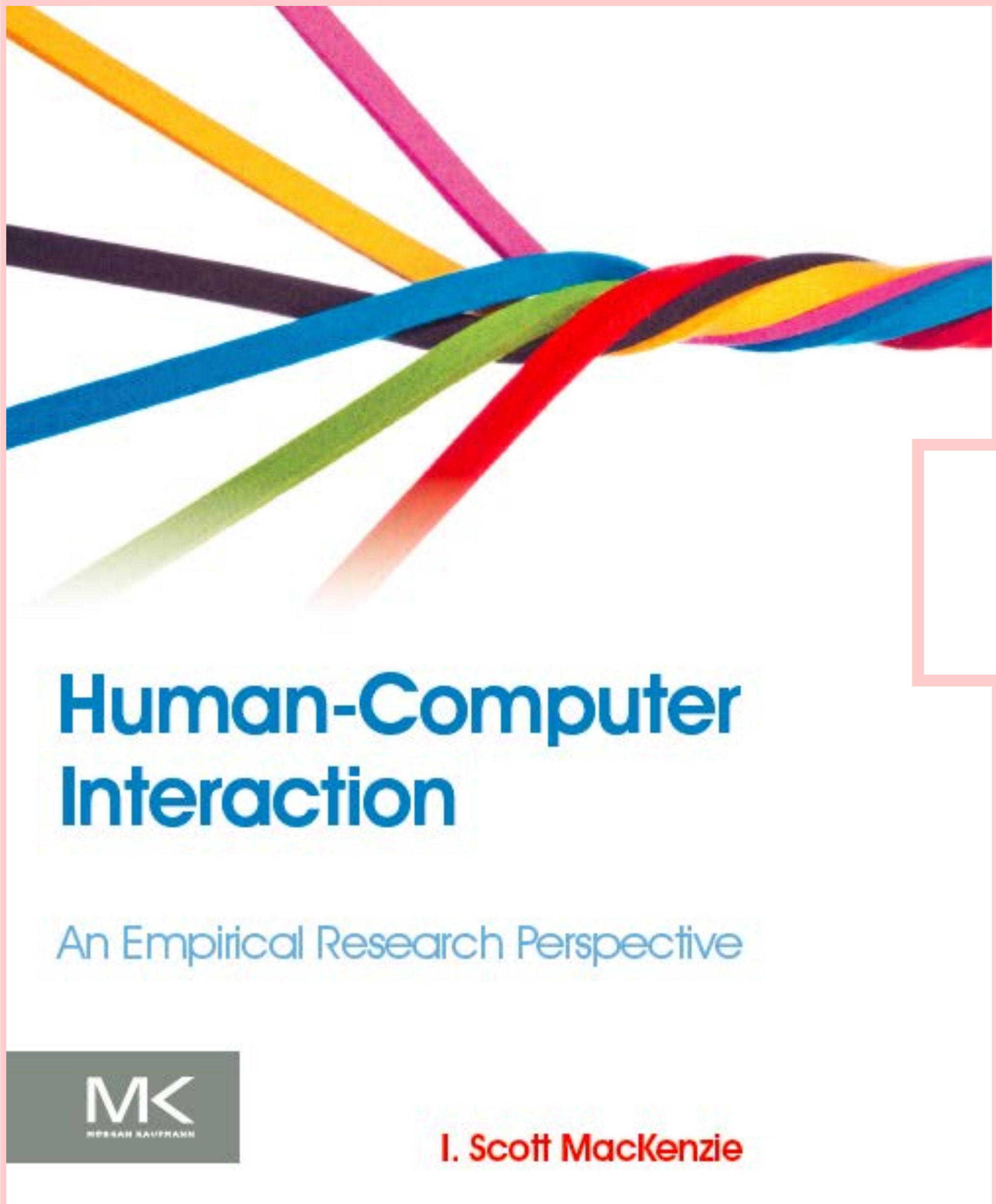



# Chapter 2
# The Human Factor

# Models of the Human

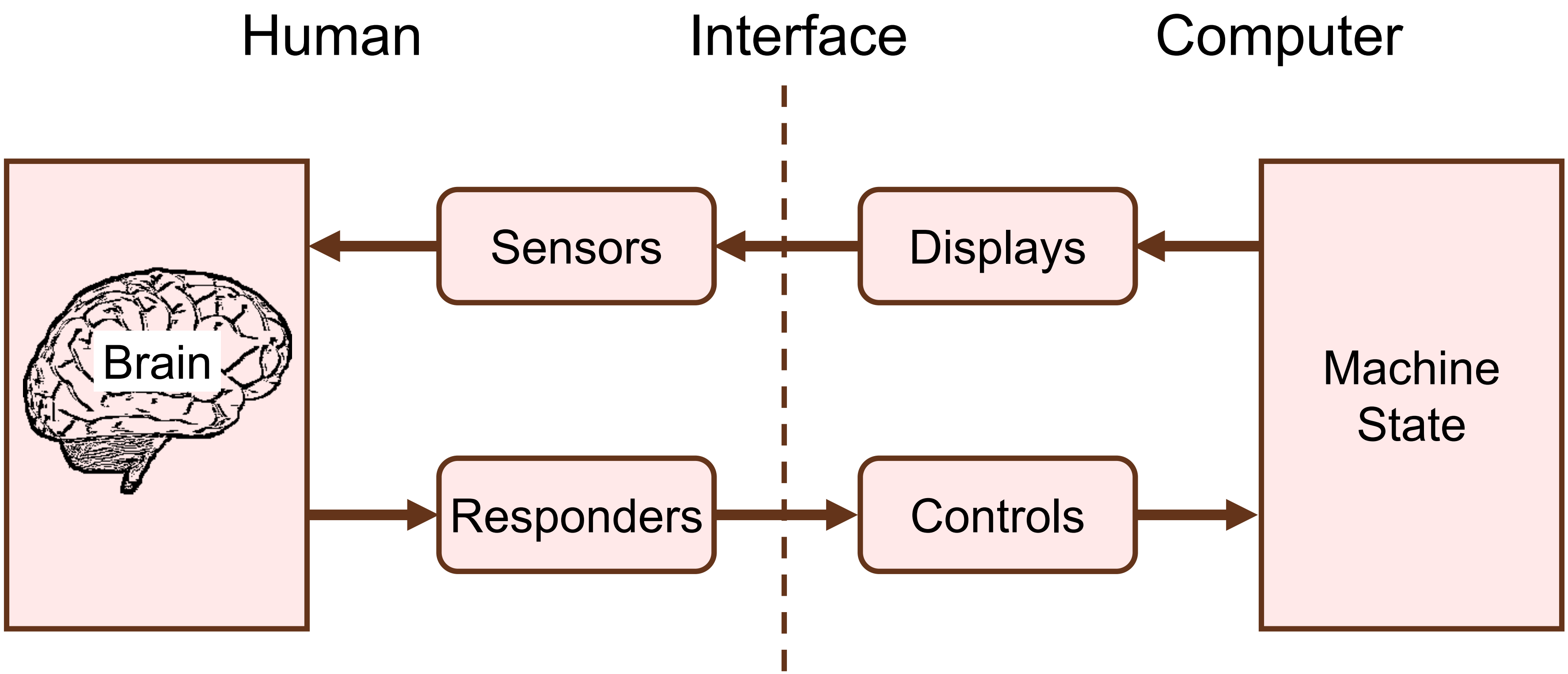
- Descriptive models are tools for thinking (see Chapter 7)
- It would be useful to have a descriptive model for the human
- In fact, there are many (e.g., Model Human Processor, Chapter 1)
- We begin with two useful models for the human…

# Newell's Time Scale of Human Action[1]

| Scale (sec) | Time Units | System | World (theory) |
|---|---|---|---|
| $10^7$ | Months | | **SOCIAL BAND** |
| $10^7$ | Weeks | | |
| $10^6$ | Days | | |
| $10^5$ | 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 | |

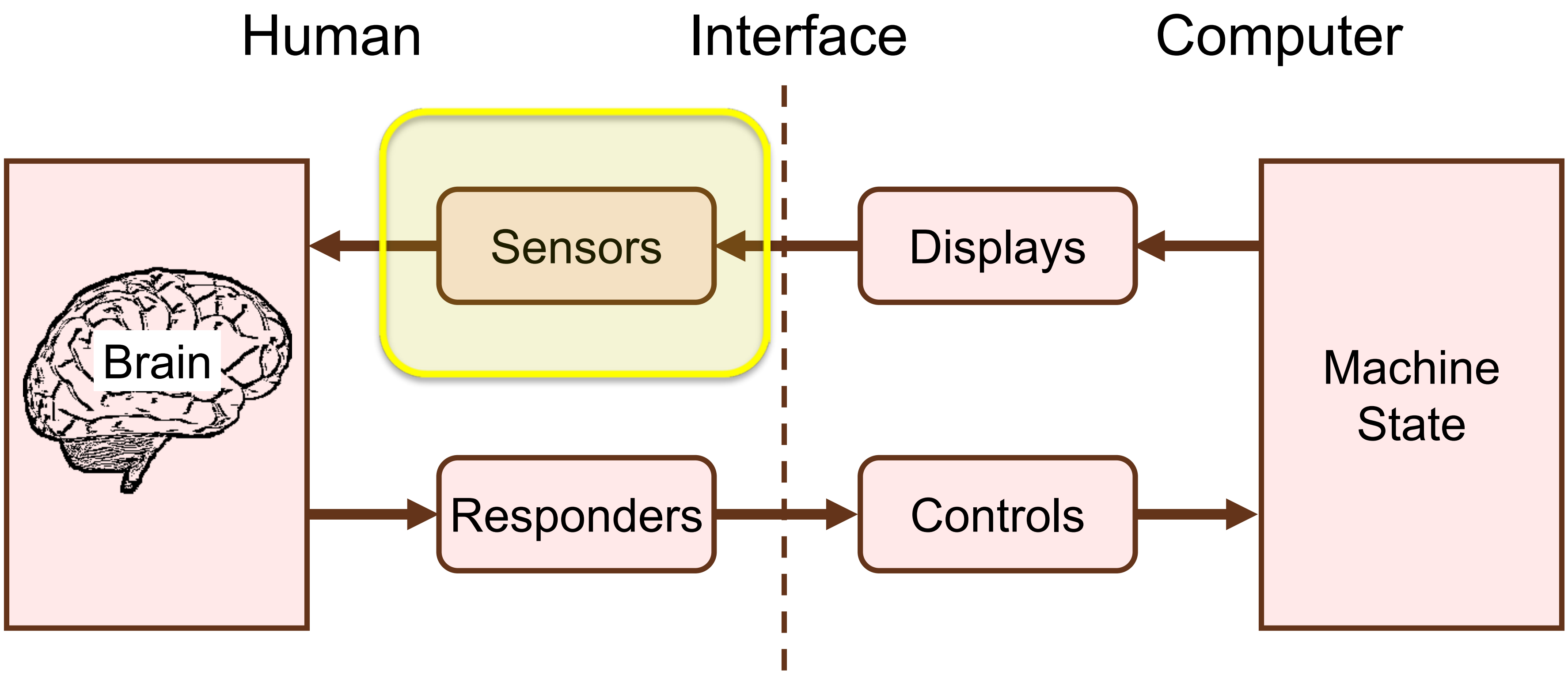
[1] Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Harvard University Press.

# Human Factors Model[1]




[1] Kantowitz, B. H., & Sorkin, R. D. (1983). *Human factors: Understanding people-system relationships*. New York. New York: Wiley.

# Human Factors Model[1]




[1] Kantowitz, B. H., & Sorkin, R. D. (1983). *Human factors: Understanding people-system relationships*. New York. New York: Wiley.

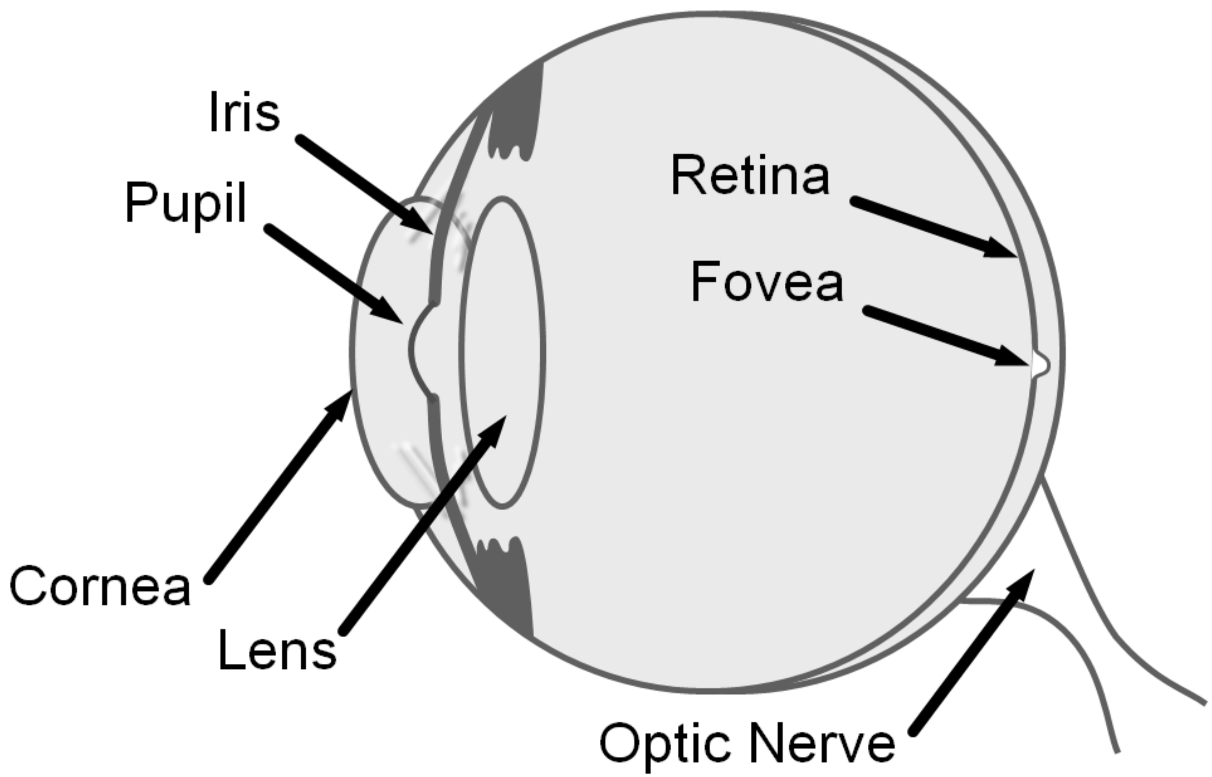
# Human Senses

| | |
|---|---|
| Rosa: | You deny everything except what you want to believe. That's the sort of man you are. |
| Bjartur: | I have my five senses, and don't see what need there is for more. |
| | (Halldór Laxness, *Independent People*) |

