HUMAN ABILITIES

690A- Advanced Methods in HCI

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Slides from Prof. Joanna McGrenere and Dr. Leila Aflatoony
Includes slides from Prof. Karon MacLean and Jessica Dawson

LEARNING GOALS

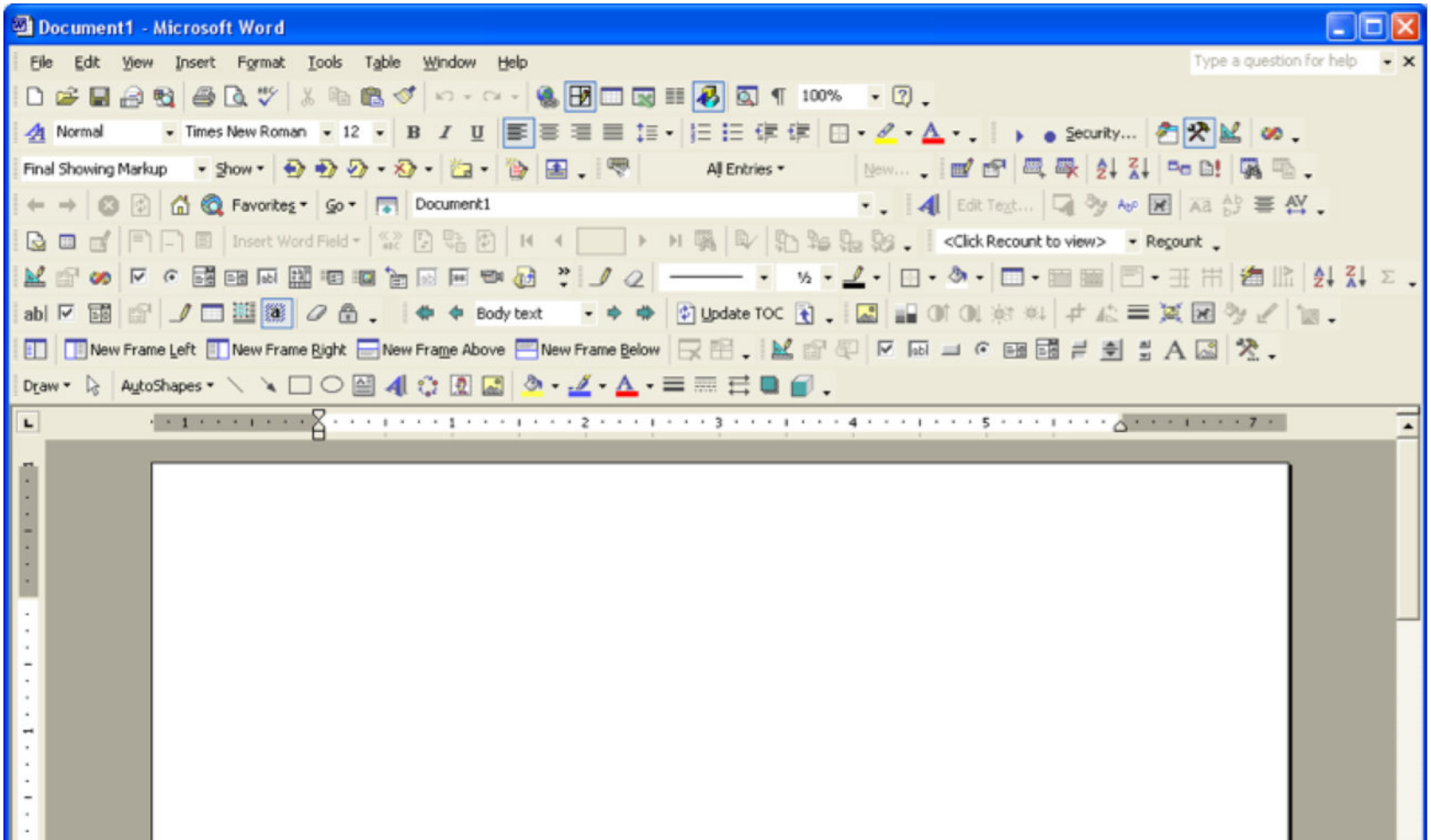
- understand human abilities, perception and action subsystems.
- understand models and theories of human performance and abilities.
    - Attention, divided attention, color, focus, motor, etc.
- be able to identify and apply knowledge of human abilities in designing interfaces for humans.
- understand vision systems, change blindness examples, and how related to interface design.
- explain Fitts' law, how to revisit an interface considering this principle, and how else Fitts' law can be used.

HUMAN-CENTERED DESIGN

Beyond understanding the tasks (task-centered design), the type of users (persona-based design) that we want to support, as well as an appropriate conceptual model…

… **we *must* understand human abilities in order to do detailed interface and interaction design**.

IS THIS A GOOD INTERFACE?

