The Human Factor

CS6501: Human-Computer Interaction

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Fall 2020, Department of Computer Science

University of Virginia | School of Engineering & Applied Science

The Human Factor

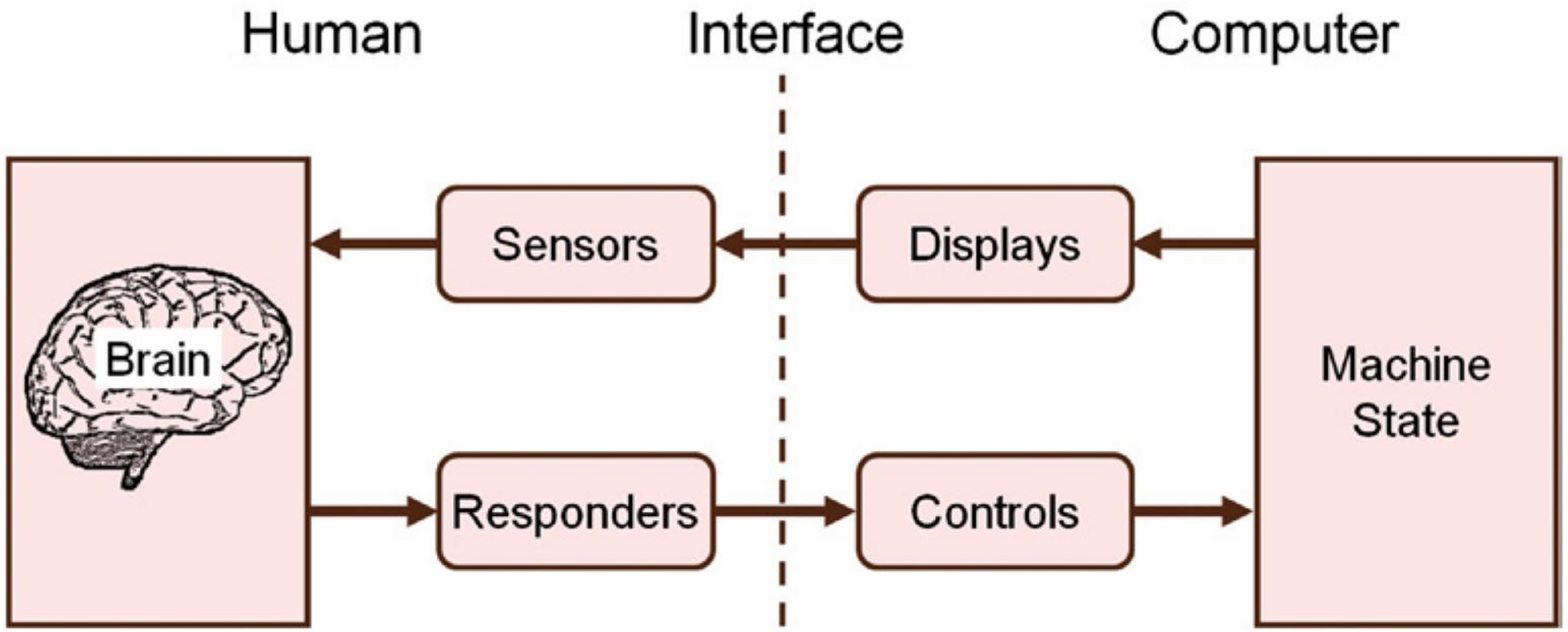
- Computers function according to their programmed capabilities.
- Humans are complicated and differ across many dimensions
  - Young, old, female, male
  - Experts, novices, strong, weak
  - Able-bodied, disabled, sighted, blind
  - Motivated, lazy, tired, alert
- No interface can work well for every user
  - “Know thy user” – Shneiderman and Plaisant, 2005, p66

Understanding the Human

The more we understand humans, the better are our chances of designing interactive systems that work as intended

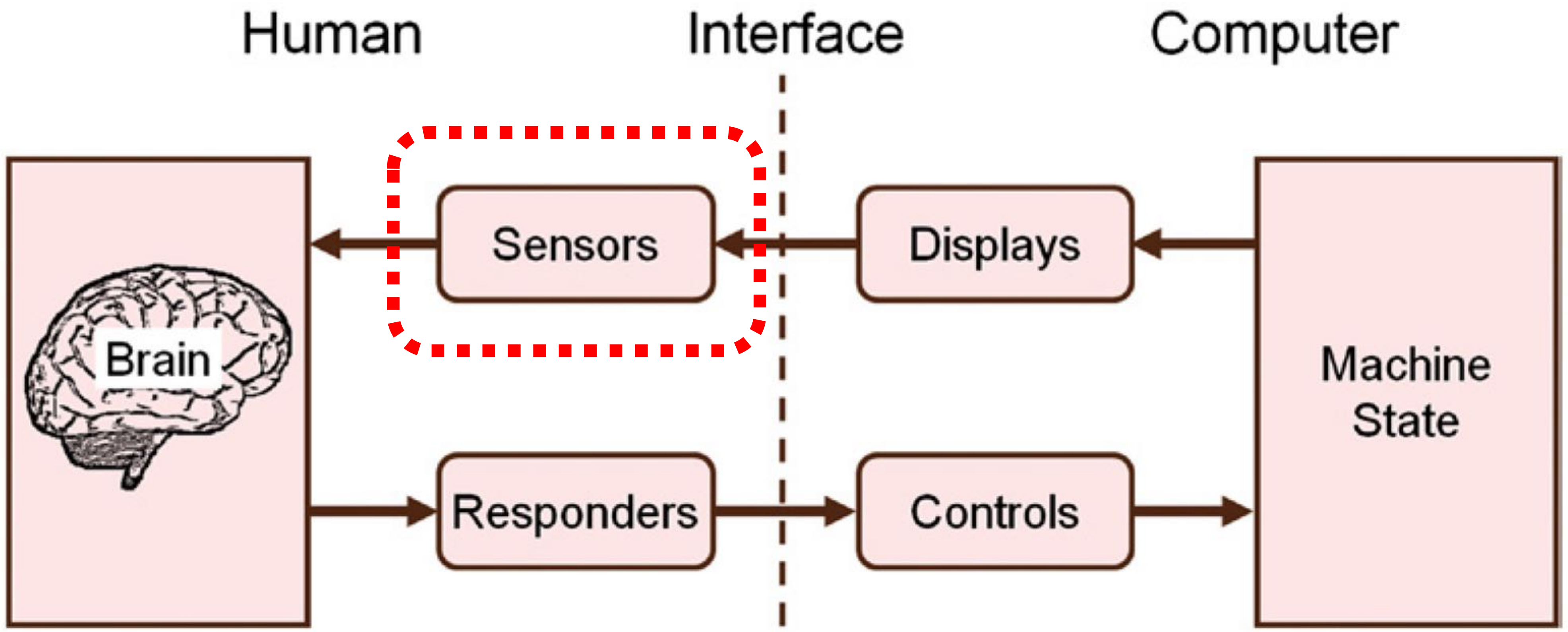
- Why do humans make mistakes?
- Why do humans forget how to do things?
- Why do humans get confused while installing apps on their computers?
- Why do humans have trouble driving while talking on a mobile phone?

Human Factors Model



Kantowitz, B. H., & Sorkin, R. D. (1983).
Human factors: Understanding People-System Relationships