- The five senses:
  - Vision (sight)
  - Hearing (audition)
  - Touch (tactition)
  - Smell
  - Taste

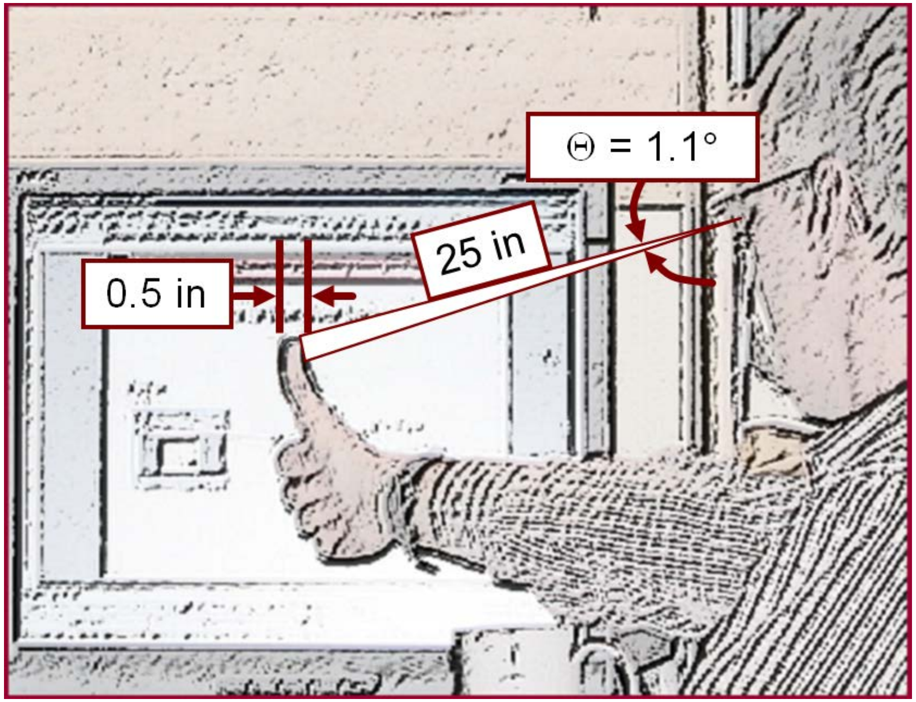
# Vision (The Eye)

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



# Fovea Image

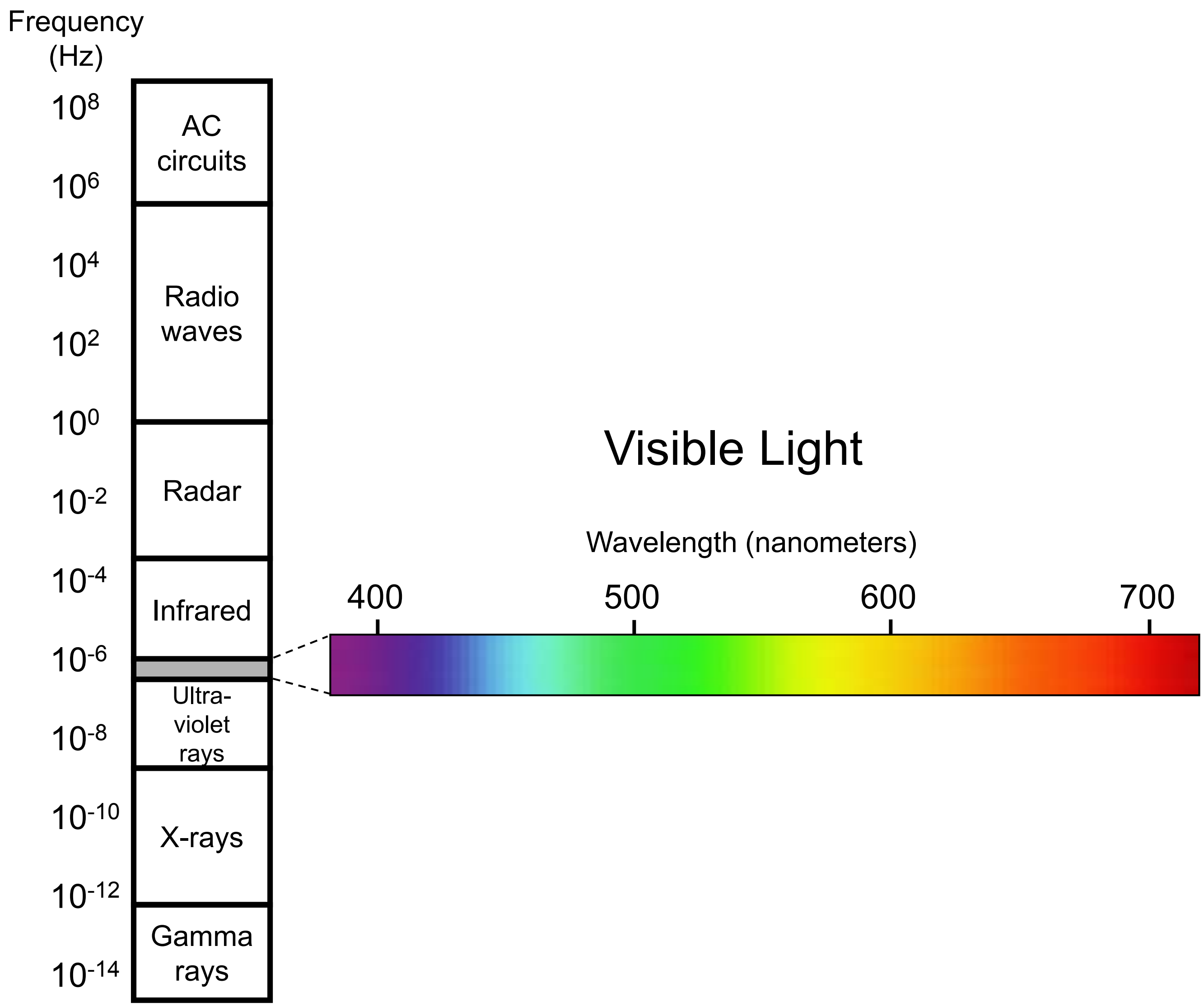
- Sharp central vision
- 1% of retina, 50% of visual cortex
- Fovea image is ≈1° of visual angle:



# Visual Stimulus

- Physical properties of light…
  - Frequency
  - Intensity (luminance)
- Create subjective properties of vision…
  - Colour (next slide)
  - Brightness

# Colour Spectrum



# Fixations and Saccades

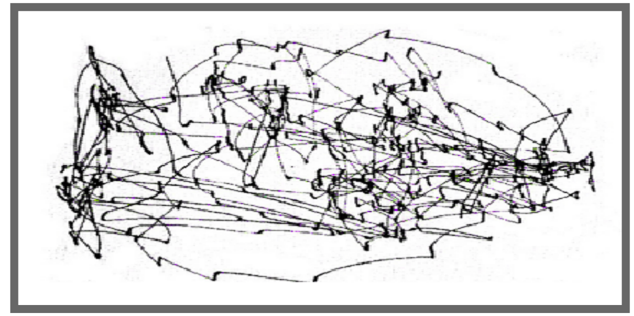
- Fixation
  - Eyes are stationary (dwell)
  - Take in visual detail from the environment
  - Long or short, but typically at least 200 ms
- Saccade
  - Rapid repositioning of the eye to fixate on a new location
  - Quick: ≈120 ms

“Remember the position of people and objects in the room”

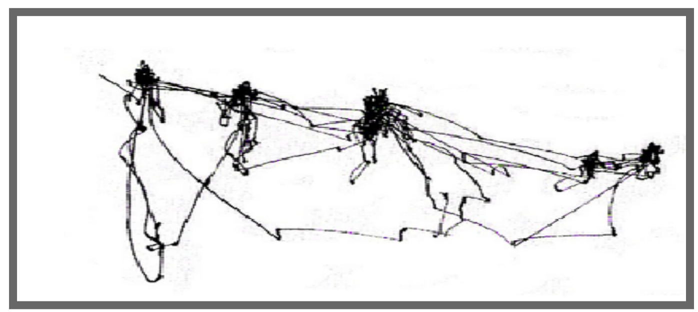
“Estimate the ages of the people”

# Yarbus' Eye Tracking Research (1965)[1]

*The Unwanted Visitor*
by Ilya Repin (1844-1930)



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



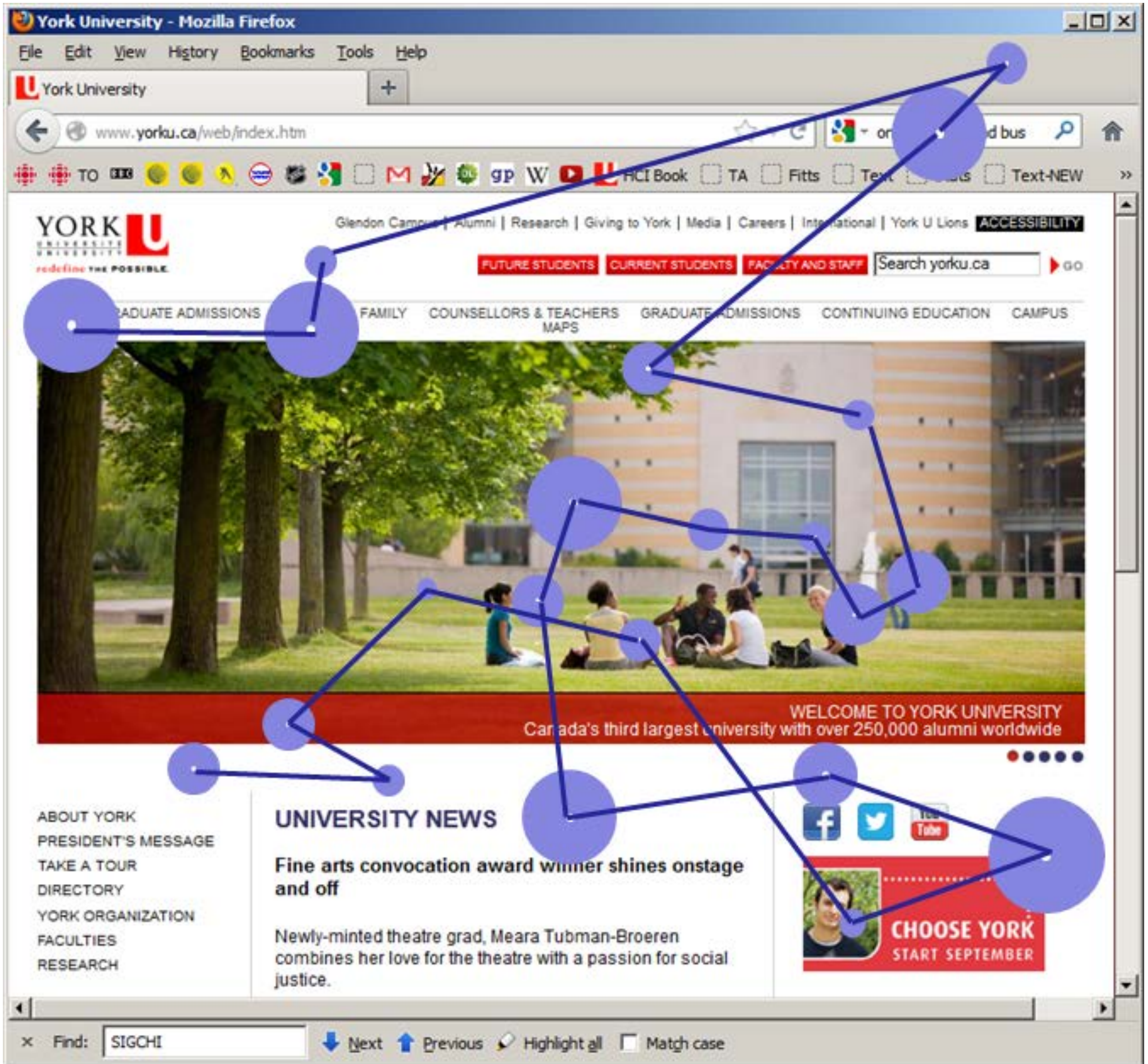
"Estimate the ages of the people"

[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

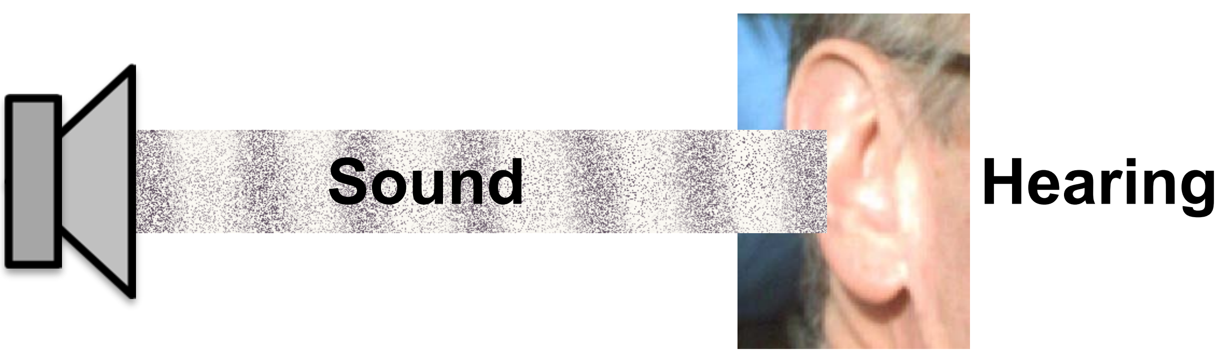
- Visual depiction of saccades and fixations
- Saccades → straight lines
- Fixations → circles
  - Diameter of circle $\propto$ duration of fixation
- Applications
  - User behaviour research (e.g., reading patterns)
  - Marketing research (e.g., ad placement)

# Scan Path Example



# 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 (via larynx)



# Auditory Stimulus

- Physical properties of sound…
  - Frequency
  - Intensity
- Create subjective properties of hearing…
  - Pitch
  - Loudness

# Properties of Sounds

- Loudness
- Pitch
- Timbre (next slide)
- Attack (after next slide)

