

Lecture 8

Human Input-Output Channels - Part II

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In the Last Lecture

- Input-Output Channels
- Input via Senses
- Output via Effectors
- Vision
- Human Eye
- Visual Perception
- Capabilities and Limitations

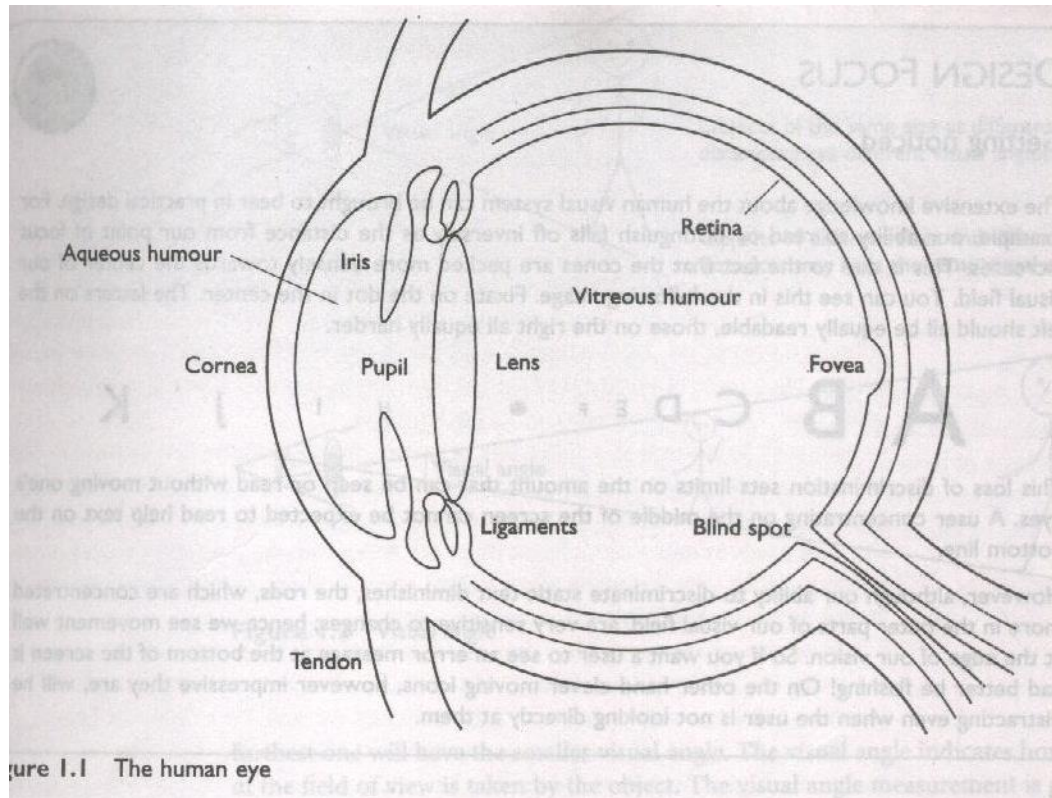
Input via Senses

- Vision
- Hearing
- Touch
- Taste
- Smell

Output via Effectors (Responders)

- Limbs
- Fingers
- Eyes
- Head
- Vocal system

Human Eye



Visual Perception

- Size
- Depth
- Brightness
- Color

Factors Affecting Visual Perception

- Perception of depth
 - Cues to determine relative positions of objects
 - Objects overlapping
- Size and height of object
 - Provides cue for distance
- Familiarity
 - Certain size helps to judge the distance accordingly

Perceiving Brightness

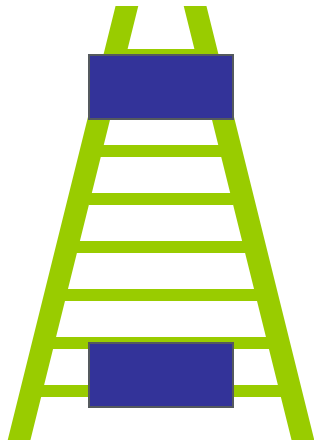
- Brightness
 - subjective reaction to levels of light
 - affected by luminance of object
- Luminance
 - Depends on
 - Amount of light falling on object
 - Reflective properties of object
 - Measured by photometer
- Contrast
 - Function of the luminance of an object and the luminance of its background

Perceiving Color

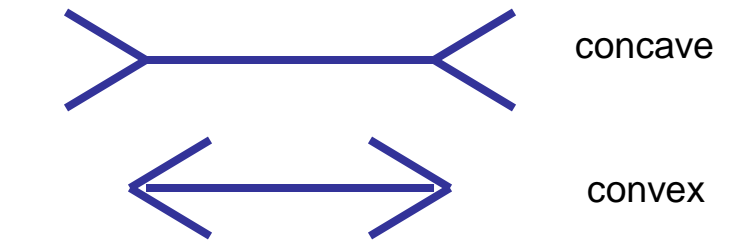
- 3 components
 - Hue
 - Determined by the spectral wavelength
 - Blue (short)
 - Green (medium)
 - Red (long)
 - 150 hues determined by eye
 - Intensity
 - Brightness of color
 - Saturation
 - Amount of whiteness in the color
- 7 million colors can be perceived

Over Compensation Illusions

- Optical illusions sometimes occur due to over compensation
 - Our perception of size is not reliable



the Ponzo illusion



the Muller Lyer illusion

Proof-Reading Illusion

The quick brown

fox jumps over the

the lazy dog.

In Today's Lecture

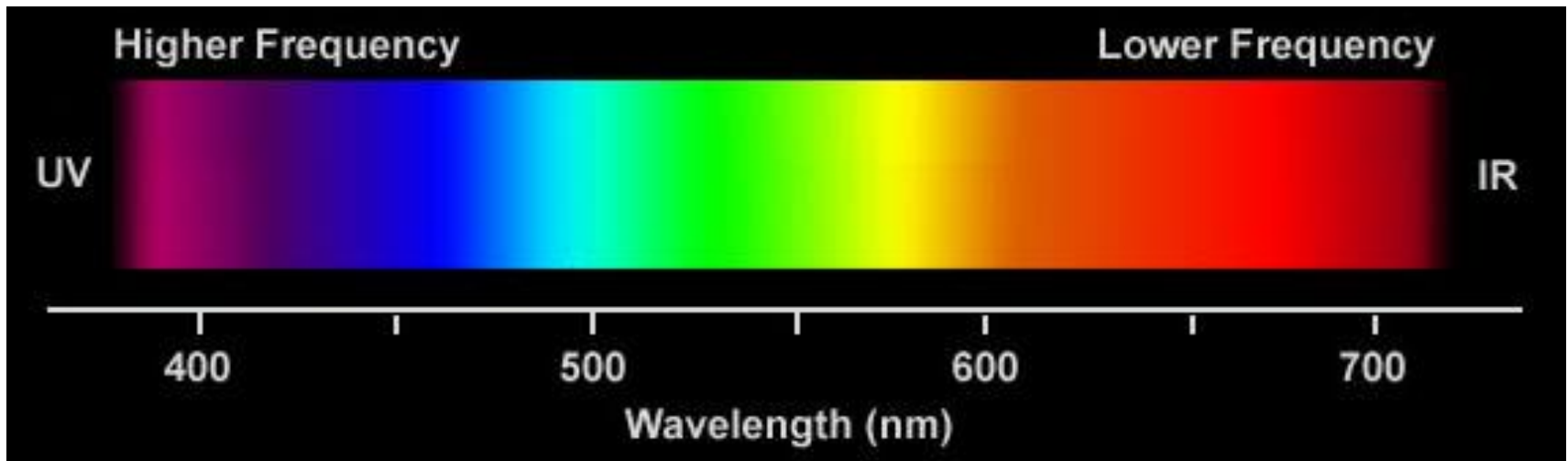
- Vision
 - Color Theory
 - 3D Vision
 - Reading
- Hearing
 - Human Ear
 - Processing Sound
- Touch (Haptic Perception)
 - Skin Physiology
 - Types of haptic senses
- Movement
 - Movement Perception

Why Study Color?

