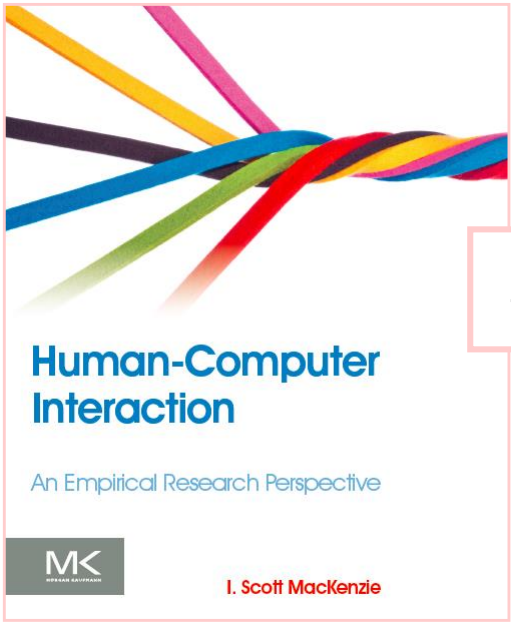
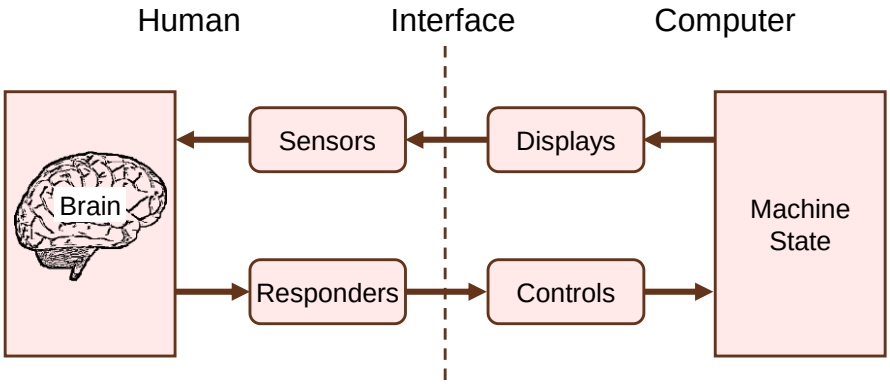



Chapter 2
The Human Factor

# Human Factors Model[1]

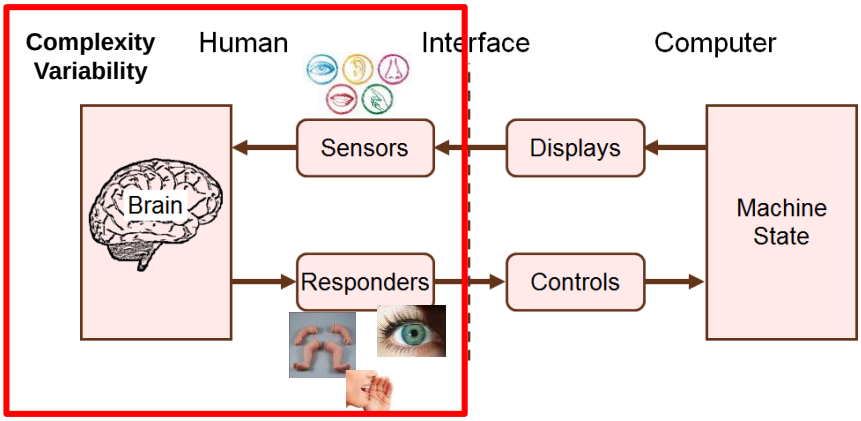



[1] Kantowitz, B. H., & Sorkin, R. D. (1983). *Human factors: Understanding people-system relationships*. New York. New York: Wiley.