# Timbre (음색)

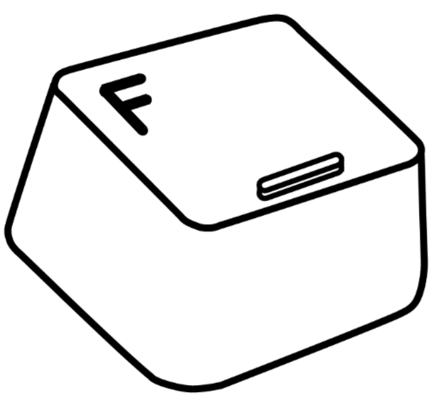
- Aka *richness*, *brightness*
- Results from harmonic structure of sound
- E.g., a musical note of 200 Hz, has harmonics at 400 Hz, 600 Hz, 800 Hz, etc.
- Notes of the same frequency from different instruments are distinguished, in part, due to timbre

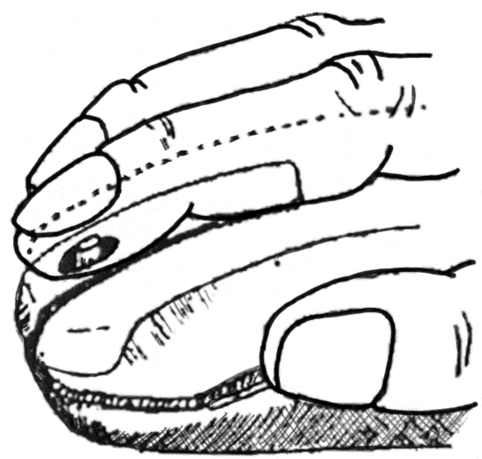
# Attack(음의 발생)

- 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)

# 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:

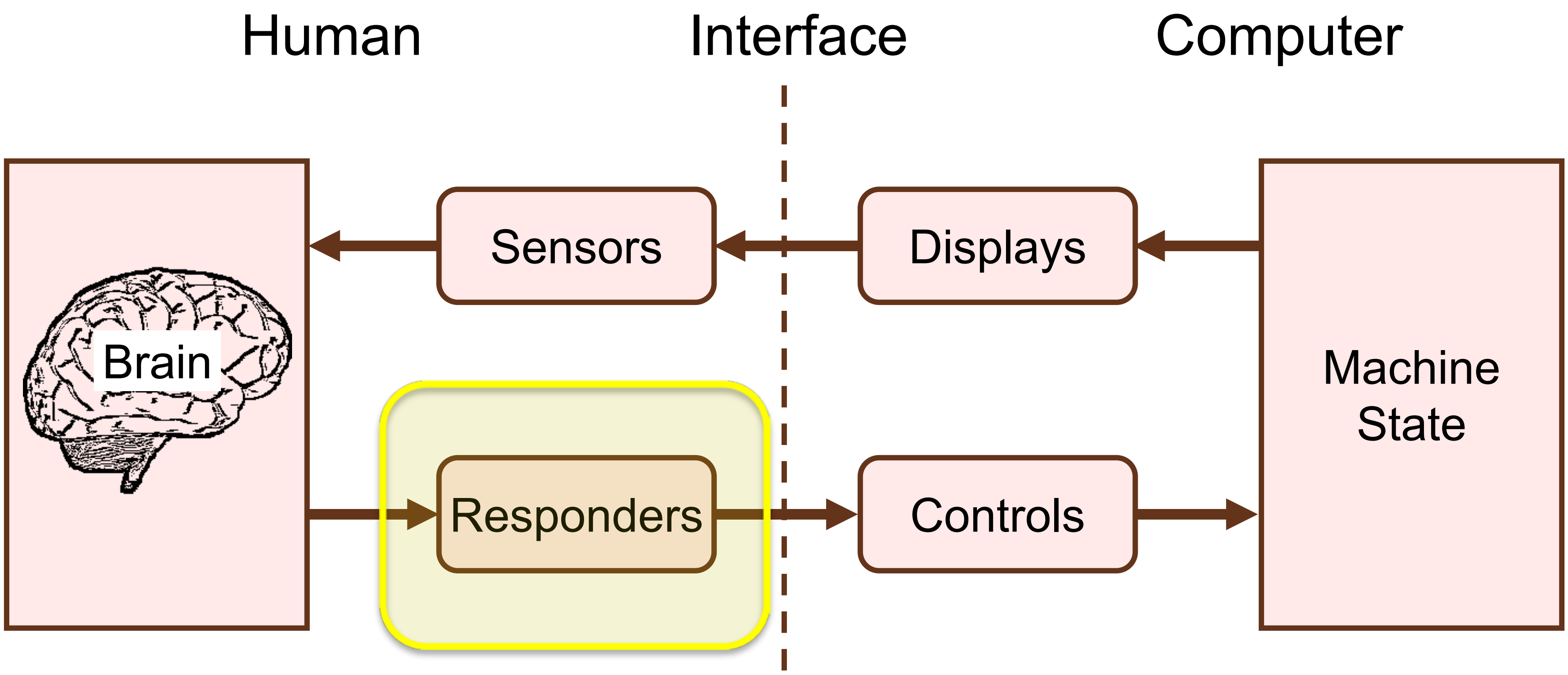


# Smell and Taste

- 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
- Only a few examples in HCI (e.g., Brewster et al., 2006; Bodnar et al., 2004)

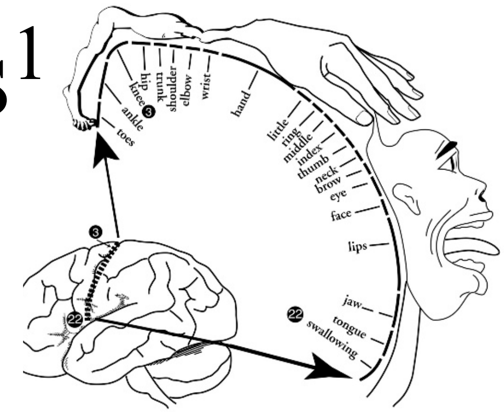
# Human Factors Model

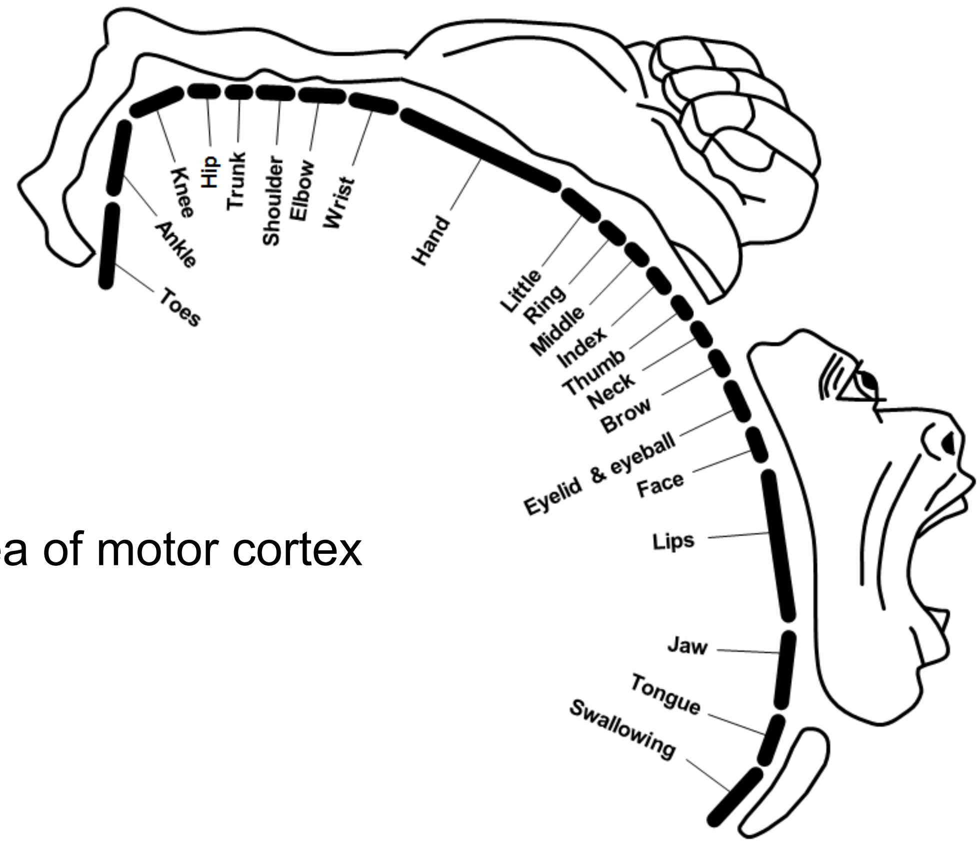


# Responders

- Humans control their environment through responders, for example…
  - A finger to text or point
  - Feet to walk or run
  - Eyebrow to frown
  - Vocal chords to speak
  - Torso to lean
- Penfield’s (1990) motor homunculus
  - Shows human responders and the relative area of motor cortex dedicated to each (next slide)

# Motor Homunculus[1]

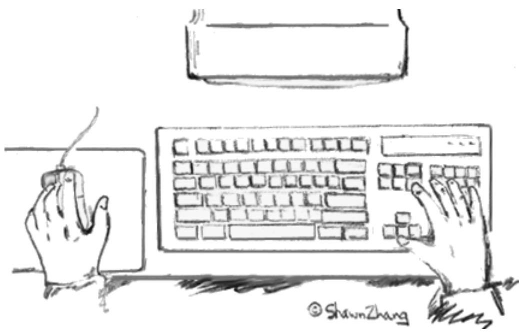


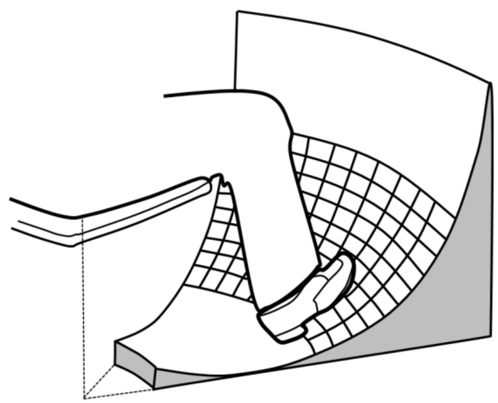




Area of motor cortex

[1] Penfield, W., & Rasmussen, T. (1990). *The cerebral cortex of man: A clinical study of localization of function*. New York: Macmillan.

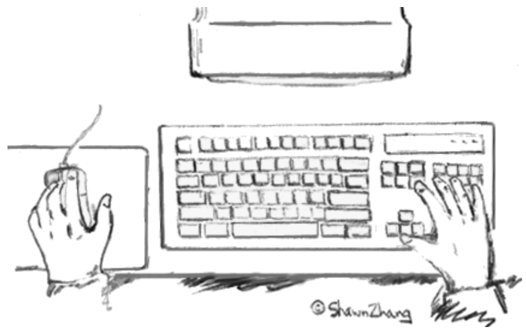
# Responder Examples



# Handedness

- Some users are left handed, others right handed



- Handedness exists by degree
- Edinburgh Handedness Inventory used to measure handedness (next slide)

# Edinburgh Inventory for Handedness[1]

| | 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** |
|---|---|---|
| | | |

Instructions

Mark boxes as follows:

x preference

xx strong preference

blank no preference

Scoring

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.

Interpretation of RESULT

-100 to -40 left-handed

-40 to +40 ambidextrous

+40 to 100 right-handed

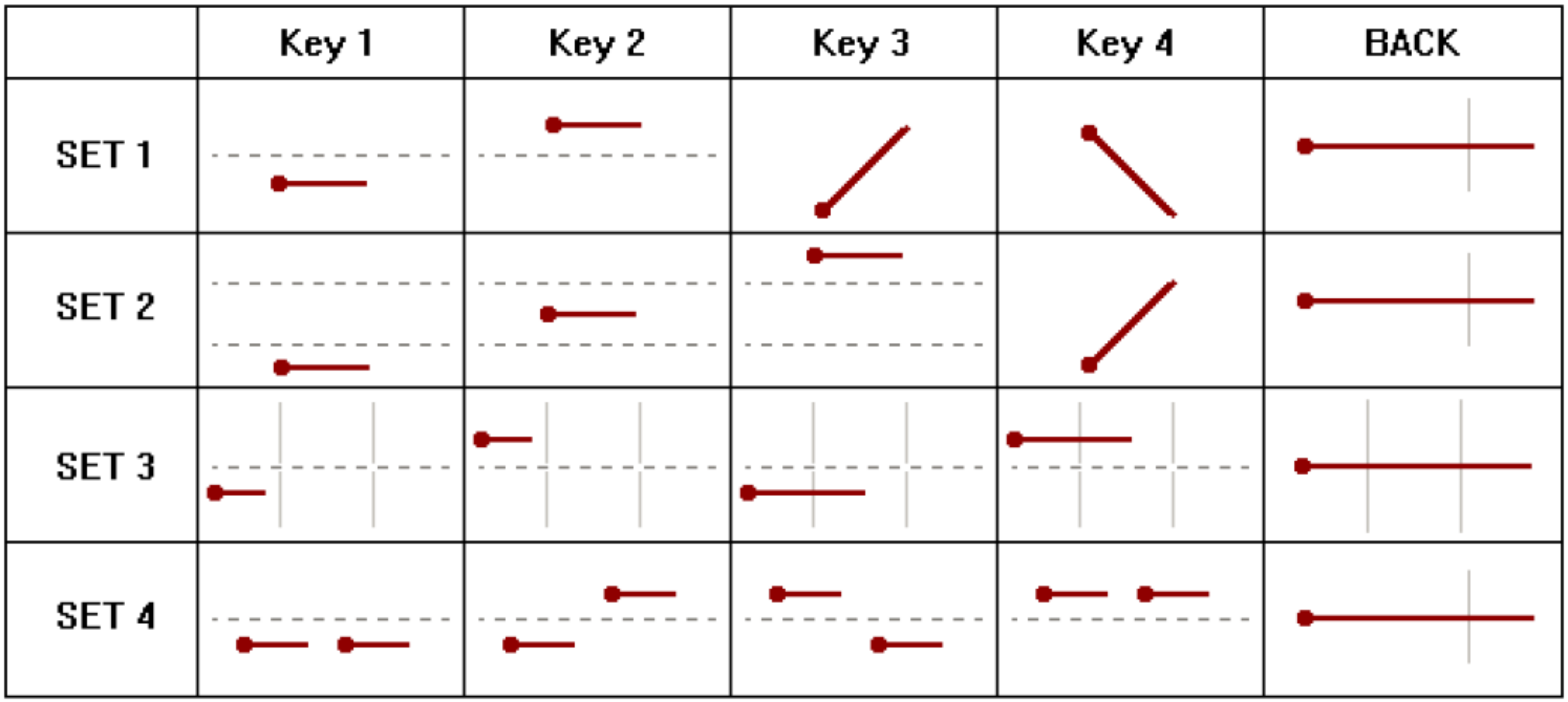
[1] Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsycholologia, 9*, 97-113.