Human Factors Model

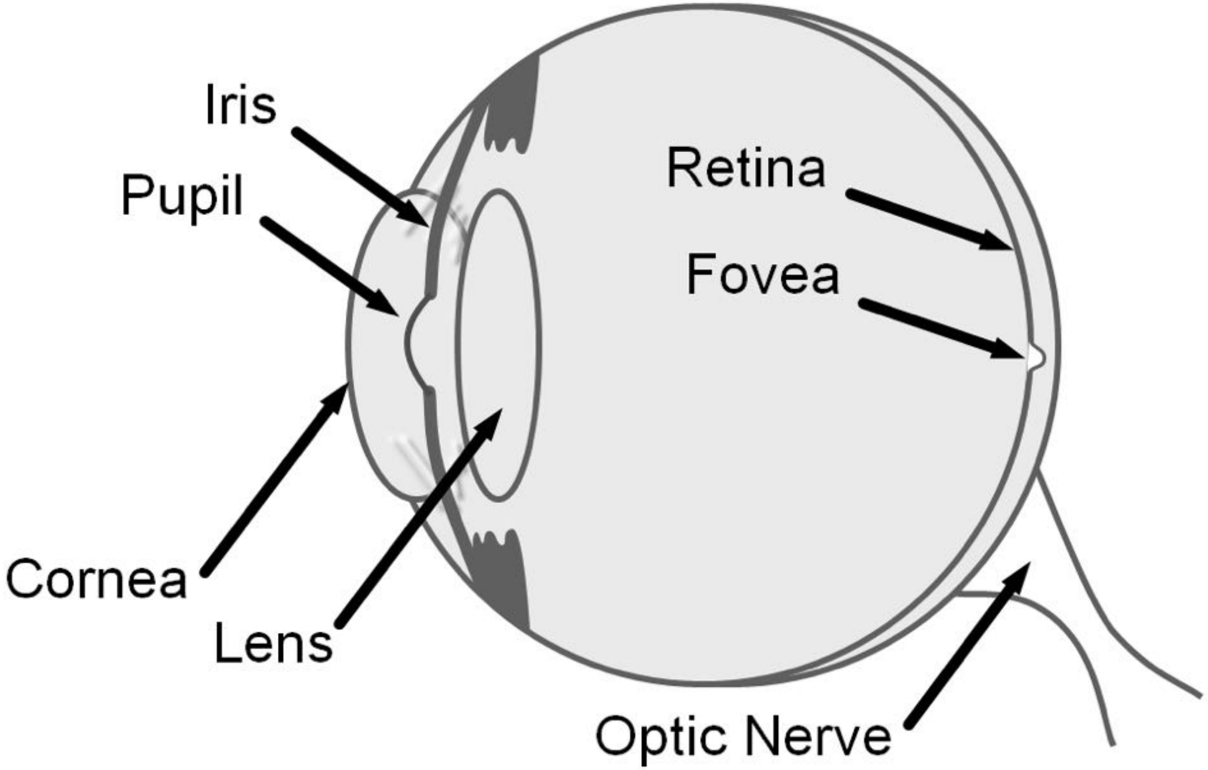


Human Senses

- Vision (sight)
- Hearing (audition)
- Touch (tactition)
- Smell
- Taste

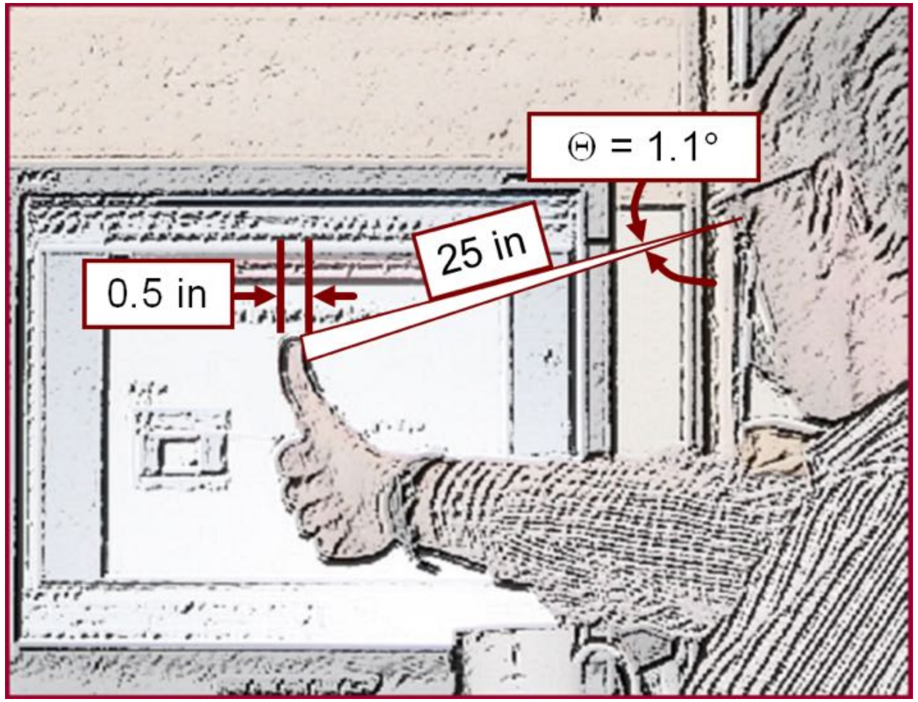
Vision (The Eye)

- People obtain about 80% of their information through vision (the eye)



Fovea Image

- Sharp central vision
- 1% of retina, 50% of visual cortex
- Fovea image is ≈1° of visual angle:

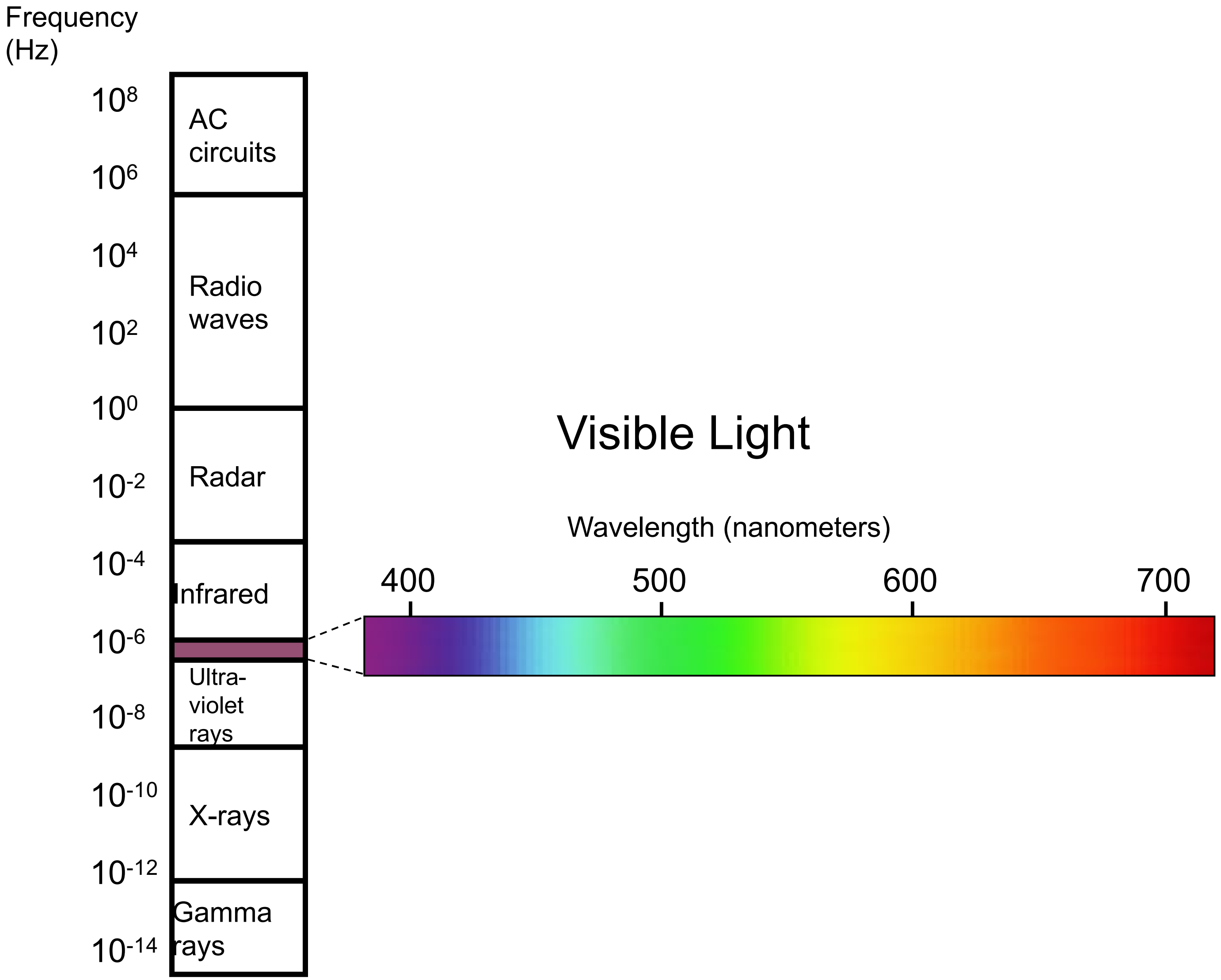


Visual Stimulus

- Physical properties of light…
  - Frequency
  - Intensity (luminance)

- Create subjective properties of vision…
  - Color
  - Brightness

Color Spectrum

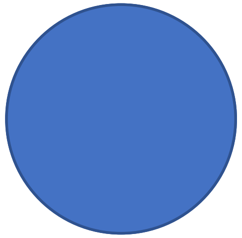


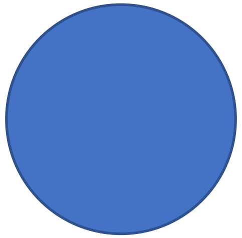
Fixations and Saccades

- Fixation
  - Eyes are stationary (dwell)
  - Take in visual detail from the environment
  - Long or short, but typically at least 200 ms
- Saccade
  - Rapid repositioning of the eye to fixate on a new location
  - Quick: $\approx$120 ms

Smooth Pursuit

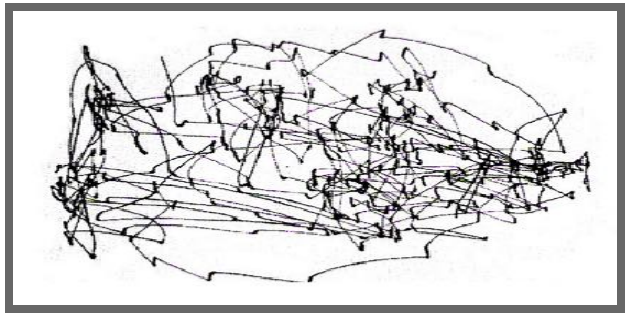
- Try to slowly shift gaze between the two objects



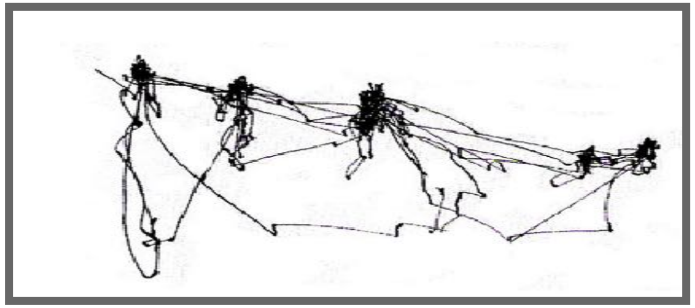


Yarbus' Eye Tracking Research (1965)[1]

The Unwanted Visitor
by Ilya Repin (1844-1930)



"Remember the position of people and objects in the room"