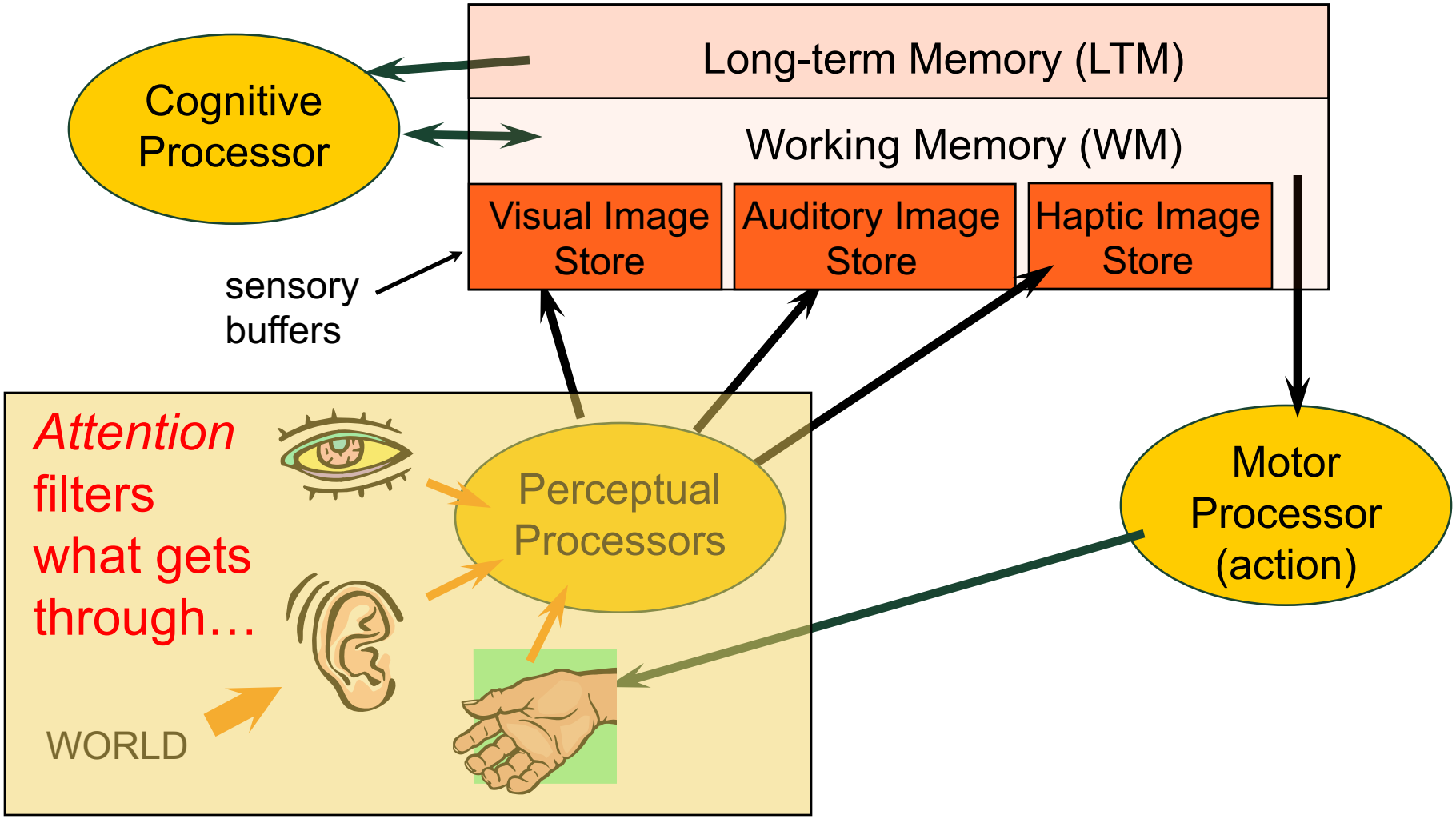


HOW DO WE CHARACTERIZE HUMAN ABILITIES?

Where do we start?

With a model of the human.

MODEL HUMAN PROCESSOR (MHP) : ONE MODEL FOR PERCEPTION → MEMORY → COGNITION



"The Psychology of Human-Computer Interaction", 1983 Card, Moran, & Newell

PERCEPTION & ACTION SUBSYSTEMS

subsystems may operate in parallel (theory):

input (perception):

- **visual** subsystem for what we see (most studied)
- **acoustic** subsystem for what we hear
- **haptic** subsystem for what we feel

output (action):

- **vocal** (**articulatory**) subsystem for what we speak
- **motor** subsystem for how we move
- **brain waves!** think to interact (brain-computer interfaces)

SMELLMAP: AMESTERDAM

Kate McLean, IEEE vis 2014, art program
https://visap.uic.edu/2014/art/Smellmap.pdf

ANALOGIES TO A COMPUTER SYSTEM

can be a helpful way to think about it:

perception, audition, motor control = system I/O

- each has associated memory ("cache")
- limits on input speed ("sample rate") and throughput capacity

cognition = CPU

- includes multi-level main memory
- multithreading ? *we don't really understand how this works in people*

use analogy with caution:

some systems do NOT work this way.

TAKEAWAYS FOR THIS LECTURE

When designing for humans, you need to factor in knowledge of their abilities.

There are many models and theories of human performance / ability, we will touch on only a few today.

This lecture brings together content from 4 different lectures in HCI. Each of those lectures only scratches the surface, so this one is even more abridged.

ATTENTION

Is a filter on perceptual input.

It's one important mechanism for information moving between types of memory (image store -> working memory -> long term member)

PERCEPTUAL LIMITATIONS

The following is intended to illustrate just how bad our senses really are

EXAMPLE: CHANGE BLINDNESS

in upcoming images,

- image will blink or flicker
- image changes with each blink

raise your hand as soon as you identify change

images from O'Regan, Rensink & Clark 1999
(Ron Rensink of this dept)

AIRPLANE

DINERS

AIRPLANE WITHOUT BLINK:

DINERS WITHOUT BLINK:

VISION SYSTEM: LIKE A CAMERA?

seems like it:

***camera*:** keep steady, adjust focal lens length

***eye*:** focal point always moving, yet we perceive the world as being sharp and in focus

but how does it really work?

***camera*:** film is exposed all at once by light from scene

eye*:** electrical signals travel to brain, which ***gradually + selectively updates a mental image of a scene

→ camera is a poor metaphor for vision!

HOW DOES THIS RELATE TO INTERFACE DESIGN?

What are some everyday situations where ‘change blindness’ occur?

For those situations, how might you help by changing the design?

DIVIDED ATTENTION

Microsoft PowerPoint - [444-07_humanAbilities_preattentiveANDmemory.ppt]

pre-attentive lessons

- rapid visual search (<= 10 msec/item)
- easy to attend to
- makes symbols distinct
- based on simple visual attributes
- faces etc are not pre-attentive

24

JM: removed:

rules for making things distinct can be used for individual symbols or areas
do not use large areas of strong color
orthogonality - use a different channel for a different type of information