# 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.)

# Non-speech Example[1]

- NVVI = non-verbal voice interaction

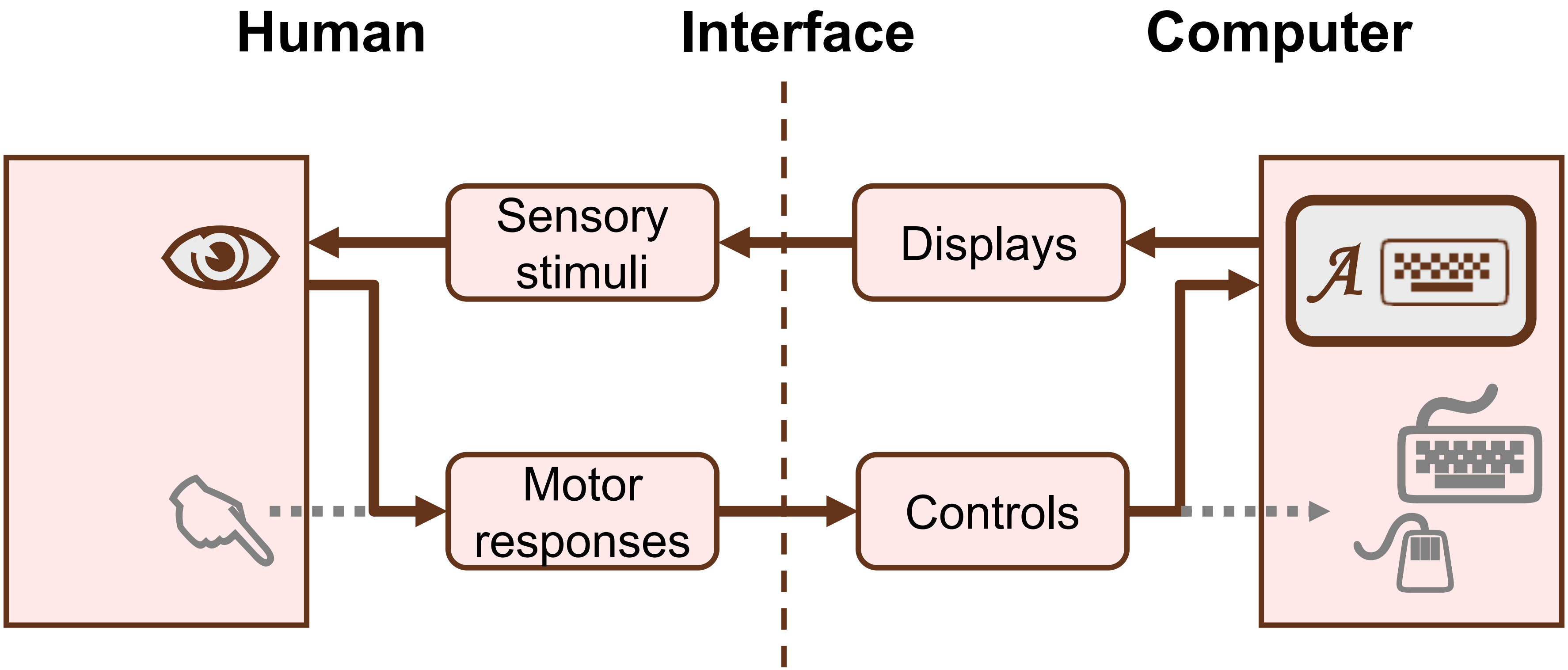



[1] Sporka, A., Felzer, T., Kruniawan, S., Polacek, O., Haiduk, P., & MacKenzie, I. S. (2011). CHANTI: Predictive text entry using non-verbal vocal input. *Proceedings of the ACM Conference on Human Factors in Computing Systems – CHI 2011*, 2463-2472.New York: ACM.

# The Eye as a Responder

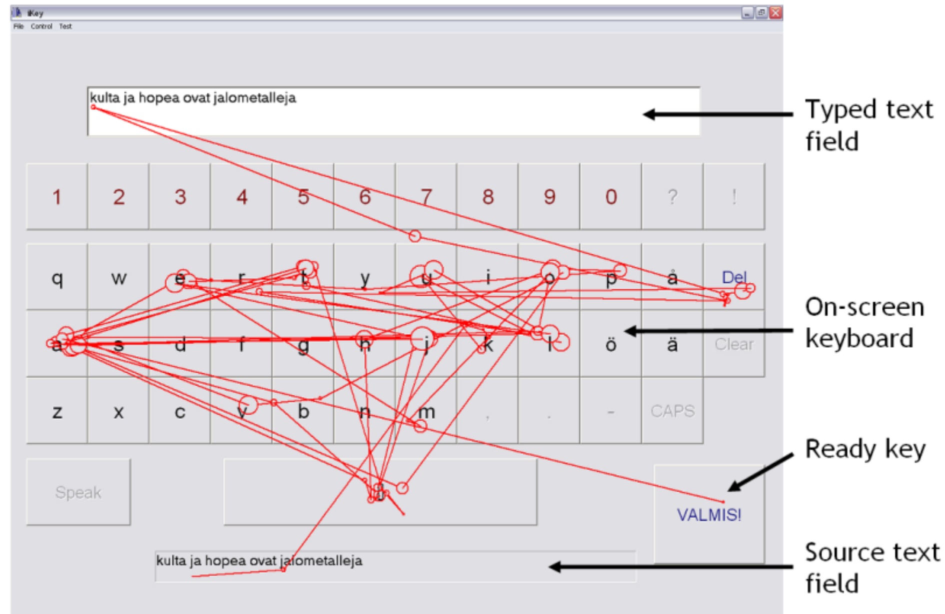
- As a controller, the eye is called upon to do "double duty"
    1. Sense and perceive the environment/computer
    2. Act as a controller via saccades and fixations
- This suggests a modification to the human factors model presented earlier (next slide)

# Modified Human Factors Model[1]



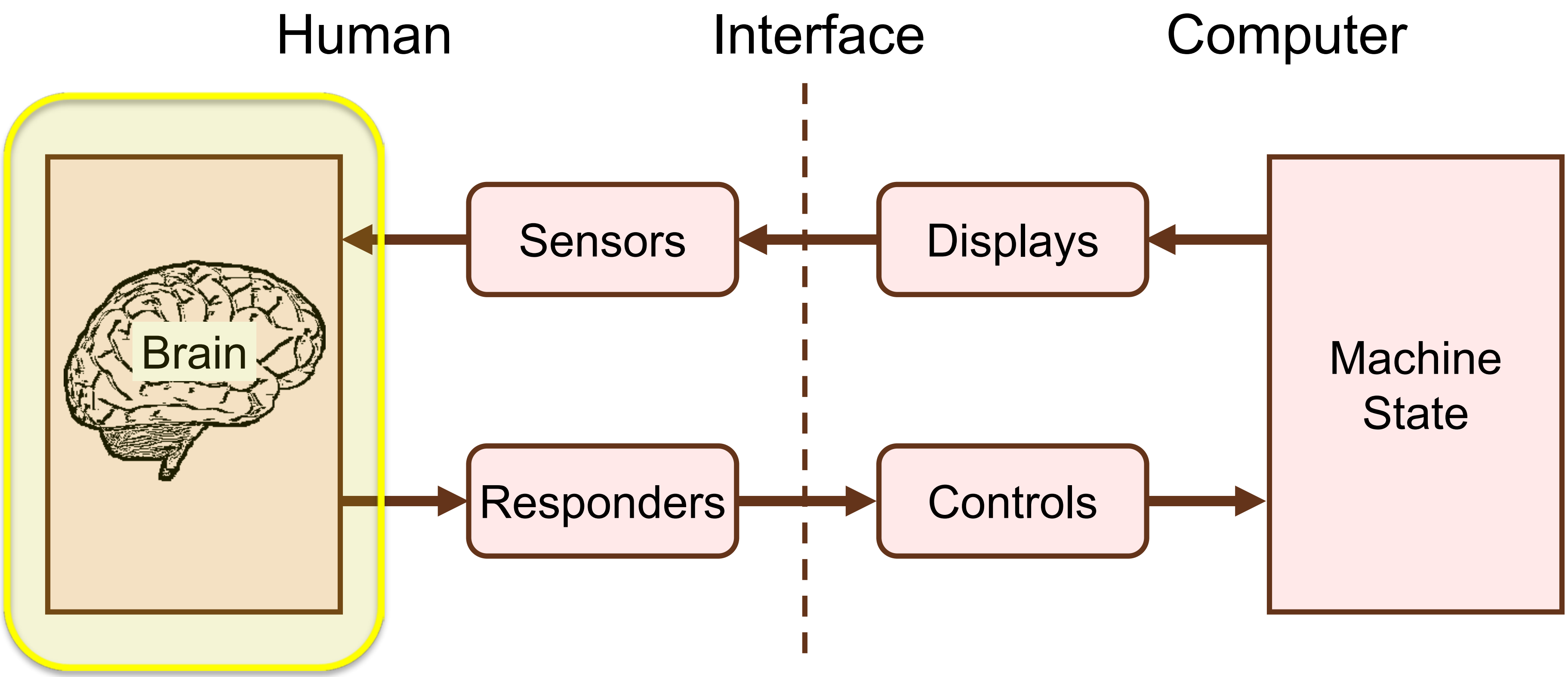

[1] MacKenzie, I. S. (2012). Evaluating eye tracking systems for computer input. In Majaranta, P., Aoki, H., Donegan, M., Hansen, D. W., Hansen, J. P., Hyrskykari, A., & Räihä, K.-J. (Eds.) *Gaze interaction and applications of eye tracking: Advances in assistive technologies*, pp. 205-225. Hershey,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

# Example - Eye Typing[1]


[1] Majaranta, P., MacKenzie, I. S., Aula, A., & Räihä, K.-J. (2006). Effects of feedback and dwell time on eye typing speed and accuracy. *Universal Access in the Information Society (UAIS), 5*, 199-208.

# Human Factors Model



# The Brain

- Most complex biological structure known
- Billions of neurons
- Enables human capacity for…
  - Pondering, remembering, recalling, reasoning, deciding, communicating, etc.
- Sensors (human inputs) and responders (human outputs) are nicely mirrored, but it is the brain that connects them

# Human Uniqueness

- With associations and meaning attached to sensory input, humans are vastly superior to the machines they interact with:

> People excel at perception, at creativity, at the ability to go beyond the information given, making sense of otherwise chaotic events. We often have to interpret events far beyond the information available, and our ability to do this efficiently and effortlessly, usually without even being aware that we are doing so, greatly adds to our ability to function.[1]

[1] Norman, D. A. (1988). *The design of everyday things*. New York: Basic Books.

# Perception

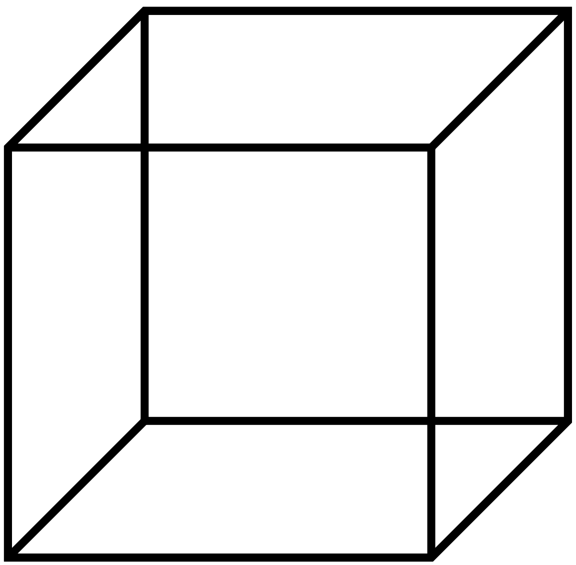
- 1st stage of processing for sensory input
- Associations formed…
  - Auditory stimulus → harmonious, discordant
  - Visual stimulus → familiar, strange
  - Tactile stimulus → warm, hot
  - Smell stimulus → pleasurable, abhorrent
  - Taste stimulus → sweet, sour

# Psychophysics

- Branch of experimental psychology
- Studied since the 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)

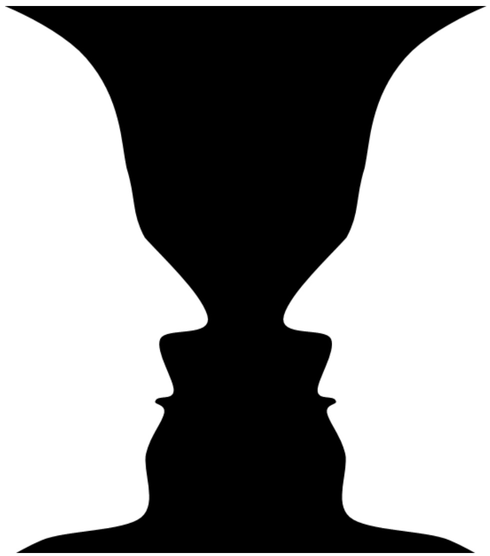
# Ambiguity

**Necker cube**



Which surface is at the front?

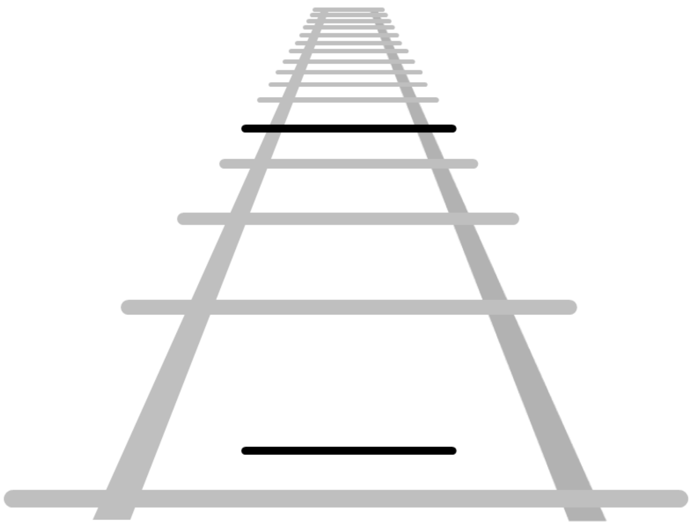
**Rubin vase**



Wine goblet or two faces?