- Color can be a powerful tool to **improve** user interfaces, but its inappropriate use can severely reduce the performance of the systems we build

Color

- Sensory response to electromagnetic radiation in the spectrum between wavelengths 0.4 - 0.7 micrometers



Color Theory

- Primary Color
- Secondary Color
- Tertiary Color
- Color Harmony
- Color Context

Color Theory

- Primary Color
 - Red, yellow and blue
 - 3 pigment colors that can not be mixed
 - Can not be formed by any combination of other color
- Secondary Color
 - formed by mixing the primary colors
- Tertiary Color
 - formed by mixing one primary and one secondary color



PRIMARY COLORS
Red, yellow and blue



SECONDARY COLORS
Green, orange and purple



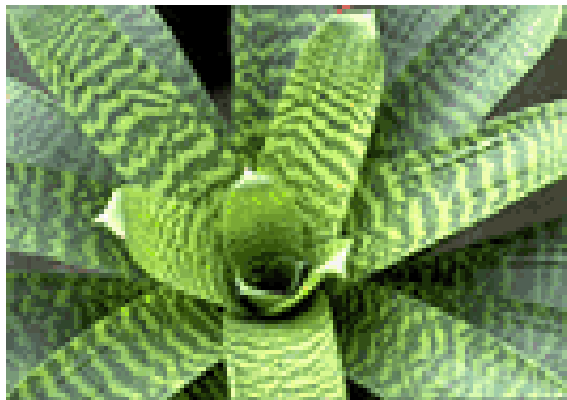
TERTIARY COLORS
Yellow-orange, red-orange, red-purple, blue-purple, blue-green and yellow-green

Color Harmony

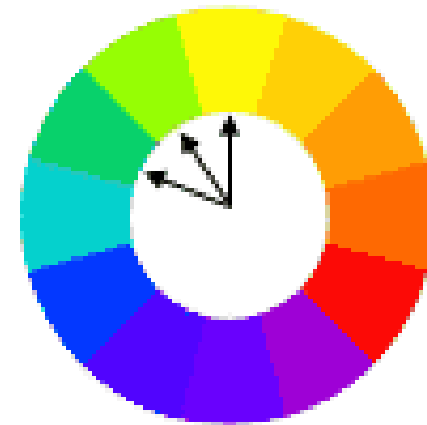
- pleasing arrangement of parts, whether it be music, poetry, color, or even an ice cream sundae
- When something is not harmonious, it's either boring or chaotic
- extreme unity leads to under-stimulation
- extreme complexity leads to over-stimulation.
- Harmony is a dynamic equilibrium.

Color Harmony

- Some Formulas for Color Harmony
 - analogous colors
 - any three colors which are side by side on a 12 part color wheel
 - yellow-green, yellow, and yellow-orange
 - Usually one of the three colors predominates.



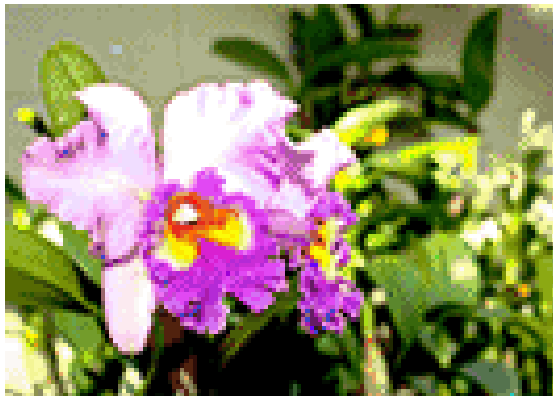
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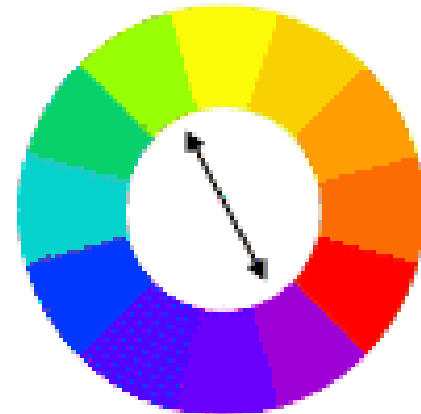
A color scheme based on analogous colors

Color Harmony

- Some Formulas for Color Harmony
 - complementary colors
 - any two colors which are directly opposite each other
 - red and green and red-purple and yellow-green



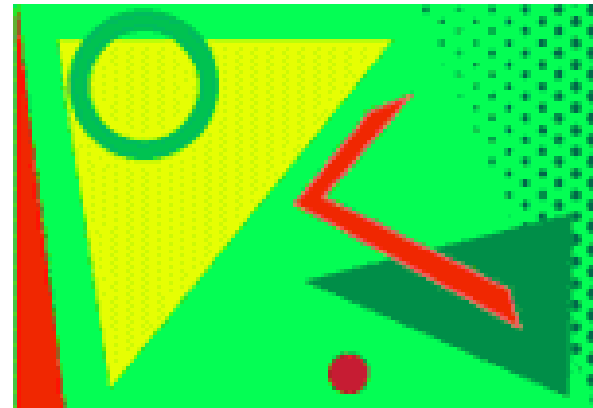
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A color scheme based on complementary colors

Color Harmony

- Nature provides a perfect departure point for color harmony
- red yellow and green create a harmonious design, regardless of whether this combination fits into a technical formula for color harmony

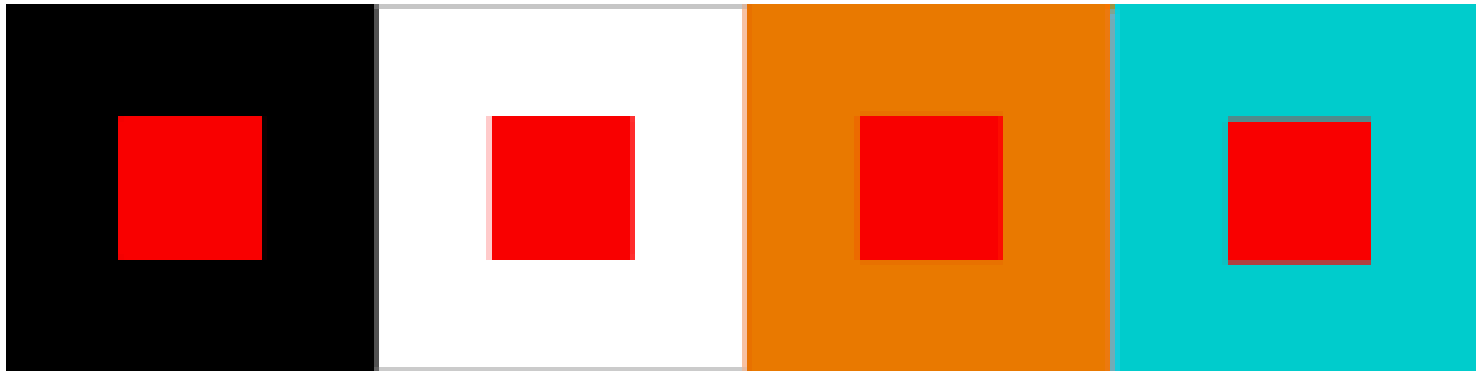


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A color scheme based on nature