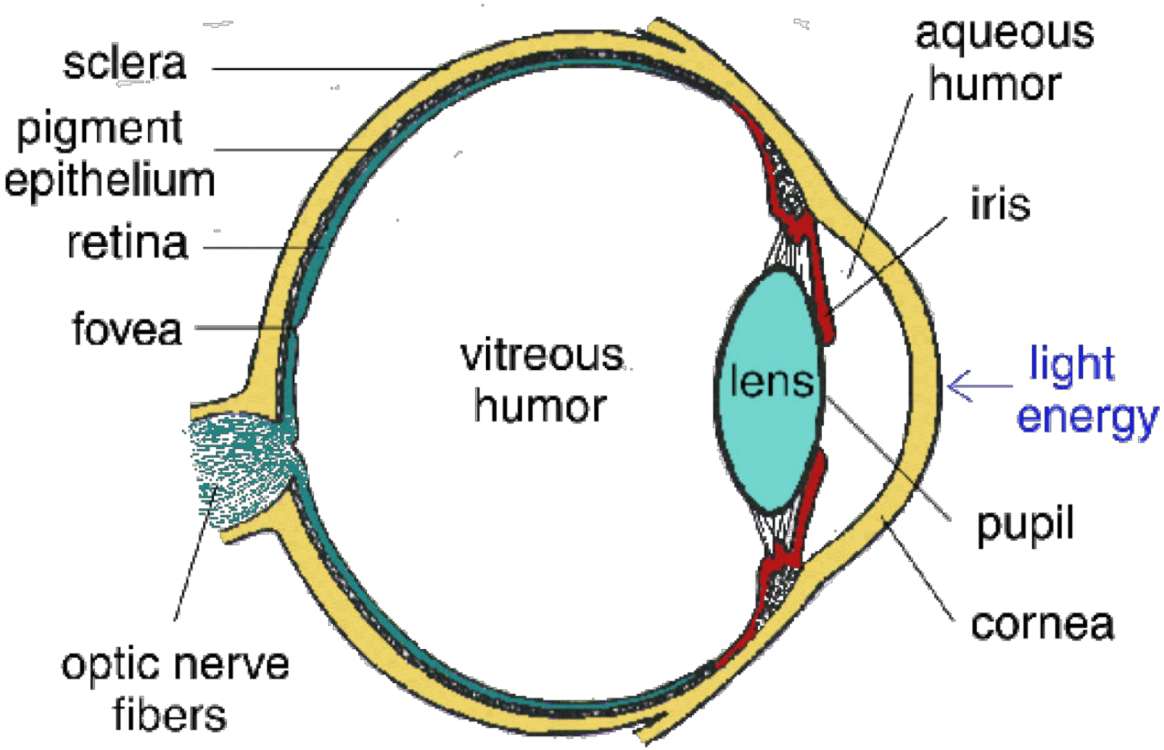
joanna@cs.ubc.ca has 1 new message

COLOR

color can substantially *improve* user interfaces…

but inappropriate use can severely *reduce* usability

HUMAN VISUAL SYSTEM



light passes through lens

focused on retina

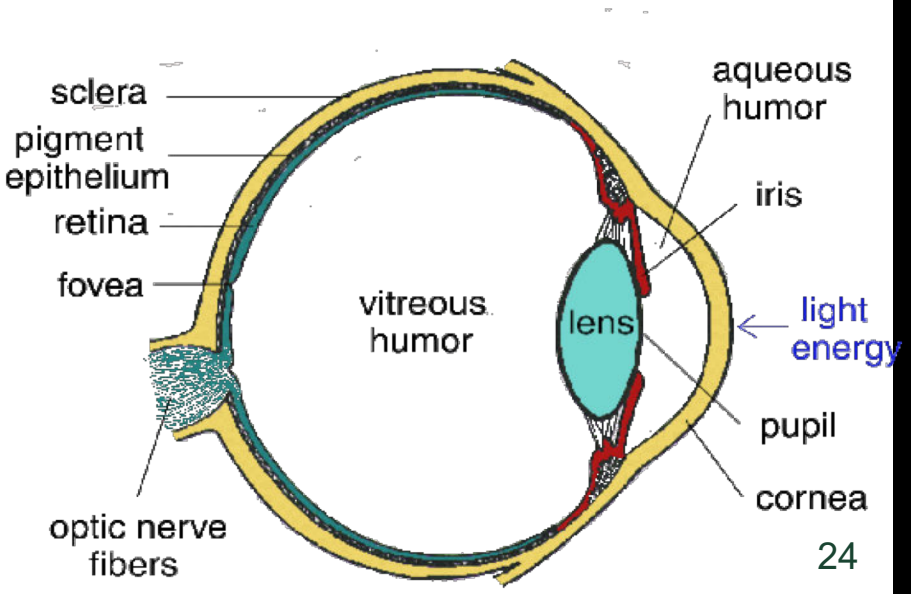
RETINA

center of retina (fovea) has most of the cones

- allows for high acuity of objects focused at center

edge of retina (periphery) is dominated by rods

- allows detecting motion in periphery

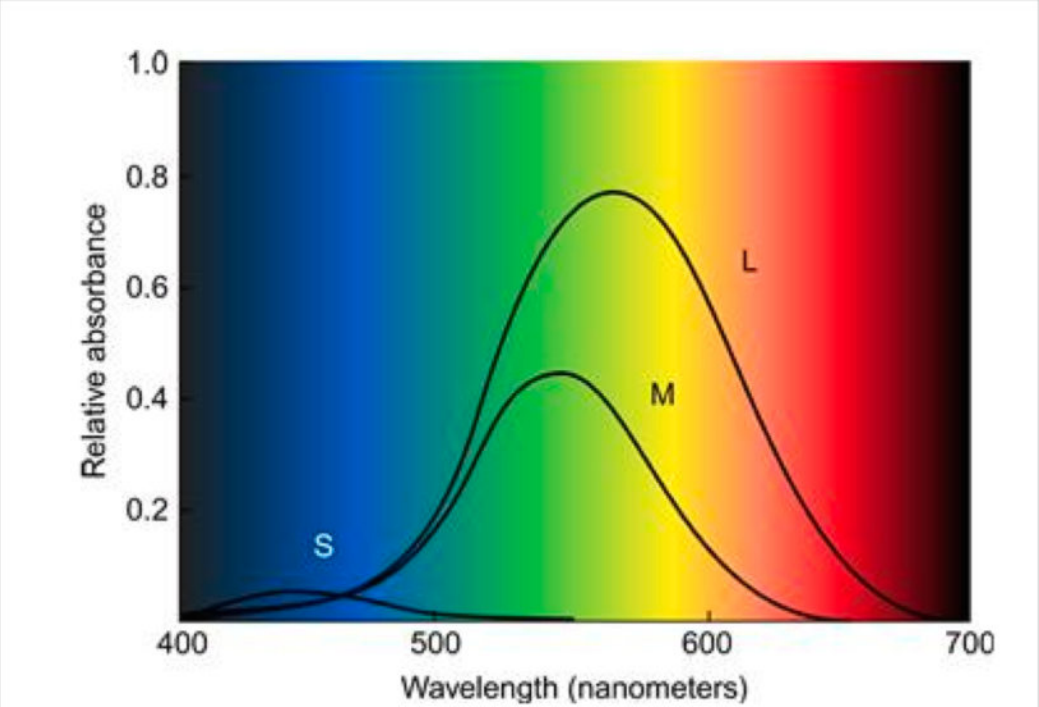


TRICHROMACY THEORY

cone receptors used to sense color

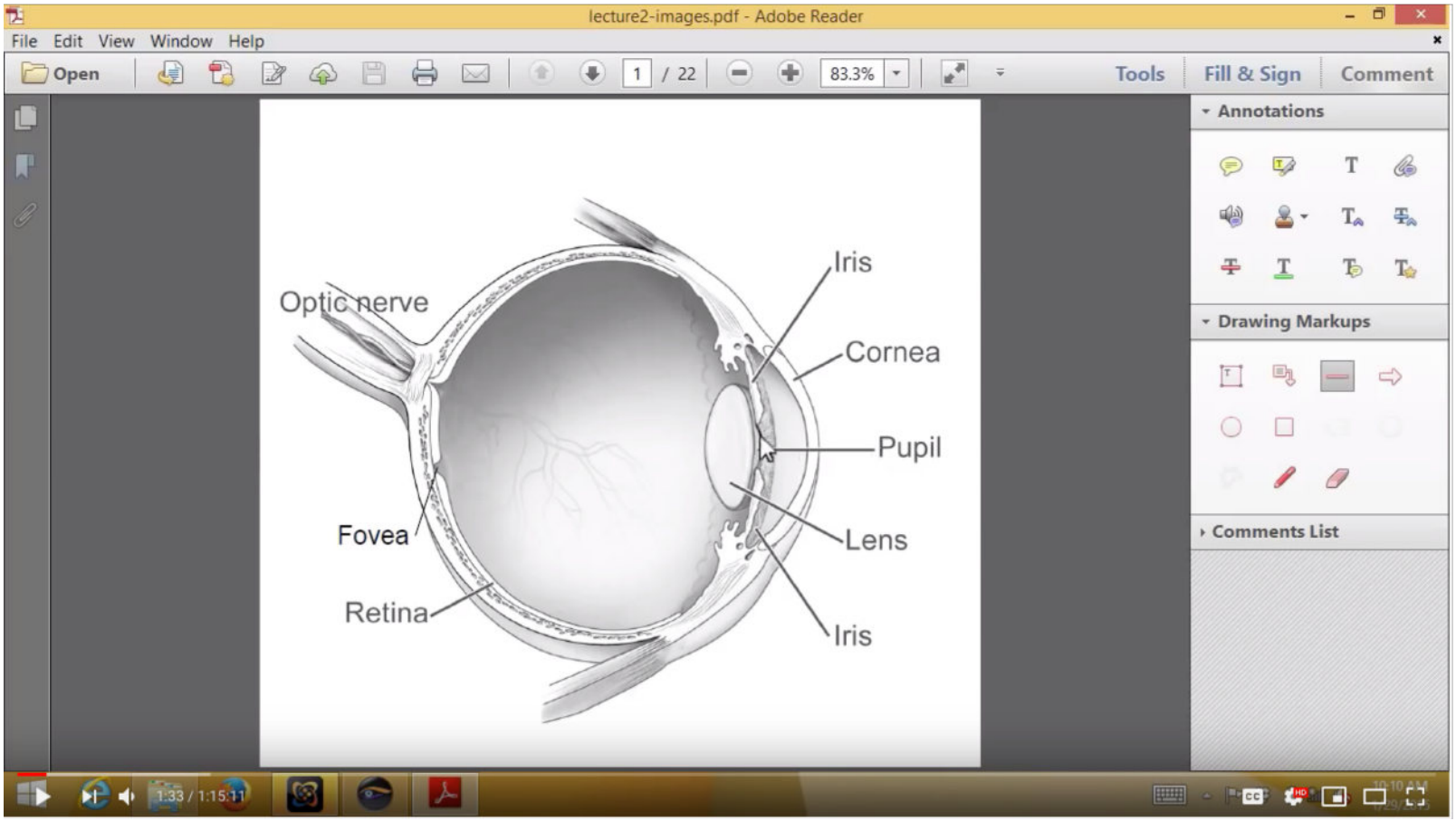
3 types: Short, Medium, Long (really more yellow)