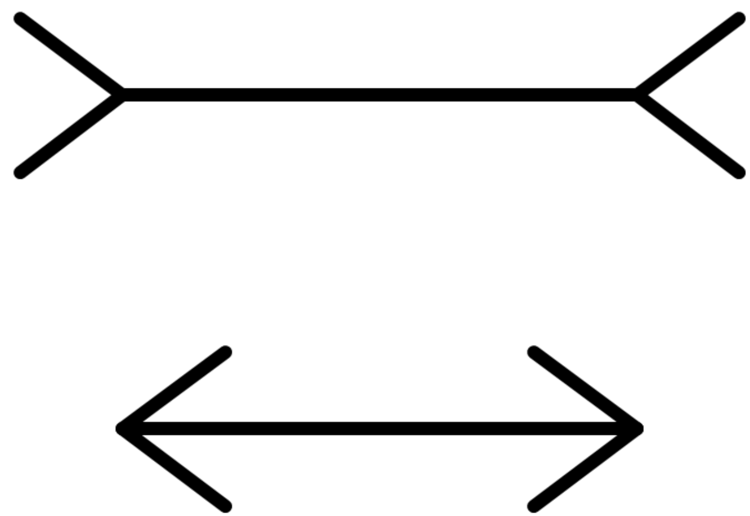
# Illusion

**Ponzo lines**



Which black line is longer?

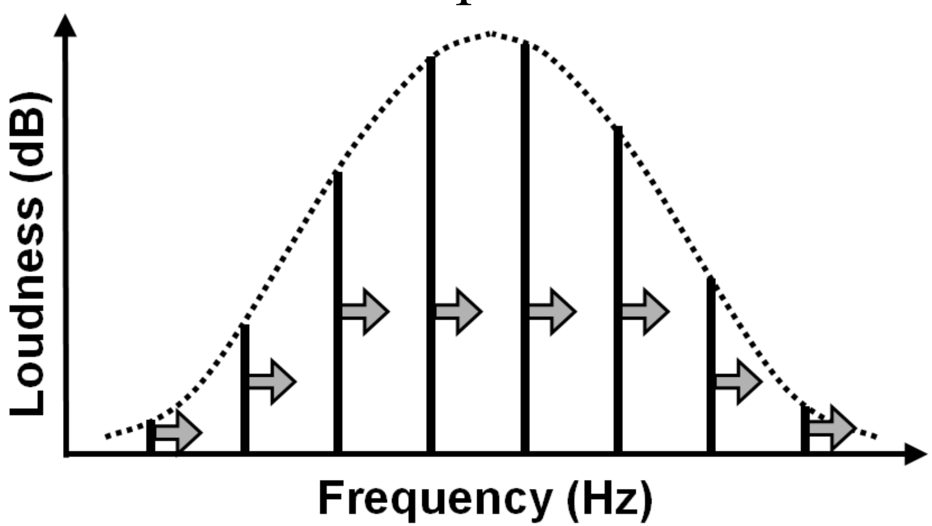
**Műller-Lyer arrows**



Which horizontal line is longer?

# Illusion – Other Senses

- If illusion is possible for the visual sense, the same should be true for the other senses
- Tactile/haptic illusion: phantom limb
- Auditory illusion:
  - Shepard scale, Shepard-Risset glissando
  - Visit *YouTube* for examples



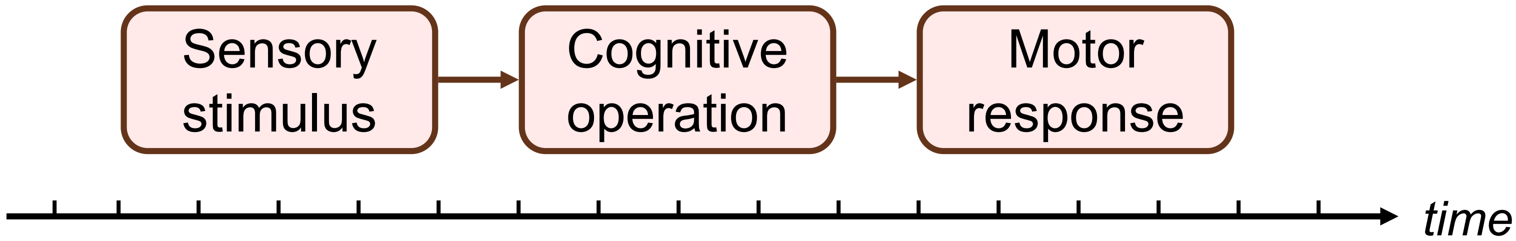
# Cognition

- Cognition is the human process of conscious intellectual activity
  - E.g., thinking, reasoning, deciding
- Spans many fields
  - E.g., neurology, linguistics, anthropology
- Sensory phenomena → easy to study because they exist in the physical world
- Cognitive phenomena → hard to study because they exist within the human brain

# “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 (next slide)

# Making a Decision – in Parts




| 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 |

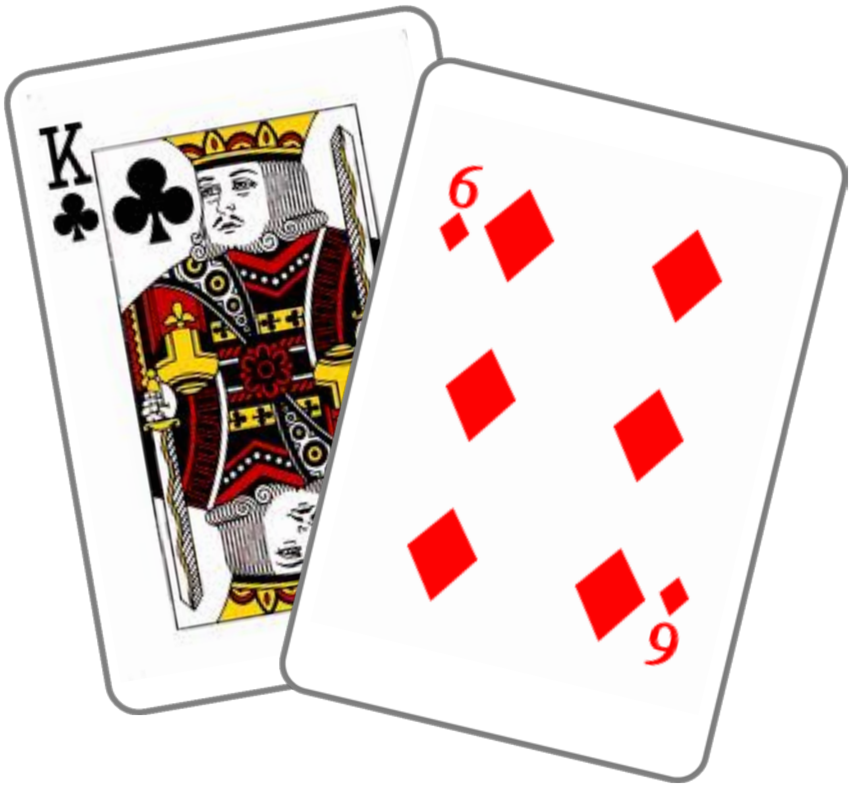
Large variation!

# 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
- These are *reaction time* tasks (discussed shortly)

# A More Involved Decision

Black Jack hand:




Another card?
(dealer has 17)

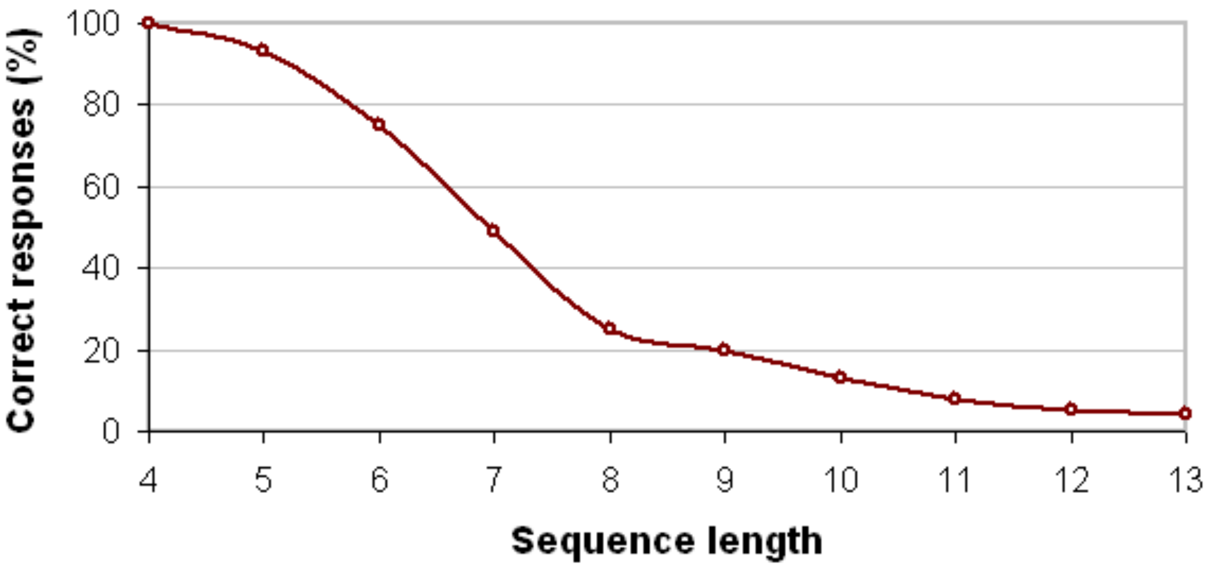
# Memory

- Vast repository
- Long-term memory
  - Declarative/explicit area → information about events in time and objects in the external world (data segment)
  - Implicit/procedural area → information about how to use objects and how to do things (code segment)
- Short-term memory
  - Aka *working memory*
  - Information is active and readily available for access
  - Amount of working memory is small, about 7 (±2) units or chunks[1]

[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.

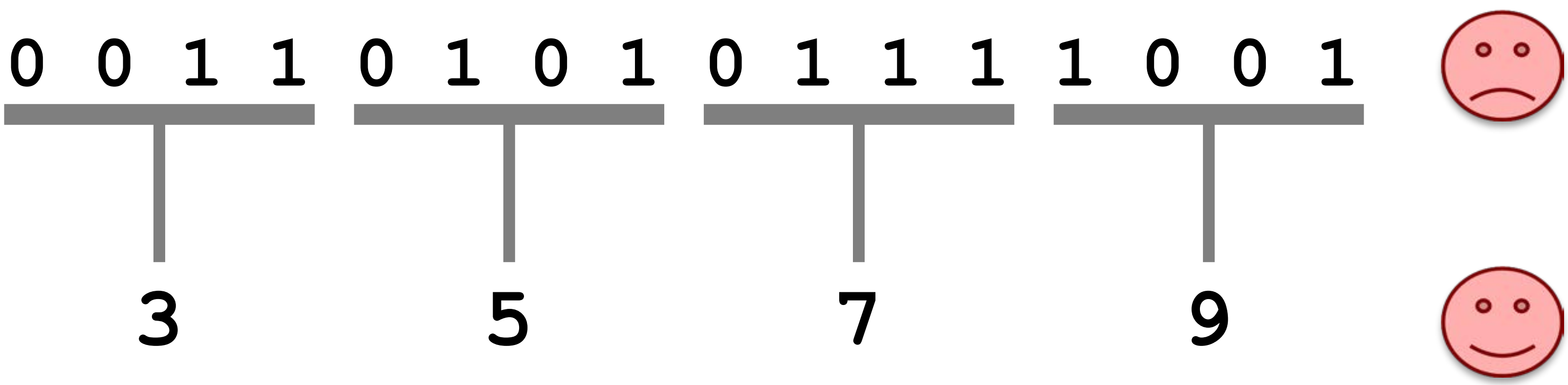
# Short Term Memory Experiment

- Random sequences of digits recited to subjects
- Sequences vary from 4 to 13 digits
- After recitation, subjects copy sequence from memory to a sheet of paper
- Transcriptions on sheets scored (correct/incorrect)
- Results ($n \approx 60$):



# 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…



# Language

- The mental faculty that allows humans to communicate
- As speech, available to (almost) all humans without effort
- As writing, only available with considerable effort
- HCI interest: primarily in writing, creation of text

Humankind is defined by language; but civilization is defined by writing.[1]

[1] Daniels, P. T., & Bright, W. (Eds.). (1996). *The world's writing systems*. New York: Oxford University Press.

# Corpus

- One way to characterise written text is a corpus
- Large collection of representative text samples
- A corpus may be reduced to a word-frequency list:

| Word Rank | English | French | German | Finnish | SMS English | SMS Pinyin |
|---|---|---|---|---|---|---|
| 1 | the | de | der | ja | u | wo (我) |
| 2 | of | la | die | on | i | ni (你) |
| 3 | and | et | und | ei | to | le (了) |
| 4 | a | le | in | että | me | de (的) |
| 5 | in | à | den | oli | at | bu (不) |
| … | … | … | … | … | … | … |
| 1000 | top | ceci | konkurrenz | muista | ps | jiu (舅) |
| 1001 | truth | mari | stieg | paikalla | quit | tie (贴) |
| 1002 | balance | solution | notwendig | varaa | rice | ji (即) |
| 1003 | heard | expliquer | sogenannte | vie | sailing | jiao (角) |
| 1004 | speech | pluie | fahren | seuran | sale | ku (裤) |
| … | … | … | … | … | … | … |

# Part-of-speech Tagging

- Some corpora include part-of-speech (POS) tagging
- Each word is tagged by its category (e.g., noun, verb, adjective)
- Used in word prediction to narrow search space[1]
- Example:

The *paint* is dry. **(noun)**

Children *paint* with passion. **(verb)**

[1] Gong, J., Tarasewich, P., & MacKenzie, I. S. (2008). Improved word list ordering for text entry on ambiguous keyboards. *Proceedings of the Fifth Nordic Conference on Human-Computer Interaction - NordiCHI 2008*, 152-161, New York: ACM.

# Statistics and Language

- Native speakers intuitively understand the statistical nature of their language
- We…
  - Insert words that are omitted or obscured:

    Ham and ______ sandwich.
  - Anticipate words:

    A picture is worth a thousand _____.
  - Anticipate letters:

    Questio_
  - Anticipate entire phrases:

    To be or __ __ __.

# Redundancy and Language

- Since humans can fill in missing parts, perhaps the missing parts can be eliminated
- This shortens the text (efficient)
- Example: 243 characters of text with vowels removed

> Th std ws flld wth th rch dr f rss,
> nd whn th lght smmr wnd strrd mdst th
> trs f th grdn, thr cm thrgh th pn
> dr th hvy scnt f th llc, r th mr
> dlct prfm f th pnk-flwrng thrn.

- 71 vowels removed
- Text shortened by 29.2%

Meaning of the text?

Summr → summer, thrgh → through, etc.

# Redundancy and Language (2)

- Vowels at beginning of words intact:

Th std ws flld wth th rch odr of rss,
and whn th lght smmr wnd strrd amdst th
trs of th grdn, thr cm thrgh th opn
dr th hvy scnt of th llc, or th mr
dlct prfm of th pnk-flwrng thrn.