Color Context

- How color behaves in relation to other colors and shapes is a complex area of color theory.
- Compare the contrast effects of different color backgrounds for the same red square



Color Context

- Different readings of the same color

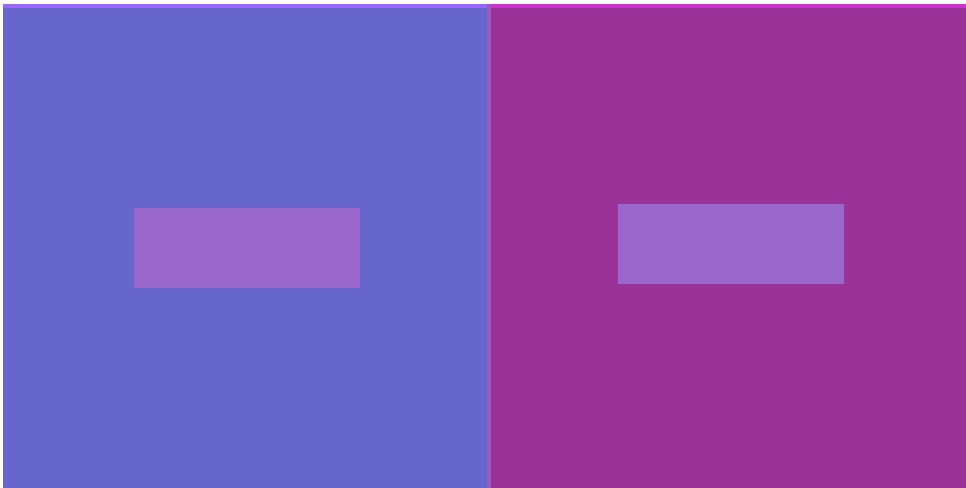


Figure a

Which is the lighter vertical bar?

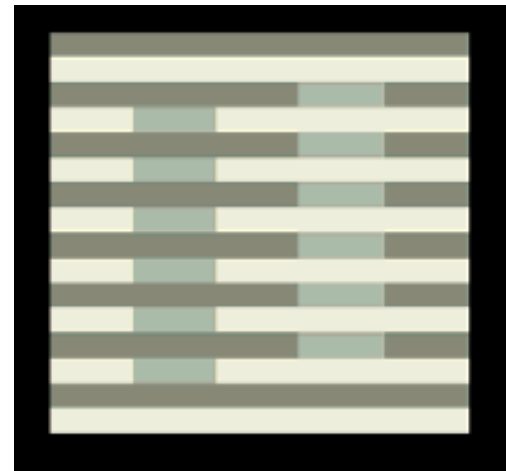
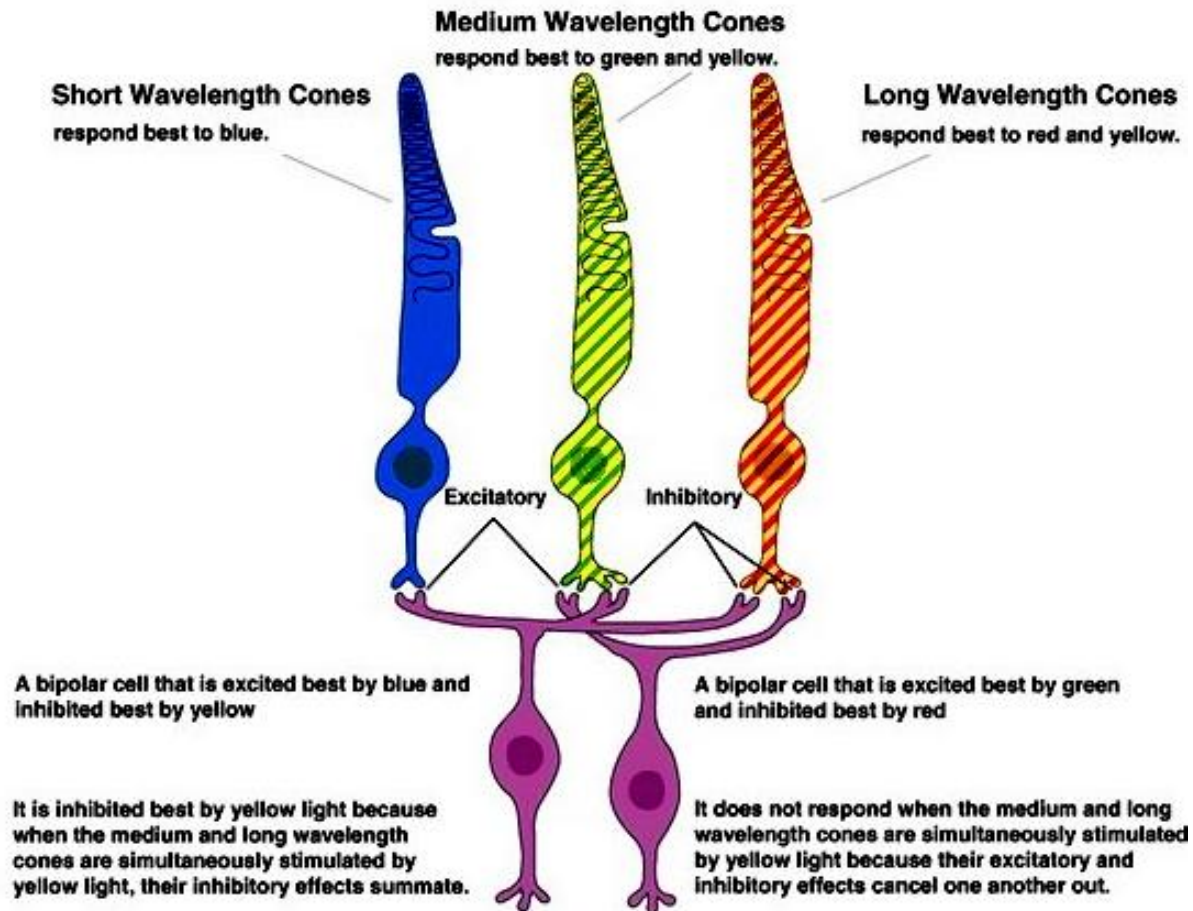


