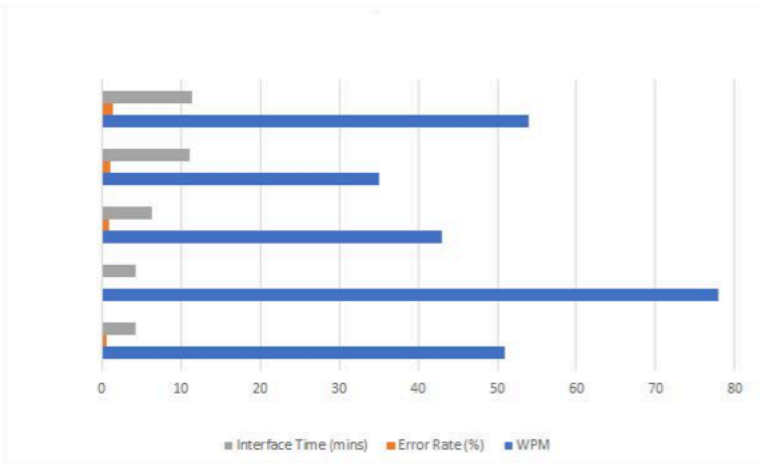
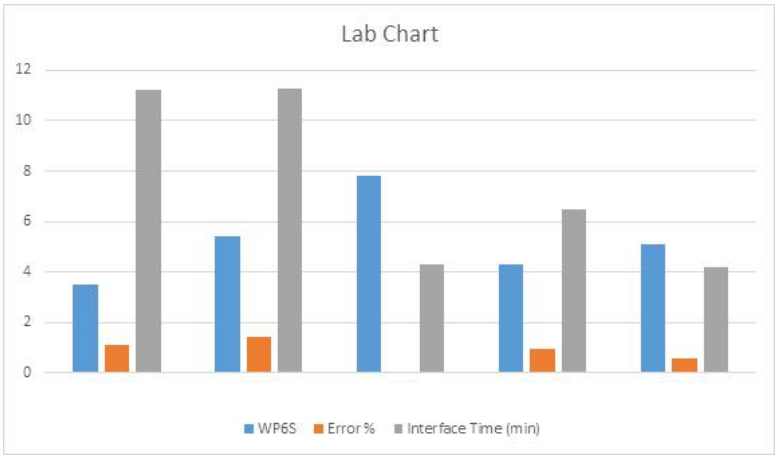
# Human Perception and Capabilities

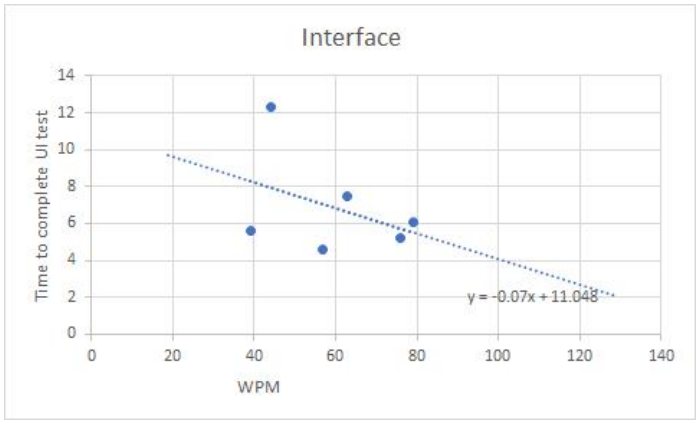
Lecture 3-4

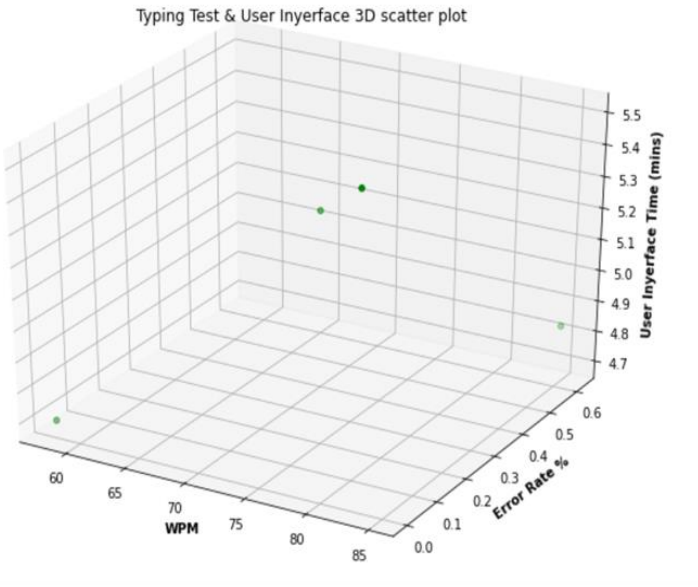
## Lab 1 comments

- My observations: most people used Excel
  - Jupyter/matplotlib/seaborn encouraged options
- Many possibilities for what to plot