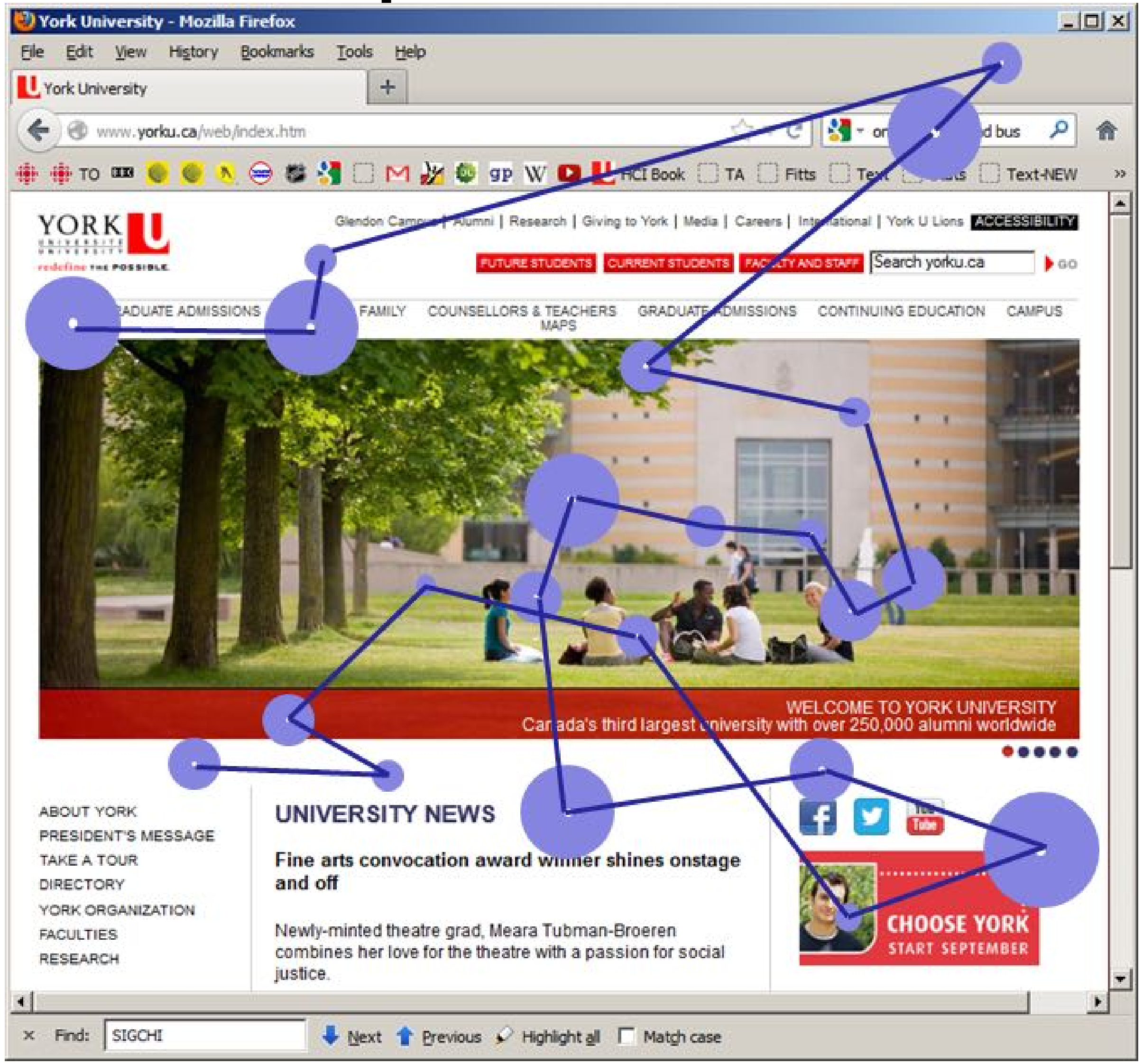
"Estimate the ages of the people"

[1] Tatler, B. W., Wade, N. J., Kwan, H., Findlay, J. M., & Velichkovsky, B. M. (2010). Yarbus, eye movements, and vision. *i-Perception, 1*, 7-27..

Scan Paths

- Visual depiction of saccades and fixations
- Saccades → straight lines
- Fixations → circles
  - Diameter of circle $\propto$ duration of fixation
- Applications
  - User behaviour research (e.g., reading patterns)
  - Marketing research (e.g., ad placement)

Scan Path Example



Gaze and Touch Interaction on Tablets

Ken Pfeuffer, Hans Gellersen
Lancaster University
k.pfeuffer@lancaster.ac.uk, hwg@comp.lancs.ac.uk

Hearing (Audition)

- Sound → cyclic fluctuations of pressure in a medium, such as air
- Created when physical objects are moved or vibrated
- Examples
  - Slamming a door, plucking a guitar string, shuffling cards, speaking

- Physical properties of sound
  - Frequency
  - Intensity

Subjective properties of hearing

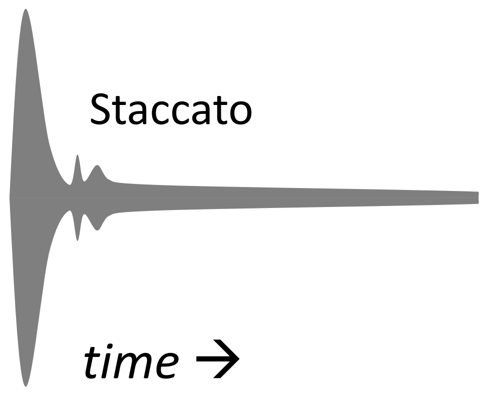
- Pitch
- Loudness
- Timbre
- Attack

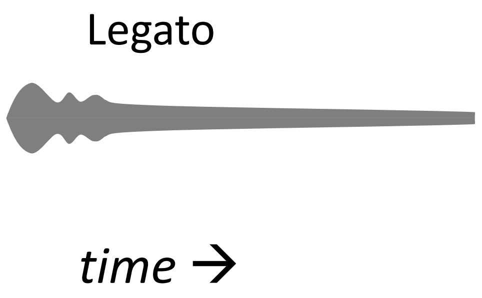
Timbre

- Aka *richness*, *brightness*
- Results from harmonic structure of sound
- E.g., a musical note of 200 Hz, has harmonics at 400 Hz, 600 Hz, 800 Hz, etc.
- Notes of the same frequency from different instruments are distinguished, in part, due to timbre

Attack

- Aka *envelope*
- Results from the way a note and its harmonics build up and transition in time – from silent, to audible, to silent
- Considerable information in the onset envelop
- Assists in distinguishing notes of the same pitch coming from different instruments
- Onset envelop created through articulation (e.g., legato, staccato)





Hearing (Audition)

- Can be used for
  - Notification
  - Immersion
  - Feedback
  - Spatial Awareness

Hearing (Audition)

- Can be used for
  - Notification
  - Immersion
  - Feedback
  - Spatial Awareness

He

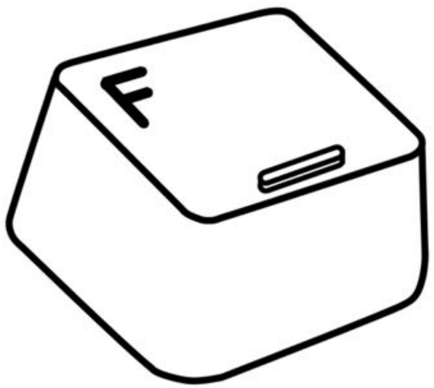
- Ca

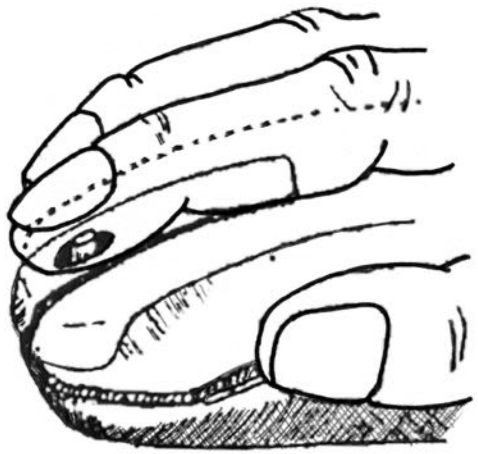
Shengdong Zhao, Pierre Dragicevic, Mark Chignell, Ravin Balakrishnan, and Patrick Baudisch. 2007. Earpod: eyes-free menu selection using touch input and reactive audio feedback. CHI 2007


HindSight
Enhancing Spatial Awareness by Sonifying Detected Objects in Real-Time 360-Degree Video
Eldon Schoop
James Smith
Bjoern Hartmann
CHI 2018

Touch (Tactition)

- Part of somatosensory system, with…
- Receptors in skin, muscles, joints, bones
  - Sense of touch, pain, temperature, position, shape, texture, resistance, etc.
- Tactile feedback examples:





Touch and Tactile Feedback

Guiding directions

Notifications

Feedback

Touch and Tactile Feedback

bhaptics TactSuit

Touch and Tactile Feedback

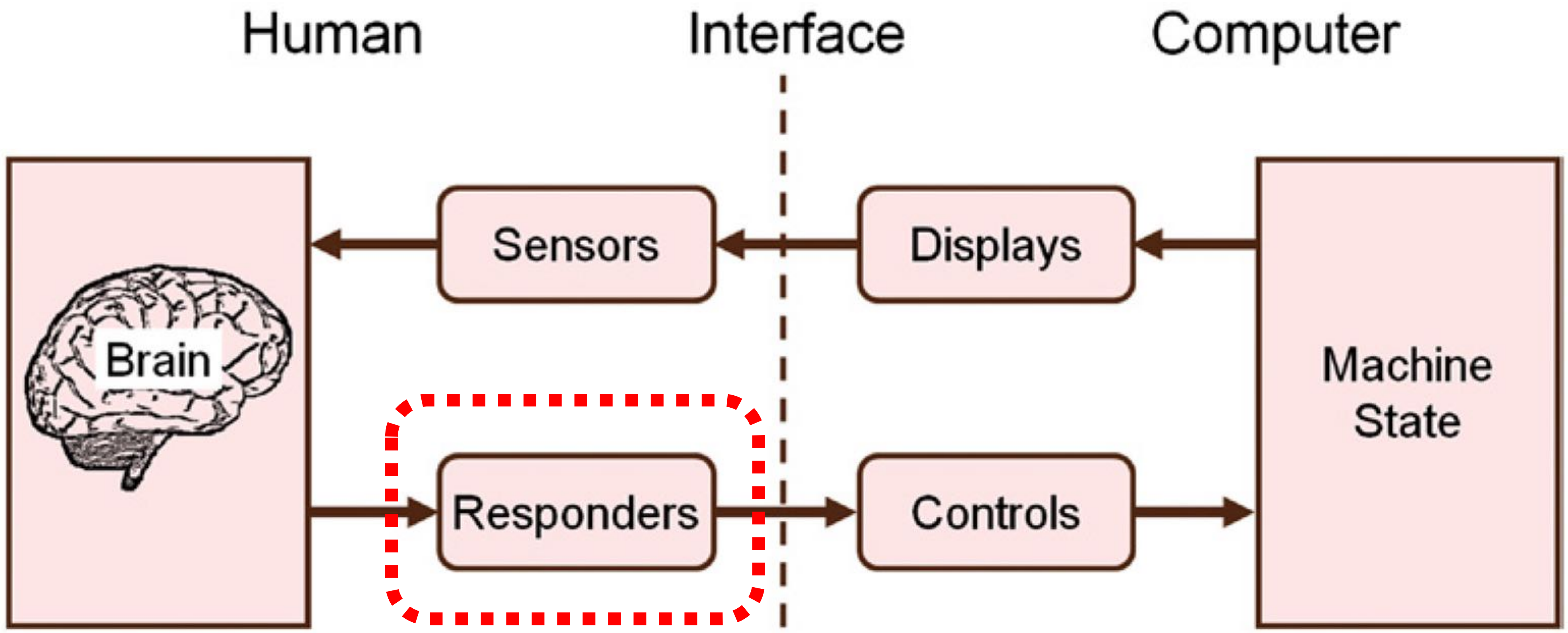
Apple Trackpad

Smell and Taste

- Smell (olfaction)
  - Ability to perceive odours
  - Occurs through sensory cells in nasal cavity
- Taste (gustation)
  - Chemical reception of sweet, salty, bitter, and sour sensations
- Flavour
  - A perceptual process that combines smell and taste

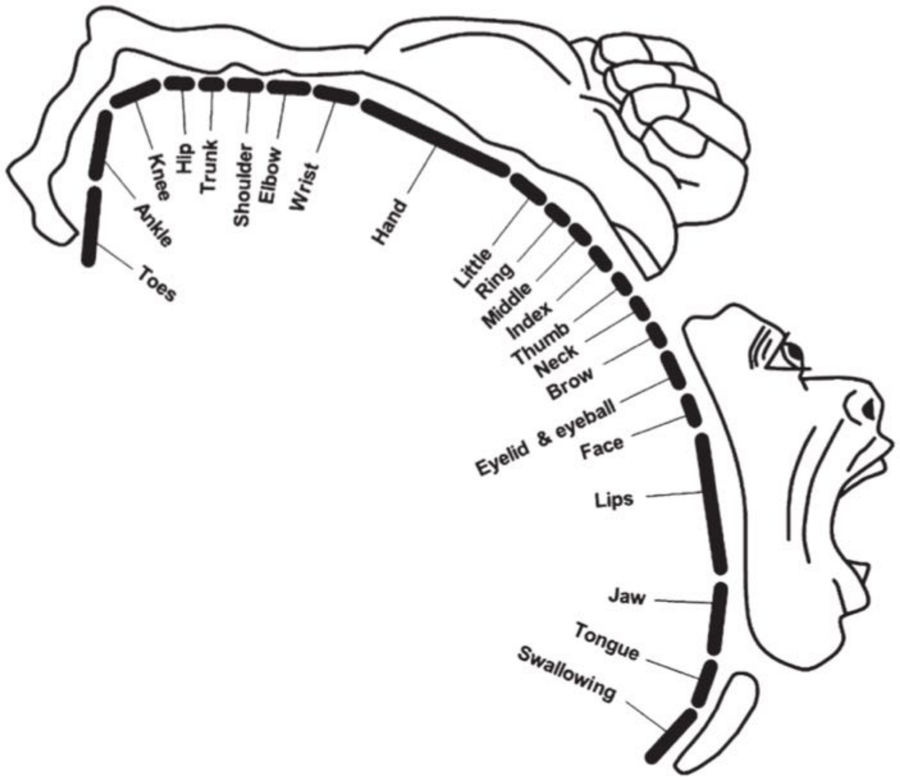
Seah, S. A. et al., SensaBubble: a chrono-sensory mid-air display of sight and smell. CHI 2014

Human Factors Model



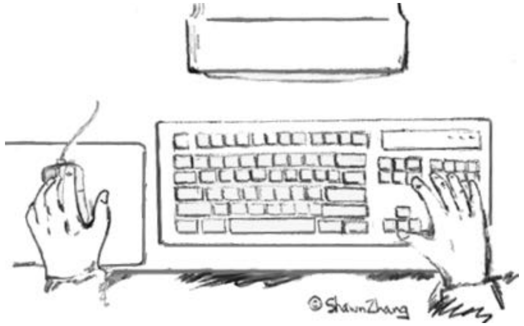
Penfield’s Motor Homunculus

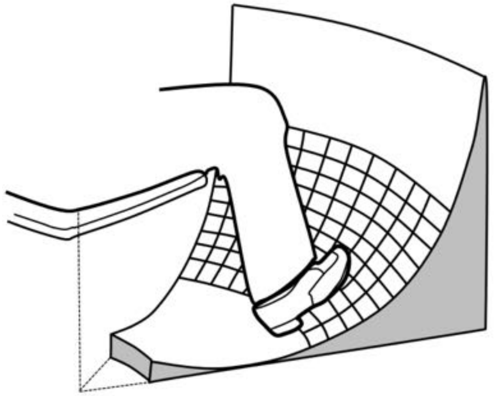
- Relative area of motor cortex dedicated to each human responder



“those groups of muscles having a large area devoted to them are heuristically promising places to connect with input device transducers if we desire high performance”
-Card et al., 1991

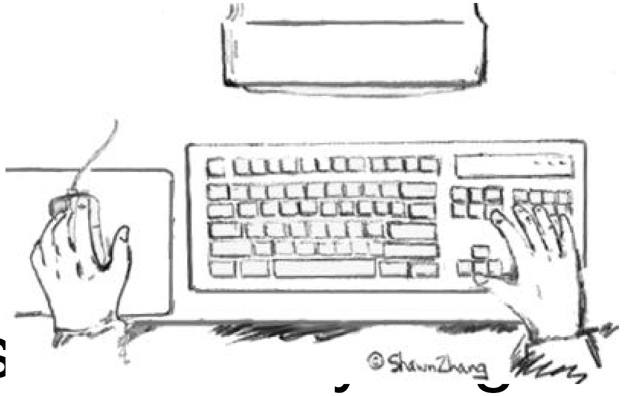
Responder Examples





Handedness

- Some users are left-handed, others right-handed



- Handednes

Edinburgh Inventory for Handedness

	Left	Right
1. Writing	☐☐	☐☐
2. Drawing	☐☐	☐☐
3. Throwing	☐☐	☐☐
4. Scissors	☐☐	☐☐
5. Toothbrush	☐☐	☐☐
6. Knife (without fork)	☐☐	☐☐
7. Spoon	☐☐	☐☐
8. Broom (upper hand)	☐☐	☐☐
9. Striking a match	☐☐	☐☐
10. Opening box (lid)	☐☐	☐☐
Total (count checks)		

Difference	Cumulative Total	**RESULT**

<u>Instructions</u>

Mark boxes as follows:

x	preference
xx	strong preference
blank	no preference

<u>Scoring</u>

Add up the number of checks in the "Left" and "Right" columns and enter in the "Total" row for each column. Add the left total and the right total and enter in the "Cumulative Total" cell. Subtract the left total from the right total and enter in the "Difference" cell. Divide the "Difference" cell by the "Cumulative Total" cell (round to 2 digits if necessary) and multiply by 100. Enter the result in the "RESULT" cell.

<u>Interpretation of RESULT</u>

-100 to -40	left-handed
-40 to +40	ambidextrous
+40 to 100	right-handed

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychololgia, 9*, 97-113.

