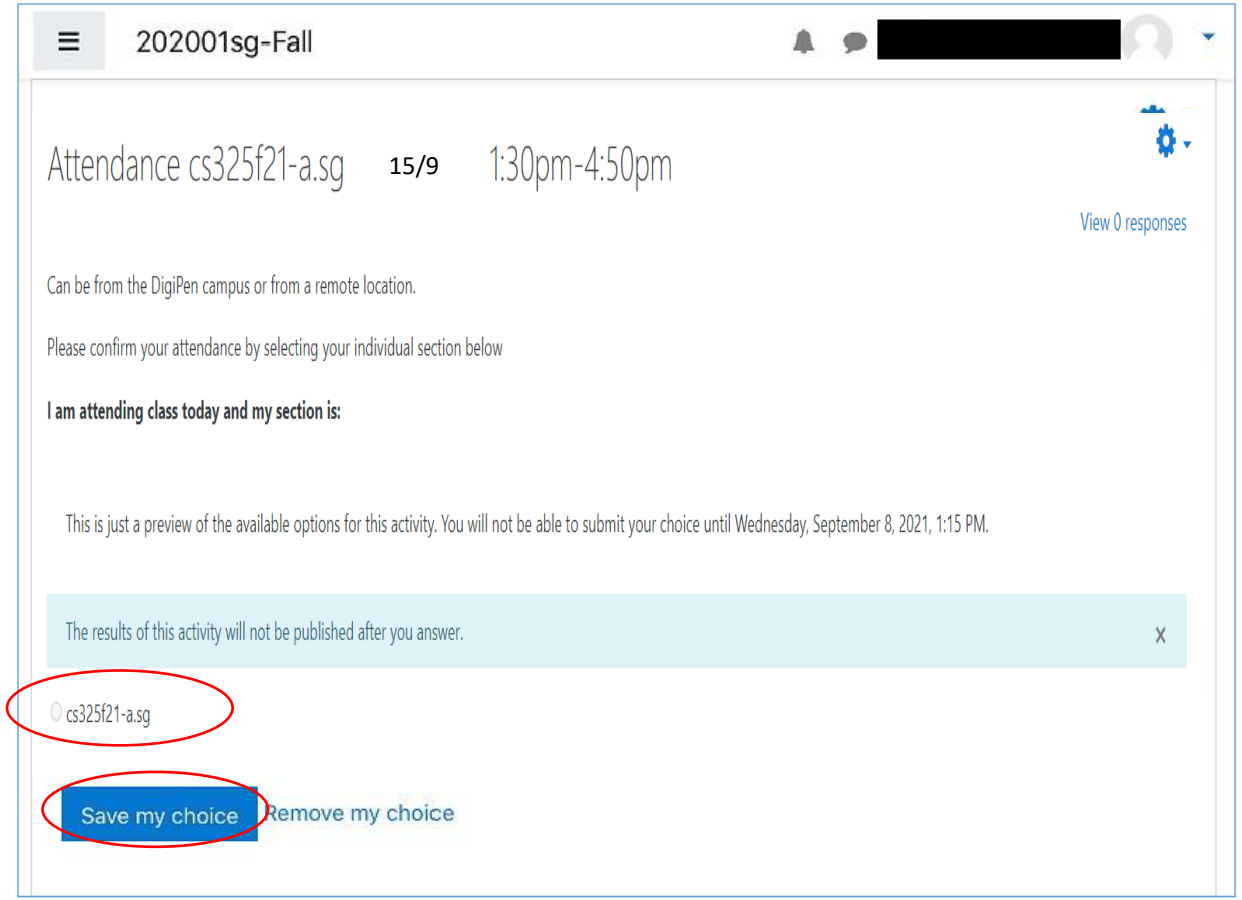
CS325 – attendance taking on Moodle



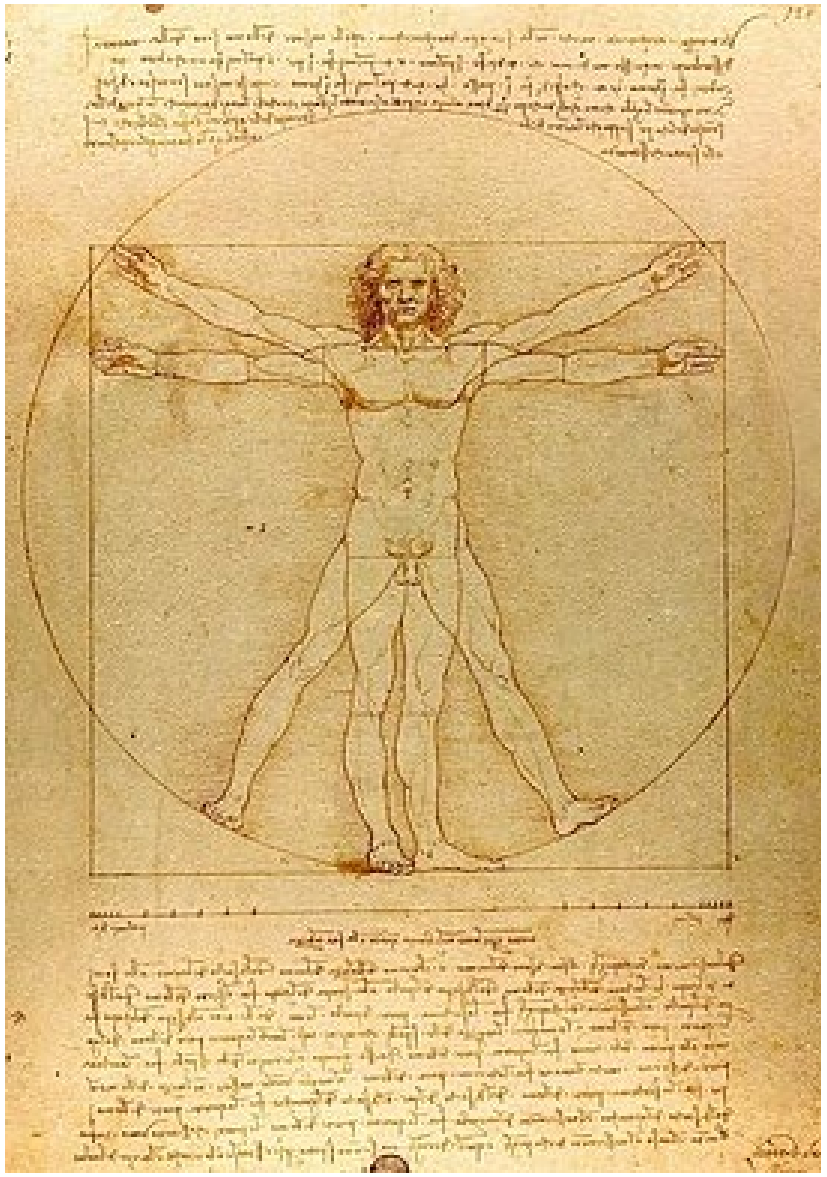
Time window:
1:15pm – 1:45pm

CS325
USER INTERFACE AND USER EXPERIENCE DESIGN
Week 2 – Human Capabilities

Dr Frank Guan

The human

- Information i/o …
  - visual, auditory, haptic, movement
- Information stored in memory
  - short-term
  - long-term
- Information processed and applied
  - Reasoning
  - Problem solving
  - Skill
  - Error
- Emotion influences human capabilities
- Each person is different

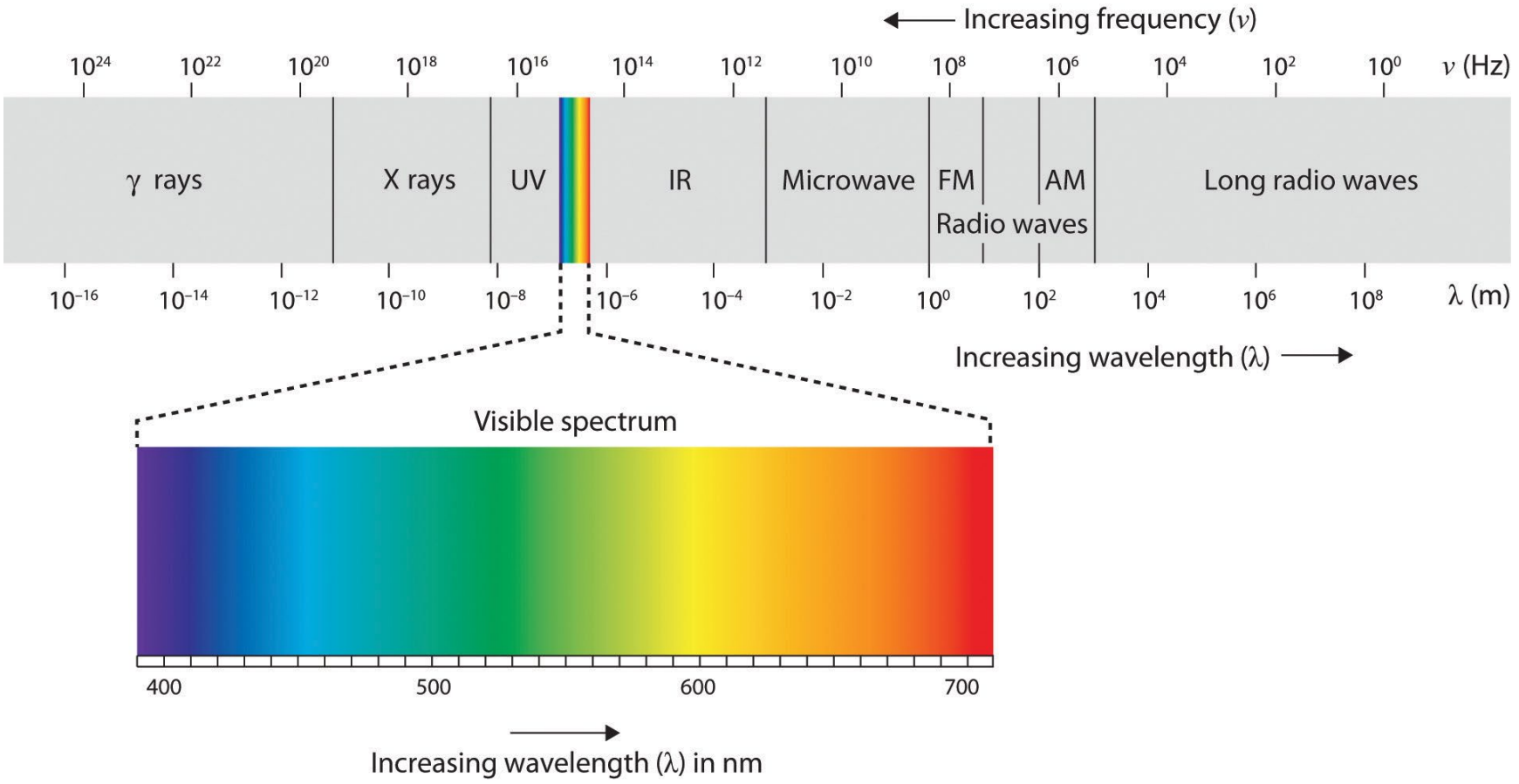


Sensing

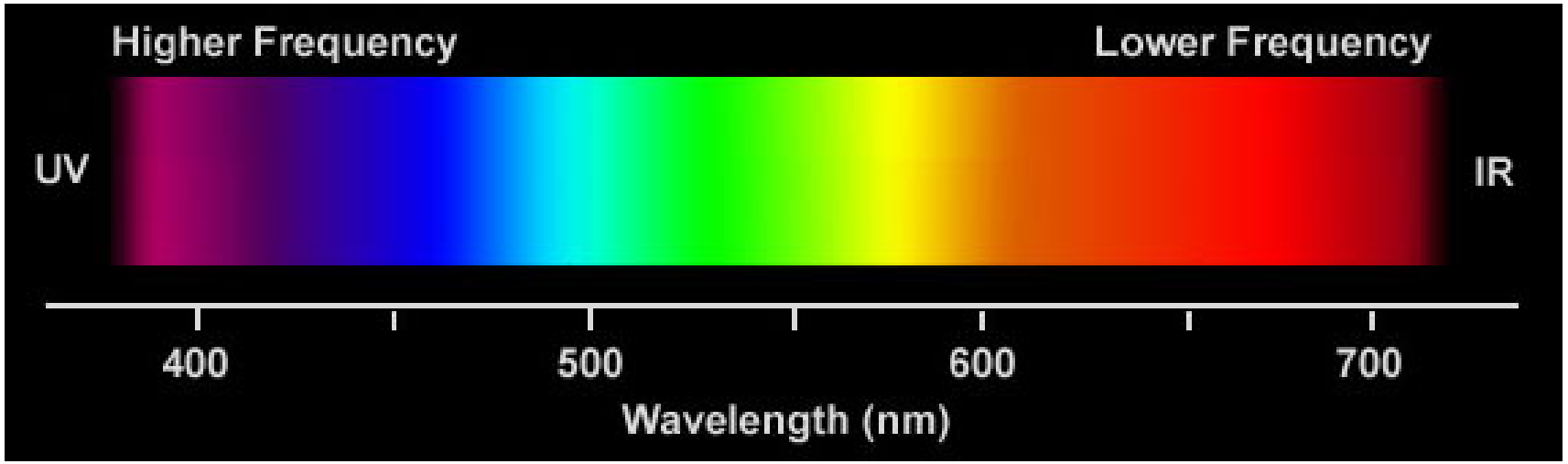
Senses

- **Vision**
- **Hearing**
- **Touching**
- Smell
- Taste

The Electromagnetic Spectrum



The Visible Spectrum



A typical human eye will respond to wavelengths from about 390 nm to 700 nm

Vision - human eyes

- Light reflects from objects
- Retina receives image
- Images are focused upside-down on retina
- Light received and transformed into electrical energy