- each sensitive to different band of spectrum
- balance of activity between 3 types to achieve all colours in visible spectrum



from *Ware (2013). Information Visualization, Perception for design*

DIGITAL IMAGE PROCESSING LECTURE



Rich Radke, Rensselaer Polytechnic Institute:
https://www.youtube.com/watch?v=eK4ZAsKgCg4

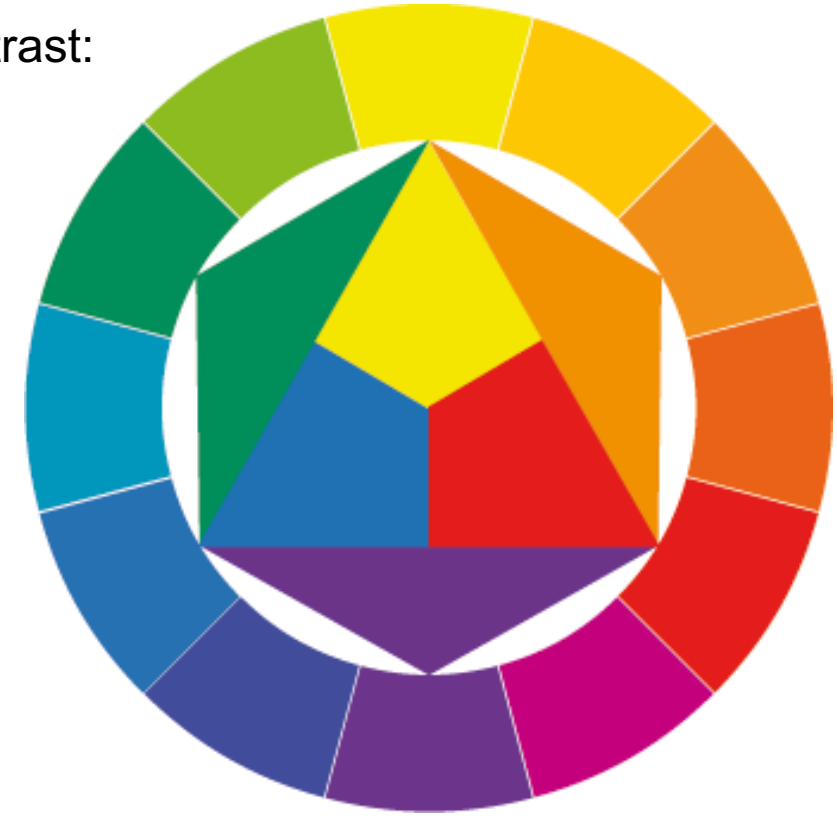
HOW WE SEE COLORS

Colm Kelleher: https://www.youtube.com/watch?v=l8_fZPHasdo

JOHANNES ITTEN, COLOR THEORY

Itten theorized seven types of color contrast:

(1) contrast by hue,
(2) contrast by value,
(3) contrast by temperature,
(4) contrast by complements,
(5) simultaneous contrast,
(6) contrast by saturation,
(7) contrast by extension.



FOCUS

wavelengths of light focus at different distances behind eye's lens

→ need for constant refocusing (causes fatigue)

Most people see the red closer than the BLUE but some see the opposite effect

reproduced from *Ware (2013). Information Visualization, Perception for design*

BUT TRICHROMACY THEORY INSUFFICIENT…

Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.
Older users need brighter colors.

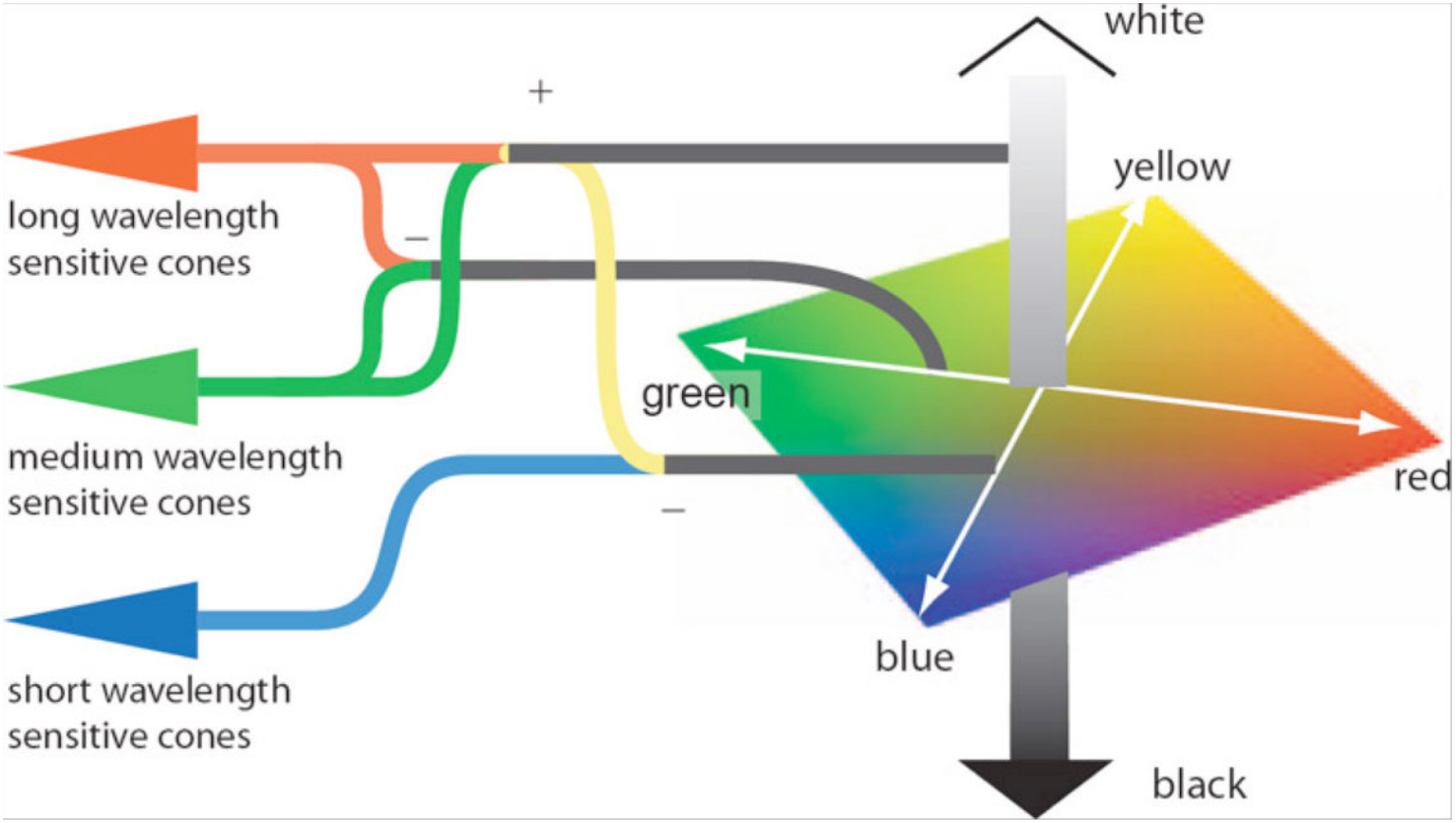
Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.

Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.
Older users need brighter colors.

Showing small yellow text on a white background is a bad idea.
Pure yellow excites both our M and L cones, making yellow the brightest of colours.
Need a lot of luminance contrast

reproduced from *Ware (2013). Information Visualization, Perception for design*

COLOR CHANNELS: OPPONENT PROCESS THEORY



Input from cones processed into three distinct channels immediately after receptors

From *Ware (2008). Visual Thinking for Design. p68*

LUMINANCE "CHANNEL"

carries ~2/3 more details than either of the chromatic channels

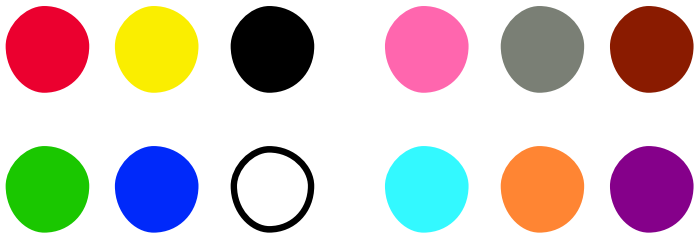
therefore chromatic channels alone not suitable for fine details, small fonts, etc.

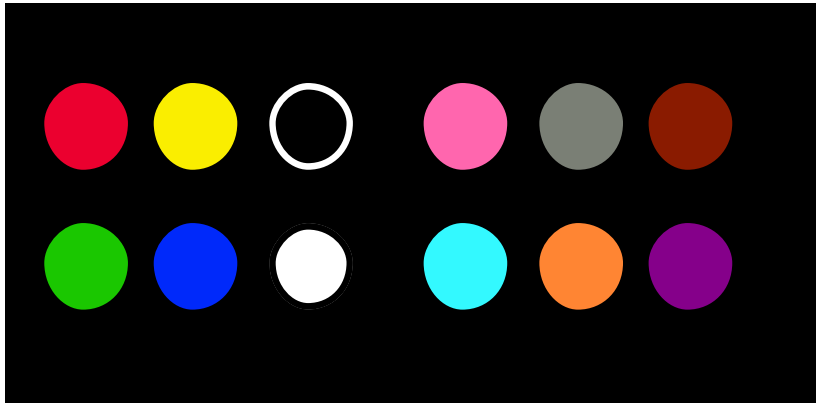
implications:

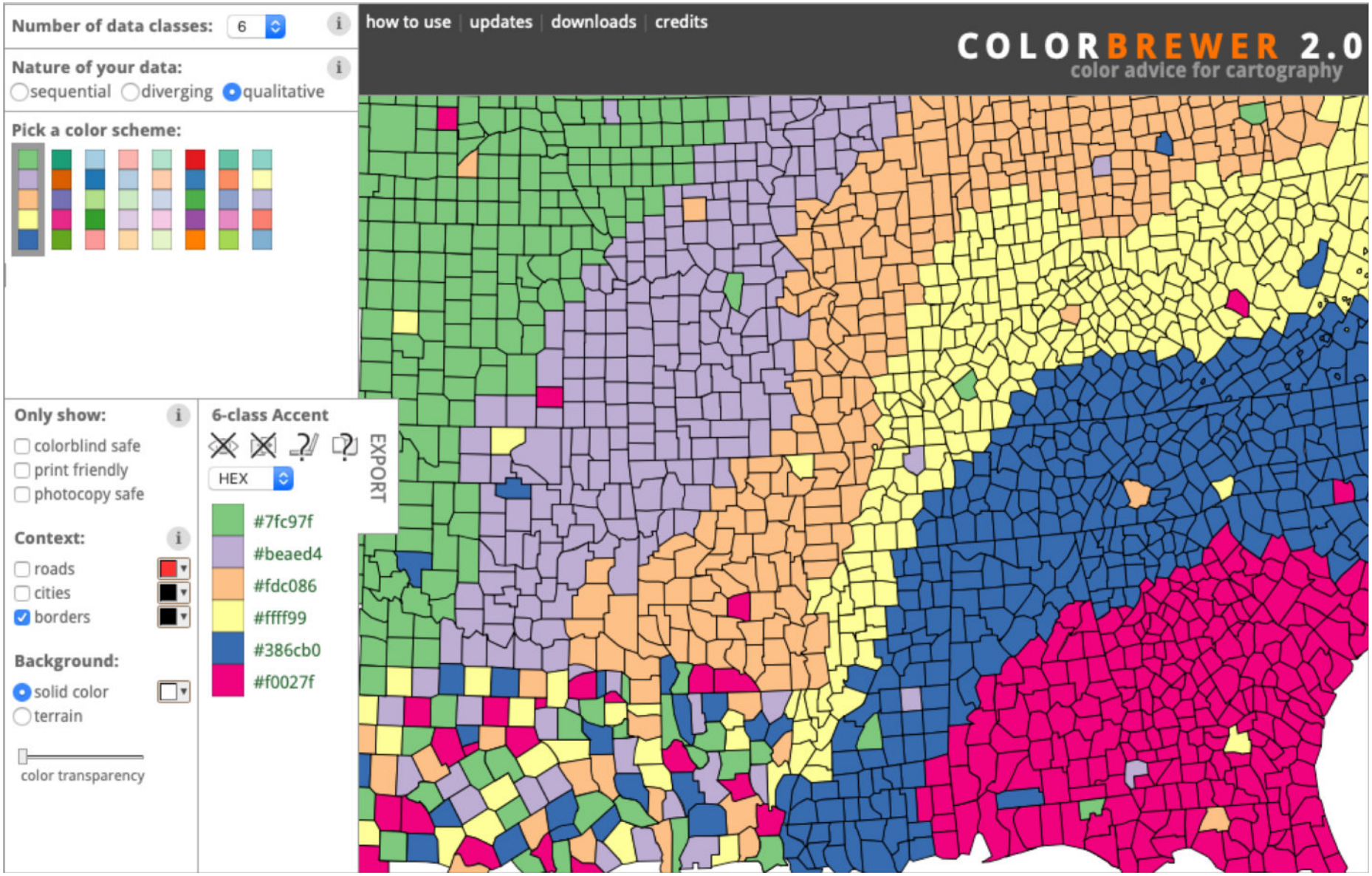
- luminance contrast critical for fine details
- harder to focus on edges created by color alone
    - best to use both luminance & color differences