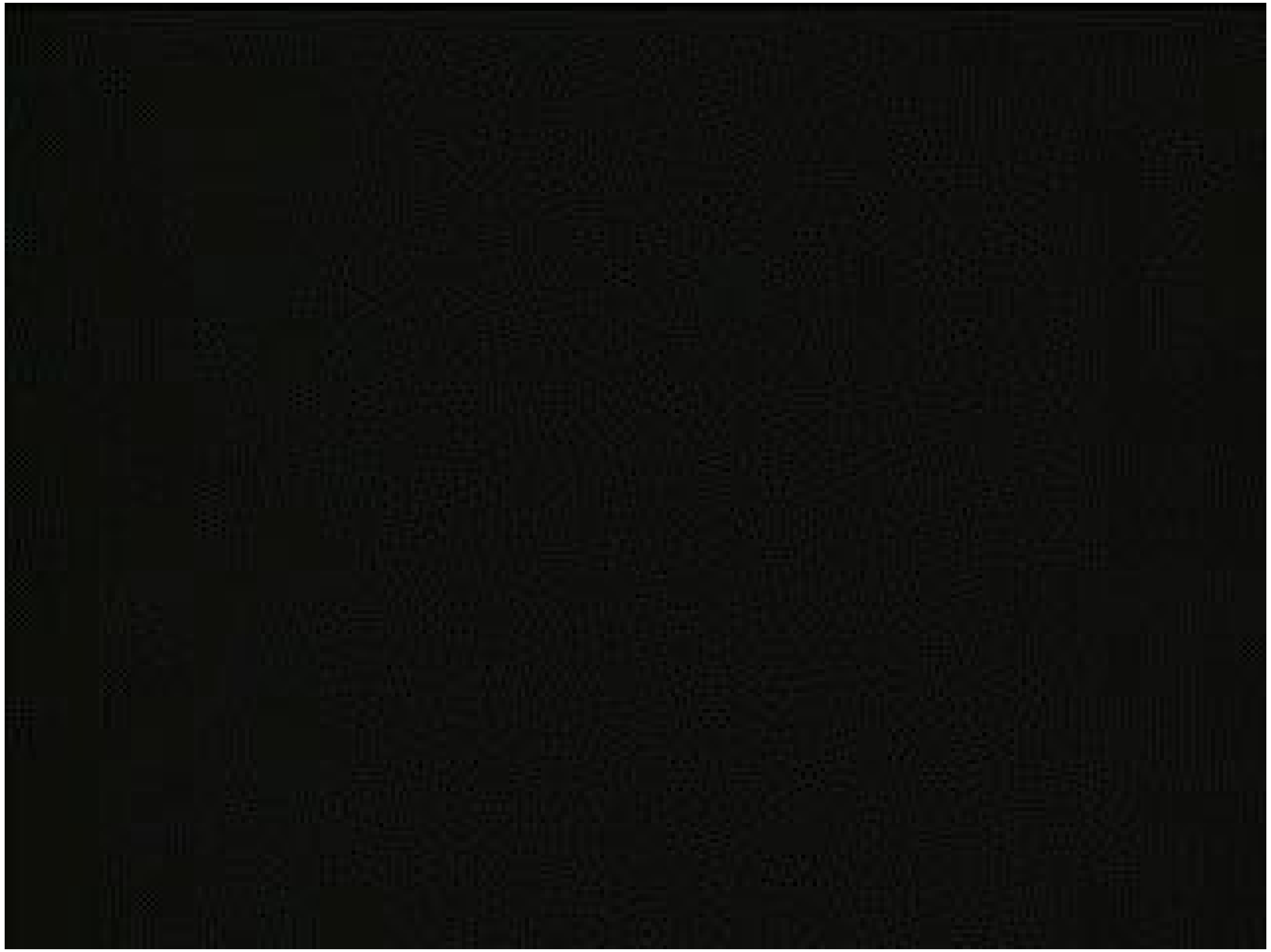
Human Voice

- Human vocal chords are responders
- Sounds created through combination of…
  - Movement in the larynx
  - Pulmonary pressure in the lungs
- Two kinds of vocalized sounds:
  1. Speech
  2. Non-speech
- Both with potential for computer control
  - Speech + speech recognition
  - Non-speech + signal detection (e.g., frequency, loudness, duration, change direction, etc.)

Put That There – Verbal Input

Richard A. Bolt, “Put-that-there”: Voice and gesture at the graphics interface. *Siggraph 1980*

Non-Verbal Input

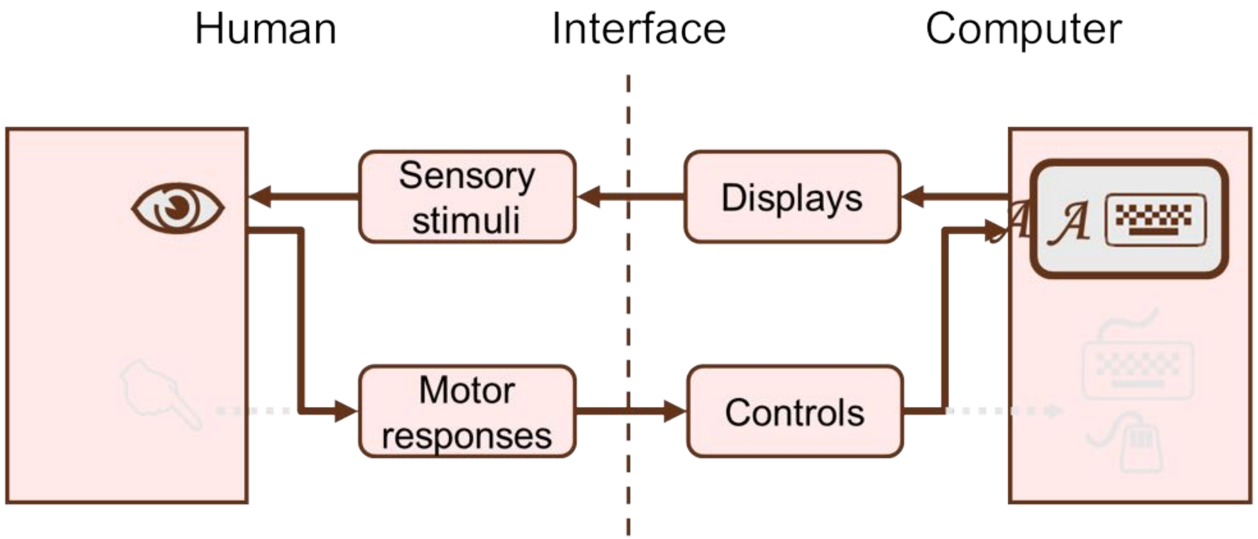


Igarashi, T., & Hughes, J. F. Voice as sound: using non-verbal voice input for interactive control. *UIST 2001*

Apple Voice Control

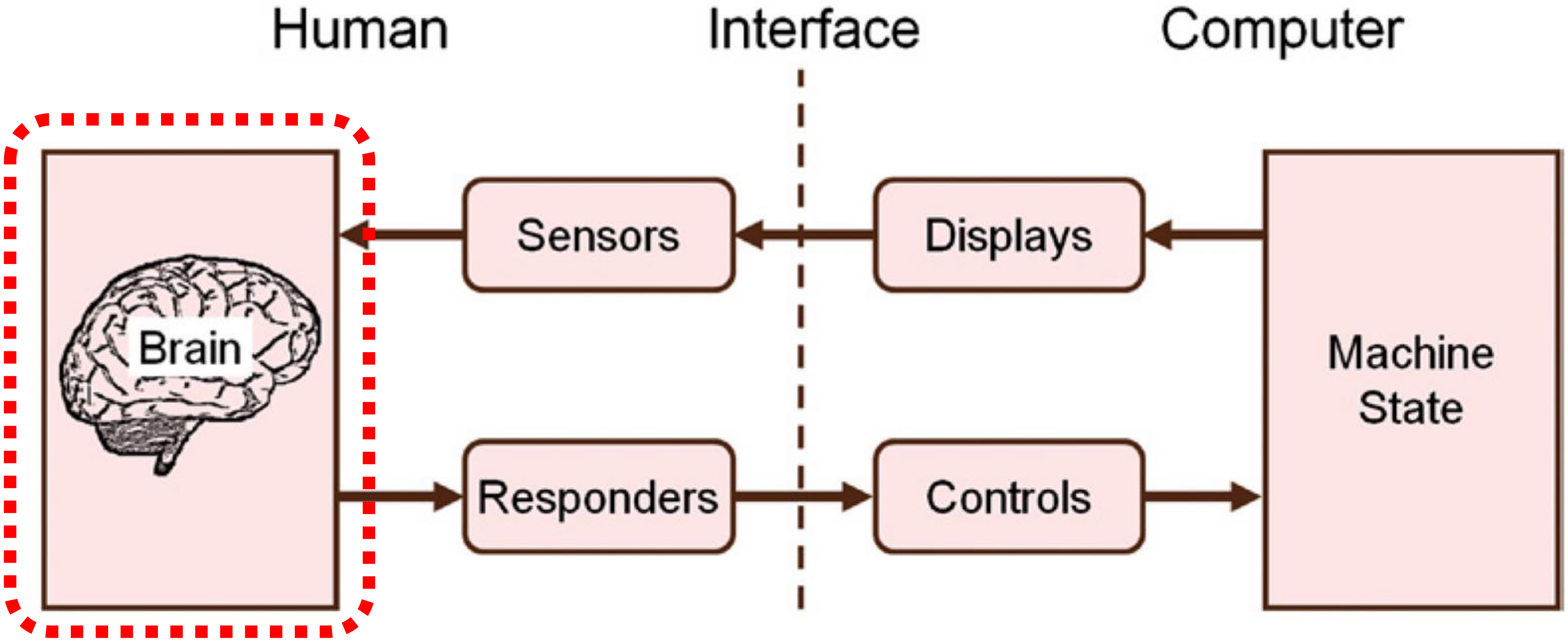
The Eye as a Responder

- As a responder, the eye is called upon to do "double duty"
  1. Sense and perceive the environment/computer
  2. Act as a controller via saccades and fixations



[1] MacKenzie, I. S. (2012). Evaluating eye tracking systems for computer input. In Majaranta, P., Aoki, H., Donegan, M., Hansen, D. W., Hansen, J. P., Hyrskykari, A., & Räihä, K.-J. (Eds.) *Gaze interaction and applications of eye tracking: Advances in assistive technologies*, pp. 205-225. Hershey, PA: IGI Global.

Human Factors Model



The Brain

- Most complex biological structure known
- Sensors (human inputs) and responders (human outputs) are nicely mirrored, but it is the brain that connects them
- Three core functions:
    - Perception
    - Cognition
    - Memory

Perception

- 1^{st} stage of processing for sensory input
- Interpretation of sensory signals
  - Auditory stimulus → harmonious, discordant
  - Visual stimulus → familiar, strange
  - Tactile stimulus → warm, hot
  - Smell stimulus → pleasurable, abhorrent
  - Taste stimulus → sweet, sour

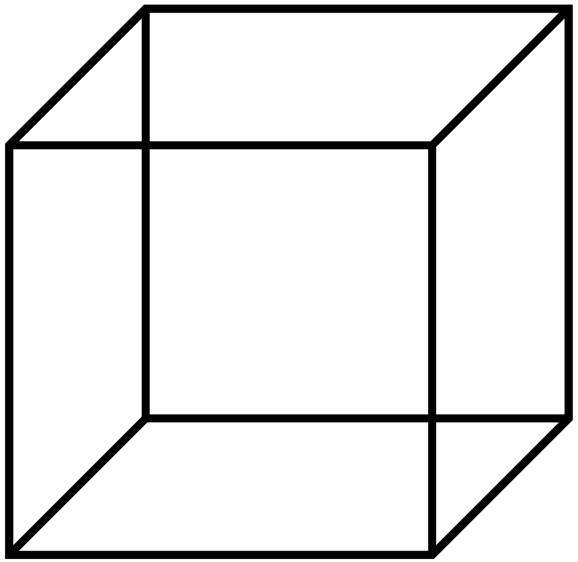
Psychophysics

- Branch of experimental psychology
- Since 19th century
- Relationship between human perception and physical phenomena
- Experimental method:
  - Present subject with two stimuli, one after the other
  - Stimuli differ in a physical property (e.g., frequency)
  - Randomly vary the difference
  - Determine threshold below which the subject deems the two stimuli "the same"
  - This threshold is the *just noticeable different* (JND)