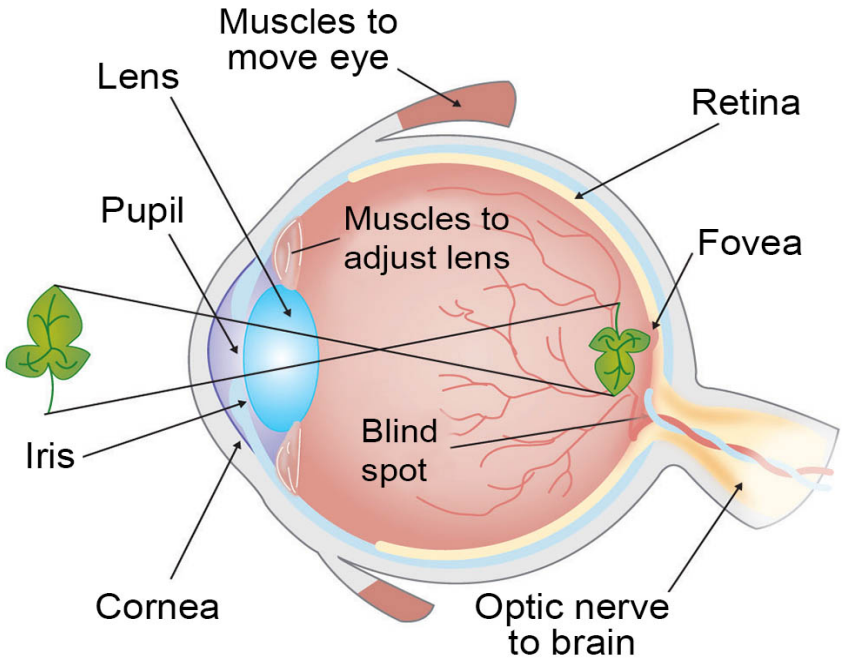
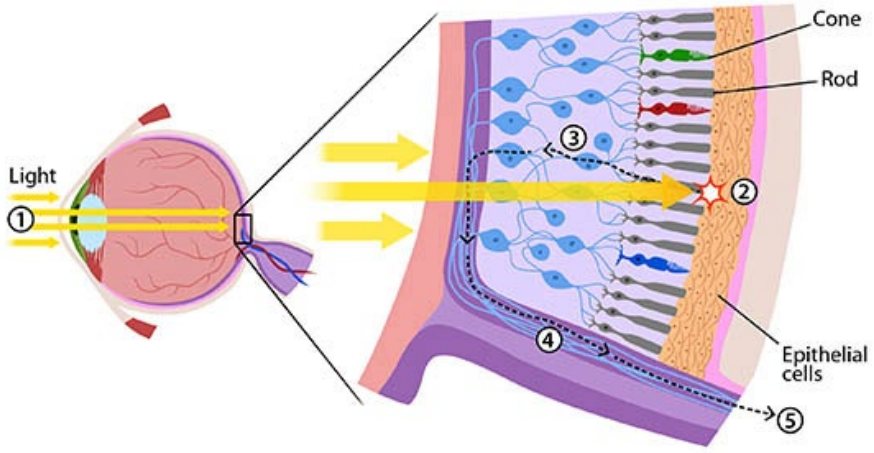
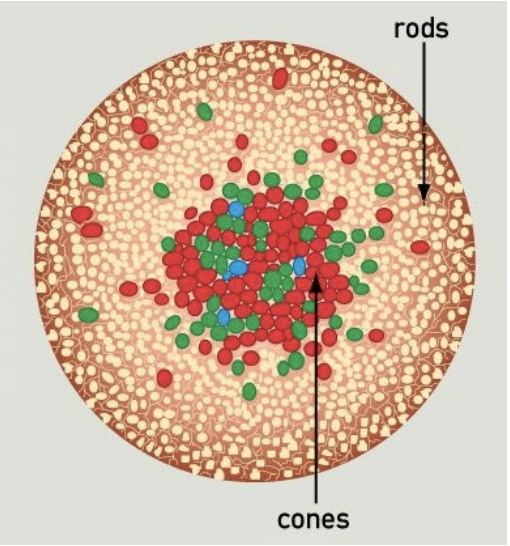


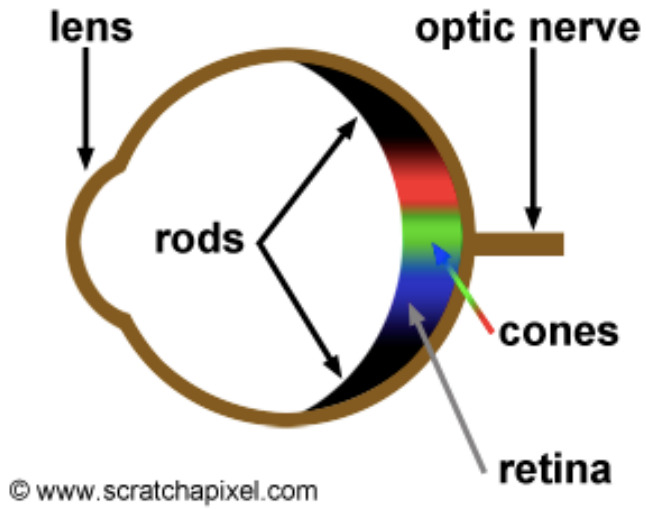
Image source: https://askabiologist.asu.edu/rods-and-cones

Two Types of Retina Cells

- Rods (120 million)
  - Monochrome
  - Sensitive to entire visible spectrum
  - Small
  - Fast-acting
  - Distributed throughout retina
- Cones (6 million)
  - Three types: Red, Green, Blue
  - Each type sensitive to limited range of visible light
  - Cones are larger cells than rods
  - Cones are less sensitive
  - Strongly concentrated in *Fovea*
  - Relatively few cones outside fovea







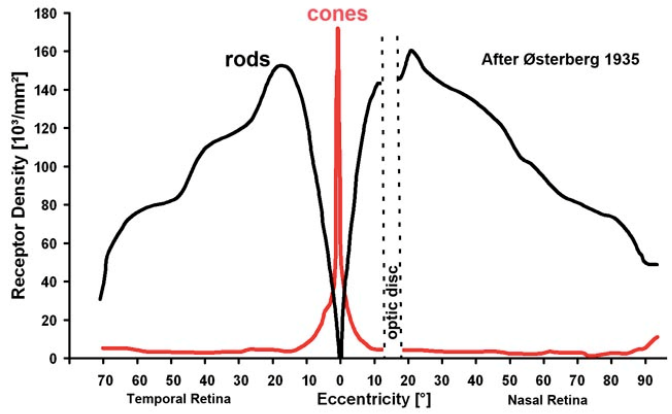
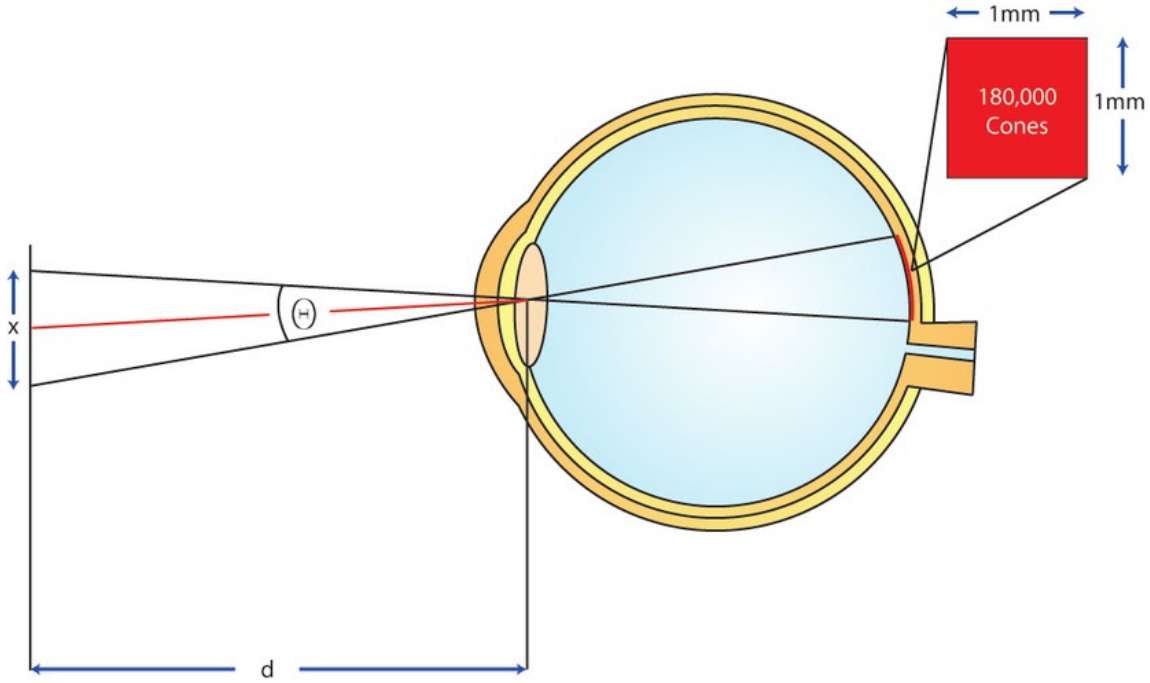


Fig. 20. Graph to show rod and cone densities along the horizontal meridian.

Fovea

- High-resolution area of Retina
  - It’s what you point your eyes at to get good image
  - About 2 degrees visual angle
  - Densely packed with Rods + Cones



Source: https://www.researchgate.net/publication/220862119_Visual_Saliency_for_Smell_Impulses_and_Application_to_Selective_Rendering/figures?lo=1

Color Perception via Cones

"Photopigments" used to sense color

3 types: blue, green, "red" (really yellow)

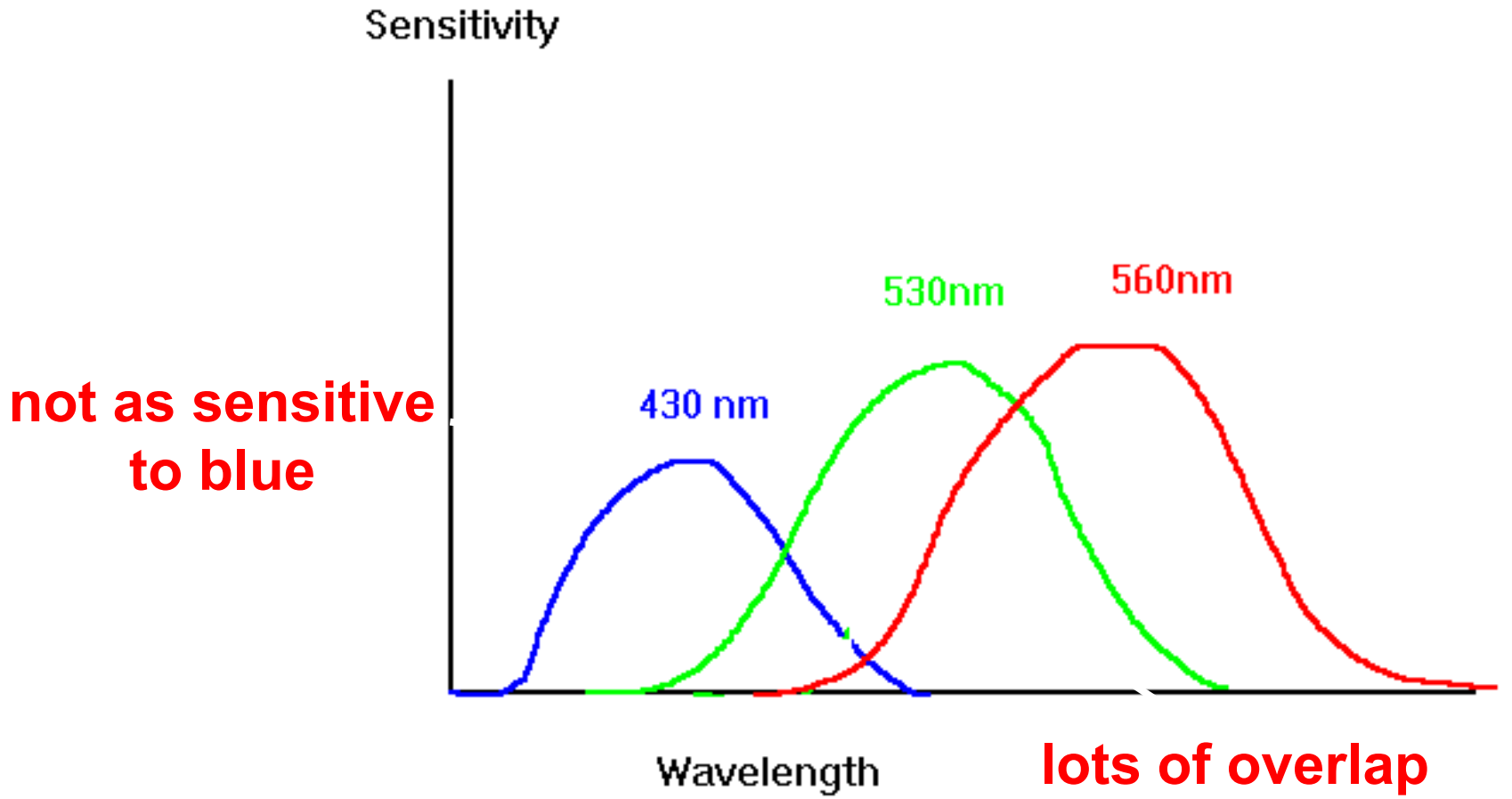
Each sensitive to different band of spectrum

ratio of neural activity of the 3 colors combined gives the continuous perception of color