COLOR GUIDELINES (EX.)

recommended colors for *encoding categories of information (e.g., on a map)*:






Number of data classes: 6
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
Nature of your data:
sequential diverging qualitative
Pick a color scheme:
Only show:
colorblind safe
print friendly
photocopy safe
6-class Accent
HEX
EXPORT
#7fc97f
#beaed4
#fdc086
#ffff99
#386cb0
#f0027f
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency

COLOR GUIDELINES (EX.)

generally want to avoid single-color distinctions and encodings (color blindness)

- e.g. ↑ ↓ better than ■ ■

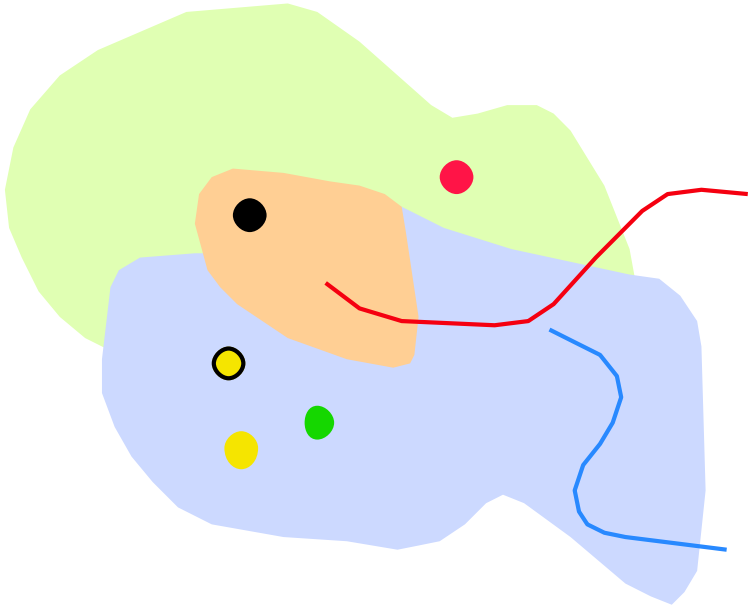
COLOR GUIDELINE (EX.)

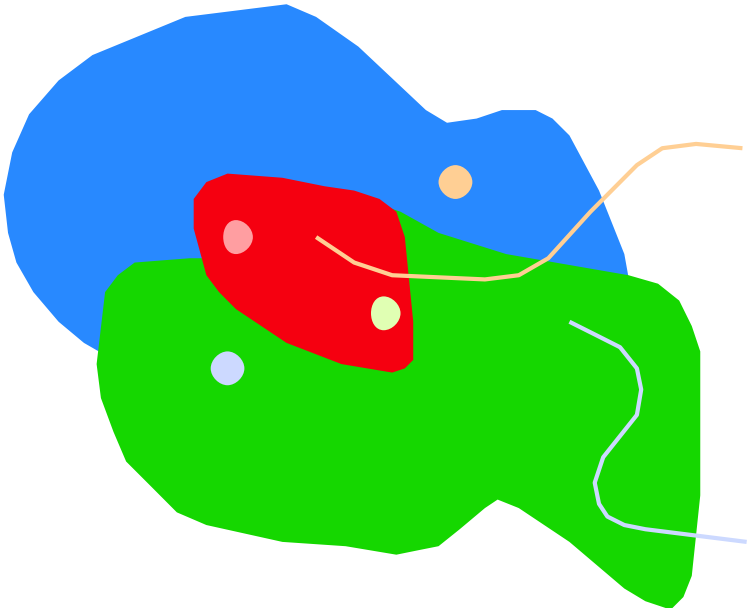
Don’t rely on color (changes) in the periphery to “grab attention”

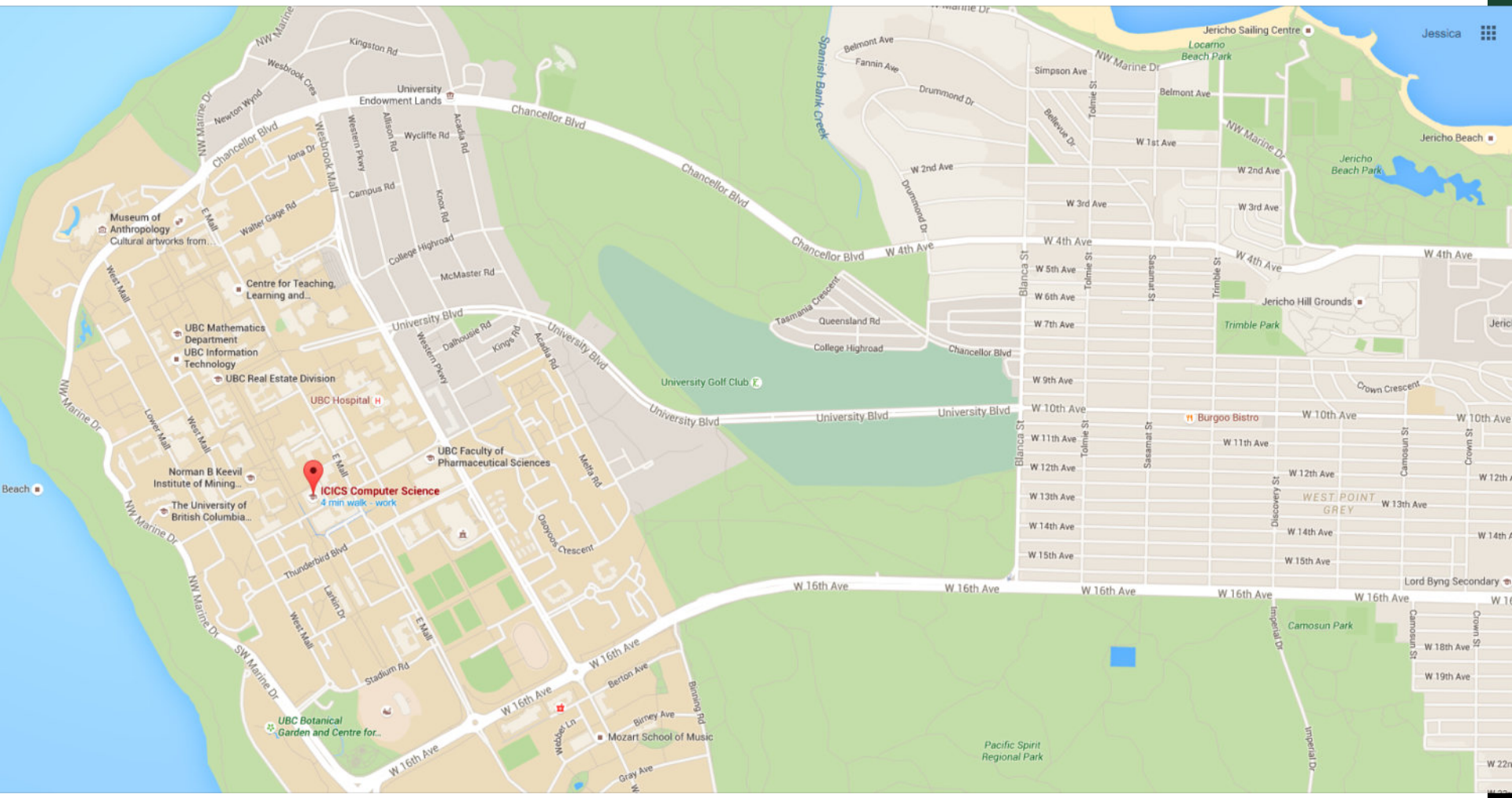
COLOR GUIDELINES (EX.)