0
10
20
30
40
50
60
70
80
Interface Time (mins)
Error Rate (%)
WPM

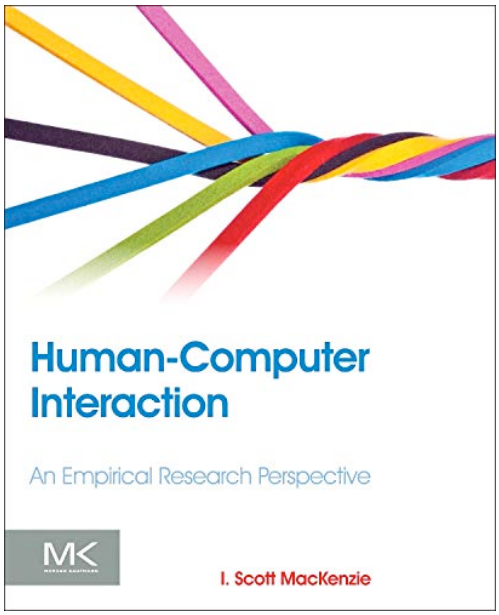

Lab Chart
12
10
8
6
4
2
0
WP6S
Error %
Interface Time (min)


Interface
Time to complete UI test
WPM
y = -0.07x + 11.048
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140


Typing Test & User Inyerface 3D scatter plot
WPM
Error Rate %
User Inyerface Time (mins)
60
65
70
75
80
85
0.0
0.1
0.2
0.3
0.4
0.5
0.6
4.7
4.8
4.9
5.0
5.1
5.2
5.3
5.4
5.5

# Studying the Human

- HCI: **Human** Computer Interaction
- Early HCI work took findings/approaches from Psychology to apply to interactions with computers
  - Perception
  - Cognition
  - Motor function
- Used to guide system development
- Continue to measure, refine, experiment



# Time Scale of Human Action

- Social Band
- Rational Band
- Cognitive Band
- Biological Band
  - Less relevant for most HCI research/practice you will be part of

| Scale (sec) | Time Units | System | World (theory) |
|---|---|---|---|
| $10^{7}$ | Months | | **SOCIAL BAND** |
| $10^{6}$ | Weeks | | |
| $10^{5}$ | Days | | |
| $10^{4}$ | Hours | Task | **RATIONAL BAND** |
| $10^{3}$ | 10 min | Task | |
| $10^{2}$ | Minutes | Task | |
| $10^{1}$ | 10 sec | Unit task | **COGNITIVE BAND** |
| $10^{0}$ | 1 sec | Operations | |
| $10^{-1}$ | 100 ms | Deliberate act | |
| $10^{-2}$ | 10 ms | Neural circuit | **BIOLOGICAL BAND** |
| $10^{-3}$ | 1 ms | Neuron | |
| $10^{-4}$ | 100 μs | Organelle | |

# Cognitive Band

- 100 milliseconds to 10 seconds
  - Pointing devices, selection techniques, text entry, gestural input
  - Times based on reaction times and biomechanical properties
- Consider how users perform multitouch rotation gestures
  - Does the angle of rotation impact performance?
  - Do users pivot from the thumb or rotate multiple touchpoints?
  - Does the starting angle impact performance?

For reference: https://dl.acm.org/citation.cfm?id=2481423

# Rational Band

- Occupy minutes or hours
  - Tasks, like web site use, user search strategies, OS navigation
  - Users must experience an interface and **make decisions** about their next actions
- Consider an evaluation of user search behavior
  - How often do users "branch" their search results?
  - How many "branches" do users generate during a typical search?
  - Why do users establish a new "branch"

For reference: https://dl.acm.org/citation.cfm?id=2124322

# Social Band

- Days, weeks, months
  - Activities such as as workplace habits, social networking, online dating, privacy
  - Require development of social bonds or establishing norms/ standards
- Consider a study on how people develop relationships in online dating
  - Interviews with members of the community
  - Participation/observation in active forums
- Qualitative methods dominate
  - Although often opportunity for mixed methods studies/data analytics too
    - For Reference: https://theblog.okcupid.com