Illusions

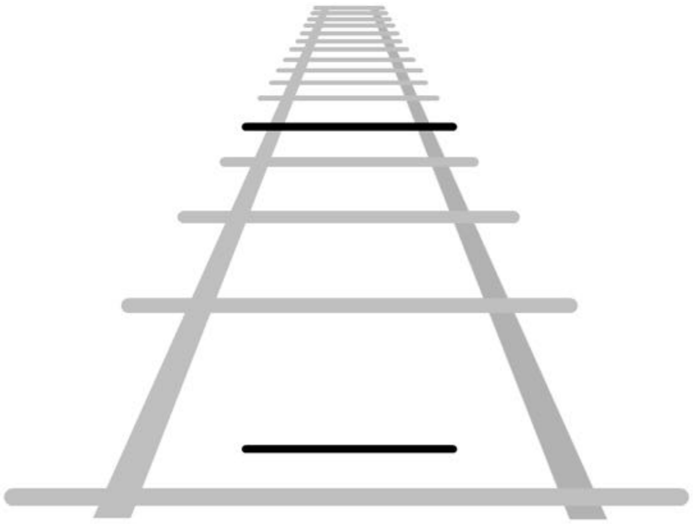
- Interpretation can be difficult and ambiguous – leading to illusions

Necker cube



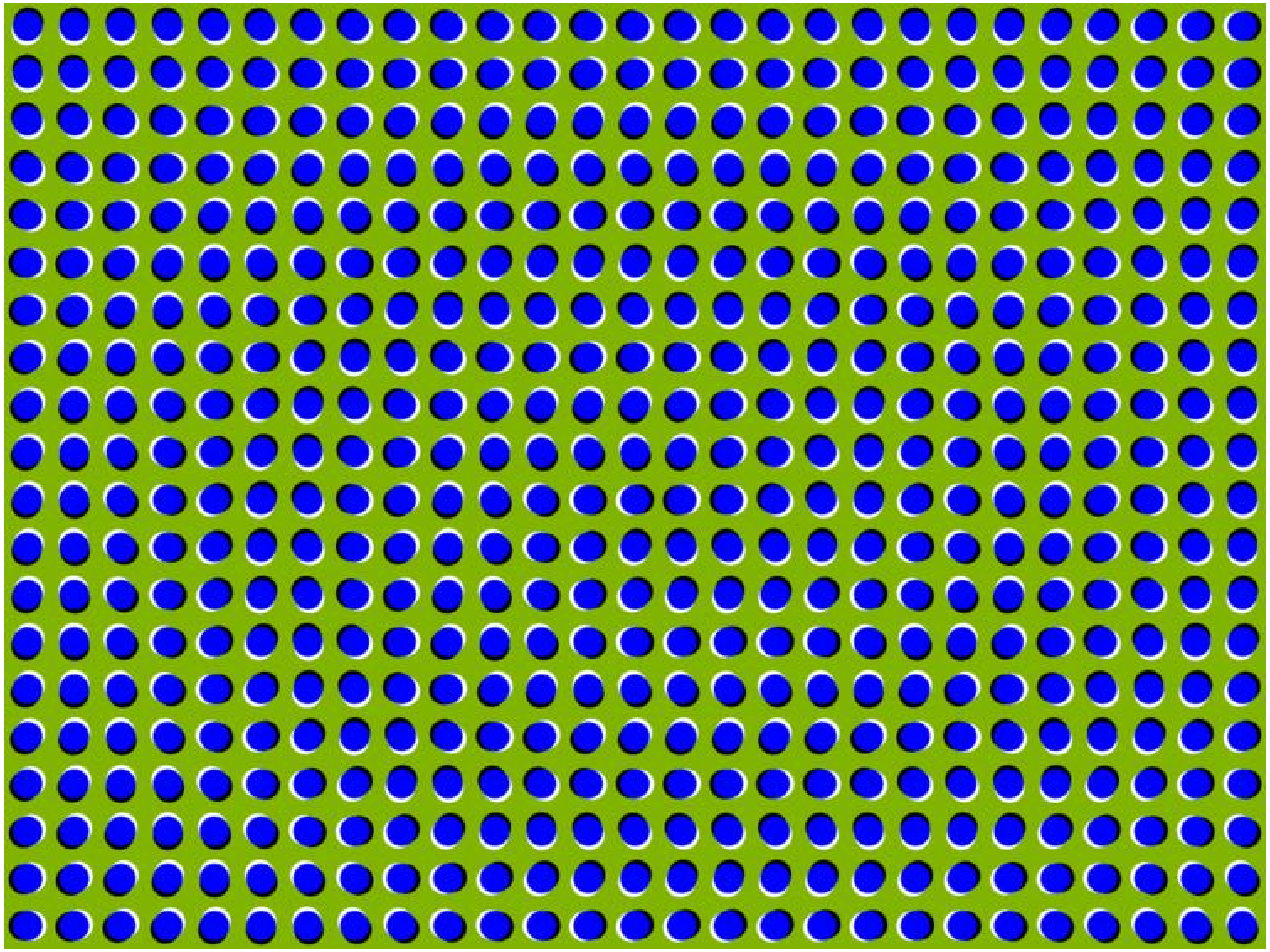
Which surface is at the front?

Ponzo lines



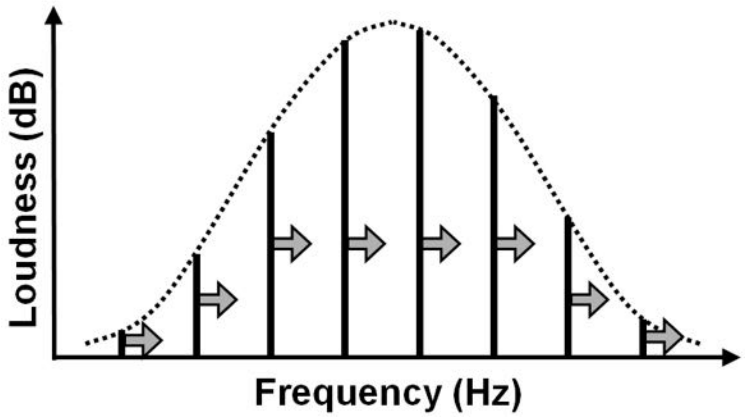
Which black line is longer?

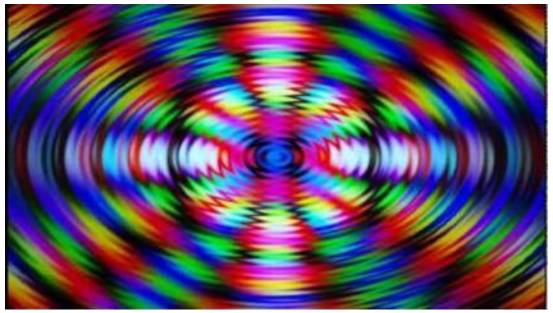
Illusions



Illusion – Other Senses

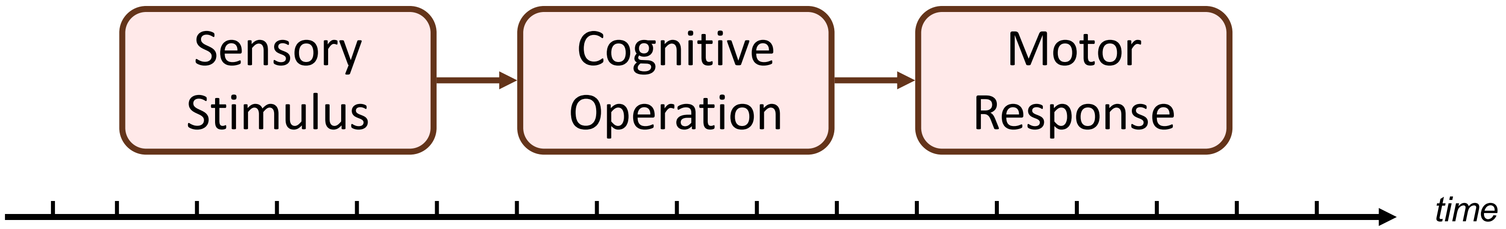
- If illusion is possible for the visual sense, the same should be true for the other senses
- Tactile illusion: Sensory Saltation
  - Also called cutaneous rabbit illusion
- Auditory illusion: Sheppard-Risset glissando





Cognition

- Human process of conscious intellectual activity
- Thinking, reasoning, deciding, etc.

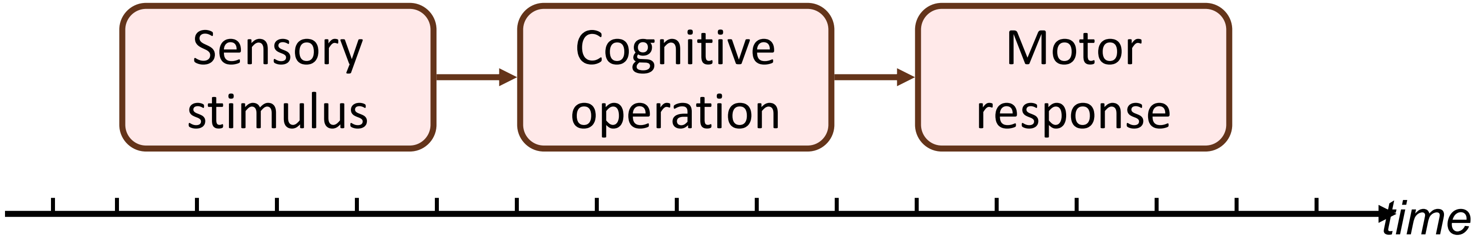


Operation	Typical time (ms)
Sensory reception	1 – 38
Neural transmission to brain	2 – 100
Cognitive processing	70 – 300
Neural transmission to muscle	10 – 20
Muscle latency and activation	30 –70
Total:	113 - 528

“Making a Decision”