large areas: low saturation

small areas: high saturation (strong contrast with background)



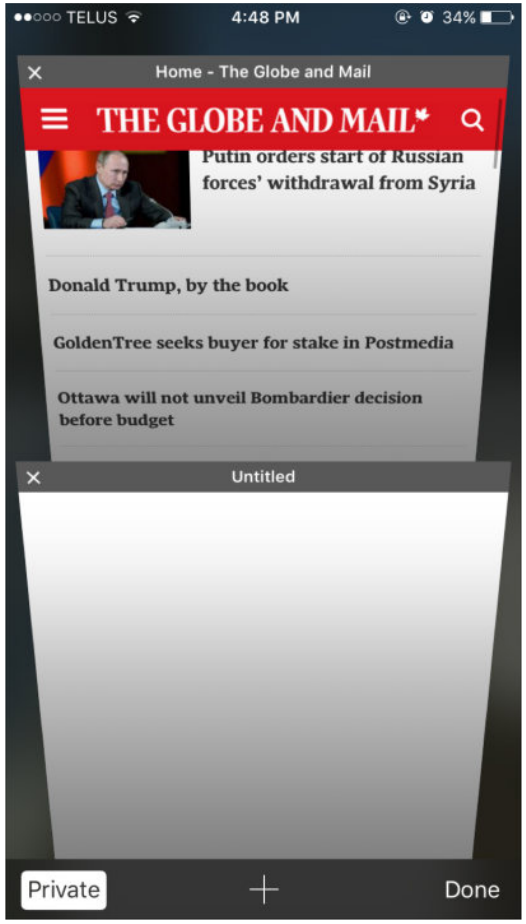


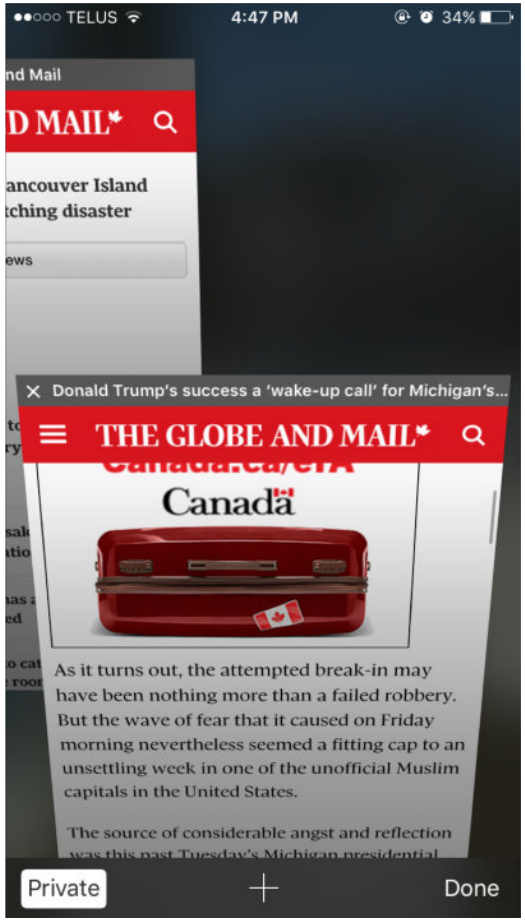


- Red objects are processed pre-attentively (10 ms or less per item) – they “pop out” – we attend to them first.
- Attention and color are related!

MOTOR

PREDICT PERFORMANCE / JUSTIFY DESIGN

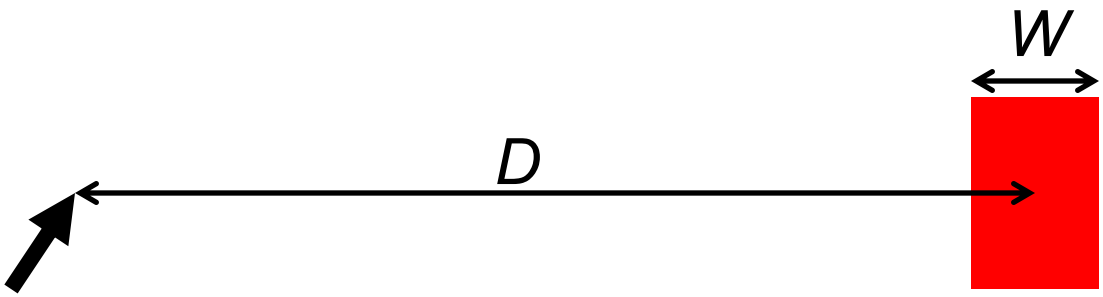




Compare the 'swipe left to close' interaction over 'select the x to close' interaction. Which do you think is better?

FITTS' LAW

PAUL FITTS, 1954



$$\underbrace{MT}_{\text{Movement Time}} = a + b\underbrace{\log_2\left(\frac{D}{W}+1\right)}_{\text{Index of Difficulty } (ID\ [bits])}$$

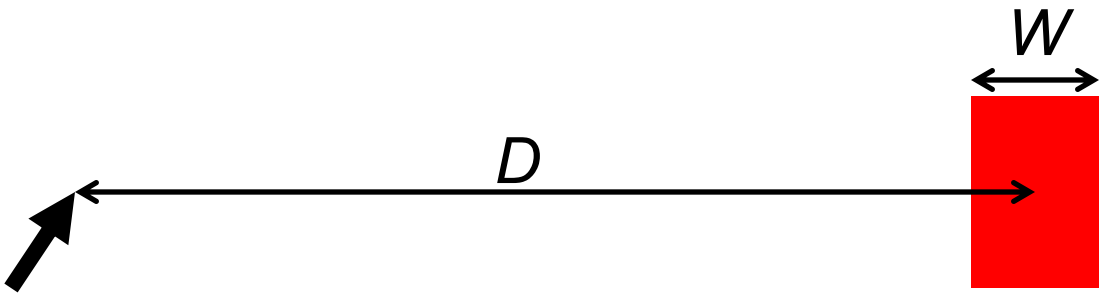
Index of Performance (*IP*) = *ID/MT* (bits/s)

- sometimes called *bandwidth* or *throughput*

task difficulty is analogous to information:
→ execution time is interpreted as
human rate of processing information

FITTS' LAW

PAUL FITTS, 1954



task difficulty for selecting a target (such as a menu item or icon)

is proportional to the *distance* (D) to the target and

inversely proportional to the *width* (W) of the target

HOW ELSE CAN WE USE FITTS' LAW?