Distribution of Photopigments

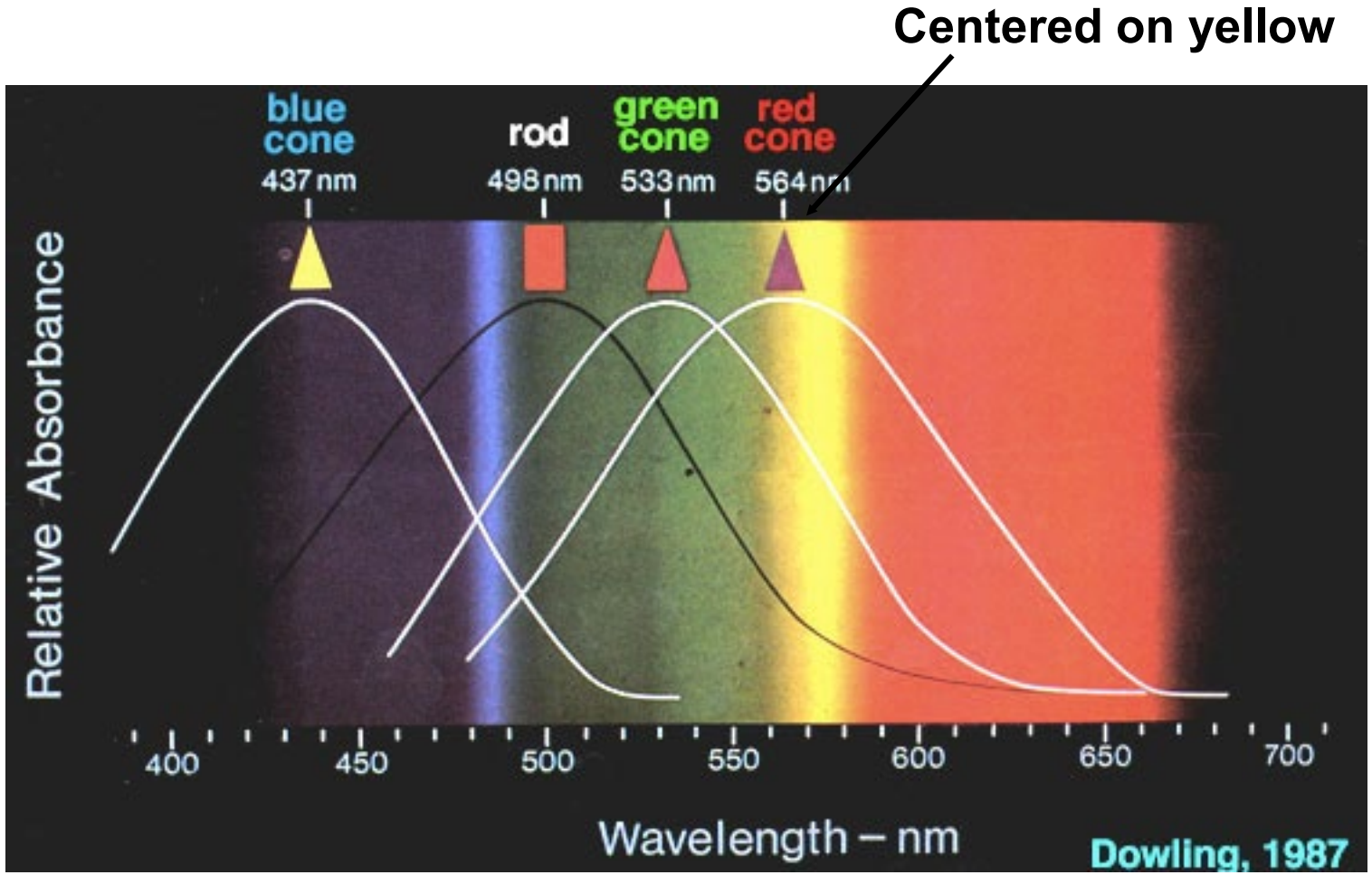
- Not distributed evenly
  - Mainly reds (64%), very few blues (4%)
  - Insensitivity to short wavelengths (blue)
- No blue cones in retina center (high acuity)
  - “disappearance” of small blue objects when fixate on them
- Lens of the eye yellows with age and absorbs shorter wavelengths
  - Sensitivity to blue is reduced further
- Implications
  - Blue colored edges and shapes are hard to see
  - Don’t use blue for text or small objects!
  - Avoid red and green in the periphery

Color Sensitivity



https://www.siggraph.org/education/materials/HyperGraph/color/images/colorspc.gif

Color Sensitivity



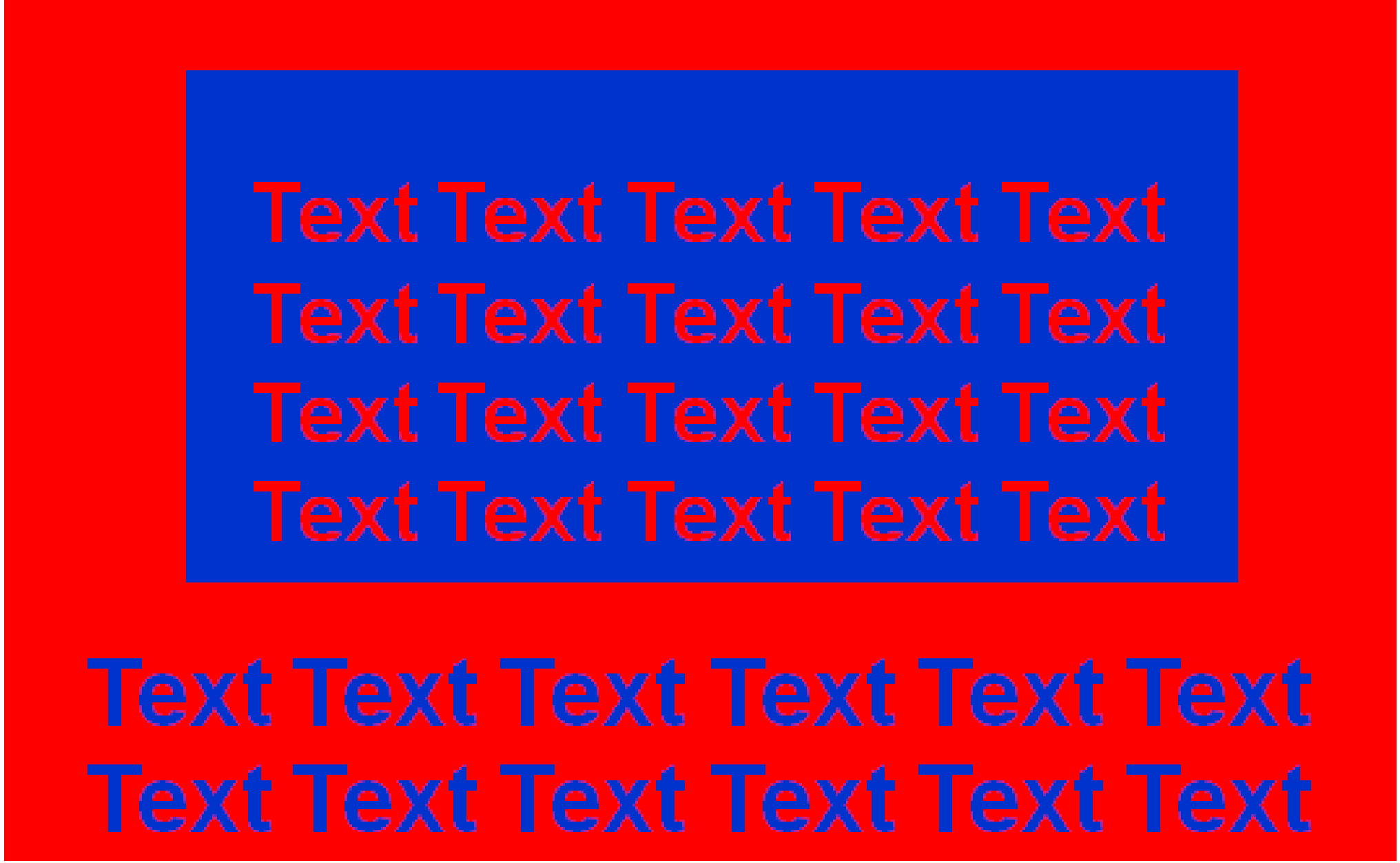
http://retina.umh.es/webvision/imageswv/spectra.jpeg

Color Sensitivity & Image Detection

- Most sensitive to the center of the spectrum
  - blues and reds must be brighter than greens and yellows to be perceived as the same
- Brightness determined mainly by green and red cones
  - Y = 0.3 Red + 0.59 Green + 0.11 Blue
- Shapes detected by finding edges
  - Use brightness & color differences
- Implication
  - Hard to deal with blue edges & shapes

Focus

- Different wavelengths of light focused at different distances behind eye's lens
  - constant refocusing will cause fatigue
  - Need to be careful about color combinations
- Saturated colors (i.e. pure colors) require more focusing than desaturated colors (i.e. pastels)
  - No excessive use of saturated colors in UIs
  - Unless something really needs to stand out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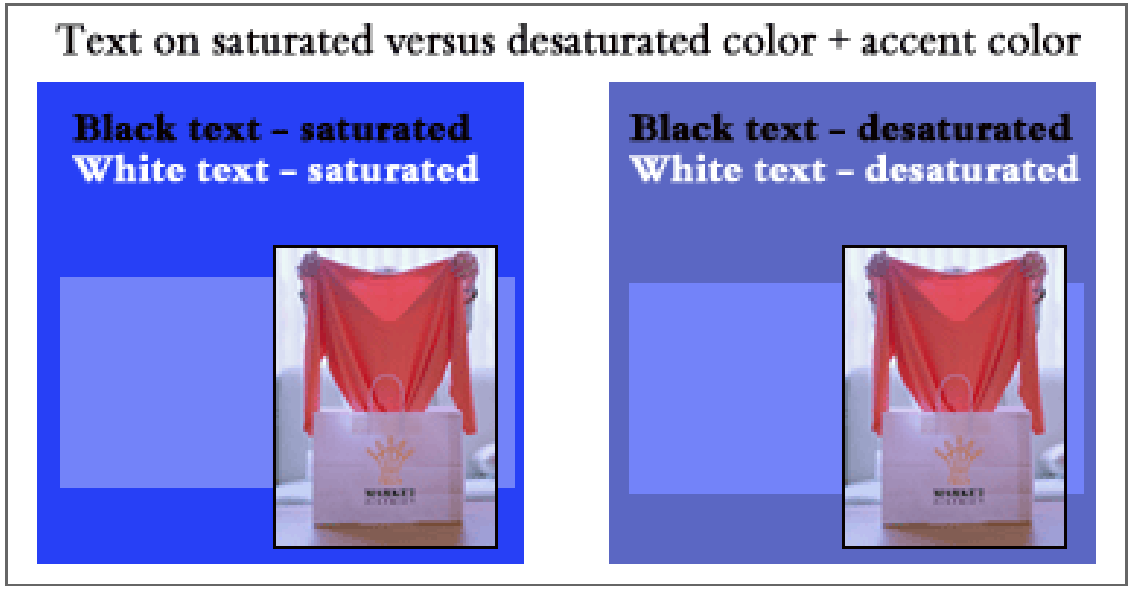


http://www.pallasweb.com/color.html

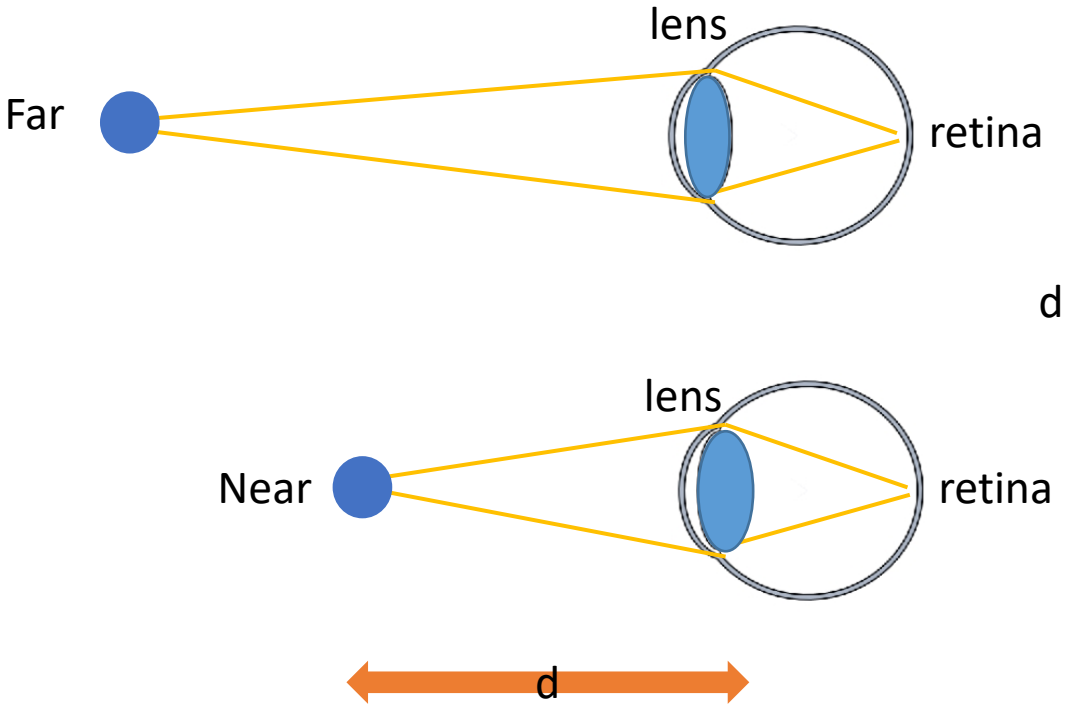
Interpreting the signal

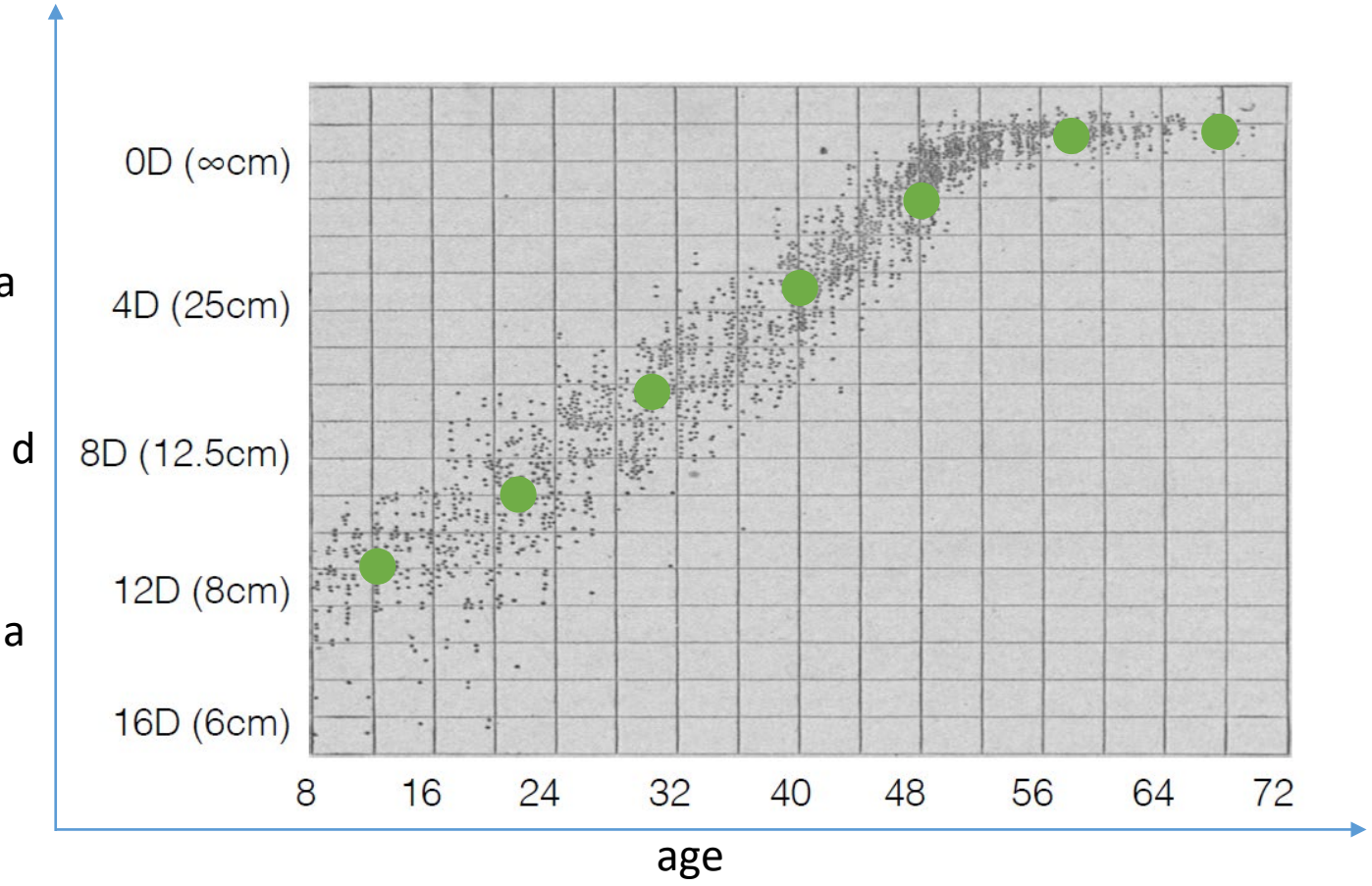
- Size and depth
  - Visual angle indicates how much of view object occupies
    (relates to size and distance from eye)
  - Visual acuity is ability to perceive detail (limited)
  - Familiar objects perceived as constant size
    (in spite of changes in visual angle when far away)
  - Cues like overlapping help perception of size and depth