- Not possible to directly measure the time for a human to “make a decision”
- When does the measurement begin and end?
- Where is it measured?
- On what input is the human deciding?
- Through what output is the decision conveyed?
- There is a sensory stimulus and motor response that bracket the decision

Making a Decision – in Parts



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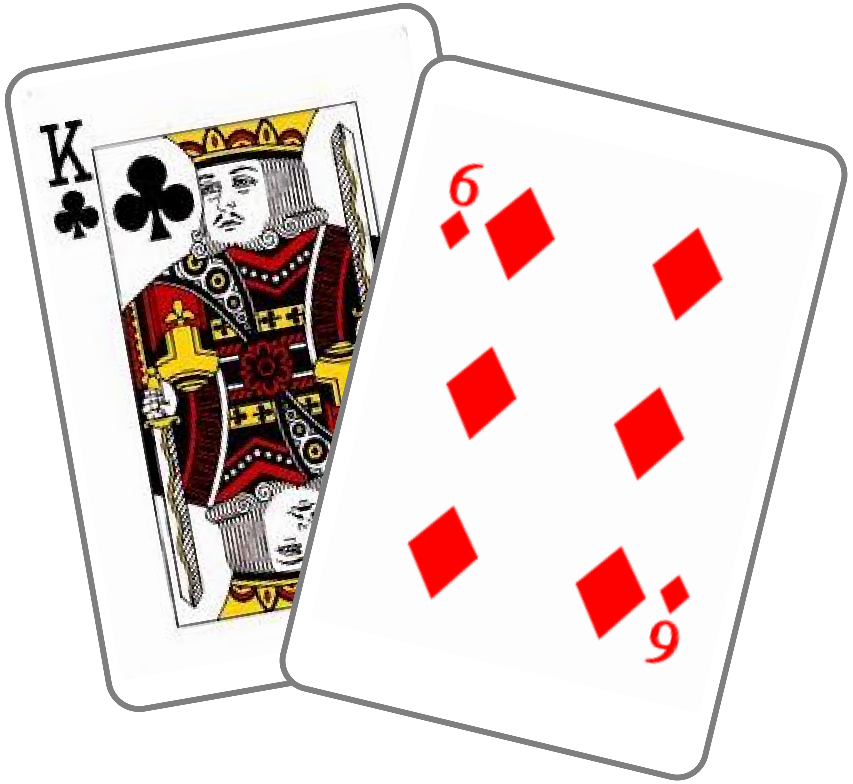
Large variation!

Examples of Simple Decisions

- Driving a car → decision to depress the brake pedal in response to a changing signal light
- Using a mobile phone → decision to press REJECT-CALL in response to an incoming call
- Reading news online → decision to click the CLOSE button on a popup ad

A More Involved Decision

Blackjack hand:

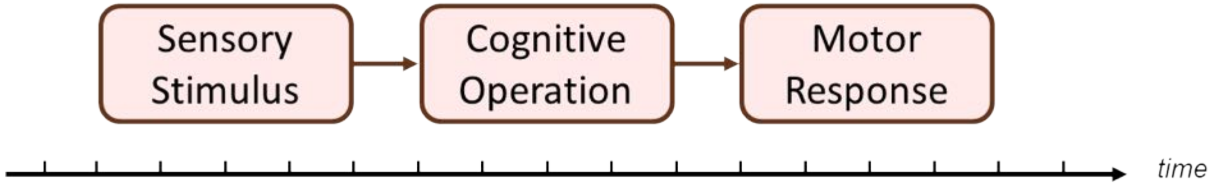


Total=16

Another card?

Information Processing Models

- Models the information processes of user interacting with a computer
- Predicts which cognitive processes are involved
- Enables calculations to be made of how long tasks will take



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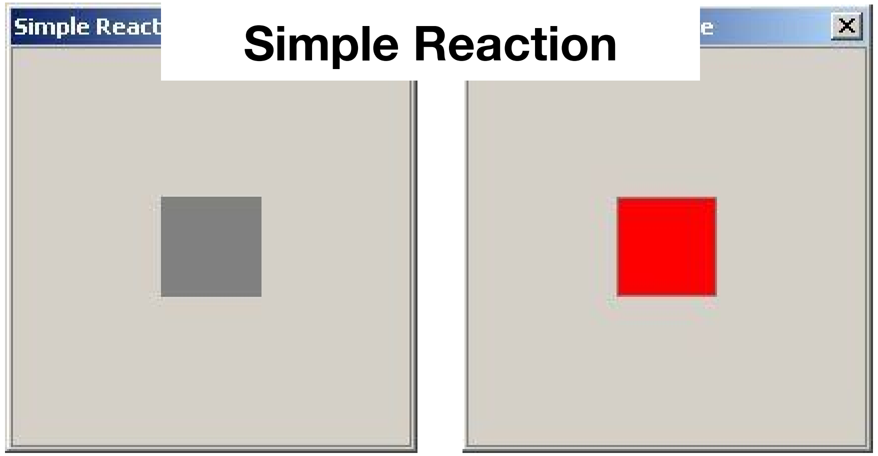
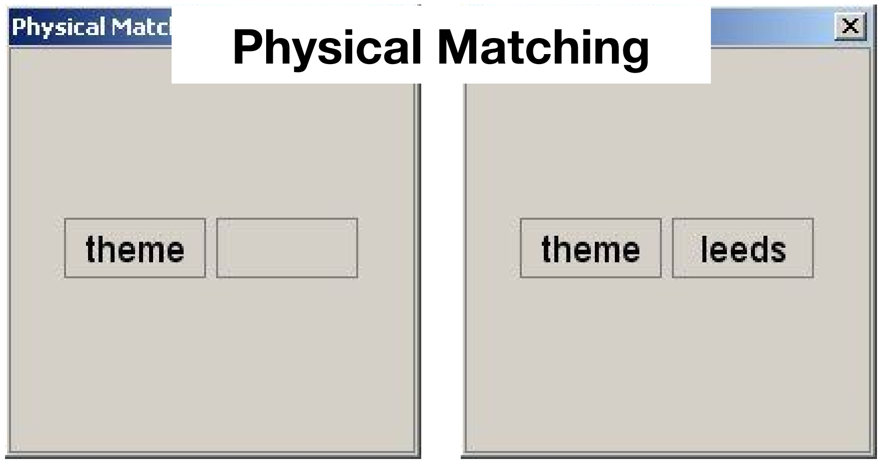
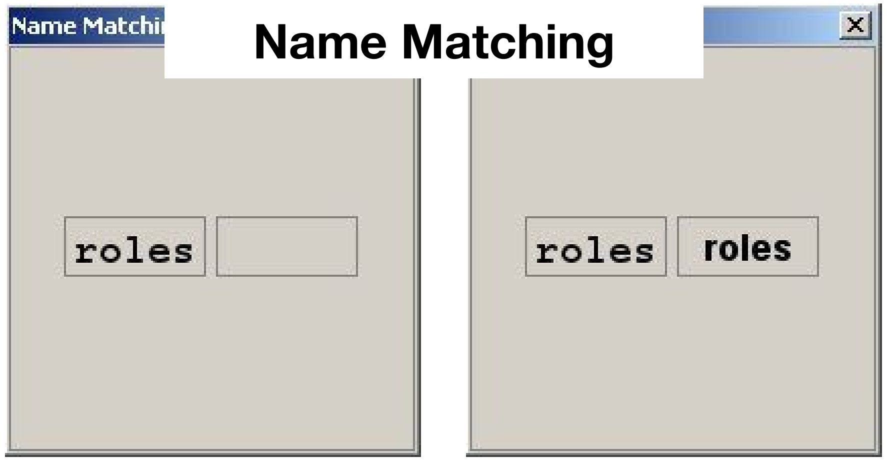
Reaction Time

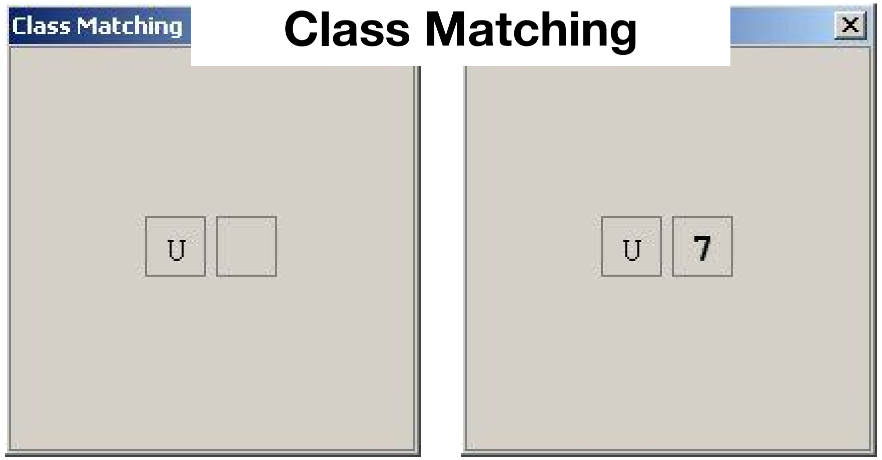
- One of the most primitive manifestations of human performance is simple reaction time
- Definition: The delay between the occurrence of a single fixed stimulus and the initiation of a response assigned to it
- Example: Pressing a button in response to a stimulus light