2

# 2. The Human Factor

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




3

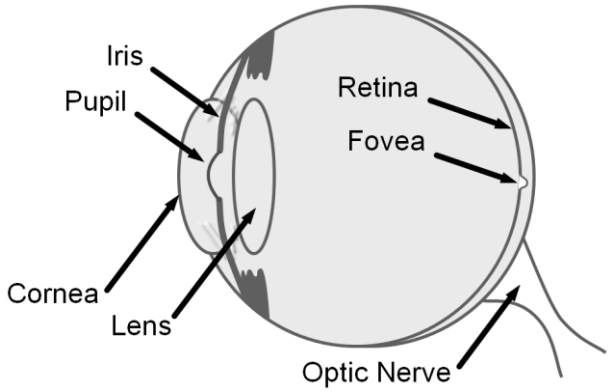
# Human Senses

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

4

# Vision (The Eye)

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




5

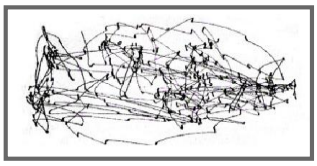
# Fixations and Saccades

- 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

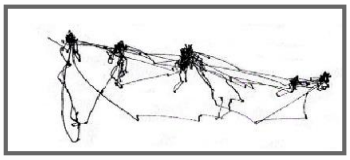
6

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

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



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

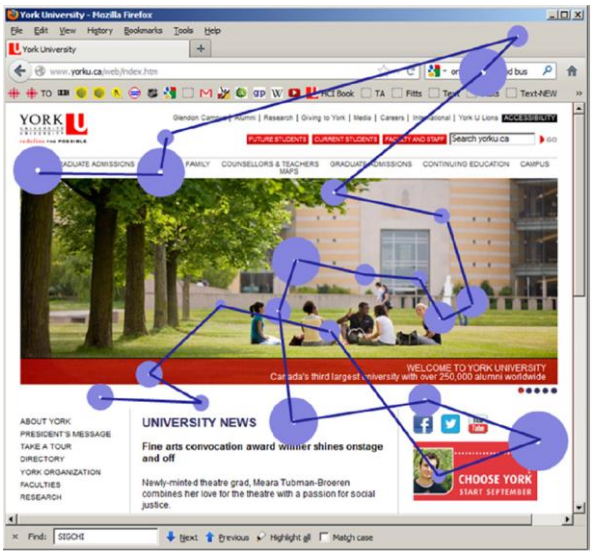


"Estimate the ages of the people"

[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..

7

# Eye Tracking Research




8

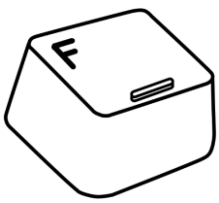
# Hearing (Audition)

- Sound → cyclic fluctuations of pressure in a medium, such as air
- Created when physical objects are moved or vibrated
- Physical properties of sound…
  - Frequency
  - Intensity

9

# 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:



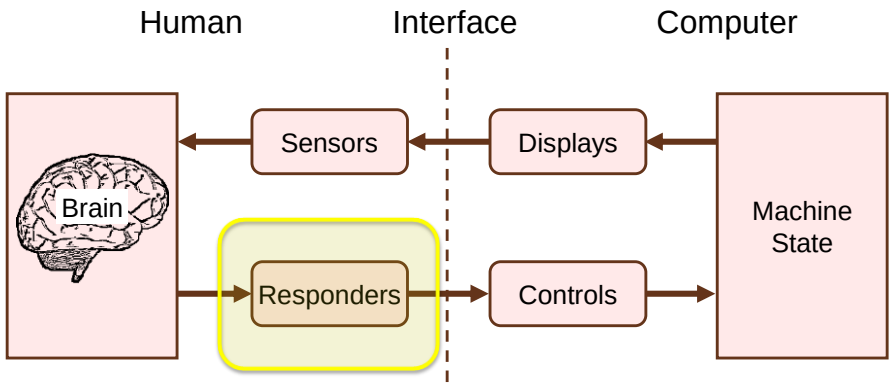

10

# 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)

11

# Human Factors Model




12

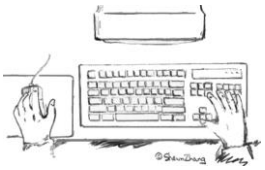
# Responders

- 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

13

# Handedness

- Some users are left handed, others right handed. Important in interaction design.