Interpreting the signal (cont)

- The visual system compensates for:
  - Movement
  - Changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur

Human eye accommodation range

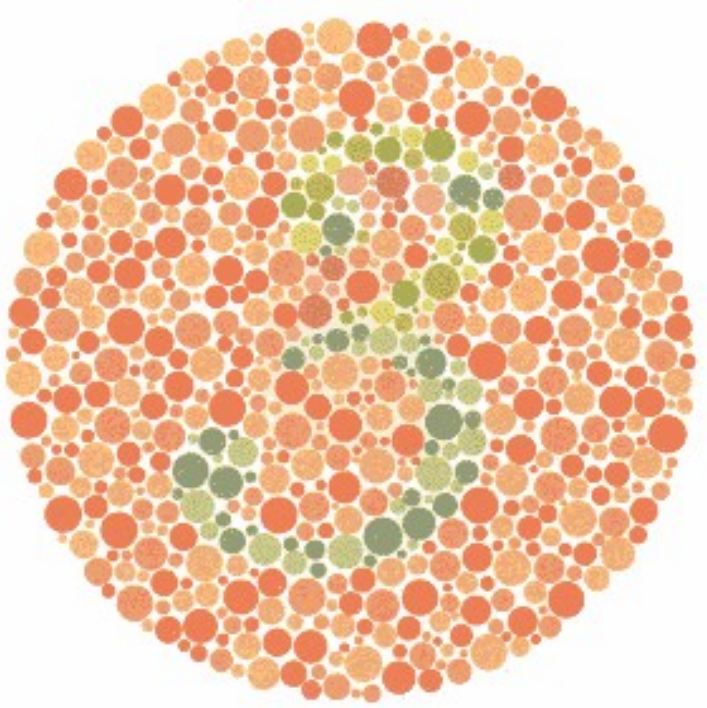




A. Duane, 1912. Normal values of the accommodation at all ages. Journal of the American Medical Association (1912), pp. 1010-1013.

Color Deficiency (Color Blindness)

- Trouble discriminating colors
  - affects about 9% of population (8% males and 1% females are colour blind)
- Two main types
  - *different photopigment response* most common
    - reduces capability to discern small color differences
  - *red-green deficiency* is best known
    - lack of either green or red photopigment
    - Cannot discriminate colors dependent on red and green
    - (protanopia and deuteranopia)



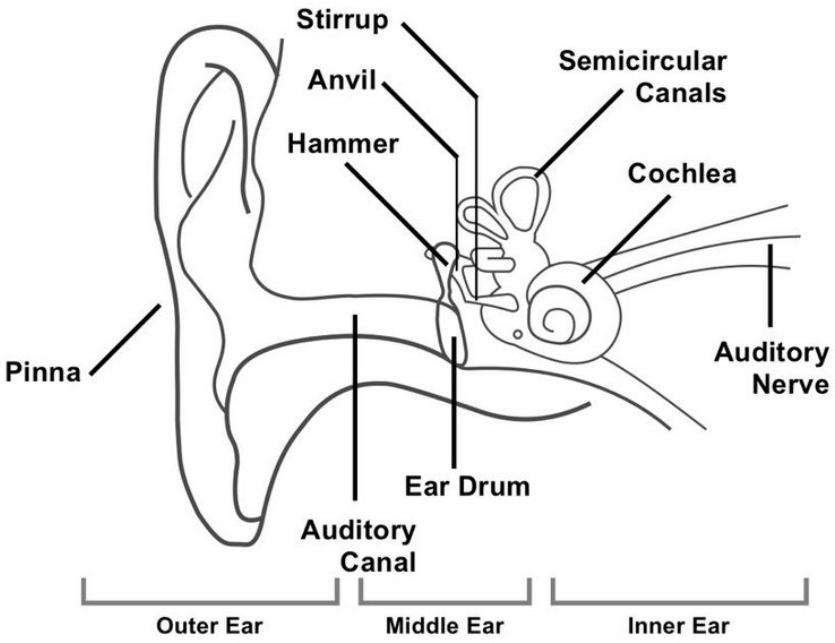
Future viewing

- Color Psychology: 10 Ways Color Influences your Choices & Changes your Feelings
  - https://www.youtube.com/watch?v=8n9BzzWy4zY

- The Meaning Of Colors And Their Importance In Website Design
  - https://www.youtube.com/watch?v=jz6s-N5ySa8

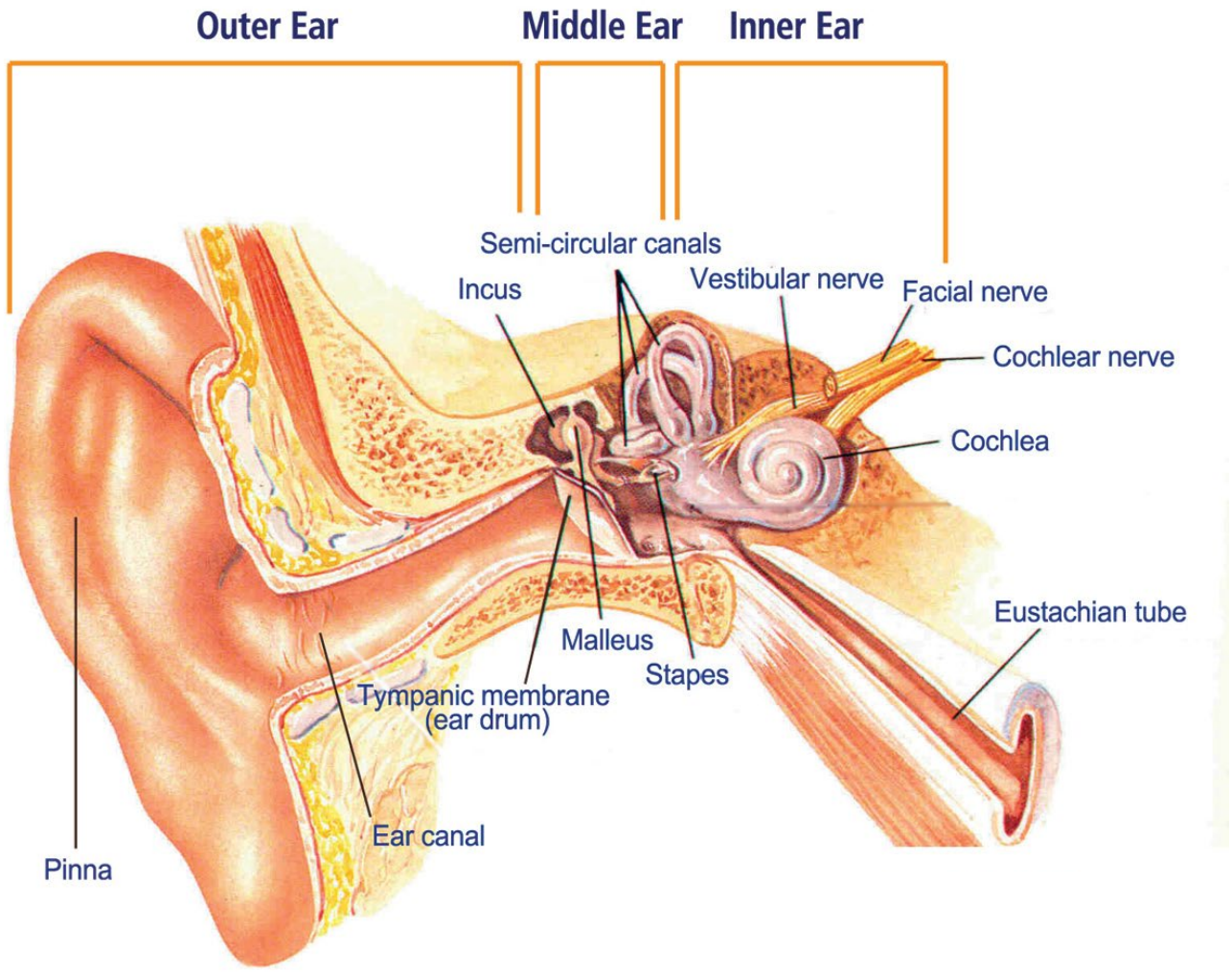
Hearing

- Provides information about environment:
  - Distances
  - Directions
  - Classification (objects), etc.
- Physical apparatus:
  - outer ear – protects inner and amplifies sound
  - middle ear – transmits sound waves as vibrations to inner ear
  - inner ear – chemical transmitters are released and cause impulses in auditory nerve
- Sound
  - pitch – sound frequency
  - loudness – amplitude
  - timbre – type or quality

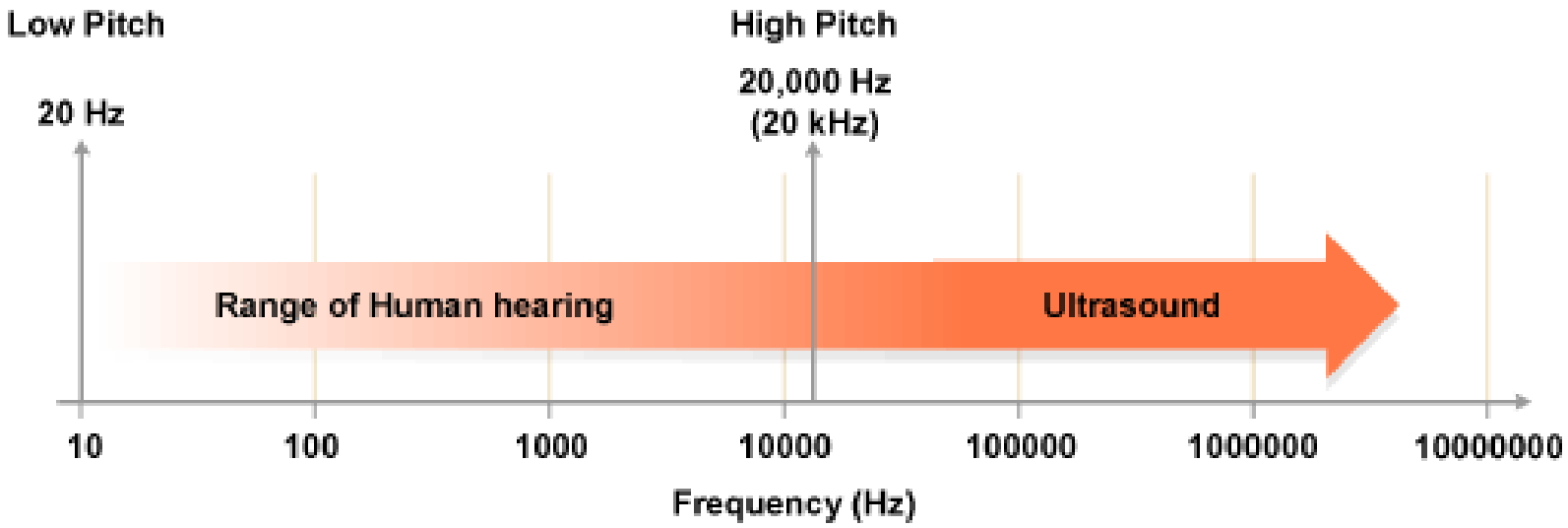


Source: https://www.researchgate.net/publication/324547019_A_Framework_for_Speechreading_Acquisition_Tools/figures?lo=1&utm_source=google&utm_medium=organic

Human Auditory System



Hearing Range



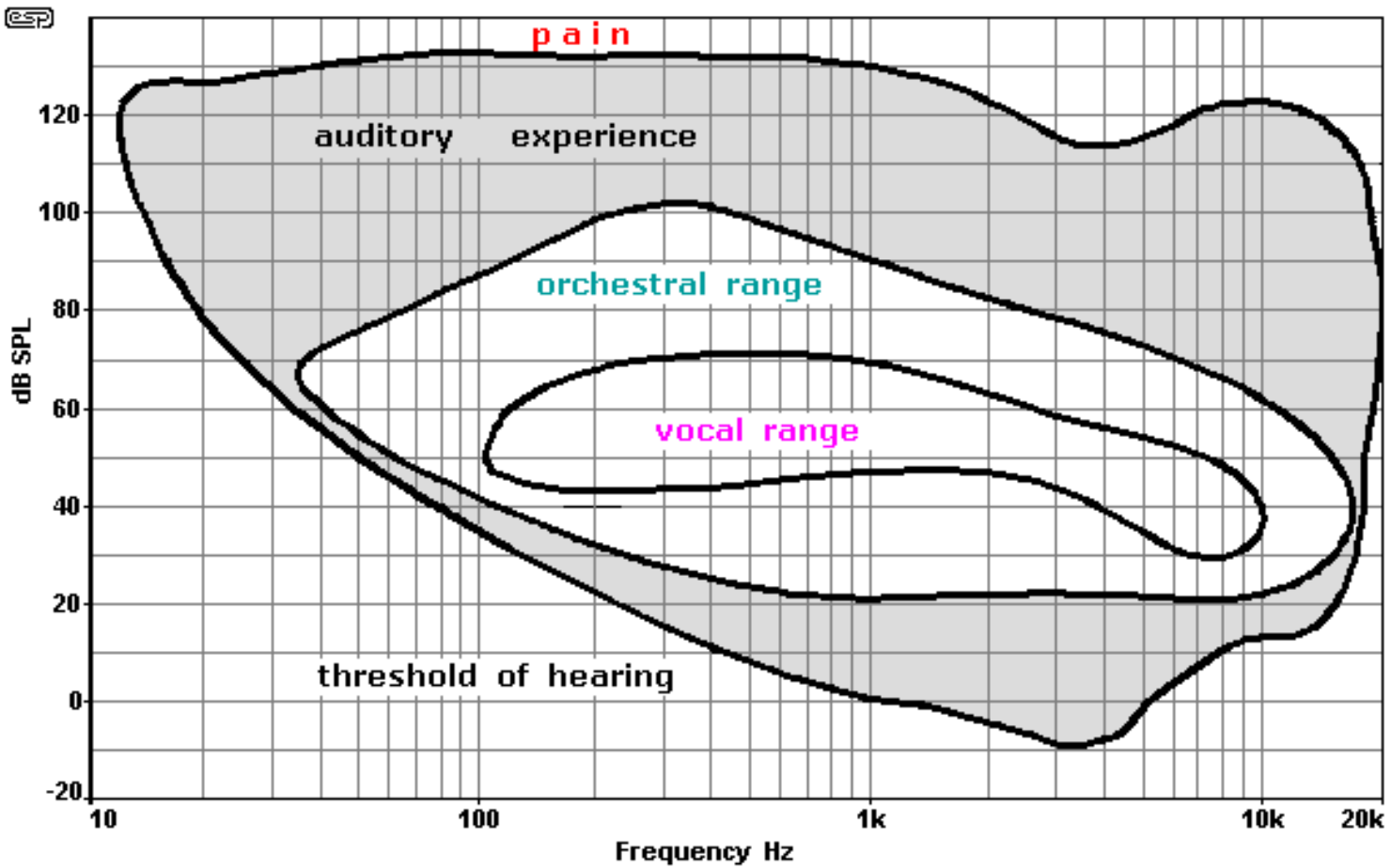
http://www.hear-it.org/what-db-and-frequency