Figure b

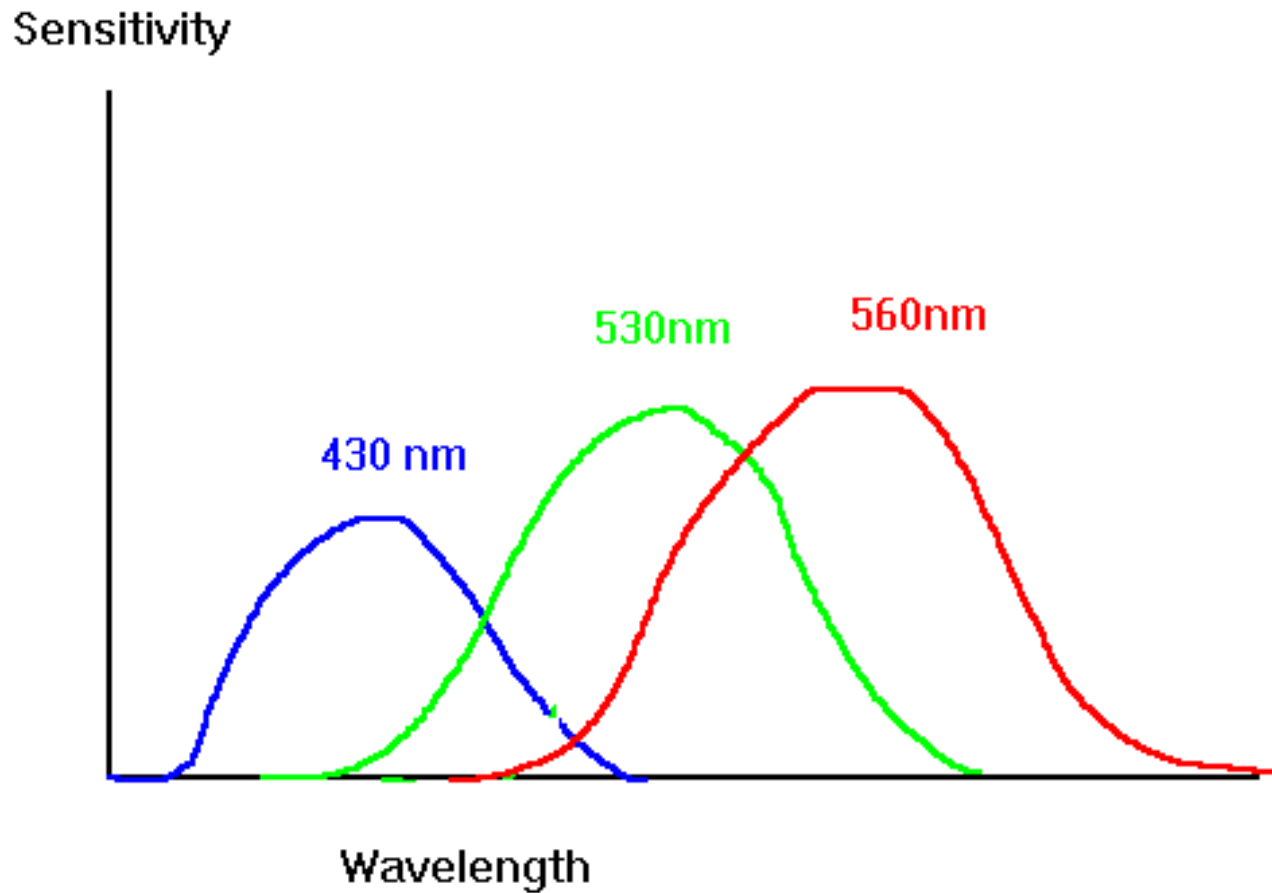
Color Perception via Cones

- Photopigments” used to sense color
- 3 types
 - blue, green, “red” (really yellow)
 - each sensitive to different band of spectrum
 - ratio of neural activity of the 3 → color
 - other colors are perceived by combining stimulation

Color Perception via Cones

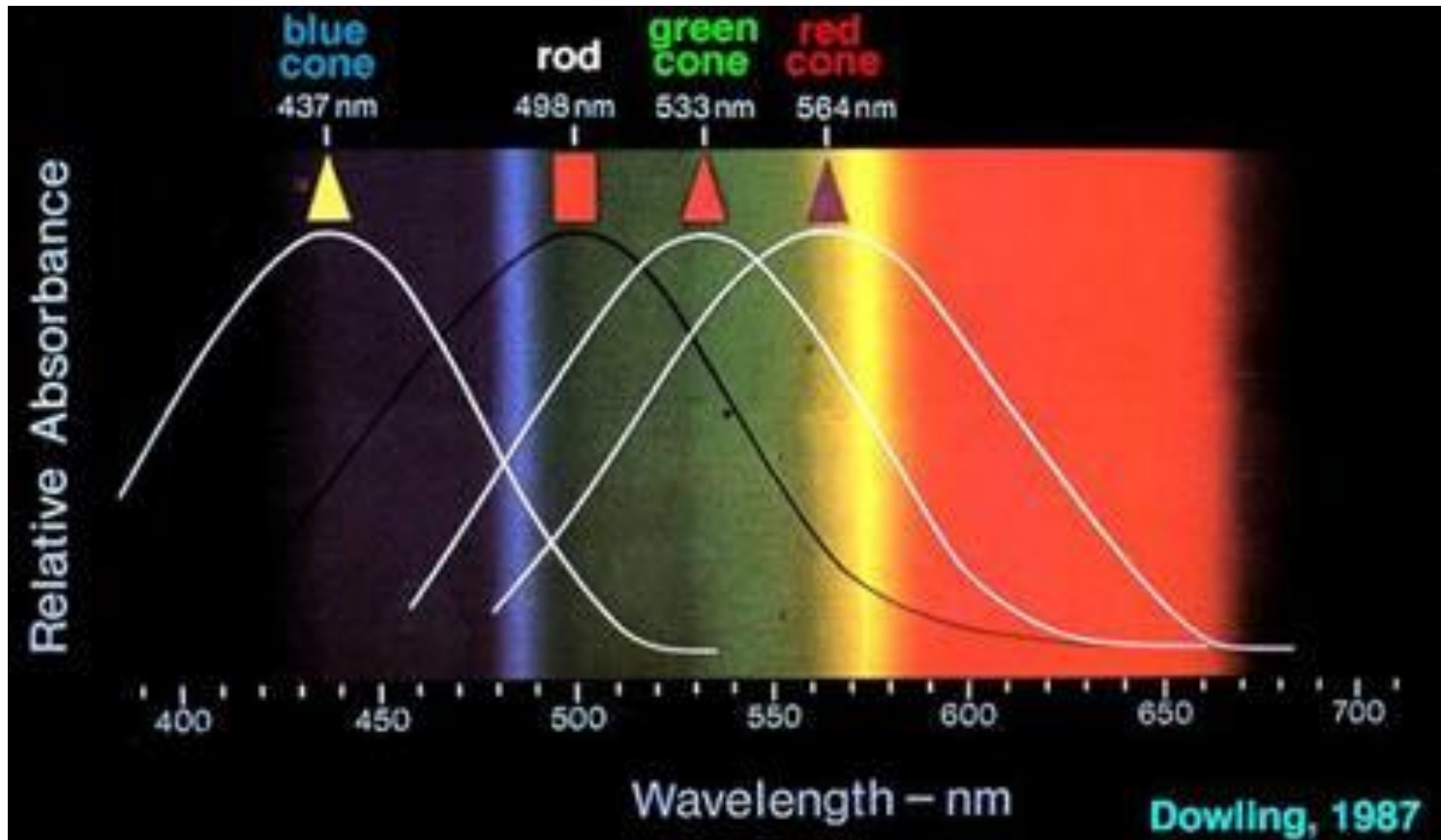


Color Sensitivity



from: <http://www.cs.gsu.edu/classes/hypgraph/color/coloreff.htm>

Color Sensitivity



Distribution of Photopigments

- Photopigments” used to sense color
- Not distributed evenly
 - mainly reds (64%) & very few blues (4%) →?
 - insensitivity to short wavelengths
 - cyan to deep-blue
- Center of retina (high acuity) has **no** blue cones →?
 - disappearance of small blue objects you fixate on