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

14

# 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.

15

# Challenge (home)

- Use a spreadsheet to implement the Edimburgh Inventory (see right)
- Calculate your score

| | Left | Right | |
|---|---|---|---|
| 1. Writing | | 2 | |
| 2. Drawing | | 2 | |
| 3. Throwing | | 2 | |
| 4. Scissors | | 1 | |
| 5. Toothbrush | | 2 | |
| 6. Knife | | 1 | |
| 7. Spoon | | 2 | |
| 8. Broom | | 1 | |
| 9. Striking a match | | 1 | |
| 10. Opening box | 1 | | |
| TOT | 1 | 14 | |
| | | | |
| DIFFERENCE | 13 | | |
| CUMULATIVE TOT | 15 | | |
| **Result** | **87** | **Right-handed** | |

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# 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.)

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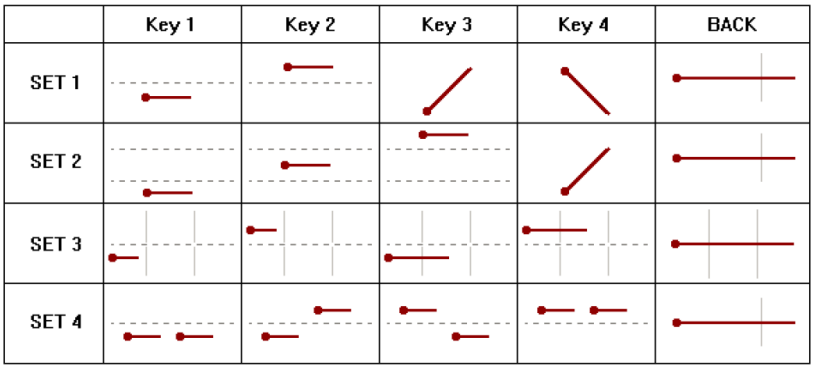
# Non-speech Example[1]

- 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.

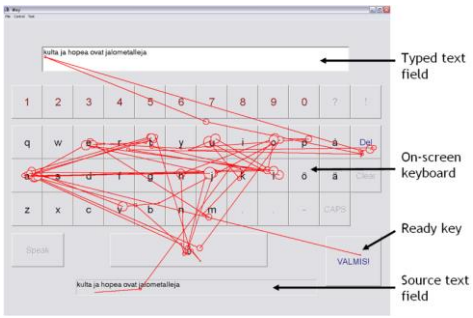
18

# 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

19

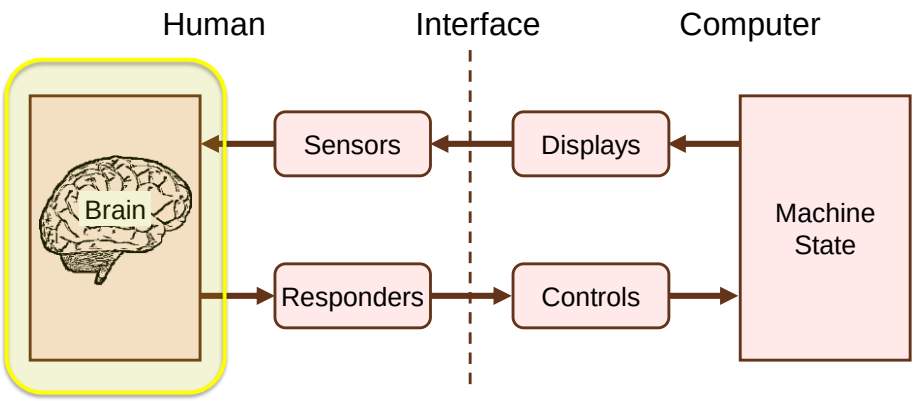
# Example - Eye Typing[1]




[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.