- Frequency
- The frequency of a sound is the number of cycles of a sound wave in one second. The unit of measurement is hertz (Hz). The frequency of a sound increases as the number of cycles per second increase.
- Vibrations between 20 and 20,000 cycles per second are interpreted as sound by a normal healthy person.
- A high-pitched sound could be a bird singing.
- Low-pitched sounds could be thunder heard from far away.

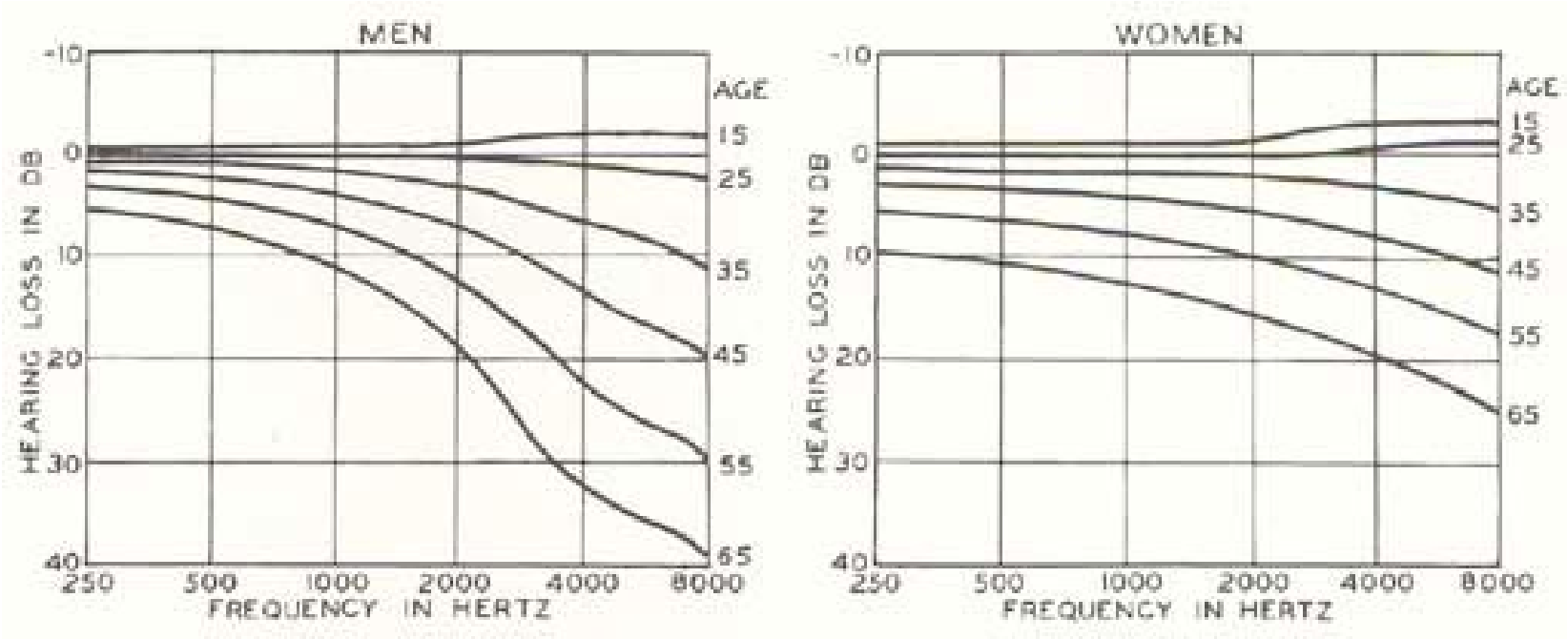
http://www.hear-it.org/what-db-and-frequency

- DeciBel (dB)
- used world-wide for the measurement of sound levels. The deciBel scale is a logarithmic scale where a doubling of sound pressure corresponds to a 6 dB increase in level.
- It is important to realize that the term 'dB' can have different meanings and is not a fixed value like the volt or the meter etc. The value of a dB depends on the context in which it is used.
- Here are some examples of different sound intensities as expressed in dB(HL):
- 180 dB: Rocket at take-off, 140 dB: Jet engine at take-off
- 120 dB: Rock band, 110 dB: Loud thunder
- 90 dB: City traffic, 80 dB: Loud radio
- 60 dB: Ordinary conversation, 30 dB: Soft whisper
- 0 dB: Softest sound a person can hear

Hearing Range



Age-related Hearing Loss

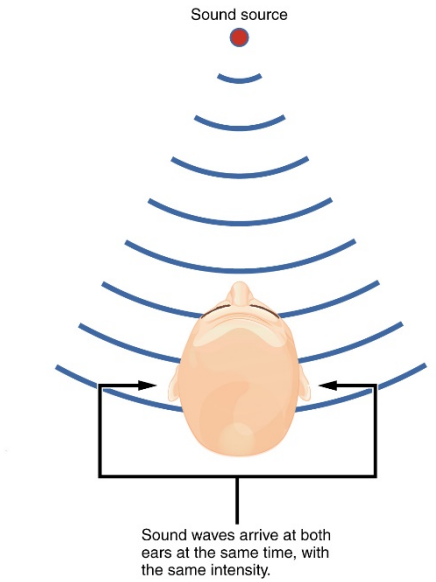


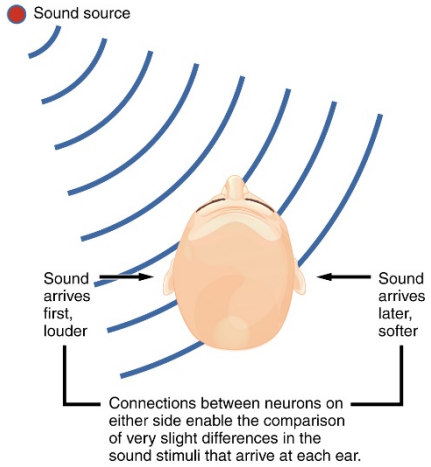
Hearing

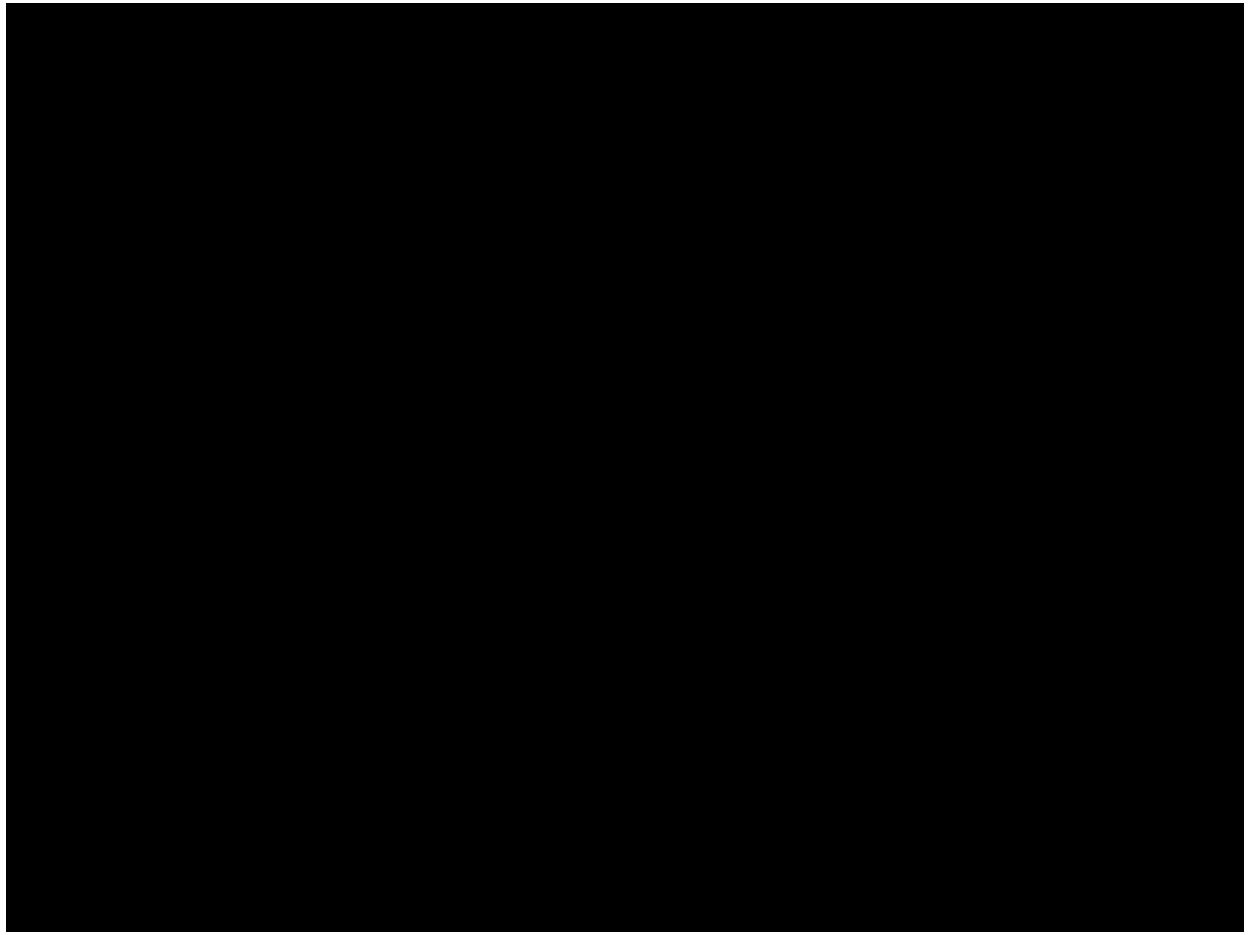
- 20Hz to 20kHz frequency range
- Two ears; Stereo vs Mono
- Differences of around 1.5Hz can be heard
- Implications
  - Older people cannot hear higher frequencies
  - Sounds should not be too high pitched

3D Audio

- 3D Audio cues:
  - Interaural **Time** Difference
  - Interaural **Intensity** Difference
  - Pinnae filtering
  - Body filtering







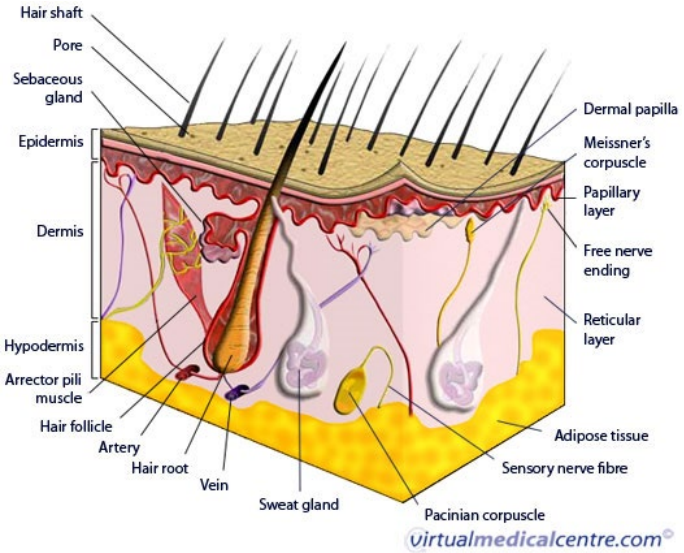
Source: https://open.oregonstate.education/aandp/chapter/15-3-hearing/