Color Sensitivity & Image Detection

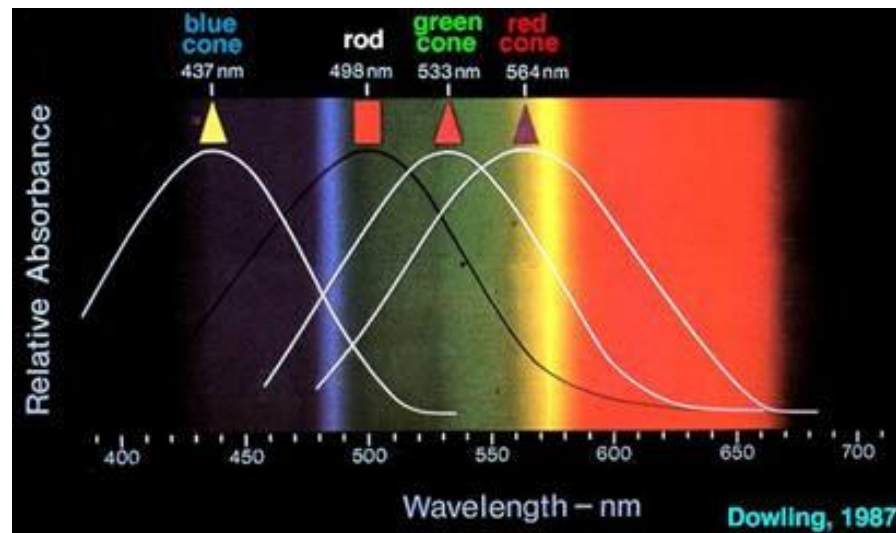
- Most sensitive to the center of the spectrum
 - blues & reds must be brighter than greens & yellows
- Brightness determined mainly by R+G
 - combine brightness & color differences for sharpness
- Shapes detected by finding edges
- Implications?
 - hard to deal w/ blue edges & blue shapes

Color Sensitivity & Image Detection

- As we age
 - lens yellows & absorbs shorter wavelengths →?
 - sensitivity to blue is even more reduced
 - fluid between lens and retina absorbs more light
 - perceive a lower level of brightness
- Implications?
 - don't rely on blue for text or small objects!
 - older users need brighter colors

Focus

- Different wavelengths of light focused at different distances behind eye's lens
 - need for constant refocusing → ?
 - causes fatigue
 - be careful about color combinations

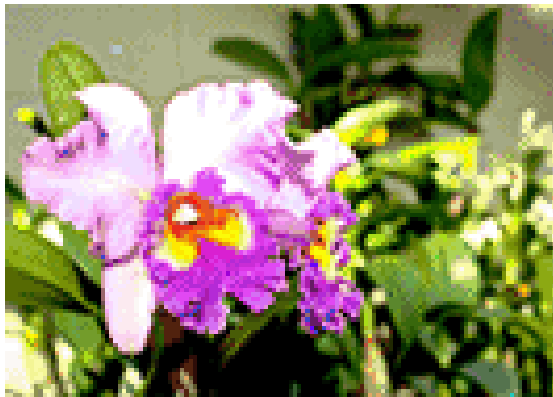


Focus

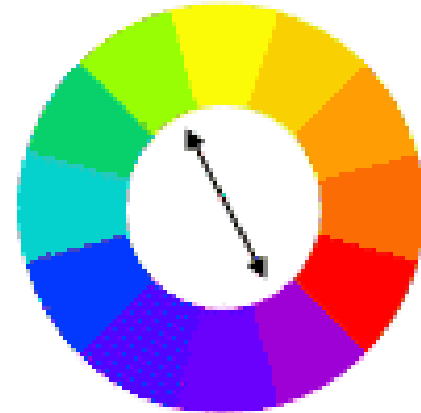
- Different wavelengths of light focused at different distances behind eye's lens
 - need for constant refocusing → ?
 - causes fatigue
 - be careful about color combinations
- Pure (saturated) colors require more focusing than less pure (desaturated)
 - don't use saturated colors in UIs unless you really need something to stand out (stop sign)

Color Guidelines

- Opponent colors go well together
 - (red & green) or (yellow & blue)
 - Hering's opponent colors diagram →
- Pick non-adjacent colors on the hue circle



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Color Guidelines

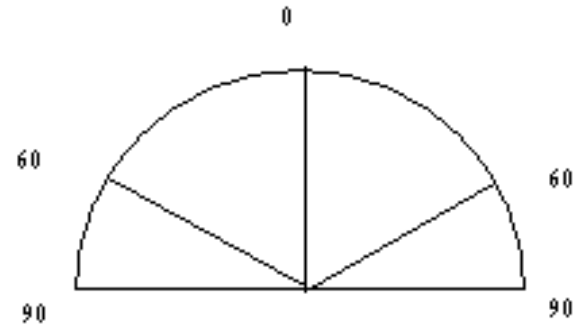
- Size of detectable changes in color varies
 - hard to detect changes in reds, purples, & greens
 - easier to detect changes in yellows & blue-greens
- Older users need higher brightness levels to distinguish colors
- Hard to focus on edges created by color alone →?
 - use both brightness & color differences
- Avoid red & green in the periphery - why?
 - lack of RG cones there -- yellows & blues work in periphery

Color Guidelines

- Avoid pure blue for text, lines, & small shapes
 - blue makes a fine background color
 - avoid adjacent colors that differ only in blue
- Avoid single-color distinctions
 - mixtures of colors should differ in 2 or 3 colors
 - e.g., 2 colors shouldn't differ only by amount of red
 - helps color-deficient observers

Color Guidelines

- Accurate color discrimination
 - ± 60 degree of straight head position.
 - Not uniform across the whole field of vision
- Limit of color awareness
 - ± 90 degree of straight head position
- Cultural issue
 - Society classifies color differently



3D vision

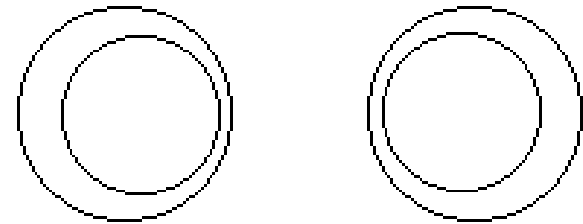
- give an immediate perception of depth on the basis of the difference in points of view of the two eyes.
- Also known as *binocular vision* and *stereopsis*
- most reliable clue for depth
- This is possible only when the eyes of a creature look in the same direction, and have overlapping fields.
- Stereopsis gives a reliable distance clue as far away as 450 meters

2D to 3D

- Strong Clues
 - apparent sizes of objects of known size
 - overlapping and parallax
 - shadows and perspective
- Weaker Clues
 - atmospheric perspective (haze and scattering)
 - speed of movement
 - observed detail
- Strongest Clue
 - stereopsis

2D to 3D

- free fusion
 - Keep two pictures side by side
 - each eye sees its picture straight ahead
 - a third, fused, image appears
 - appears strikingly solid
 - Brain regards this real one
- stereo pair
 - The two images are called a *stereo pair*



If you fuse this stereopair, you will see a frustum of a right cone in three dimensions.

