are, if you're seeing an especially colorful sunset in L.A., it's because the smog is low that day, not because it's heavy.
Stated another way...

Closer to the horizon, the sky fades to a lighter blue or white. The sunlight reaching us from low in the sky has passed through even more air than the sunlight reaching us from overhead. As the sunlight has passed through all this air, the air molecules have scattered and rescattered the blue light many times in many directions. Also, the surface of Earth has reflected and scattered the light. All this scattering mixes the colors together again so we see more white and less blue.

What Makes a Red Sunset?

As the Sun gets lower in the sky, its light is passing through more of the atmosphere to reach you. Even more of the blue light is scattered, allowing the reds and yellows to pass straight through to your eyes.
Parts of the Eye

1A. Aqueous Humor: clear watery fluid that supplies nourishment to the eye

The Pupil is inside the round muscle called the Iris (which is the colored part of the eye)

The Iris lets more or less light into the eye

The Lens is behind the Iris and finishes the focusing process started by the cornea

The Retina is the light-sensitive area at the back of the eye. Has 3 layers: Ganglion, Bipolar cells, and Photoreceptors.

Vitreous Humor: clear jelly-like fluid which nourishes the eye and gives it shape

The Iris opening that changes size depending on the amount of light in the environment

Changes shape to bring objects into focus
Parts of the Eye

1. Cornea: Bends light waves so the image can be focused on the retina.
2. Iris: Its muscles control the size of the pupil.
3. Pupil: Iris opening that changes size depending on the amount of light in the environment.
4. Lens: Changes shape to bring objects into focus.
5. Retina: Contains photoreceptor cells.
6. Fovea: Central area of retina; greatest density of photoreceptors.
7. Optic nerve: Sends visual information to the brain.
8. Blind spot (optic disc): Where the optic nerve leaves the eye. There are no photoreceptor cells here.
1. **Rod and Cones** receive the photons of light and turn them into neural-electrical signals and then send the signal to the  
2. **Bipolar Cells** (these connect the Rods and Cones to the cells in the optic nerve) and then to the  
3. **Ganglion Cells** that form the optic nerve with their axons.
How The Eye Works

- Cones located in fovea
  - day vision (color)
- Rods in periphery
  - night vision (black and white)
Rods and Cones

Rods are visual sensory receptors in the back of the retina that are responsible for non-color sensitivity to low levels of light.

Cones are visual sensory receptors in the back of the retina that are responsible for color vision and sharpness of vision.
Rods and Cones

Outer segment of rod cell containing photosensitive chemicals

Nucleus

Rod

Outer segment of cone cell containing photosensitive chemicals

Nucleus

Cone
Rods and Cones

- There are about 120 million Rods in each eye and are found all over the Retina except the very center (the Fovea), which only contains Cones. Rods are sensitive to changes in brightness but NOT color (wavelength), so they only see in black and white and shades of gray. * Rods are located on the periphery of the Retina and are also responsible for peripheral vision. Because Rods work well in low light, they allow your eye to adapt to low light situations and help us see movement.

**Dark Adaption:** The recovery of the eye’s sensitivity to visual stimuli in darkness after exposure to bright lights. Occurs as your eyes recover their ability to see when going from a brightly lit state to dark state-the brighter the light was, the longer it takes the Rods to adapt to the new lower levels of light.

**Light Adaptation:** The recovery of the eye’s sensitivity to visual stimuli in light after exposure to darkness. Occurs when going from a dark room to a brightly lit one- your Cones (6 million total found mostly near the middle of the Retina) have to adapt to the increased light level, and they do so much quicker (a few seconds) than Rods adapt to darkness because about 50,000 Cones have a direct line to the Optic Nerve and Cones need a lot more light to function as they are not as sensitive to light (Rods are sensitive to light but do not register color) so they work best in bright light.

**Full Dark Adaption:** Where you go from constant light to sudden darkness (turning the lights off in your bedroom) takes about 30 min for your Rods to adjust and as you get older the process takes longer (this is why some elderly people experience “night blindness” and have difficulty seeing well enough to drive at night or get around a dark room.

Rods work well in low light and allow us to adapt when going from light to low light/dark Cones are responsible for color vision and they function best in bright light (Going from a dark movie theater to the bright outdoors, your eyes adapt quicker).

*What will it be difficult to do in dim light and why?*
When looking at stars at night, did you ever think you saw smaller stars around the larger brighter stars out of your peripheral vision when you are focusing on the larger ones? Then when you turn you head to see those small stars they disappear? What is up with that?

Here is what’s up:

The Fovea (the central area of your Retina) has no Rods, but contains a high amount of Cones, which are responsible for color vision and sharpness.

Rods work well in low light are located on the periphery of the Retina and are responsible for peripheral vision. When focusing upon a star the Fovea is the central area and the Fovea’s Cones make things sharp. If you look at a small dim object in the dark it cannot be seen if you look directly at it.

This is why when you look up at the stars at night you seem to see fainter stars next to the ones you are focusing on; to detect faint stars in the sky, you have to look just to one side of them so that their light falls on the area of the eye that contains the most rods.
Activities:

Rods and Cones: Dark Adaptation
   Autokinetik Illusion
Seeing your Retina
Figure 3.3 Common Visual Problems: Nearsightedness and Farsightedness

- **Normal eye**: In focus on retina.
- **Nearsighted eye**: Focus in front of retina.
- **Farsighted eye**: Focus behind retina.