Hearing & Audio

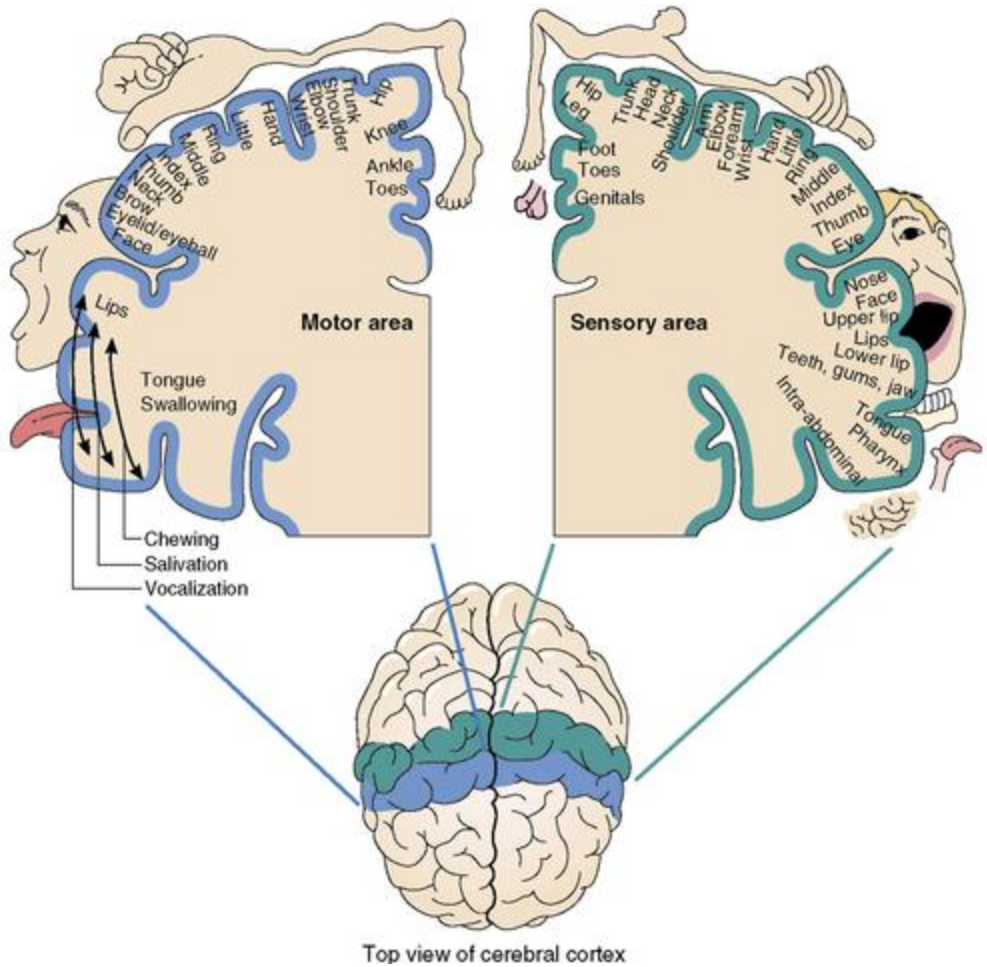
- Provides a richer, more robust environment than with mere graphic feedback.
- Present further information when the bandwidth of visual information has been exhausted
- Sounds may make tasks easier and more productive
- Audio feedback may complement graphics and text to create redundancy, reinforcing a concept in the user's mind

Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.
- Stimulus received via receptors in the skin:
  - thermoreceptors – hot and cold
  - nociceptors – pain
  - mechanoreceptors – pressure
    (some instant, some continuous)
  - Some areas more sensitive than others e.g. fingers.
- Kinethesis - perception of limb movement and position, and often includes the perception of force as well. Sense based on muscles, joints, tendons



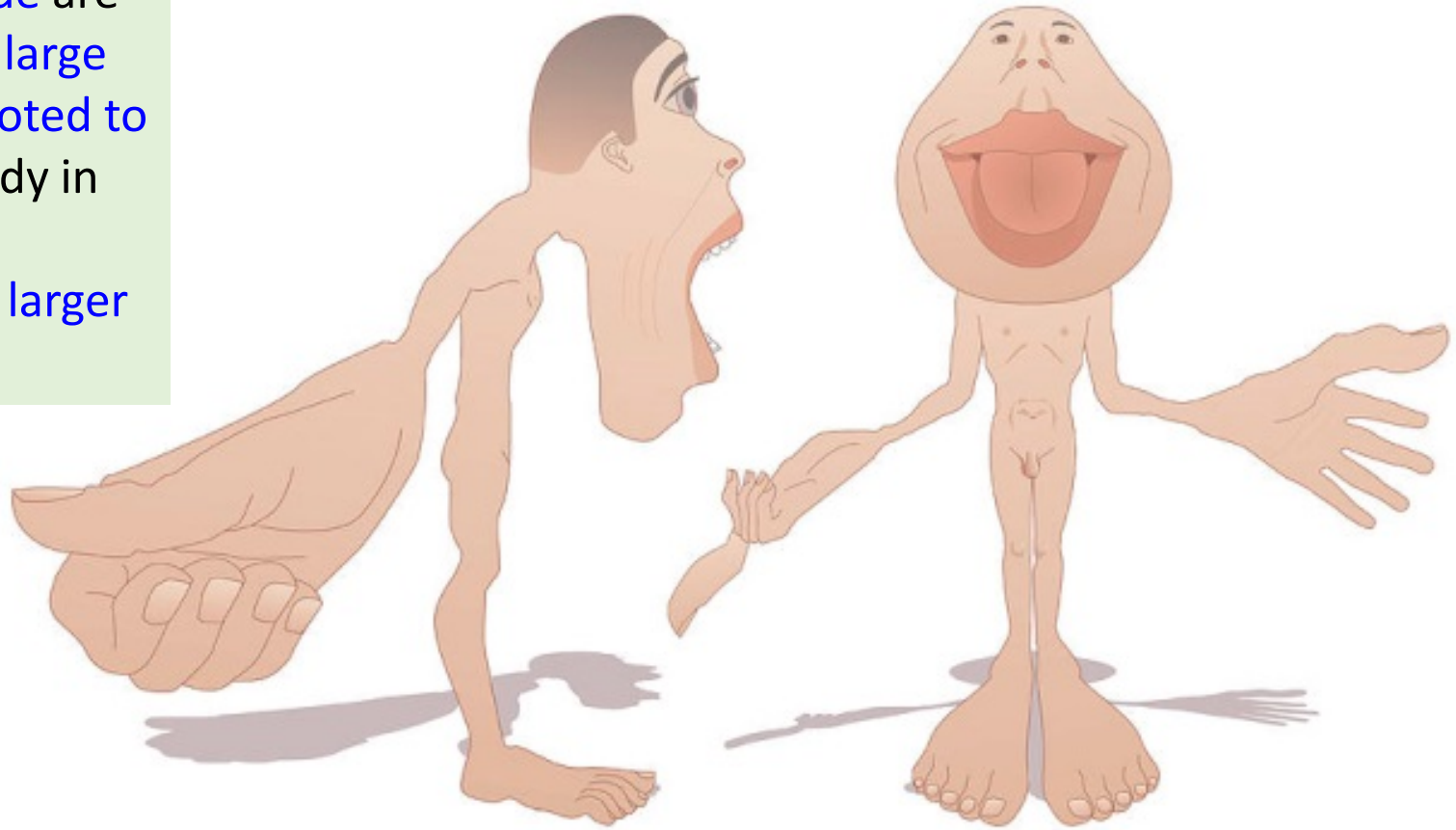
Sensory & Motor Cortex



Top view of cerebral cortex

Motor & Sensory Homunculus

hands, lips, and tongue are large, because of the large areas of cortex is devoted to these areas of the body in humans. They are represented as being larger on the homunculus.



Motor homunculus showing proportional somatotopical representation

Sensory homunculus showing proportional somatotopical representation

Haptics

- Large areas of the cortex devoted to hands, lips and tongue
- Another channel by which to present further information in the interface
- May also make some tasks easier


logitech


Inbox
3 Unread Messages
VIP
No Unread Messages
Search
New Message
3

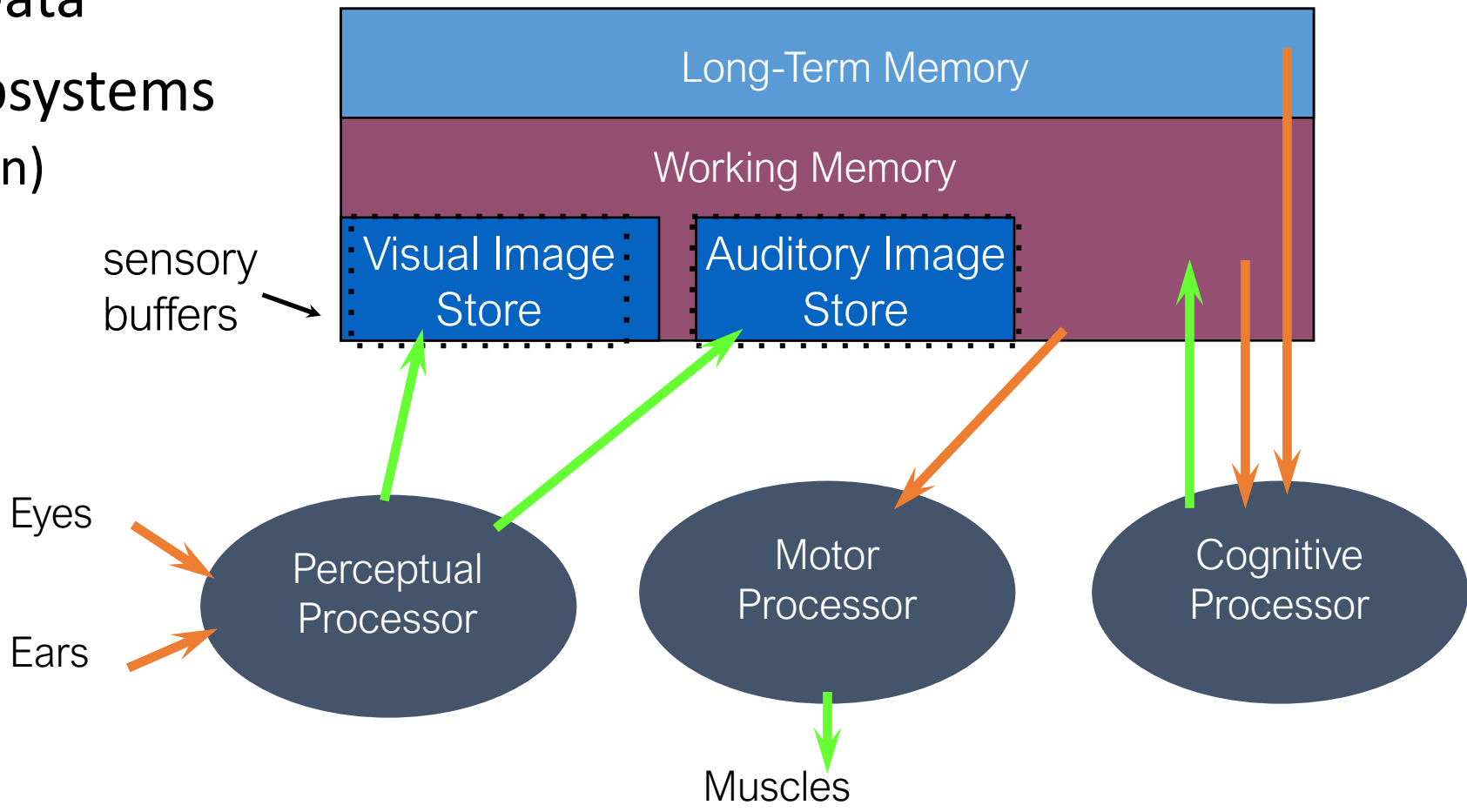
3D Touch & Taptic Engine

Need a Break?

Processing

Basics of Modeling Human Processor

- Based on Empirical Data
- Three interacting subsystems
  - Perceptual (read/scan)
  - Cognitive (think)
  - Motor (respond)



Card, Moran & Newell (1983)

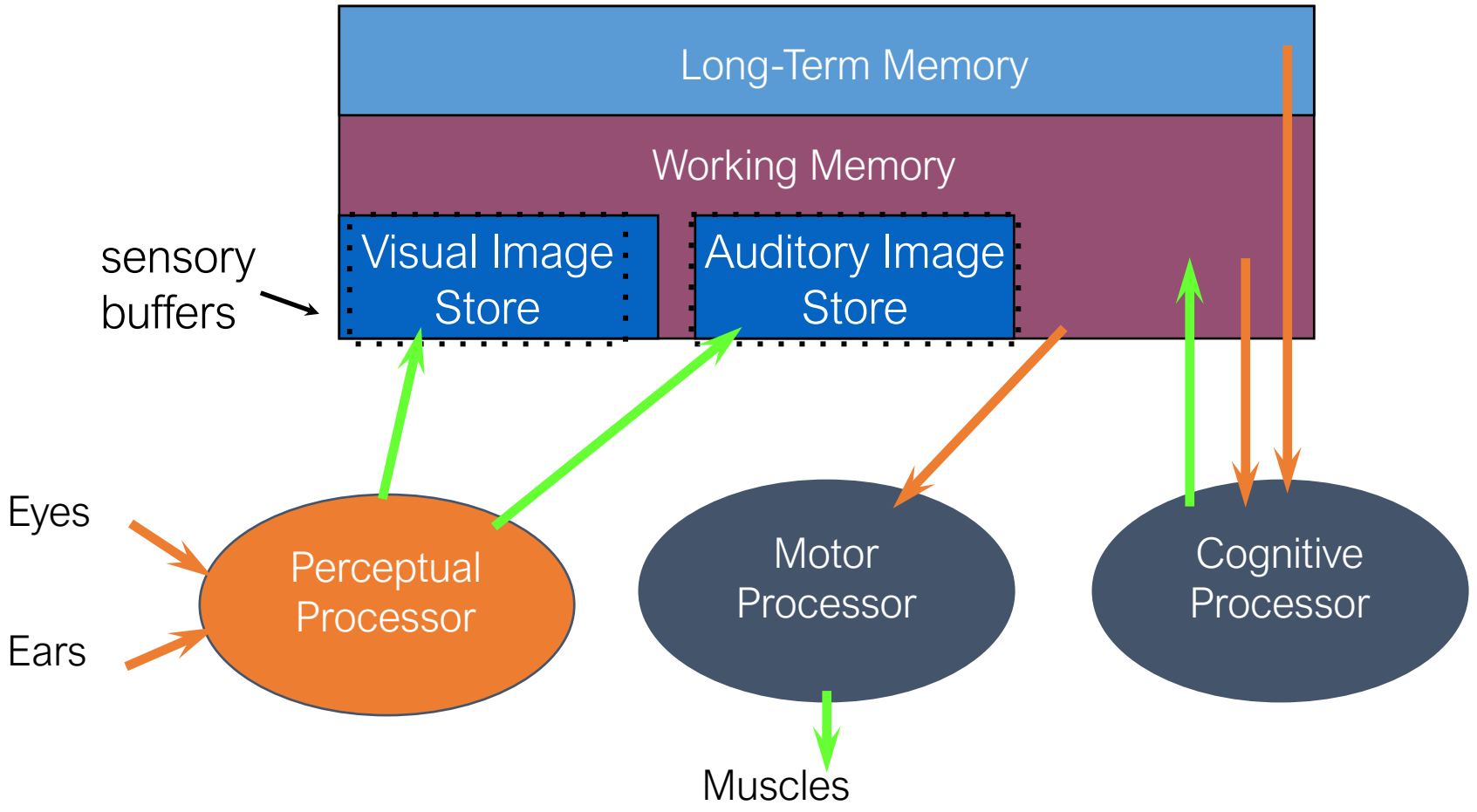
Information Processing

- Usually serial action
  - Respond to buzzer by pressing button

- Usually parallel recognition
  - Driving, reading signs, listening to radio

Model Human Processor Basics

- Parameters
  - Processors cycle time of 50-200ms
  - Memories have type, capacity, decay time