A Simple Stereopair

Reading

- Stages
 1. visual pattern perceived
 2. decoded using internal representation of language
 3. interpreted using knowledge of syntax, semantics, pragmatics
- Reading involves saccades and fixations (perception here: 94%)
- Perception occurs during fixations
- Regressions: eye move backwards and forwards
- Word shape is important to recognition

Reading

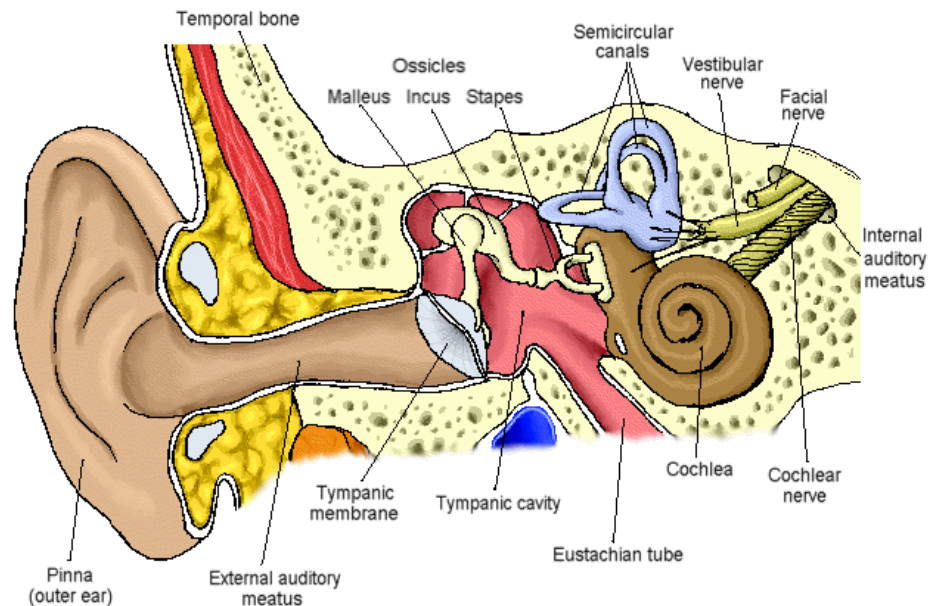
- Negative contrast improves reading from computer screen
- Average Reading Speed: 250 words per minute
 - Word shape important: Bat, BAT
- Reading speed is a measure of legibility
 - Font sizes
- Reading from computer screen slower due to ...
- Legibility can be increased using negative contrast ...

Human Auditory Perception

- Second to sight
- We under estimate amount of info received via ears
- Lets hear a few sounds
 - Sound 1 of a Vehicle coming Towards you
 - Sound 2 of a Vehicle going away from you

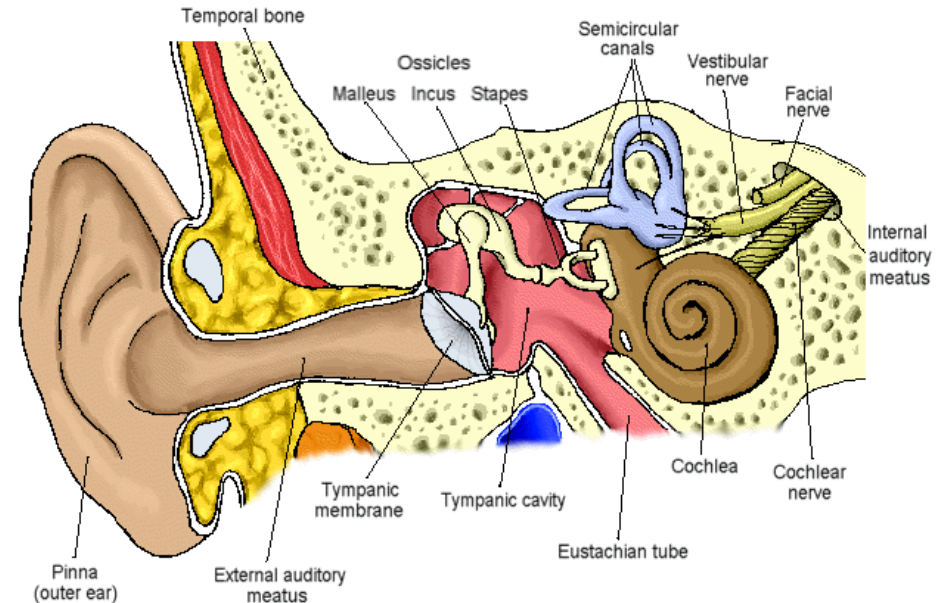
Hearing

- Provides information about environment:
distances, directions, objects etc.
- Vibration in air – Sound Waves
- Human Ear
 - Outer
 - Middle
 - Inner Ear



Human Ear

- Outer Ear
 - Visible part divided into two
 - Pinna
 - Auditory Cannal
- Outer ears purpose
 - Protect middle ear from damage
 - Middle ear temperature maintenance
 - Pinna and Cannal amplify some sounds
- Middle Ear
 - Tympanic membrane or ear drum connection to outer ear
 - Cochlea to inner ear
 - Ossicles (smallest bones in the body)
- Inner Ear
 - Filled with Cochlea fluid
 - Within are Cilia which bend with vibration and cause impulses to brain.



Processing Sound

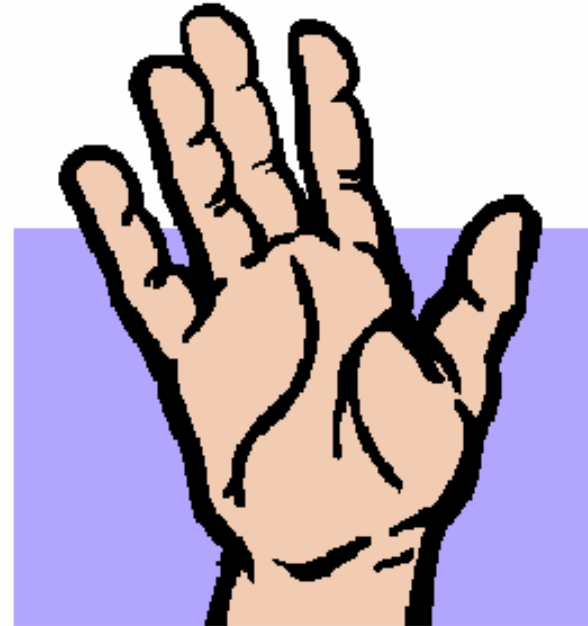
- Sound characteristics
 - Pitch
 - frequency of sound
 - Loudness
 - proportional to amplitude of sound
 - Timbre
 - relates to type of sound

Processing Sound

- Audible range 20 Hz to 15 KHz
- Distinguish between changes less than 1.5 Hz but less accurate at higher frequencies
- Different frequencies trigger neuron activity causing nerve impulses
- Auditory system filters sounds
 - Cocktail Party Effect: can attend to sounds over background noise
- Sound rarely used in interface design

Touch

what is *haptic*?