So what can we do with this information?

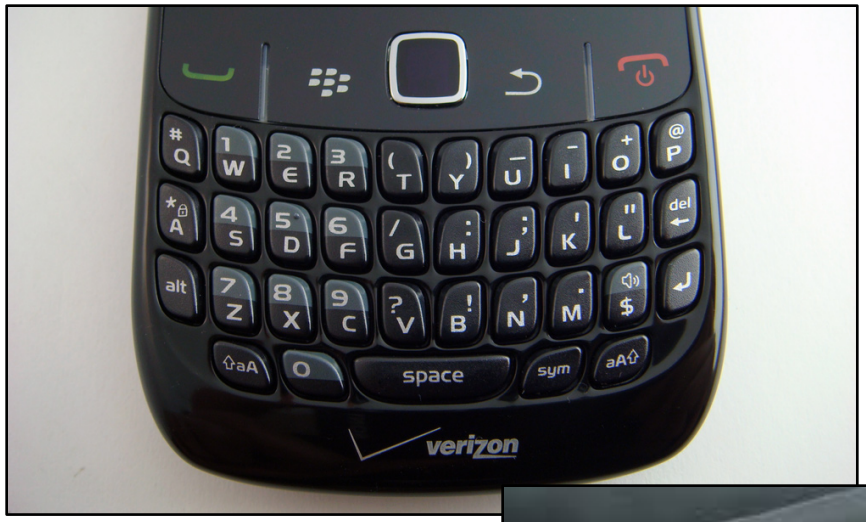
50 years of data

Device	Study	*IP* (bits/s)
Hand	Fitts (1954)	10.6
Mouse	Card, English, & Burr (1978)	10.4
Joystick	Card, English, & Burr (1978)	5.0
Trackball	Epps (1986)	2.9
Touchpad	Epps (1986)	1.6
Eyetracker	Ware & Mikaelian (1987)	13.7

Table Reference:
MacKenzie, I. Fitts' Law as a research and design tool in human computer interaction. *Human Computer Interaction, 1992, Vol. 7, pp. 91-139*

OTHER ASPECTS OF MOTOR…

TACTILE FINDABILITY: "TOUCH" KEYBOARDS

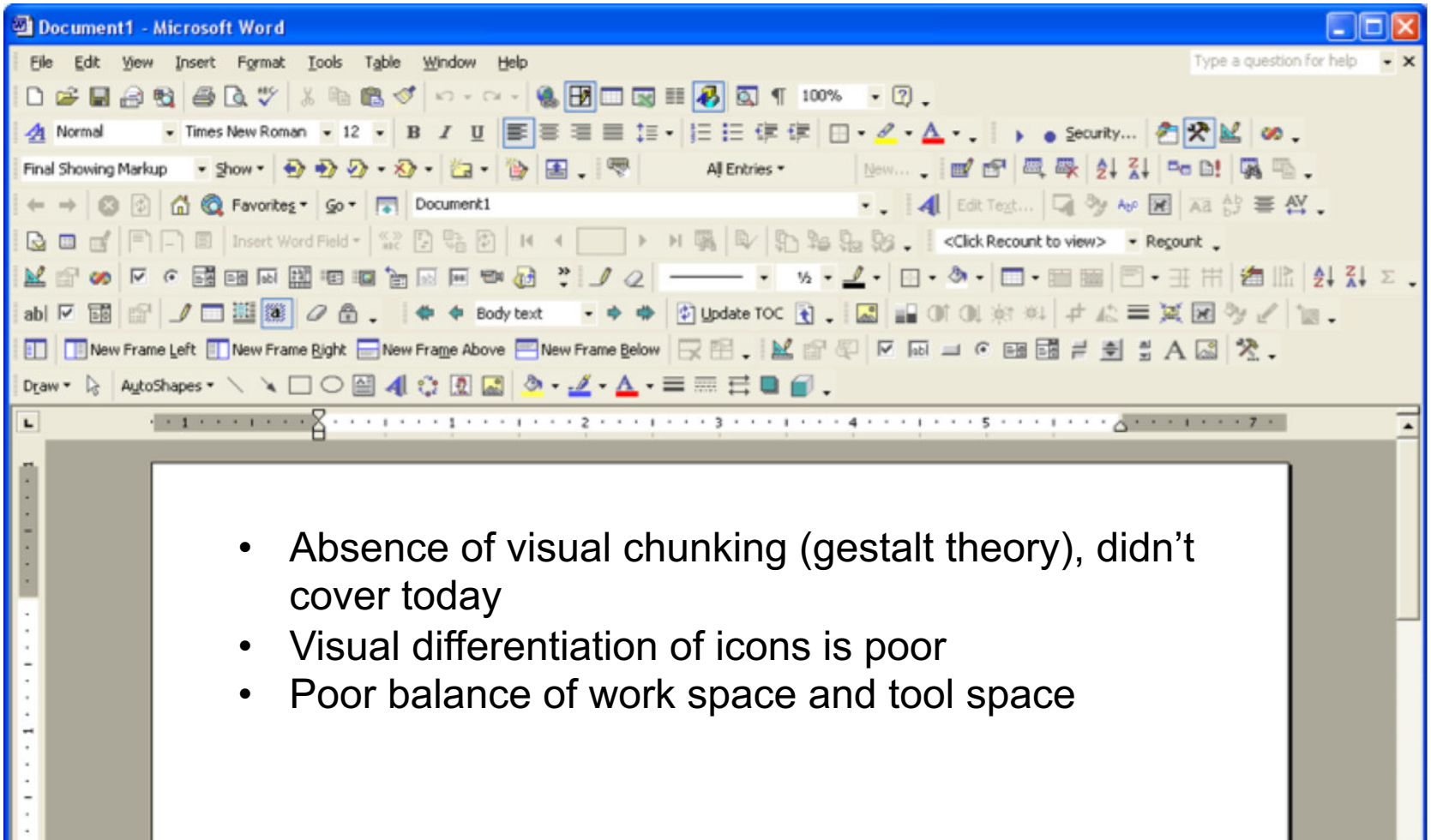


physical keys

"soft" keys have other benefits

tactus "bubble" keyboard: best of both?

BACK TO THIS INTERFACE…



- Absence of visual chunking (gestalt theory), didn't cover today
- Visual differentiation of icons is poor
- Poor balance of work space and tool space

KEY TAKEAWAYS

When doing your graduate research, ask yourself what aspect of human ability impact your design?

If you are designing a…

- **usable security system that involves passwords -> human memory**
- **biomedical tele-surgery device -> haptics and motor**
- **e-book reader for elderly people -> vision, motor, cognition changes across the lifespan**

ON DECK…

- Tue March 19th – Ideate Milestone due + presentations
- Thur March 21– start prototyping

JOHANNES ITTEN, ARTWORK