- 62 vowels removed
- Text shortened by 25.5%

Easier to understand.

- Original:

The studio was filled with the rich odour of roses,
and when the light summer wind stirred amidst the
trees of the garden, there came through the open
door the heavy scent of the lilac, or the more
delicate perfume of the pink-flowering thorn.

- Original

Oscar Wilde: *The Picture of Dorian Gray*

# Recoding

- Other ways to shorten text
- Recoding: replacing words/characters with shortened tags using linguistic tricks[1]
- Examples
  - Sound:

    th@s → that's
    gr8 → great

  - Invented acronyms:

    w → with
    gf → girlfriend
    x → times

[1] Grinter, R., & Eldridge, M. (2003). Wan2tlk? Everyday text messaging. *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems - CHI 2003*, 441-448, New York: ACM.

# SMS Shorthand

- The final frontier!
- A 13-year-old student's essay (excerpt)[1]

> My smmr hols wr CWOT. B4, we used 2go2 NY 2C my bro, his GF & thr 3 :- kids FTF. ILNY, it's a gr8 plc.

- 102 characters

- Original (for the teacher to deduce)

> My summer holidays were a complete waste of time. Before, we used to go to New York to see my brother, his girlfriend and their three screaming kids face to face. I love New York. It's a great place.

- 199 characters



[1] http://news.bbc.co.uk/2/hi/uk_news/2814235.stm

# Entropy in Language

- If redundancy is what we know, entropy is what we don't know
- Entropy is the uncertainty about forthcoming letters, words, phrases, ideas, etc.
- Shannon demonstrated entropy and redundancy in a letter guessing experiment[1]
  - Subject shown text with letters blocked
  - Subject guesses letters one at a time
  - Letters revealed as guessing proceeds:
    - Incorrect → show correct letter
    - Correct → show "-" (next slide)

[1] Shannon, C. E. (1951). Prediction and entropy of printed English. *Bell System Technical Journal, 30*, 50-64.

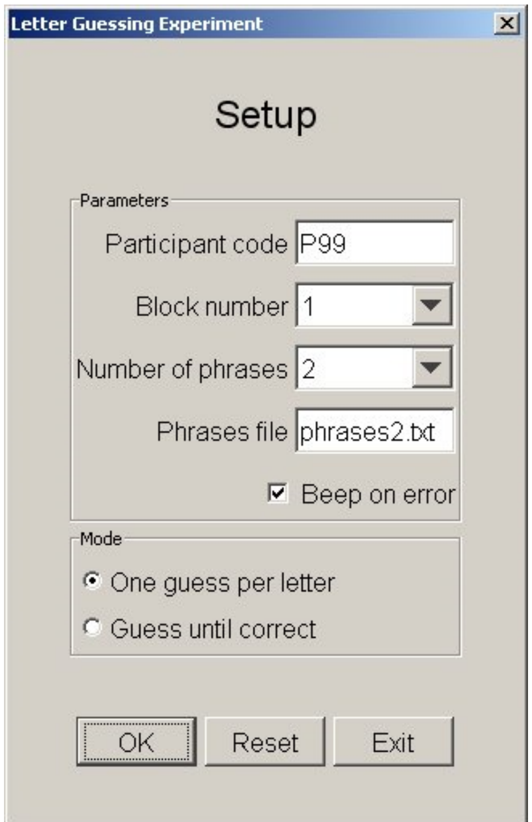
# Letter Guessing Experiment

```
THE ROOM WAS NOT VERY LIGHT A SMALL OBLONG
----ROO------NOT-V-----I------SM----OB----

READING LAMP ON THE DESK SHED GLOW ON
REA----------O------D----SHED-GLO--0-

POLISHED WOOD BUT LESS ON THE SHABBY RED CARPET
P-L-S-----O---BU--L-S--O-------SH----RE--C-----
```

# Letter Guessing Experiment (2)






Use software from book's web site:

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

# Letter Guessing Experiment (3)

- Observations:
  - Errors most common at beginning of words
  - Errors less common as a word progresses
  - Errors even less common as a phrase progresses
- Entropy discussion:
  - The two phrases (original and “reduced”) contain the same information
  - With a good statistical model, the original text can be obtained from the reduced text
  - Therefore, it is only necessary to transmit the reduced text

# Entropy of Printed English

- Shannon demonstrated how to calculate the entropy (*H*) of printed English
- Considering single letter frequencies alone,

$$H = 4.25 \text{ bits per letter}^{1}$$

- Entropy (viz, uncertainty) goes down as more letters are considered (1 previous letter, 2 previous letters, etc.)
- In the extreme (considering up to about 100 letters),

$$H \approx 1 \text{ bit per letter}$$

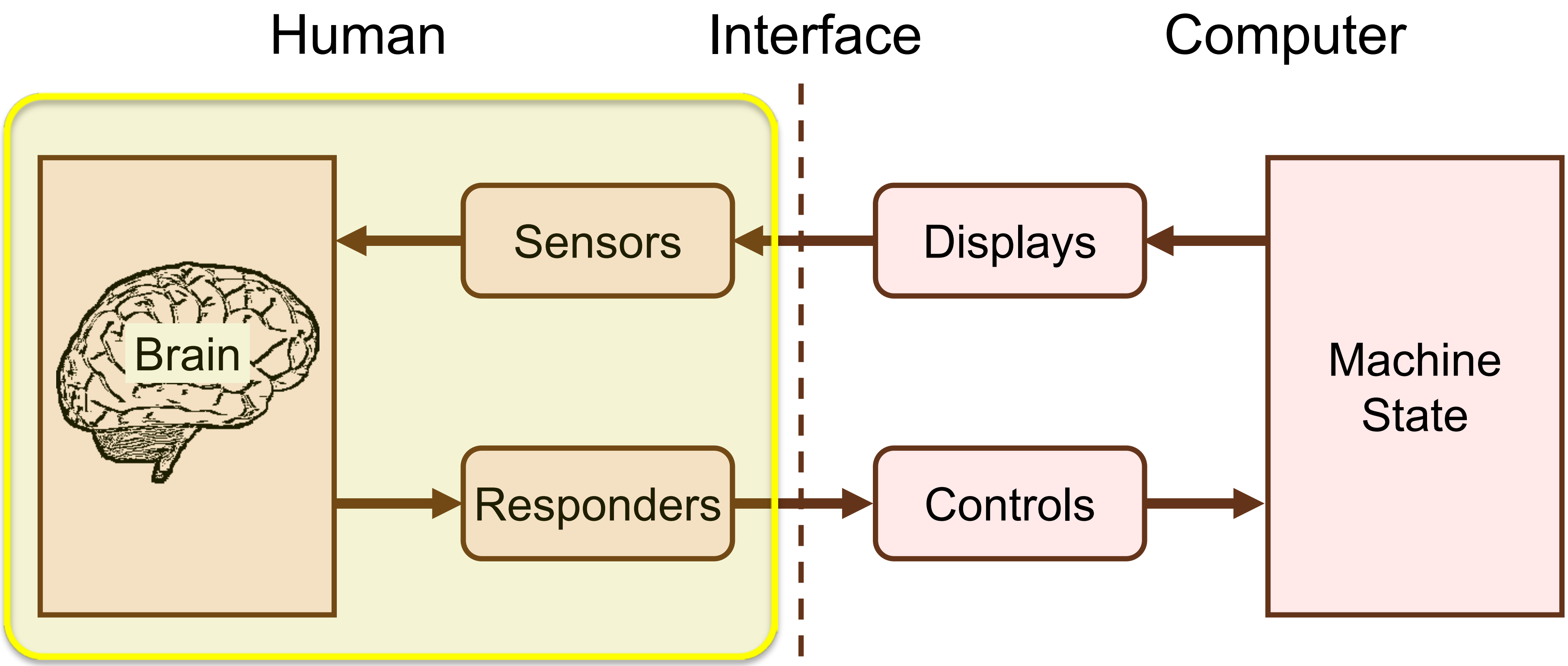
$$\text{Redundancy} \approx 75\%$$



[1] Calculation and further discussion in Chapter 7 (see Figure 7-19).

| Letter | Frequency | Probability ($p$) | $p \log_2(1/p + 1)$ |
|---|---|---|---|
| a | 24373121 | 0.0810 | 0.3028 |
| b | 4762938 | 0.0158 | 0.0950 |
| c | 8982417 | 0.0299 | 0.1525 |
| d | 10805580 | 0.0359 | 0.1742 |
| e | 37907119 | 0.1260 | 0.3981 |
| f | 7486889 | 0.0249 | 0.1335 |
| g | 5143059 | 0.0171 | 0.1008 |
| h | 18058207 | 0.0600 | 0.2486 |
| i | 21820970 | 0.0725 | 0.2819 |
| j | 474021 | 0.0016 | 0.0147 |
| k | 1720909 | 0.0057 | 0.0427 |
| l | 11730498 | 0.0390 | 0.1846 |
| m | 7391366 | 0.0246 | 0.1322 |
| n | 21402466 | 0.0711 | 0.2783 |
| o | 23215532 | 0.0772 | 0.2935 |
| p | 5719422 | 0.0190 | 0.1092 |
| q | 297237 | 0.0010 | 0.0099 |
| r | 17897352 | 0.0595 | 0.2471 |
| s | 19059775 | 0.0633 | 0.2578 |
| t | 28691274 | 0.0954 | 0.3358 |
| u | 8022379 | 0.0267 | 0.1404 |
| v | 2835696 | 0.0094 | 0.0636 |
| w | 6505294 | 0.0216 | 0.1203 |
| x | 562732 | 0.0019 | 0.0170 |
| y | 5910495 | 0.0196 | 0.1119 |
| z | 93172 | 0.0003 | 0.0036 |
| | | $H =$ | 4.25 |

# Human Factors Model




**Human Performance**
**Skilled Behaviour**
**Attention**
**Human Error**

# Human Performance

- Humans uses their sensors, brain, and responders to do things
- When the three work together to achieve a *goal*, human performance arises
- Examples:
  - Tying shoelaces
  - Folding clothes
  - Searching the web
  - Entering a text message on a mobile phone

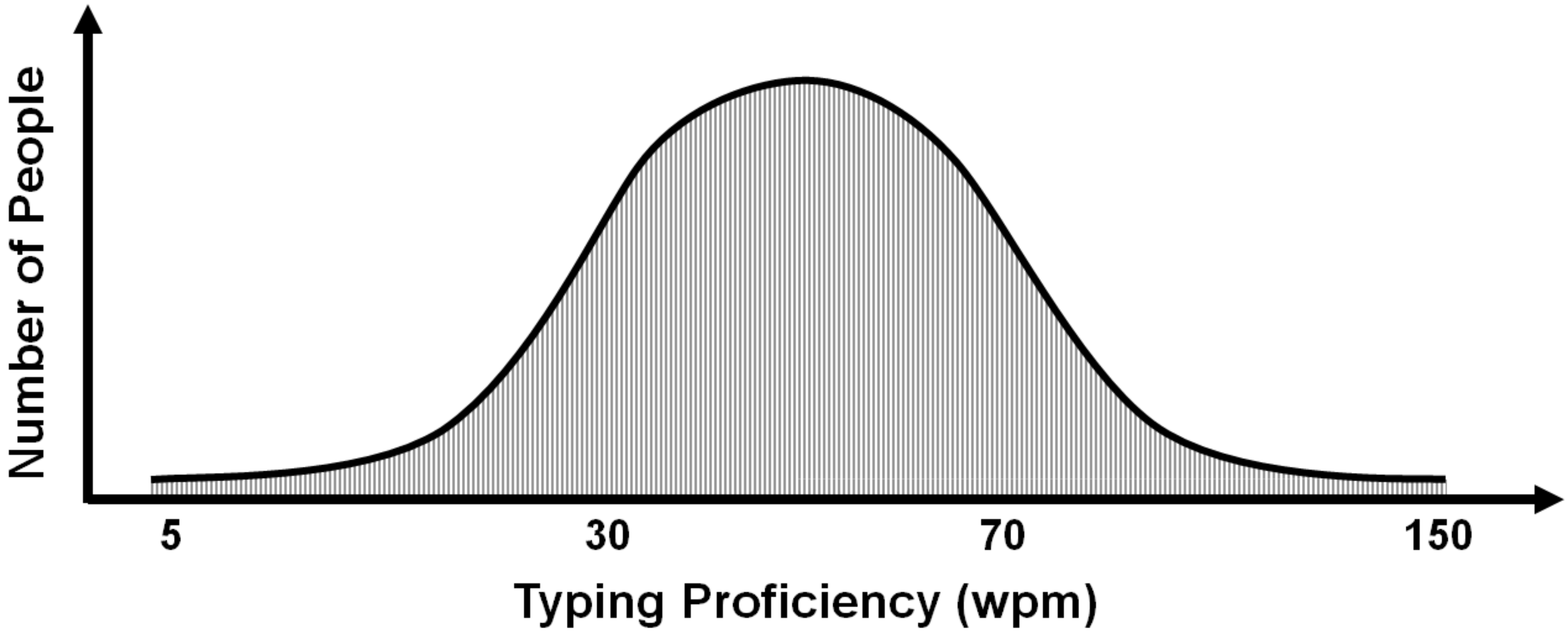
# Speed-accuracy Trade-off

- Fundamental property of human performance
- Go faster and errors increase
- Slow down and accuracy improves
- HCI research on a new interface or interaction technique must consider both the speed in doing tasks (achieving the goal!) and the accompanying accuracy

# Human Diversity

- Human performance is highly complex:
  - Humans differ (age, gender, skill, motivation, etc.)
  - Environmental conditions affect performance
  - Secondary tasks often present
- Human diversity and human performance often shown in a distribution (next slide)

# Human Diversity and Performance




Where are you on this chart?
Where is your mother?
Where is an 8-year old, just learning to use a computer?
Where is someone with a physical disability?
Where are you while using your mobile phone on a crowded bus (standing!)?