Card, Moran & Newell (1983)

Perceptual Processor

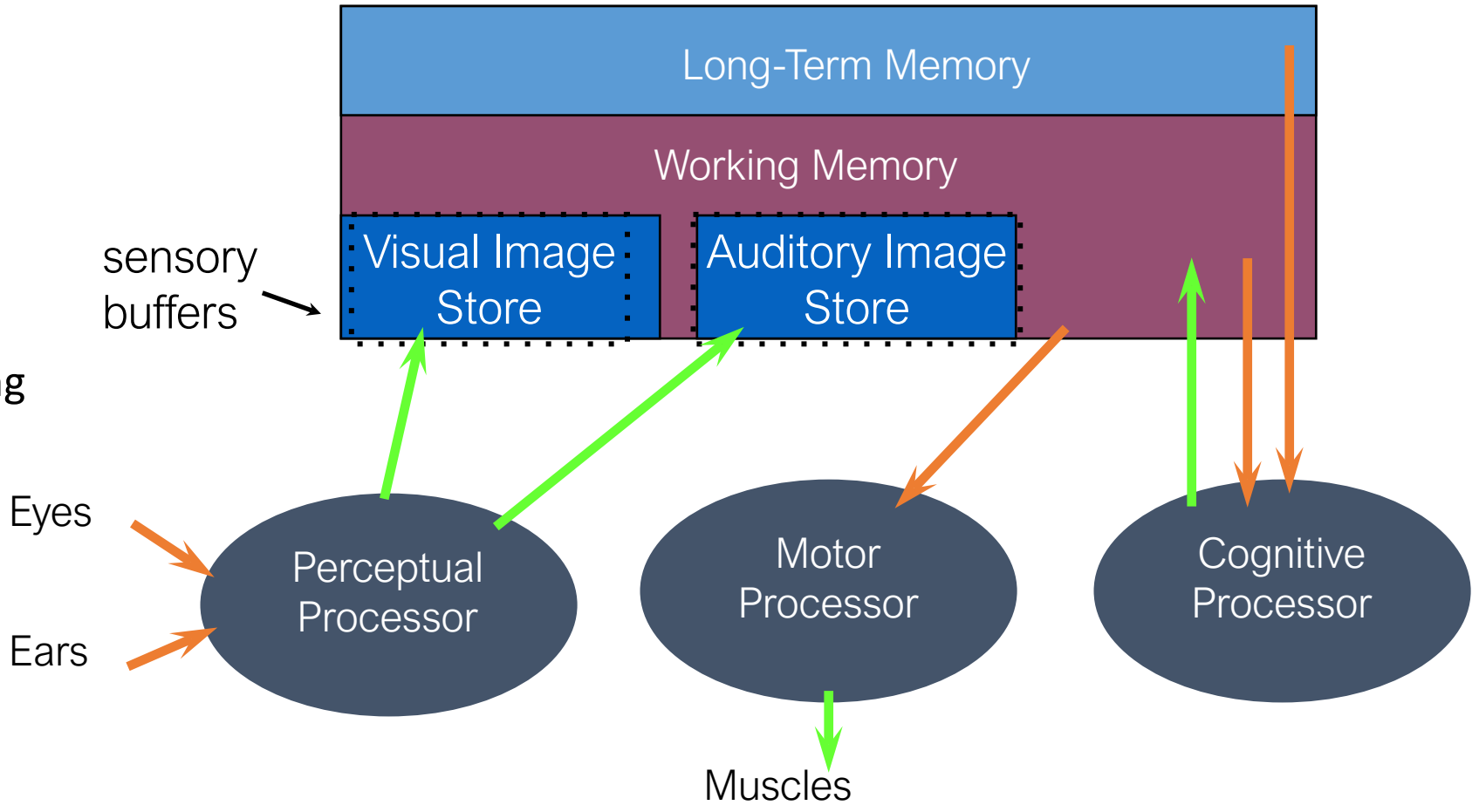
- Types
  - Visual
  - Auditory
  - Tactile
  - Taste
  - Smell
  - …
- Continually “grabs data” from the sensory system
- Cycle time: 50 - 200 ms
- Passes data to *Image Store* in unrecognized form
  - “Array of Pixels” (or whatever it is) from eyes
  - “Sound Intensities” from ears
  - …

Sensory Store

- The “input buffer” of the senses
- Stores most recent input *unrecognized*
- Storage time and capacity varies by type
  - Visual: Nominal Range
    - Capacity: [7 - 17] letters
    - Decay Time: [70 - 1000] ms
  - Audio:
    - Capacity: [4.4-6.6] letters
    - Decay Time: [900 - 3500] ms

Memory

- Two “types”
  - **Short-term memory**
    - Conscious thought, calculations
  - **Long-term**
    - Permanent, remember everything ever happened



Card, Moran & Newell (1983)

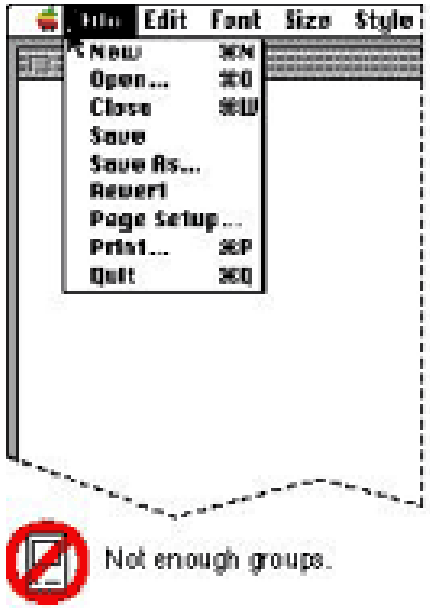
Memory: Short Term

- Short Term (Working) Memory (WM)
  - Gets basic recognition from Sensory Store
    - “Stop sign” vs. “red octagon w/white marks”
  - 7 +/- 2 “chunks”
    - 5896536328 vs. 589-653-6328
  - WM: Nominal Range
    - Capacity: [5 - 9] chunks
    - Decay Time: [5 - 226] seconds
    - Access Time: [25 - 170] ms

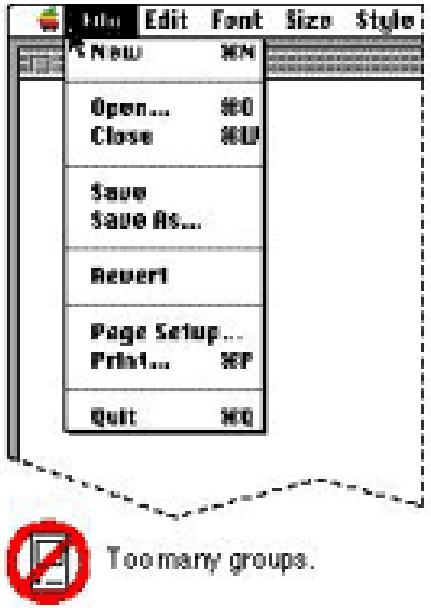
Memory: Long Term

- Long Term Memory (LTM)
  - “Unlimited” size
  - Slower access time (100ms)
  - Little decay
  - Episodic & Semantic
- Structure
  - Episodic memory
    - Events & experiences in serial form
  - Semantic memory
    - Structured record of facts, concepts & skills
- Things move from STM to LTM by rehearsal & practice and by use in context
- Implications
  - Create cognitive chunks in UI design

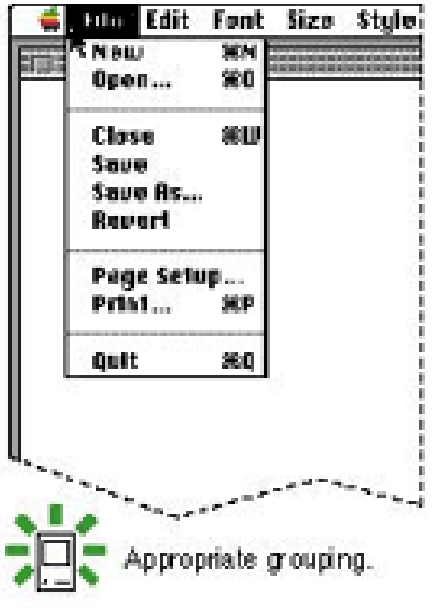
Cognitive Chunking



Not enough groups.

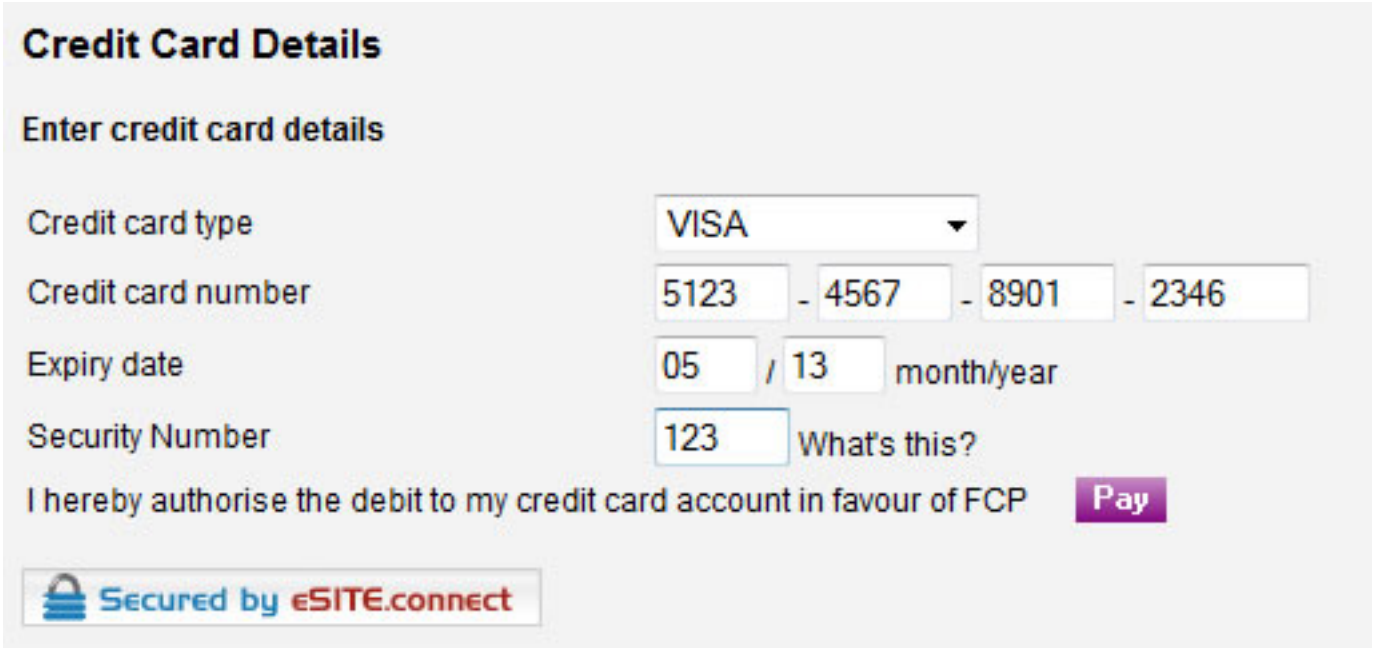


Too many groups.



Appropriate grouping.

Cognitive Chunking



Cognitive Chunking

- Visual separation
  - Use whitespace to separate group information
- Visual differentiation
  - Change visual characteristics of groups
- Visual progression
  - Rely on visual and cognitive cues to guide order in which users internalize information

Activity: Find the price for a double room at the Quality Inn in Pennsylvania

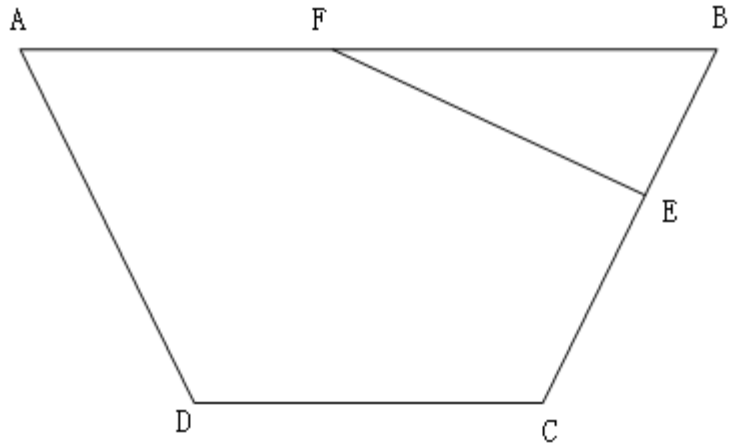
Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $118 D: $120
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $129 D: $136
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $121 D: $126
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $119 D: $125
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $123 D: $128
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $122 D: $124
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $120 D: $124
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $122 D: $125
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $132 D: $140
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $120 D: $127
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $116 D: $118

Activity: Find the price of a double room at the Holiday Inn in Columbia

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$126	$130
Charleston	Days Inn	803	881-1000	$118	$124
Charleston	Holiday Inn N	803	744-1621	$136	$146
Charleston	Holiday Inn SW	803	556-7100	$133	$147
Charleston	Howard Johnsons	803	524-4148	$131	$136
Charleston	Ramada Inn	803	774-8281	$133	$140
Charleston	Sheraton Inn	803	744-2401	$134	$142
Columbia	Best Western	803	796-9400	$129	$134
Columbia	Carolina Inn	803	799-8200	$142	$148
Columbia	Days Inn	803	736-0000	$123	$127
Columbia	Holiday Inn NW	803	794-9440	$132	$139
Columbia	Howard Johnsons	803	772-7200	$125	$127
Columbia	Quality Inn	803	772-0270	$134	$141
Columbia	Ramada Inn	803	796-2700	$136	$144
Columbia	Vagabond Inn	803	796-6240	$127	$130

Overview of the Problem



In the above diagram find the value of angle BEF when

Line AB is parallel to line DC

Angle BCD=110

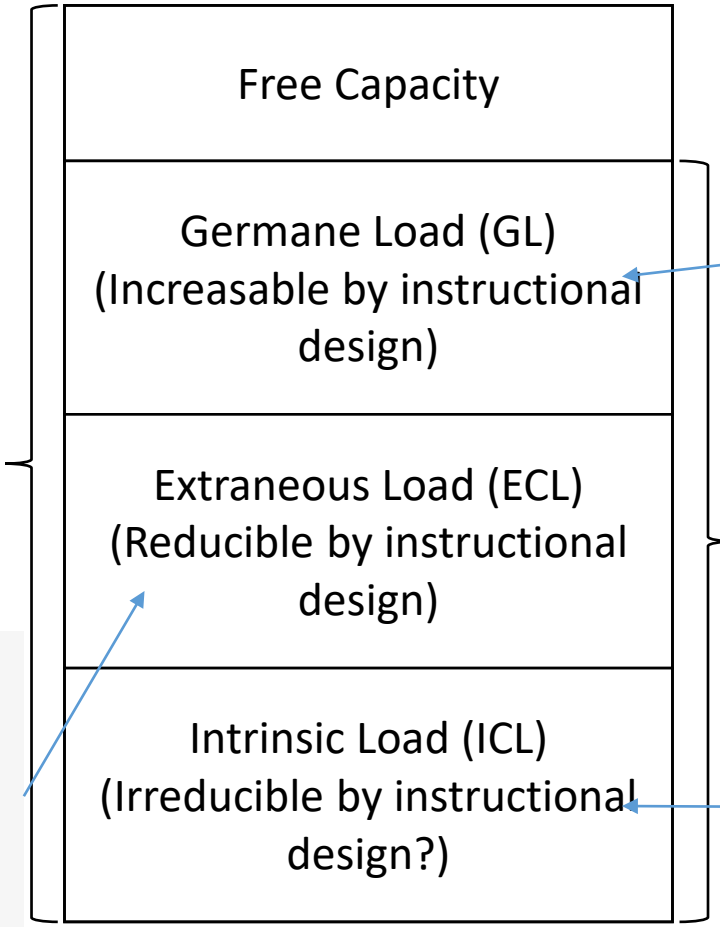
Angle BFE=50

Cognitive Load Theory

- Cognitive Load Theory is
  - a universal set of learning principles that are proven to result in efficient instructional environments as a consequence of leveraging human cognitive learning processes (Clark et al., 2006)

Cognitive Load Theory – Types of Load

factors that reduce a users total working memory capacity e.g. stress, lack of sleep.