For reference: https://dl.acm.org/citation.cfm?id=2702417

# Model of Human Computer Interaction

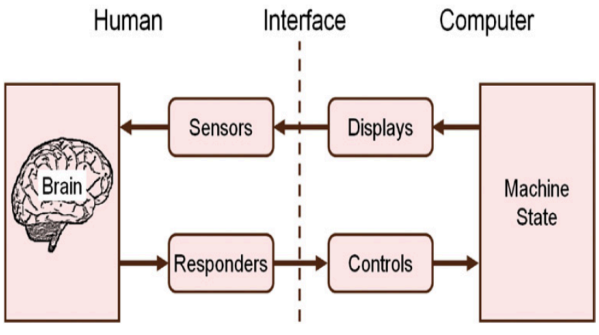



**FIGURE 2.2**

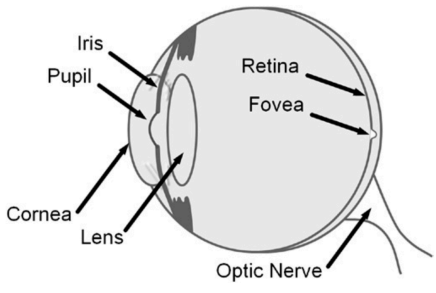
Human factors view of the human operator in a work environment.

*(After Kantowitz and Sorkin, 1983, p. 4)*

# Human Senses

# Vision

- Light passes through the lens
- The lens focuses light into an image projected onto the retina
- The retina converts visible light into neurological signals
- The centre of the retina, the fovea, processes details



# Properties of Vision

- Frequency of visible light
- Intensity
  - Eye light sensitivity varies by wavelength
- Fixations and Saccades
  - Fixations processes detail while the eyes are still
  - Saccades are rapids movements (30-120 ms) of the eyes to a new position
- Understanding human eye motion is important to understand how content is viewed
- Scanpath
  - In eye tracking studies, a sequence of fixations & saccades

# Eye-Tracking

# Eye-Tracking

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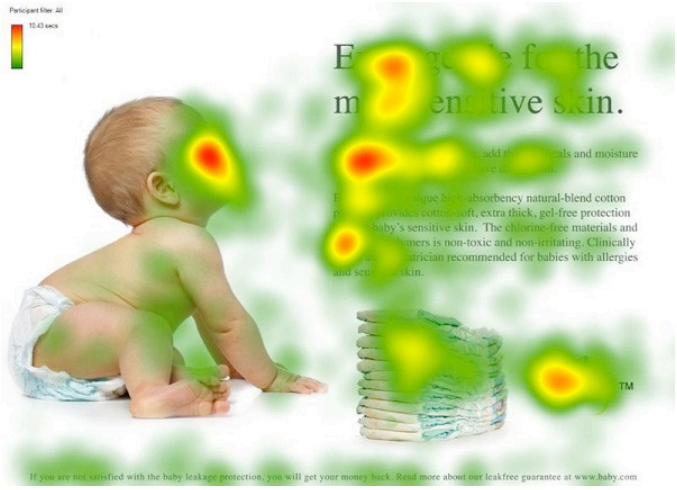


# Hearing

- Sounds are perceived from cyclic fluctuation of pressure
  - Typically in air
- Loudness
  - Subjective perception of sound pressure level
- Pitch
  - Subjective perception of frequency
- Timbre
  - Harmonic structure to be described as richness or brightness
- Envelope
  - Changes in the subjective properties over time

# Touch

- Touch / haptic
  - Through vibration, air, and ultrasound
  - For reference: https://dl.acm.org/citation.cfm?id=2663280
- Temperature
  - For reference: https://dl.acm.org/citation.cfm?id=1979316
- Pain
  - We try to avoid this in HCI
- Proprioception
  - The ability to sense the position of your body and limbs

## Smell

- Olfaction
  - The ability to perceive odours
- HCI has explored scent through scent "cubes"
  - fans that disperse scent, and pressurized delivery systems
- Olfoto: tagging photos with smells vs text
  - For reference: https://dl.acm.org/doi/abs/10.1145/1124772.1124869

## Taste

- Yes, really!
  - Chemical reception of sweet, salty, umami, bitter, and sour
- TastyFloats
  - Levitate food onto user's tongue
  - For reference: https://dl.acm.org/citation.cfm?id=3134123
- Summary of multi-sense interactions
  - For reference: https://dl.acm.org/citation.cfm?id=3134123