# 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[1]
- Example: pressing a button in response to the onset of a stimulus light

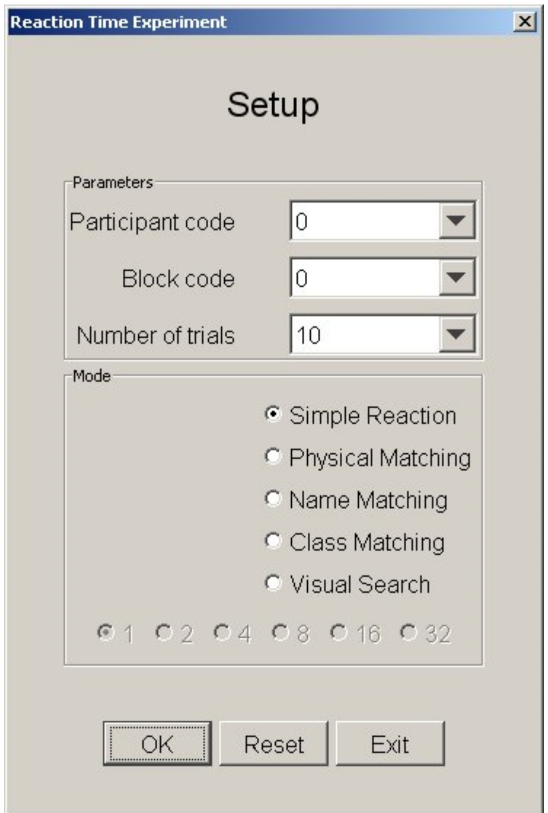
[1] Fitts, P. M., & Posner, M. I. (1968). *Human performance*. Belmont, CA. Brooks/Cole Publishing Company.

# Sensory Stimuli and Reaction Time

- Delay time varies by type of sensory stimuli
- Approximate values[1]
  - Auditory → 150 ms
  - Visual → 200 ms
  - Smell → 300 ms
  - Pain → 700 ms

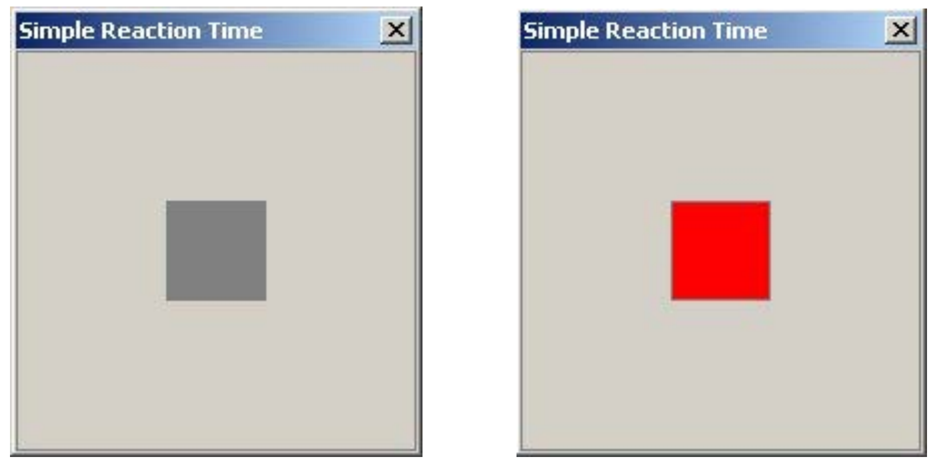
[1] Bailey, R. W. (1996). *Human performance engineering: Designing high quality, professional user interfaces for computer products, applications, and systems* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

# Reaction Time Experiment





**Simple Reaction Time**

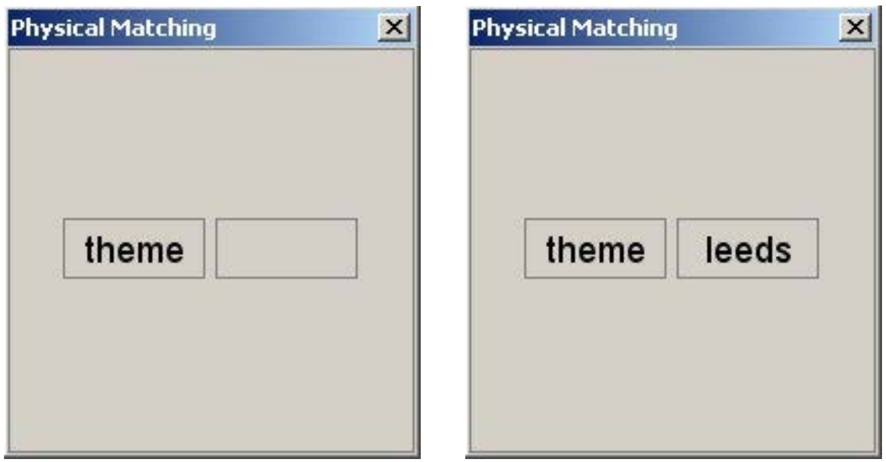


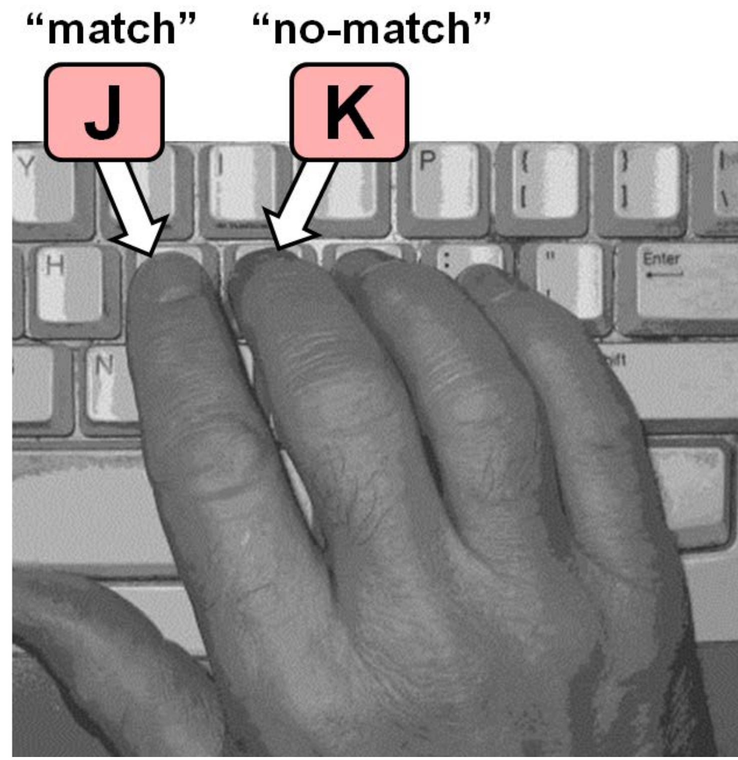

Use software from book's web site:

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

# Reaction Time Experiment (2)

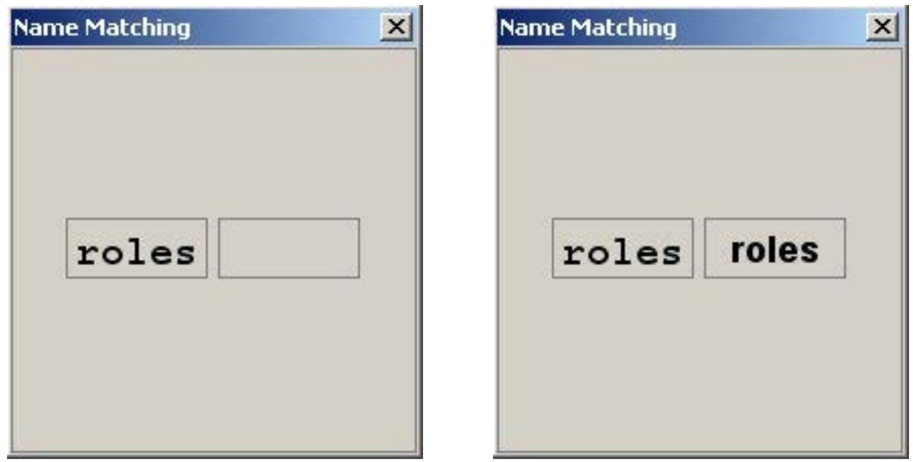
**Physical Matching**



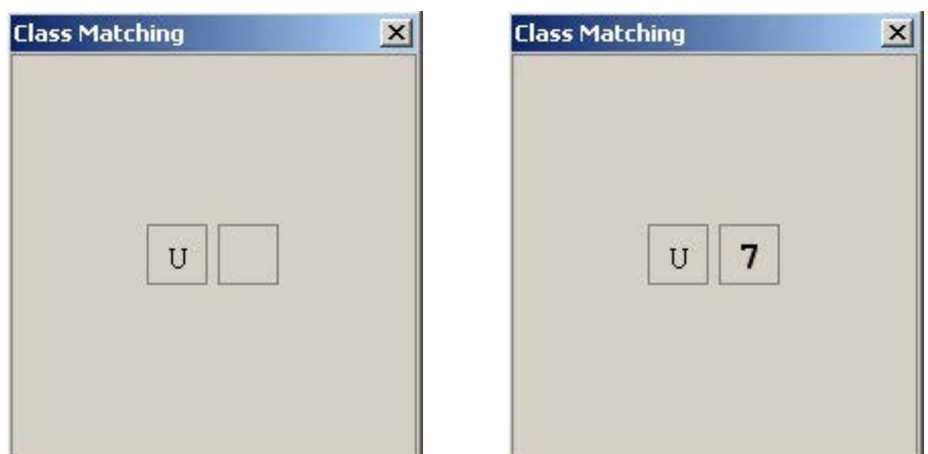



# Reaction Time Experiment (3)

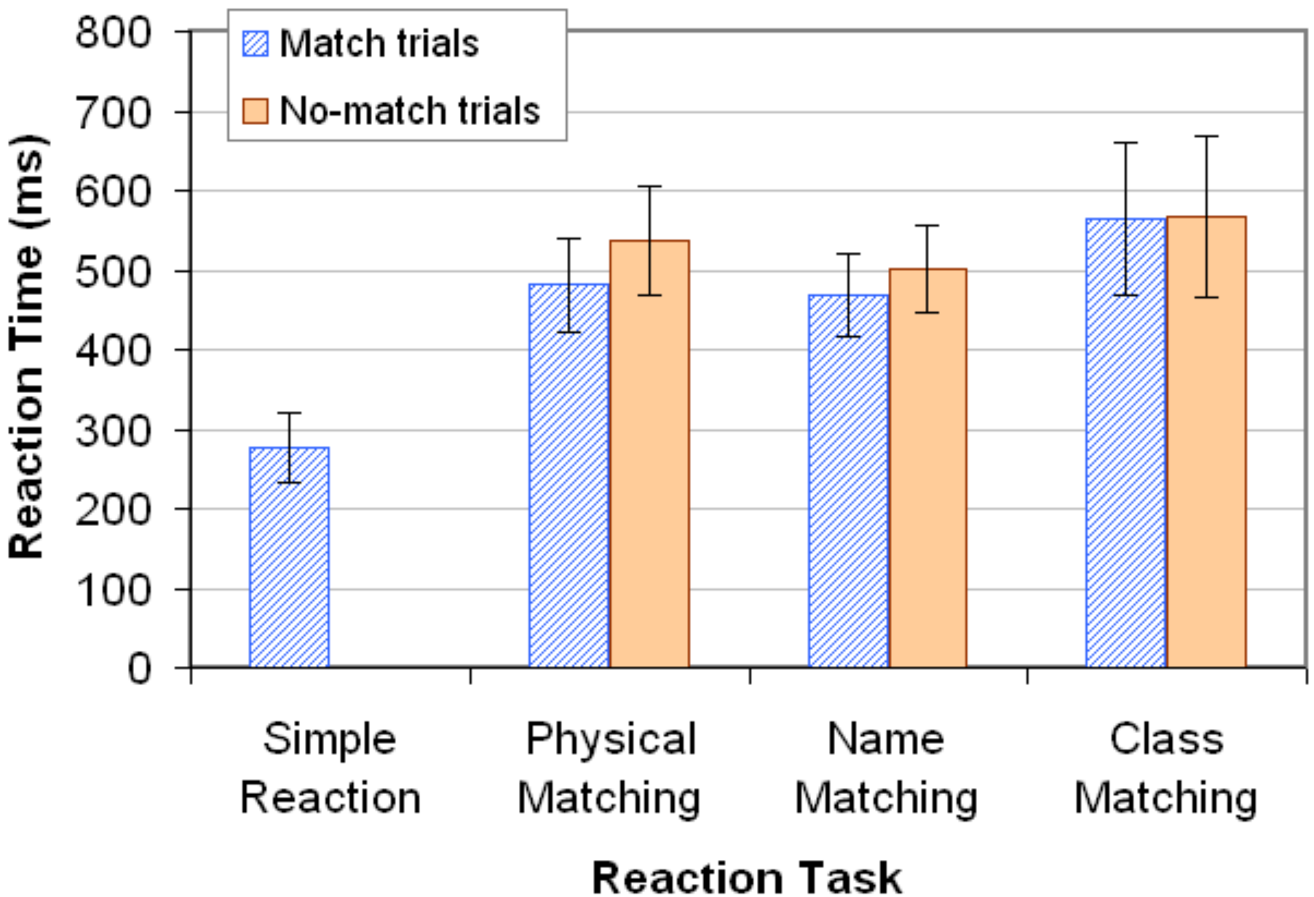
**Name Matching**




**Class Matching**

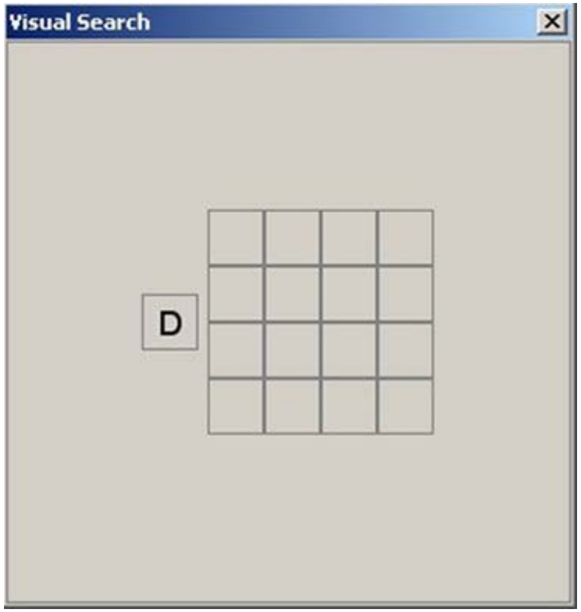


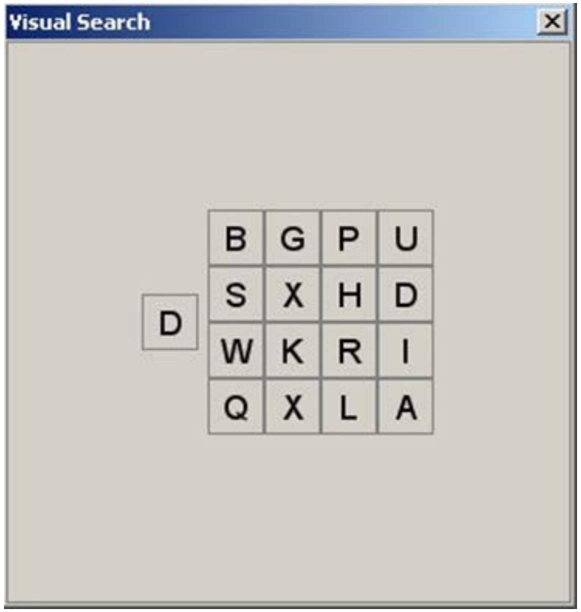
# Experiment Results



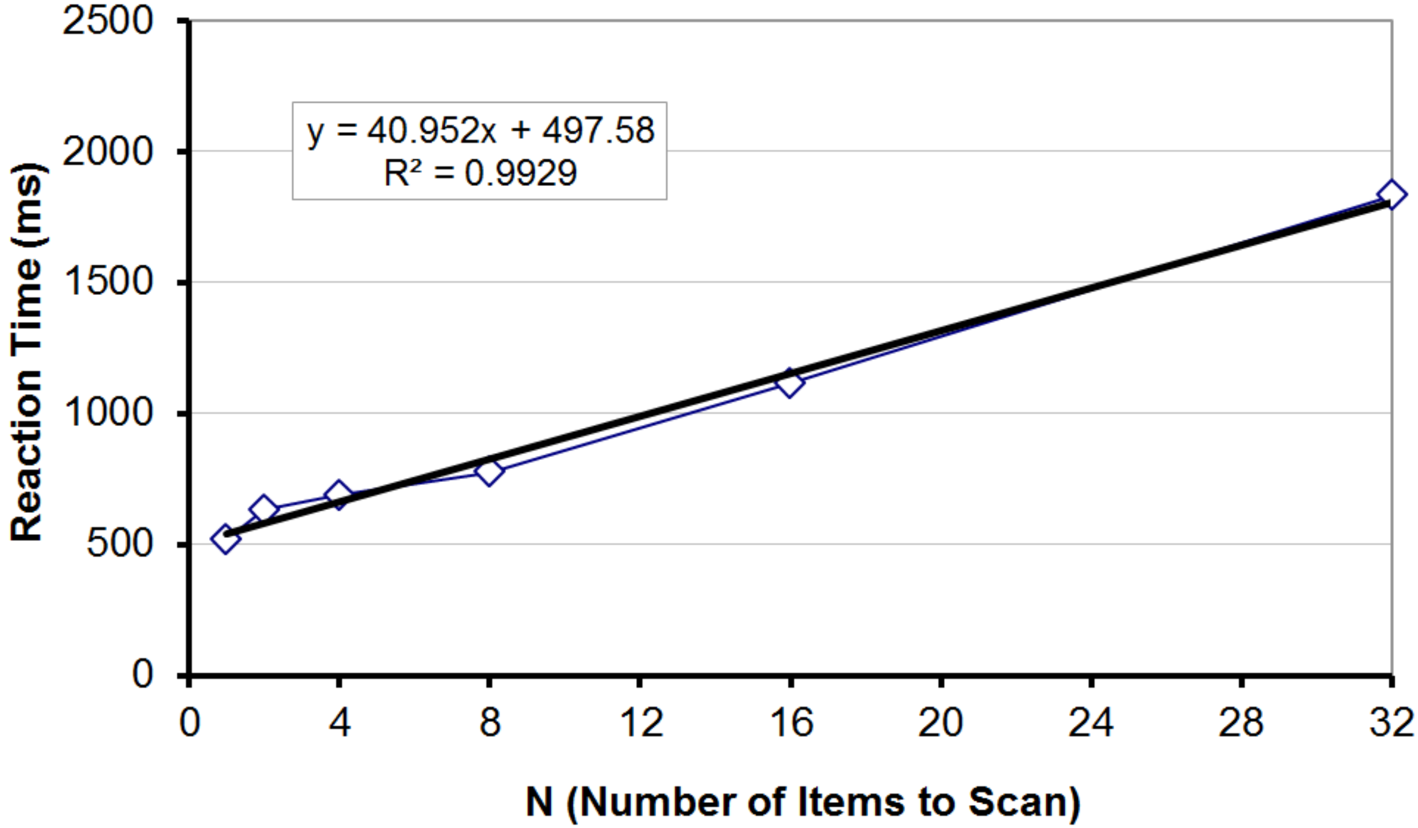
# Visual Search

- A variation on simple reaction time
- User scans a collection of items looking for desired item
- Time increases with the number of items to scan
- Included in the demo software with $N$ = 1, 2, 4, 8, 16, or 32 items



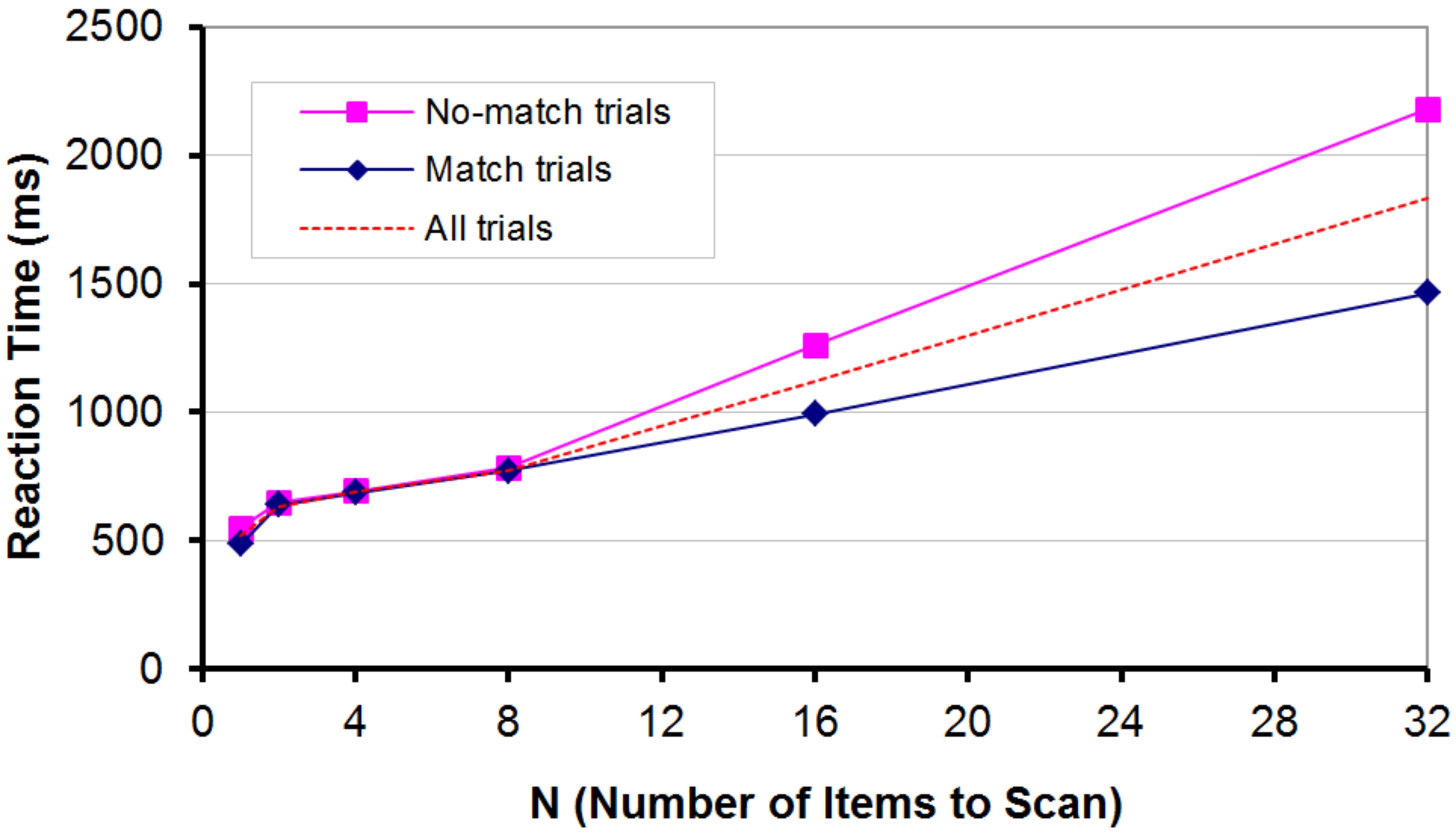



# Experiment Results (1)




**RT = 498 + 41 x N *ms***

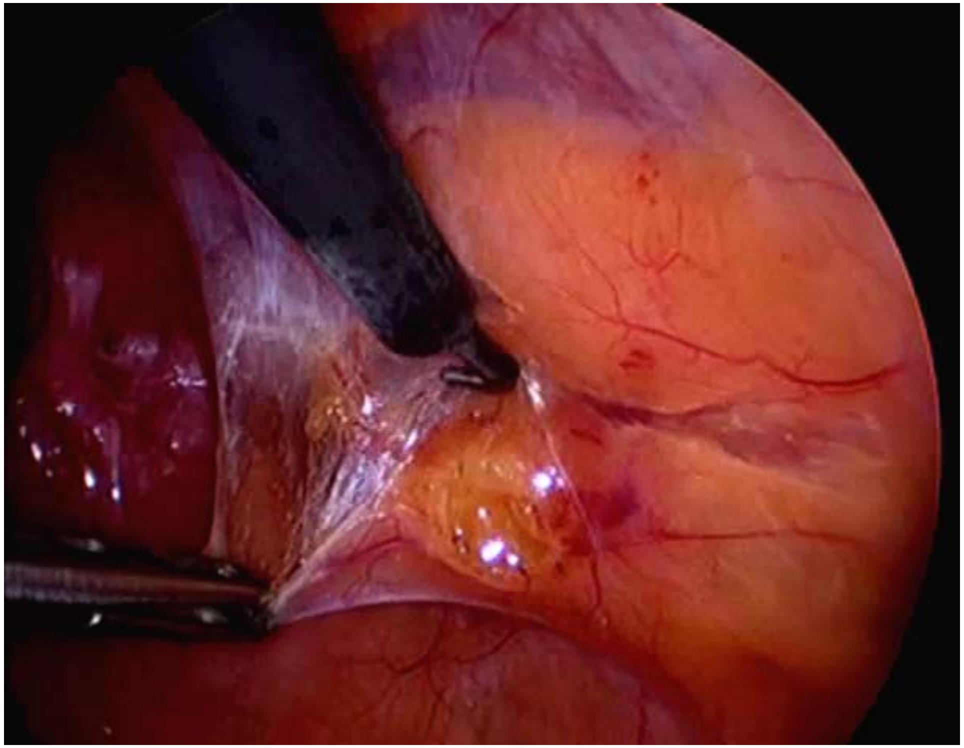
# Experiment Results (2)



# Skilled Behaviour

- For many tasks, human performance improves considerably and continuously with practice
- (Note: Very little improvement with practice in the simple reaction time tasks)
- In these tasks, there is interest in studying the **progression of learning and the performance** achieved according to the amount of practice
- Categories of skilled behavior:
  1. Sensory-motor skill (e.g., darts, gaming)
  2. Mental skill (e.g., chess, programming)
  - Some tasks required a lot of both (next slide)

# Laparoscopic Surgery[1]



[1] Photos courtesy of The Centre of Excellence for Simulation Education and Innovation at Vancouver General Hospital.

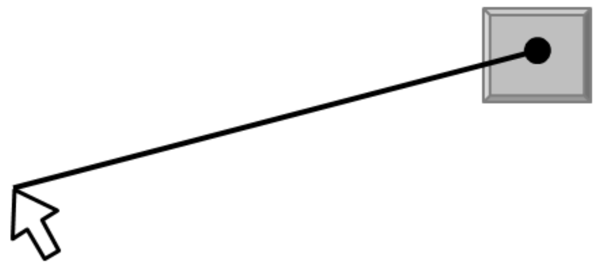
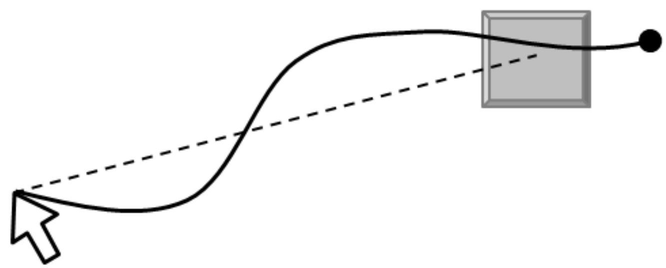
# Attention

- *Texting while driving!*
- Attention is complex:
  - Divided attention, secondary tasks
  - Which tasks require attention?
    - Can't talk and type
  - Which tasks do not require attention?
    - Can talk and walk
  - What are the human limits? *What is attention?*
- Two categories of attention
  - Divided attention (attending to more than one task)
  - Selected attention (attending to one task to the exclusion of others)

# Human Error

- Human error can be studied from many levels
- Simple view: An error is a discrete event where the outcome deviated from the desired outcome
- But, tasks that are performed in error are often at least partly correct (next slide)

# Variability and Error

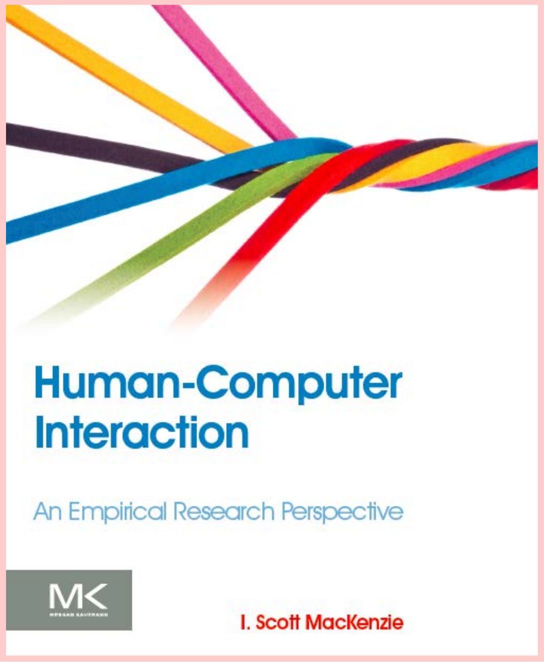
| | Target Selection | Text Entry |
|---|---|---|
| **Correct** |  | `quickly` |
| **Incorrect** |  | `qucehkly` |

What went wrong and why?

# Accidents

- A broader perspective is often necessary
- Serious accidents causing significant damage or loss of life are often attributed to *human error*
- But the fault may be a *design induced error*
- Interaction errors (e.g., an operator pressing the wrong button or entering a wrong value) are not only possible, they are, in time, **likely** and must be anticipated in the design

# Thank You


Human-Computer Interaction
An Empirical Research Perspective
MK
I. Scott MacKenzie