Total Working Memory Capacity

Total Cognitive Load

load devoted to the processing, construction and automation of schemas (fix pattern – 1st time vs many times)

generated by the manner in which info is presented to learners and is under the control of instructional designers (e.g. using visual aid, diagram)

inherent level of difficulty associated with a specific instructional topic. (e.g., the calculation of 2 + 2, versus solving a differential equation).

(Paas et al. 2004)

Major Cognitive Load Effects

- Split-Attention
  - the unnecessary splitting of a attention when trying to understand material across multiple sources
- Redundancy Effect
  - the presentation of information in a format with **both** diagrams and accompanying text (information may be unnecessary or redundant)
- Element Interactivity
  - instructional content is composed of component parts or ‘elements’; these elements may be said to *interact* if there is a relationship between them

Thinking

Thinking

- Reasoning
  - Deduction
  - Induction
  - Abduction
- Problem solving

Deduction Reasoning

- Deduction: derive logically necessary conclusion from given premises.

  e.g. If it is Friday then she will go to work.
  It is Friday
  Therefore she will go to work.

- If a = b and b = c, then a = c.
  - E.g. All birds have feathers. All robins are birds. Therefore, robins have feathers.

- Logical conclusion not necessarily true:
  - e.g. All swans are white. Jane is white. Therefore, Jane is a swan.

Deduction Reasoning (cont.)

- When truth and logical validity clash …

  e.g. Some people are babies
  Some babies cry
  Inference - Some people cry

Correct?

Inductive Reasoning

- Induction:
  - Generalize from cases seen to cases unseen

    e.g. all elephants we have seen have trunks
    therefore all elephants have trunks.

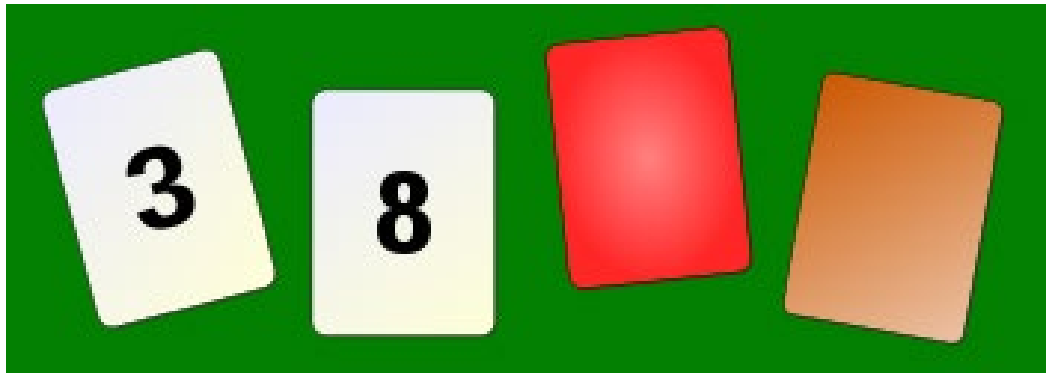
- Unreliable:
  - can only prove false not true

  … but useful!

- Humans not good at using negative evidence

    e.g. Wason's cards.

Wason's cards



Each card has a number on one side, and a patch of color on the other. Which card or cards must be turned over to test the idea that if a card shows an even number on one face, then its opposite face is red?

How many cards do you need to turn over to find out?

…. and which cards?

https://en.wikipedia.org/wiki/Wason_selection_task

Abductive reasoning

- Reasoning from event to cause

  e.g. Sam drives fast when drunk.

  If I see Sam driving fast, assume drunk.

- Unreliable:
  - can lead to false explanations

Problem solving

- Process of finding solution to unfamiliar task using knowledge.
  - E.g.
    - it is the evening before the exam and you could not find the reference book in the library.
    - You have just upgraded your Windows from Windows 7 to Windows 10 and you are lost in some functions.
    - …

- Gestalt theory
  - Proposed by a few German psychologists in 1920's and 30's
  - Draw a distinction between:
    - Reproductive thinking: involving re-use of previous experience (e.g. Windows 7 upgrade to Windows 10)
    - Productive thinking: involving a novel restructuring of the problem
  - Productive thinking
    - Insight occurs during productive thinking when the problem is suddenly restructured and the solution becomes clear

Problem solving (cont.)

- Analogy
  - Analogical mapping
    - novel problems in new domain?
    - use knowledge of similar problem from similar domain
  - Analogical mapping difficult if domains are semantically different

- Skill acquisition
  - Skilled activity characterized by chunking
    - lot of information is chunked to optimize STM
  - Conceptual rather than superficial grouping of problems
  - Information is structured more effectively

Errors

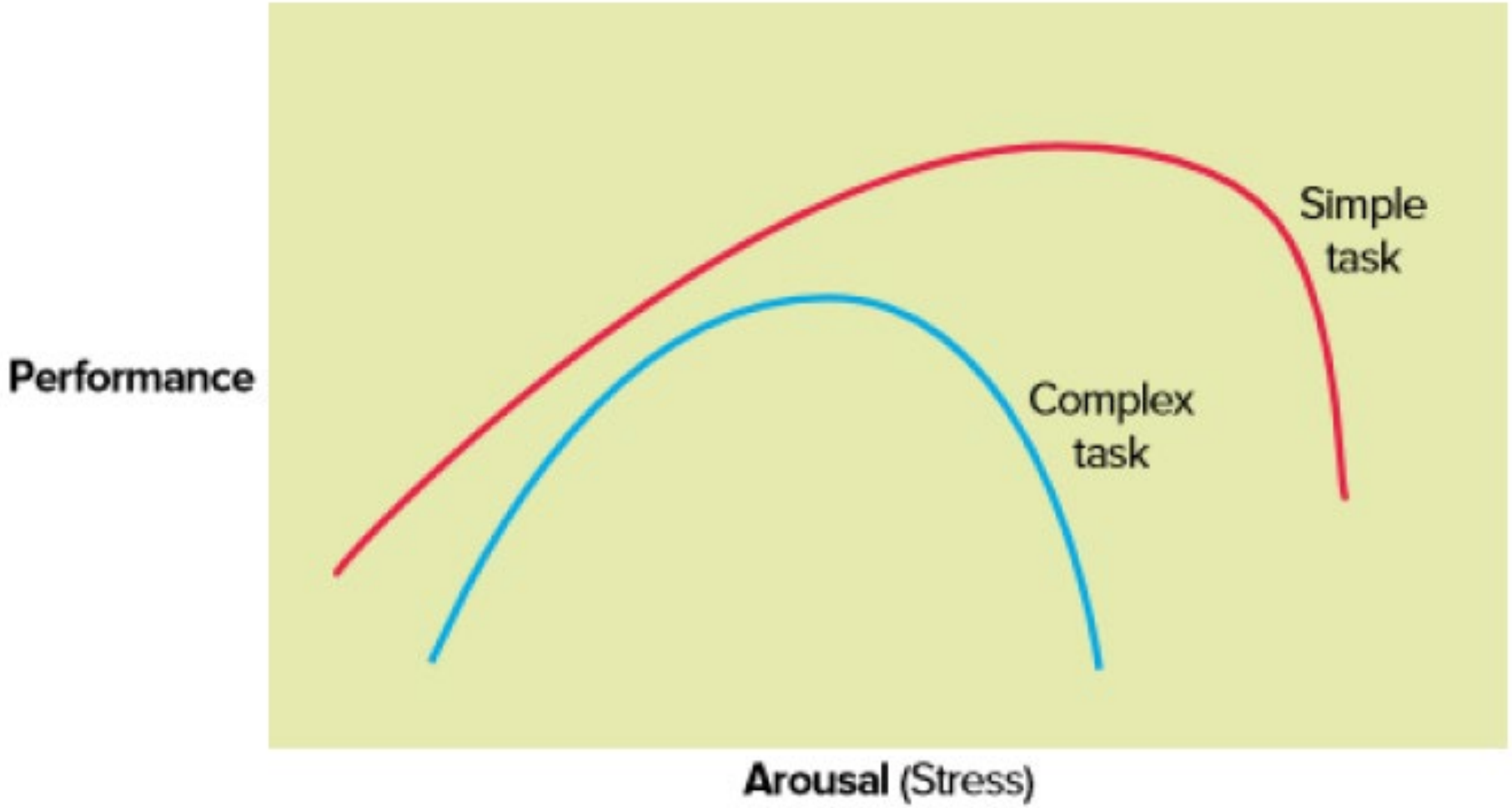
Errors and mental models

Types of error

- Mistakes
  - Wrong intention or method
  - Cause: incorrect understanding

    e.g. you want to store data that should be made accesible to web clients through SQL-queries but you buy a Microsoft Excel license. This is an error as Microsoft Excel is not designed for that purpose. In other words, you choose a wrong method for achieving your objective.
- Slips
  - Right intention, but failed to do it right
  - Causes: poor physical skill, inattention etc.
  - Change to aspect of skilled behaviour can cause slip
  - E.g. if you installed a Postgresql Server for the same reason but in your haste forgot to give the programme privileges to go through your firewall, that would be a slip. You chose the right method of achieving your objective, but you made an error in carrying out the method.

You make errors when under stress



Emotion

- Various theories of how emotion works
  - James-Lange: emotion is our interpretation of a physiological response to a stimuli
  - Cannon: emotion is a psychological response to a stimuli
  - Schacter-Singer: emotion is the result of our evaluation of our physiological responses, in the light of the whole situation we are in
- Emotion clearly involves both cognitive and physical responses to stimuli

Emotion (cont.)

- The biological response to physical stimuli is called *affect*

- Affect influences how we respond to situations
  - positive $\rightarrow$ creative problem solving
  - negative $\rightarrow$ narrow thinking

  "Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks"

  (Donald Norman)

Emotion (cont.)

- Implications for interface design
  - Stress will increase the difficulty of problem solving
  - Relaxed users will be more forgiving of shortcomings in design
  - Aesthetically pleasing and rewarding interfaces will increase positive affect

Individual Diversity

Individual Diversity

- Long term
  - Sex
- Short term
  - Effect of stress or fatigue
- Changing
  - Age
  - Physical and intellectual abilities

Cultural and International Diversity

- Users who were raised learning to read Japanese or Chinese will scan a screen differently from users who were raised learning to read English or French.

- Users from reflective or traditional cultures may prefer interfaces with stable displays from which they select a single item, while users from action-oriented or novelty-based cultures may prefer animated screens and multiple clicks.

- UI design internationalization
  - Characters, numerals, special characters, and diacriticals
  - Left-to-right versus right-to-left versus vertical input and reading
  - Date and time formats
  - Numeric and currency formats
  - Weights and measures
  - Telephone numbers and addresses
  - Names and titles (Mr., Ms., Dr.)
  - …

Users with disabilities

- Users with perceptual or motor impairments
- Enable UI accessible for people with disabilities
- International standards
  - Web Content Accessibility Guidelines (WCAG); the current version is WCAG 2.0 (best-known, best-understood, and most-documented set of accessibility guidelines)
  - Authoring Tool Accessibility Guidelines (ATAG) for developer tools and the User Agent Accessibility Guidelines (UAAG) for browsers.
  - EPUB3 for ebooks.

Older adult users

- Aging is described as:
  - “a non-uniform set of progressive changes in physiological and psychological functioning. . . . Average visual and auditory acuity decline considerably with age, as do average strength and speed of response. . . . [People experience] loss of at least some kinds of memory function, declines in perceptual flexibility, slowing of “stimulus encoding,” and increased difficulty in the acquisition of complex mental skills, . . . visual functions such as static visual acuity, dark adaptation, accommodation, contrast sensitivity, and peripheral vision decline, on average, with age. (Czaja, 1990)”
- Desktop, web, and mobile devices can be improved for all users by providing users with control over font sizes, display contrast, and audio levels.
- Interfaces can also be designed with easier-to-use pointing devices, clearer navigation paths, and consistent layouts to improve access for older adults and every user.

Children

- Emphasize on entertainment and education

- Design principles for children's software should recognize young people's intense desire for the kind of interactive engagement that gives them control with appropriate feedback and supports their social engagement with peers

- Limitations to consider
  - low capacity for abstraction
  - short attention spans
  - limited capacity to work with multiple concepts simultaneously

Summary

- Senses
  - Vision
    - pay attention to how colors combine
    - limitations of human visual perception
    - people with color deficiency
  - Hearing
    - limitations of human hearing
    - older people cannot hear high frequencies
  - Touch
    - Large areas of the cortex devoted to hands lips and tongue
- Processing
  - Modeling Human Processor
    - perceptual, motor, cognitive processors and memory
    - model allows us to make predictions
  - Long- and short-term memory
    - Interference can make hard to access long term memory
    - Cues in working memory can make it easier to access long term memory
  - Cognitive chunk
- Thinking
  - Reasoning
  - Problem solving
- Errors
- Diversity