20

# Human Factors Model




21

# The Brain

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

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# Perception

- 1st stage of processing for sensory input
- Psychophysics: branch of experimental psychology, studied since the 19th century
- Determine the *just noticeable difference* (JND): threshold below which the subject deems the two stimuli "the same"
- Experimental method:
  - Present subject with two stimuli, one after the other
  - Stimuli differ in a physical property (e.g., frequency)
  - Randomly vary the difference

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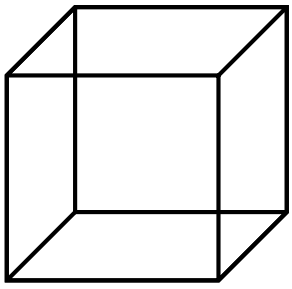
# Ambiguity

**Necker cube**



Which surface is at the front?

**Rubin vase**

Wine goblet or two faces?

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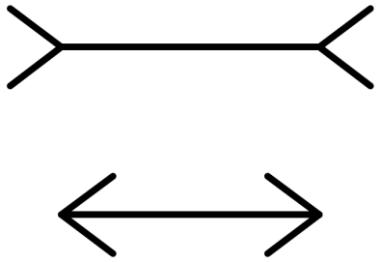
# Illusion

**Ponzo lines**

Which black line is longer?

**Műller-Lyer arrows**



Which horizontal line is longer?

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# 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

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# "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)

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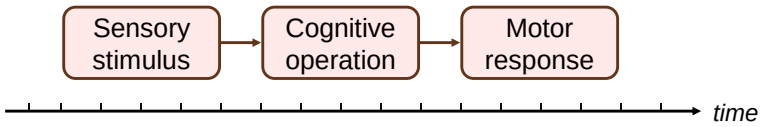
# Making a Decision – in Parts




| 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!

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# Memory

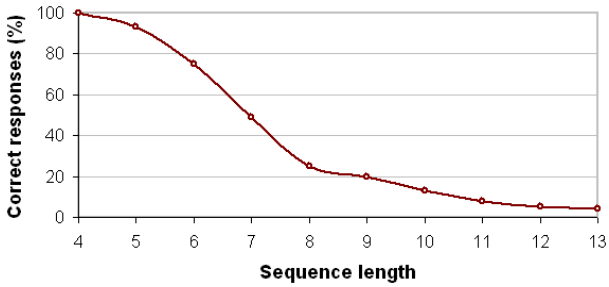
- Vast repository
- Long-term memory
  - Declarative/explicit area → information about events in time and objects in the external world
  - Implicit/procedural area → information about how to use objects and how to do things
- Short-term memory
  - Aka *working memory*
  - Information is active and readily 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.

29

# 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 ($n \approx 60$):




30

# 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.

31

# 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) |
| … | … | … | … | … | … | … |

32

# Statistics and Language

- Native speakers intuitively understand the statistical nature of their language
- We…
  - Anticipate letters

    Questio_
  - Anticipate words:

    A picture is worth a thousand _____.
  - Anticipate entire phrases:

    To be or __ __ __.

33

# 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

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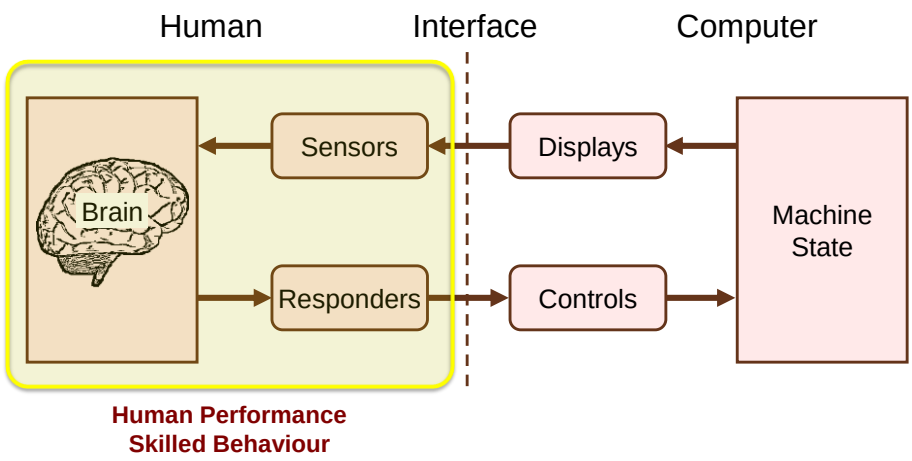
[1] http://news.bbc.co.uk/2/hi/uk_news/2814235.stm