Reaction Time Experiment



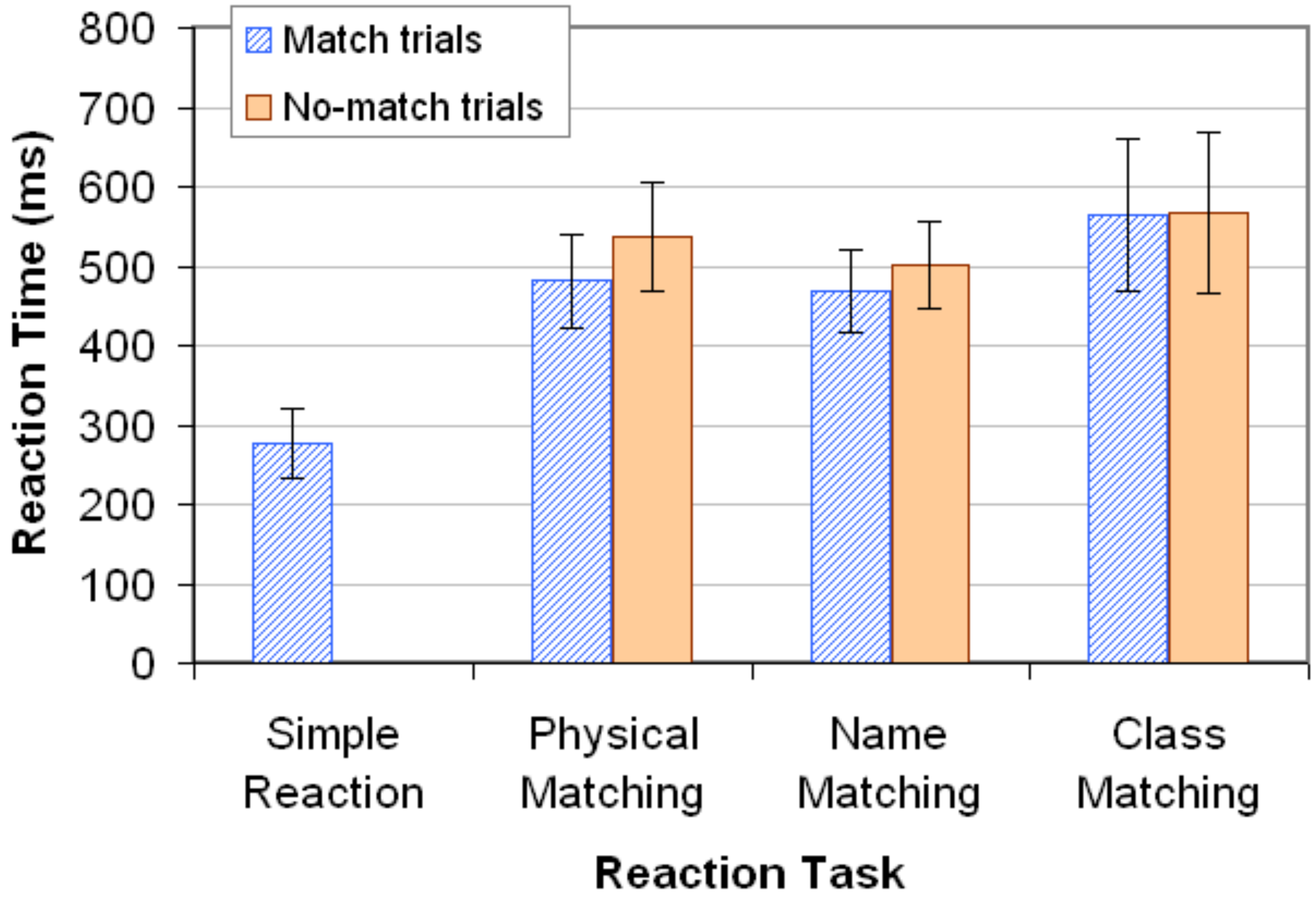






http://www.yorku.ca/mack/HCIbook/

Experiment Results

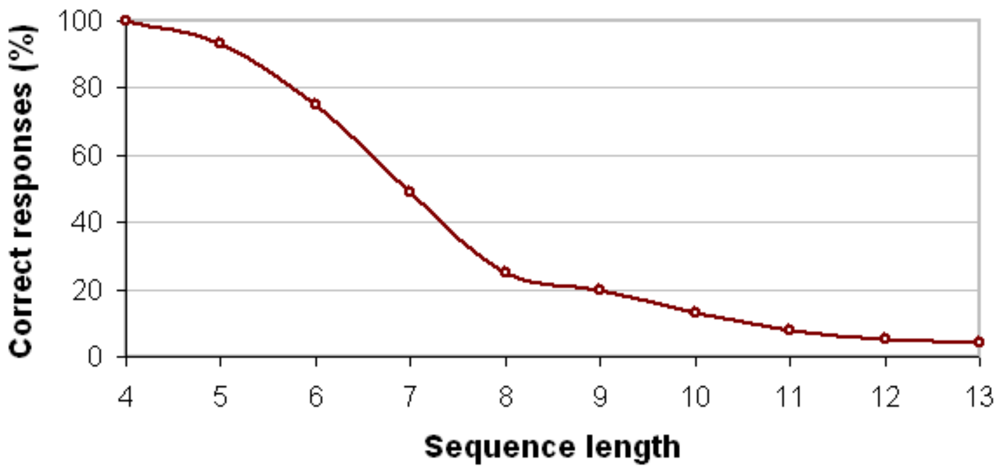


Sensory Stimuli and Reaction Time

- Delay time varies by type of sensory stimuli
- Approximate values
  - Auditory → 150 ms
  - Visual → 200 ms
  - Smell → 300 ms
  - Pain → 700 ms

Memory

- Human ability to store, retain, and recall information
- Long-term memory: Large storage of past events
- Short-term memory: active and readily available *working memory*
    - Miller's Law: Humans can remember about 7 (±2) items.



[1] Miller, G. A. (1956). The magical number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Chunking

- Units in short term memory may be recoded as a chunk
- Expands capacity of short term memory
- E.g., Commit to memory and recall…

14344305382

vs

1 434 430 5382

Video Break

BlyncSync

Enabling Multimodal Smartwatch Gestures with Synchronous Touch and Blink

Bryan Wang, Tovi Grossman
Toronto, Ontario, Canada
DGP Lab, University of Toronto

dgp Dynamic Graphics Project
University of Toronto
www.dgp.toronto.edu

Computer Science
UNIVERSITY OF TORONTO

Bryan Wang, Tovi Grossman.
BlyncSync: Enabling Multimodal Smartwatch Gestures with Synchronous Touch and Blink, *CHI 2020*

Web Programming Tutorial

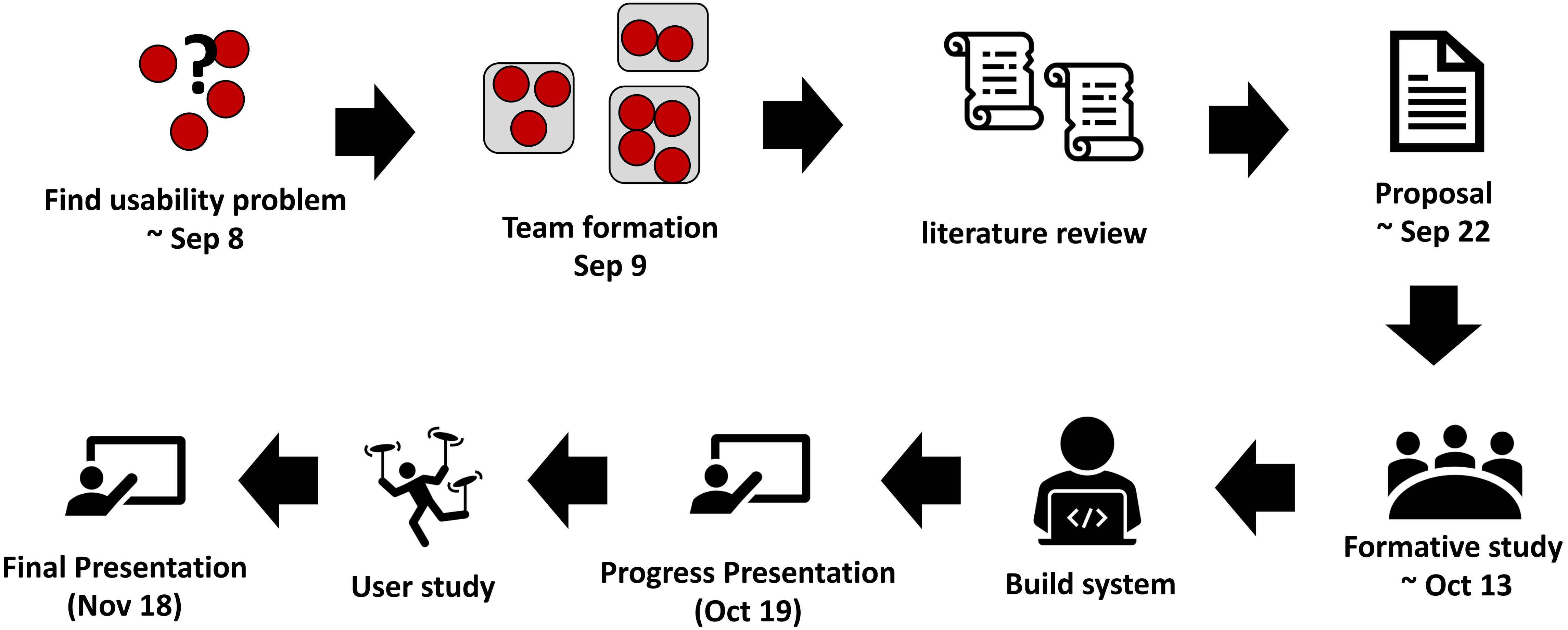
- Aashik will give three web programming tutorial sessions
- Optional but **highly recommended** if you are new to web programming
- Wednesdays at 7pm on Zoom → **Starting TODAY!**
- Topics
  - Sep 2: HTML and CSS
  - Sep 9: JavaScript
  - Sep 16: Database

Have Visual Studio Code installed on your computer

Course Project:
Make people’s lives better in this pandemic

What do we miss, what do we struggle with, or what do we like?

Course Project: Timeline



Course Project: Find a problem

- Find a usability / user experience problem, or a new way to improve the use of computers, related to the COVID-19 situation
- Due Next Tuesday (Sep 8), 11:59 **am**

Course Project: Find a problem

- After the deadline, the problems will be listed on a spreadsheet
- You will choose the ones that you want to solve or study.

- We will form project teams in Wed class

Acknowledgements

- Some of the materials are based on materials by
  - Tovi Grossman, Univ. of Toronto
  - Juho Kim, KAIST
  - Scott MacKenzie, Human-Computer Interaction: An Empirical Research Perspective

Thank you!