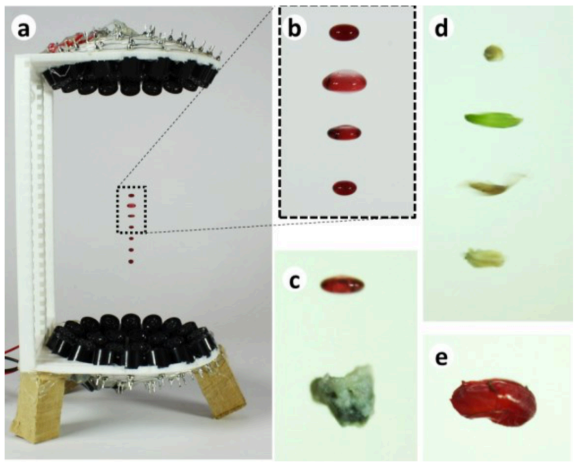



**Figure 1. Examples of levitated food morsels: a, b) Acoustic levitation of droplets of wine; c) Wine and blue cheese; d) Bread, lettuce, meat and bread; e) and a raspberry grain.**

# Human Responses

## Limbs

- Input for systems is primarily achieved by moving the limbs in 3D space
  - Think of typing, using a mouse, using a trackpad
  - We use our limbs to generate a signal that is interpreted as input

## Voice

- Speech recognition has come a long way, but we still face challenges of segmentation, recovery from errors, and information throughput

## Eyes

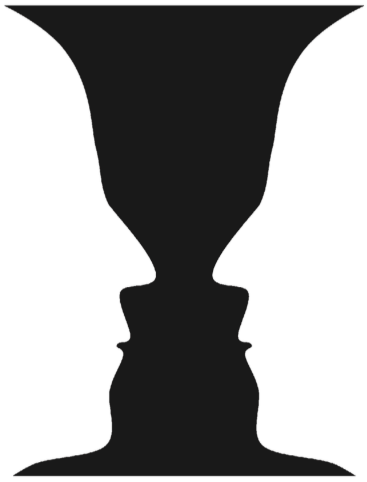
- Selection based in Gaze is a common approach in VR, and becoming more common in less instrumented environments as well
  - For example, consider common phone unlocking techniques
- Most info probably also coming in through vision, so eyes doing double tasks

## Human Brain

- Connects the sensors and responders
- Different processes/capabilities
  - Perception
  - Cognition
  - Memory

# Perception

- First stage of processing in the brain
  - Associations and meanings take shape
- Just Noticeable Difference
  - Below what threshold can humans no longer perceive difference?



For reference: https://dlnext.acm.org/doi/abs/10.1145/2556288.2557033

# Perception and Ambiguity

- Illusions work when our perception fills the gaps in ambiguous stimuli
  - Ponzo lines demonstrate how our depth perception changes how we look at the two black lines
- There are illusions that can trick our visual, aural, and haptic senses

## Cognition

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

## Memory

- Ability to store, retain, and recall information
- Short term memory capacity $7 \pm 2$
  - Has often been used to guide UI design, eg number menu items
    - Might be misunderstanding the original intent
    - Shorter menus probably still good though!

# Human Performance

# Human Performance

- Speed Accuracy Tradeoff – tasks completed faster are more error prone
  - People often prioritise speed or accuracy differently based on context
- Most of early HCI measured this, but still important and studied today
- E.g. performance with various input devices
  - But also augment overall human performance, e.g. find answers to questions with visualisation tool vs looking at raw numbers

## Reaction Time

- Different sensory modalities have different reaction times
  - 150ms audio
  - 200ms visual
  - 300ms smell
  - 700ms pain
- Visual search is another example of reaction which includes more complex cognition that simply responding to stimuli

## Skilled Behaviour

- In most tasks beyond simple responses, human performance can increase with practice
  - Like playing darts and playing chess
- Playing darts requires training of your sensor/ motor skill
- Playing chess requires training of your mental skill
- Some tasks require both

# Attention

- When task performance degrades with performed simultaneously with another, we can say that task requires attention
  - Consider walking and talking
  - Consider reading and talking
  - Driving and talking?

# Attention

- Divided attention is concentrating/performing more than one task at a time
  - Typically this will degrade performance, which is not an option in safety critical contexts like driving
- Focused attention is attending to one task to the exclusion of all others
  - The ability to ignore external events not always possible or feasible
  - In a noisy room, you might be able to have a conversation but are likely to be distracted at times.
- Sensory modalities are often thought of as channels, but in practice it is not so simple

# Human Error

- Error is a discrete event in a task where the outcome is incorrect or deviates from the desired outcome
- In practice, this kind of coarse measure of error provides a limited understanding
  - Consider the Key Stroke dataset
  - “error” in this sense isn’t even reported in this dataset, although it’s simple to calculate
- We are often trying to measure something more complicated than % of errors