# Human Factors Model




35

# Human Performance

- Humans use 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

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# 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

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# 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)

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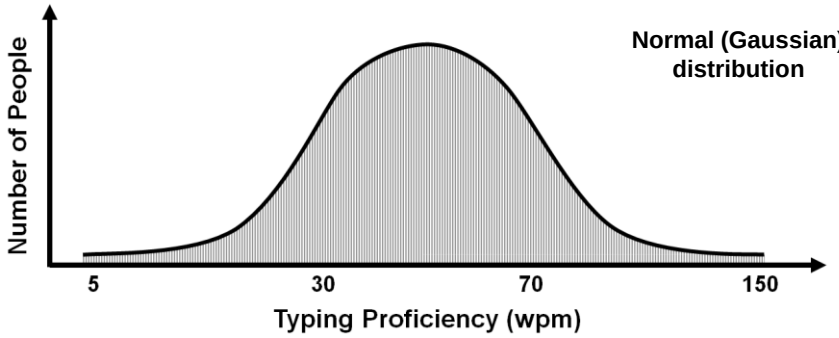
# Human Diversity and Performance




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!)?

39

# 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.

40

# 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.

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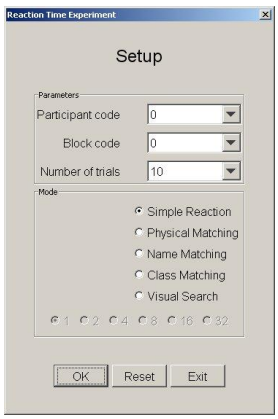
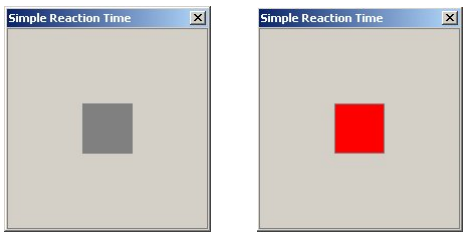
# Reaction Time Experiment





**Simple Reaction Time**




Use software from book's web site:

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

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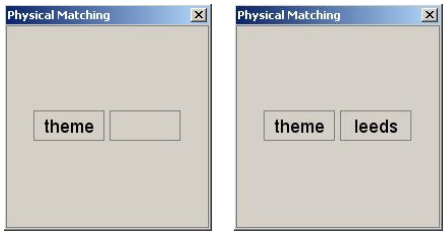
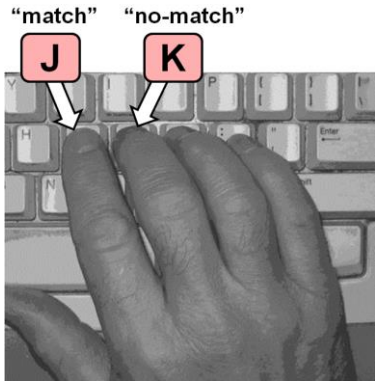
# Reaction Time Experiment (2)

**Physical Matching**

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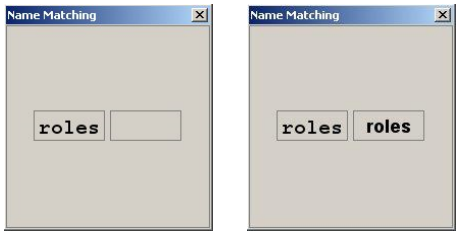
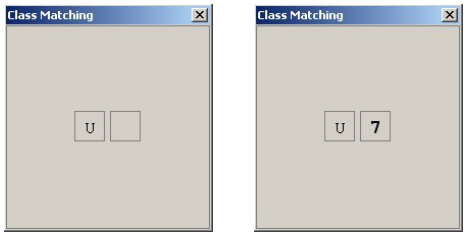
# Reaction Time Experiment (3)