“Haptesthai” in Greek : **to touch**

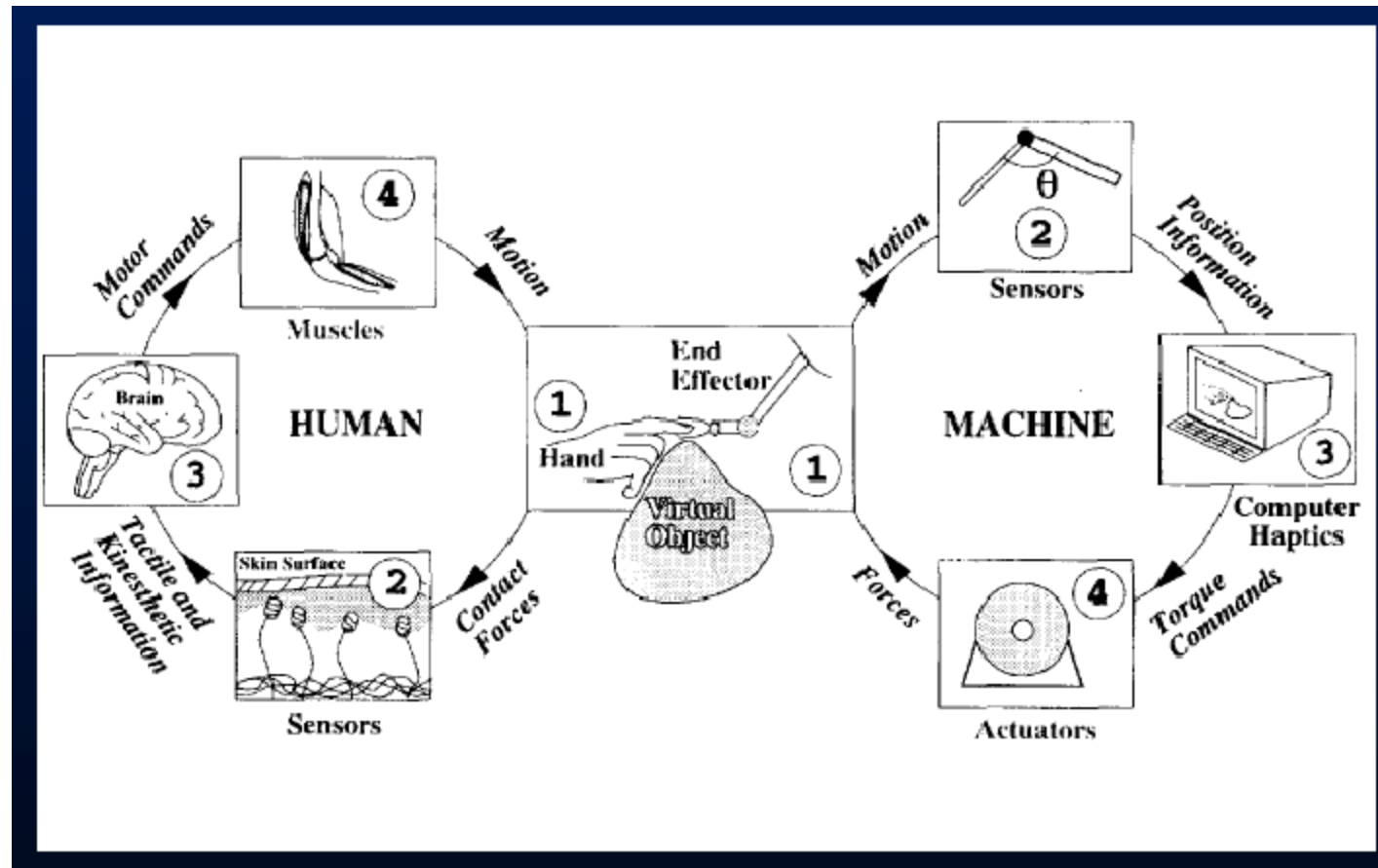
Touch (Haptic Perception)

- Close your eyes and pick a cup of tea
- What can you tell about the cup?
- Can you identify its material ?
- Is it hot of cold
- What is the texture
- Can you find the handle?
- Speed and accuracy reduced without touch

Touch (Haptic Perception)

- What has this got to do with Computers?
- Imagine a key board where you cannot feel the buttons pressed?
- Have you ever noticed the “marking” on “F” and “J” keys ?
- How your Mobile phone has an indicator to digit 5 ?
- Virtual Reality has no touch
- Provides important feedback about environment.
- May be key sense for someone who is visually impaired - braille

How haptic interaction works?



From MIT "TouchLab"

Types of human haptic sensing

- Tactile
 - sense stimulus through the skin
 - heat, pain, pressure, texture (cutaneous)
- Kinesthesia
 - sense of limb *motions*
 - affects comfort and performance
 - Due to receptors in joints:
 - Rapidly adapting: limb in particular direction
 - Slowly adapting: limb movement and static
 - Positional receptors: limb static
- Proprioception
 - awareness of limb *locations*
 - movements and shapes, temperature, and pain

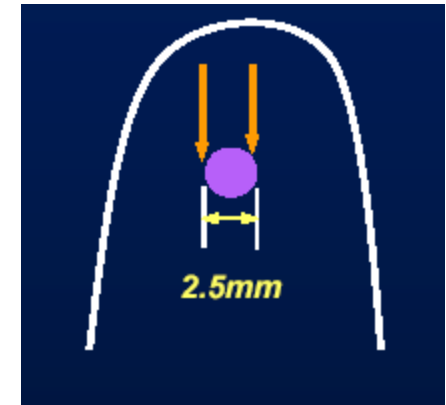
Types of human haptic sensing

- active & passive touch
 - “exploratory procedures”: directed manipulations to determine specific properties of touched objects

<i>action mode</i>	<i>source of information</i>		
	<i>cutaneous</i>	<i>kinaesthesia</i>	<i>afferent copy</i>
Tactile perception	X		
Passive kinaesthetic perception		X	
Passive haptic perception	X	X	
Active kinaesthetic perception		X	X
Active haptic perception	X	X	X

Skin Physiology

- Some areas more sensitive than others e.g. fingers.
 - 2-point threshold test
 - 2 pencils: place 12mm apart on thumb and move
 - >distance => > sensitivity
 - Fingers have highest acuity (10x forearms)
 - Spatial resolution of about 2.5 mm
 - Multiple forces closer are sensed as one
- Stimulus received via sensory receptors in the skin
 - thermoreceptors – heat and cold
 - nociceptors – pain
 - Mechanoreceptors: pressure (of concern in HCI)
 - Rapidly adapting (immediate and increased pressure)
 - Slowly adapting (continuously applied pressure)



Movement (Motor Control)

- Time taken to respond to stimulus:
 reaction time + movement time
- Movement time dependent on age, fitness etc.
- Reaction time - dependent on stimulus type:
 - visual ~ 200ms
 - auditory ~ 150 ms
 - pain ~ 700ms
- Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.