The Eyeball is too long
The Eyeball is too short
Crossing of the Optic Nerve

Light falling on the left side of each eye’s retina (from the right visual field, shown in yellow) will stimulate a neural message that will travel along the optic nerve to the visual cortex in the occipital lobe of the left hemisphere. Notice that the message from the temporal half of the left retina goes directly to the left occipital lobe, while the message from the nasal half of the right retina crosses over to the left hemisphere (the optic chiasm is the point of crossover). The optic nerve tissue from both eyes joins together to form the left optic tract before going on to the left occipital lobe. For the left visual field (shown in blue), the messages from both right sides of the retinas will travel along the right optic tract to the right visual cortex in the same manner.
Goggles
Color Vision

Color Vision Theories:

1. **Trichromatic**: 3 types of Cones: Red, Blue, and Green. These Cones “combine” to form different colors: If red Cones and green Cones are firing (faster than other Cones) in response to a stimulus then the person will see yellow. If red Cones and blue Cones are firing then the result is magenta.

2. **Opponent-Process**: Cones are arranged in pairs with four primary colors red, green, blue, and yellow: red Cones with green Cones and blue Cones with yellow Cones. If one member of the pair is stimulated, the other member of the pair cannot be working. Example: If a red Cone is stimulated, then the green Cone cannot be working. So...there are NO reddish-greens or bluish-yellows (hence Opponent-Process).

*Both theories play a part in color vision*
Trichromatic Theory

- Trichromatic theory - three types of cones: red, blue, and green
  - firing rate of cones and color
Opponent-Process Theory

Afterimages

- Opponent-process theory — four primary colors with cones arranged in pairs
Opponent-Process Color Theory

So you may be thinking “I thought the primary colors were Red, Yellow and Blue?”

Correct if you are talking about *painting*, but not when talking about *light*: Paint reflects light. The way *reflected light mixes* is different from the way *direct light* mixes.

Blend Red, Yellow, and Blue paint together (Reflected light) and what color do you get?

![Diagram showing mixing of colors]

Blend Red, Yellow, and Blue lights together (Direct light) by focusing them on the same spot and what color do you get?

![Diagram showing mixing of lights]
Here are a pair of Cones: Blue and Yellow. When one Cone within the pair is firing, it shuts off the ability of the other Cone to fire.

If you stare at a Blue image for a minute, the Blue Cone is firing and inhibiting (stopping) the Yellow Cone from firing, but, as you continue to stare, you are tiring out or weakening the Blue Cone’s ability to stop the Yellow cone from firing.

When you look away from the blue image, the Yellow Cone is no longer inhibited and will begin to fire giving you a yellow **Afterimage**.
Stare at the white dot in the center of this oddly colored flag for about 30 seconds. Now look at a white piece of paper or a white wall. Notice that the colors are now the normal, expected colors of the American flag. They are also the primary colors that are opposites of the colors in the picture and provide evidence for the opponent-process theory of color vision.
Activity

Afterimage: Religious
There are 3 main types of color blindness, (Monochromatic, Diacromatic and Tritanopia) though some people can have cones that are weaker and slightly alter the way they see color:

1. **Monochromatic colorblindness** – Very rare; person either have no cones or they have cones that are not working at all. If they do have cones they have only 1 type and therefore everything looks the same to the brain (shades of gray).

2. **Dichromatic colorblindness** – A. **Protanopia** *(Red-Green)*- the red cone does not function. B. **Deuteranopia** *(another Red-Green color deficiency)* results from the lack of functioning green cones. People with these forms would see in blues, yellows, and shades of gray.

3. **Tritanopia colorblindness** - *(blue-yellow color deficiency)*. If the blue cones are not working then the person sees in reds, greens, and shades of gray. Blue yellow color blindness is quite uncommon; people who are blue-yellow color blind will confuse some shades of blue with green, and some shades of yellow with violet. Much like red green color blindness, those who are blue yellow color blind can be categorized in two ways. However, unlike red and green color blindness, blue yellow color blindness is not more prominent in males.
What numbers do you see?

The number 8 is visible only to those with normal color vision.

The number 96 is visible to those with normal color vision, while those with red-green color blindness will see nothing but a circle of dots.
What number do you see?
Those with normal color vision see this 5. People with red-green will see a 2.
What number do you see?
Those with normal color vision see this 3.
People with red-green will see a 5.
What number do you see?

People with normal color vision will not see any number. Those with Red-Green color blindness will see a 5.
Can you trace the wiggly line?
Can you trace the wiggly line?
Ishihara Color Blindness Test

http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates/
Synesthesia

- Synesthesia – sensory information processed in wrong cortical areas
  - information interpreted as more than one sense
Synesthesia

• A *synesthete* is a person with *synesthesia*, which literally means “joined sensation.” People with this condition are rare—about 1 in 25,000. In the synesthete, the signals that come from the sensory organs, such as the eyes or the ears, go to places in the brain in which they weren’t originally meant to be, causing those signals to be interpreted as more than one sensation. A fusion of sound and sight is most common, but touch, taste, and even smell can enter into the mix.