**Name Matching**




**Class Matching**

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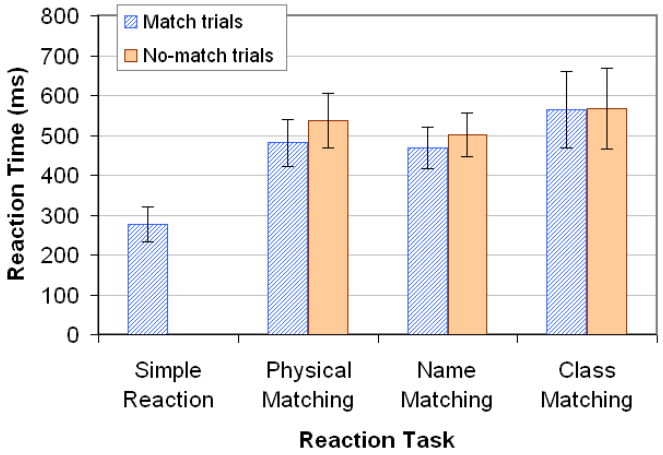
# Experiment Results

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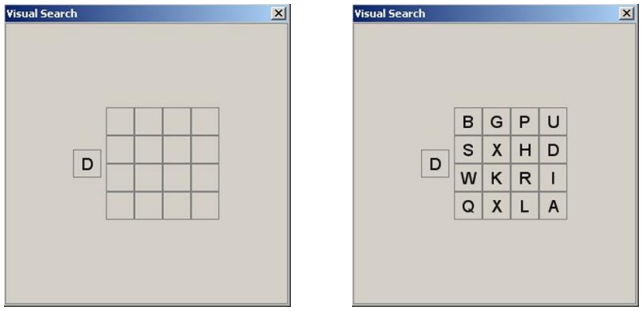
# Visual Search

- A variation on physical matching
- 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

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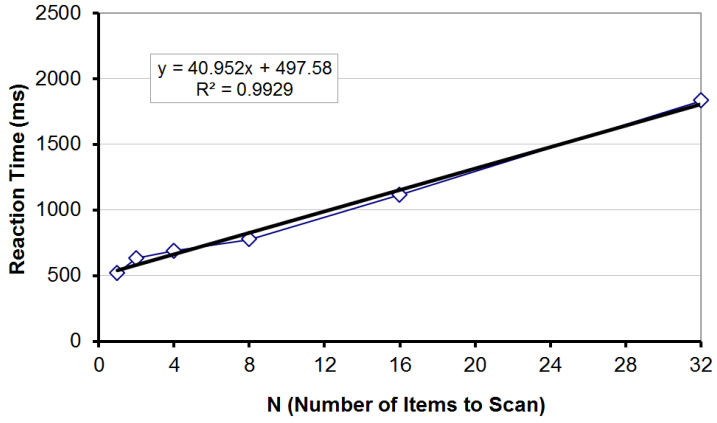
# Experiment Results (1)

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# 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)

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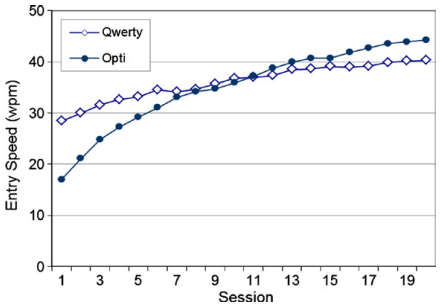
# Skilled Behaviour



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Connect to: http://join.quizizz.com

# QUESTION TIME

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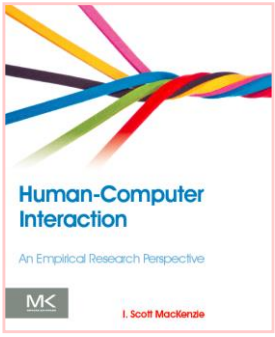
# Thank You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