Movement

- Speed and accuracy
 - Relationship between the two?
 - Depends on skill: typists

Movement

- Fitts' Law describes the time taken to hit a screen target (function of size of target and distance that has to be moved):

$$Mt = a + b \log_2(D/S + 1)$$

where: a and b are empirically determined constants

Mt is movement time

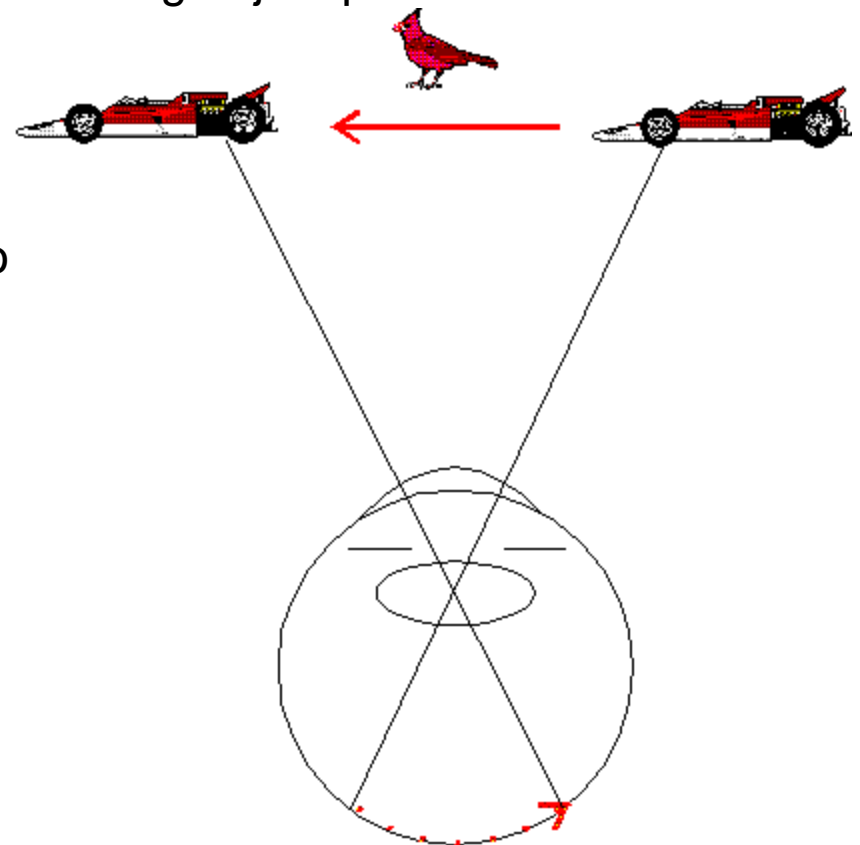
D is Distance

S is Size of target

⇒ targets as large as possible
distances as small as possible

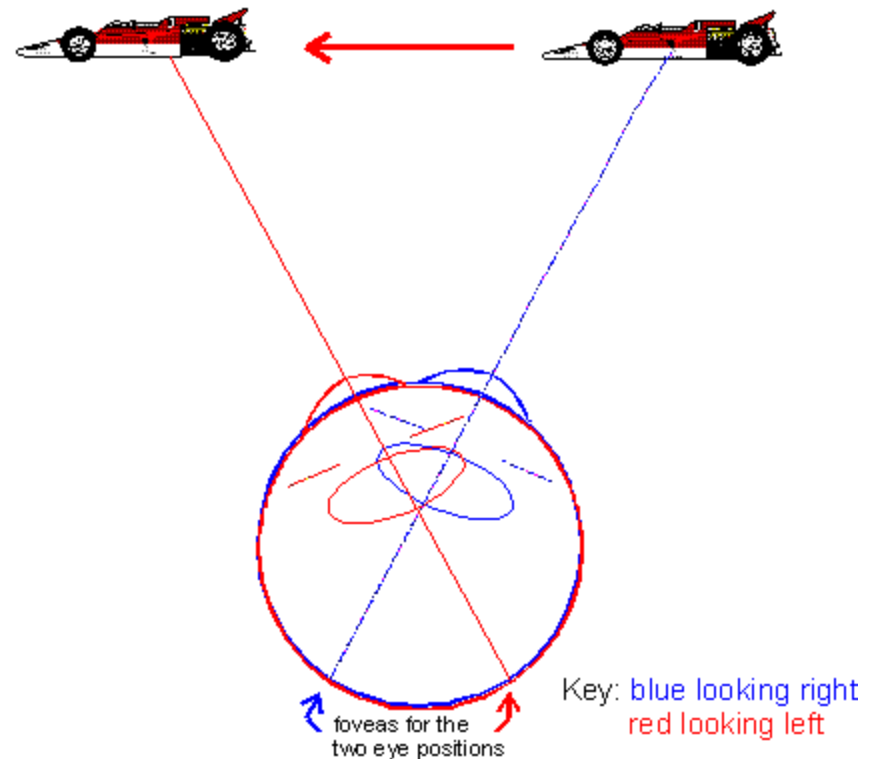
Movement Perception

- Three modes of viewing a moving object
 - hold our heads and eyes still as a moving object passes in front of us
 - Stare at bird
 - Perceive Car moves from right to



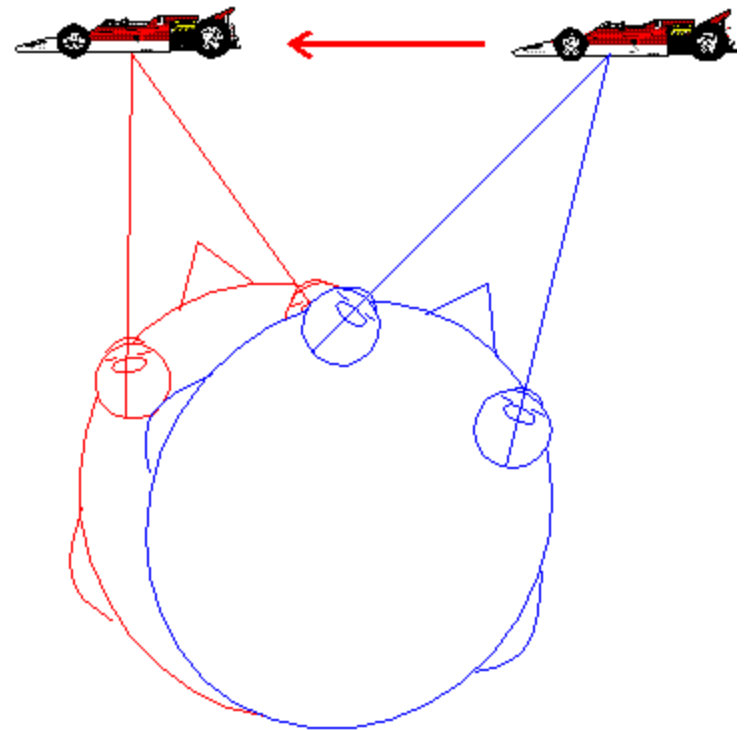
Movement Perception

- hold our heads still and let our eyes follow the object
 - image remains on the fovea during the motion of the car and your eyes.



Movement Perception

- hold our eyes steady and move only our head to follow an object
 - This causes the image to project to exactly the same retinal location at each instant (assuming you move your head at precisely the correct angular velocity) as the car moves from right to left.



Movement Perception

- Motion After Effect
 - Known as adaptation effect
 - when the stimulus is not moving
 - a waterfall example
- Explanation
 - motion detection system
 - motion detectors
 - undergo spontaneous activity
- Phi phenomenon
 - motion being seen, when there is no physical motion
 - two illuminated spots of light about 6 to 8 inches apart
- Films and Cartoons
 - Still frames are rapidly projected.

Movement Perception

- induced motion
 - Sit in a stationary train
 - When any other train passes next to you
 - You feel moving
- Auto kinetic movement
 - view a small very **dim light** in an otherwise completely **dark room**
 - After sometime in the dark, the small light will appear to move somewhat randomly
- Cortical neuron
 - specialized for movement
 - respond best when the motion is in a specific direction

Smell/olfaction

- Nose and Computing ???
- Experiments are being done to transmit smells across the net
- Biometric devices to identify one person from another

Next Lecture

- Memory Structures